A HANDBOOK OF THE WORLD'S CONIFERS

VOLUME 1

ALJOS FARJON

BRILL

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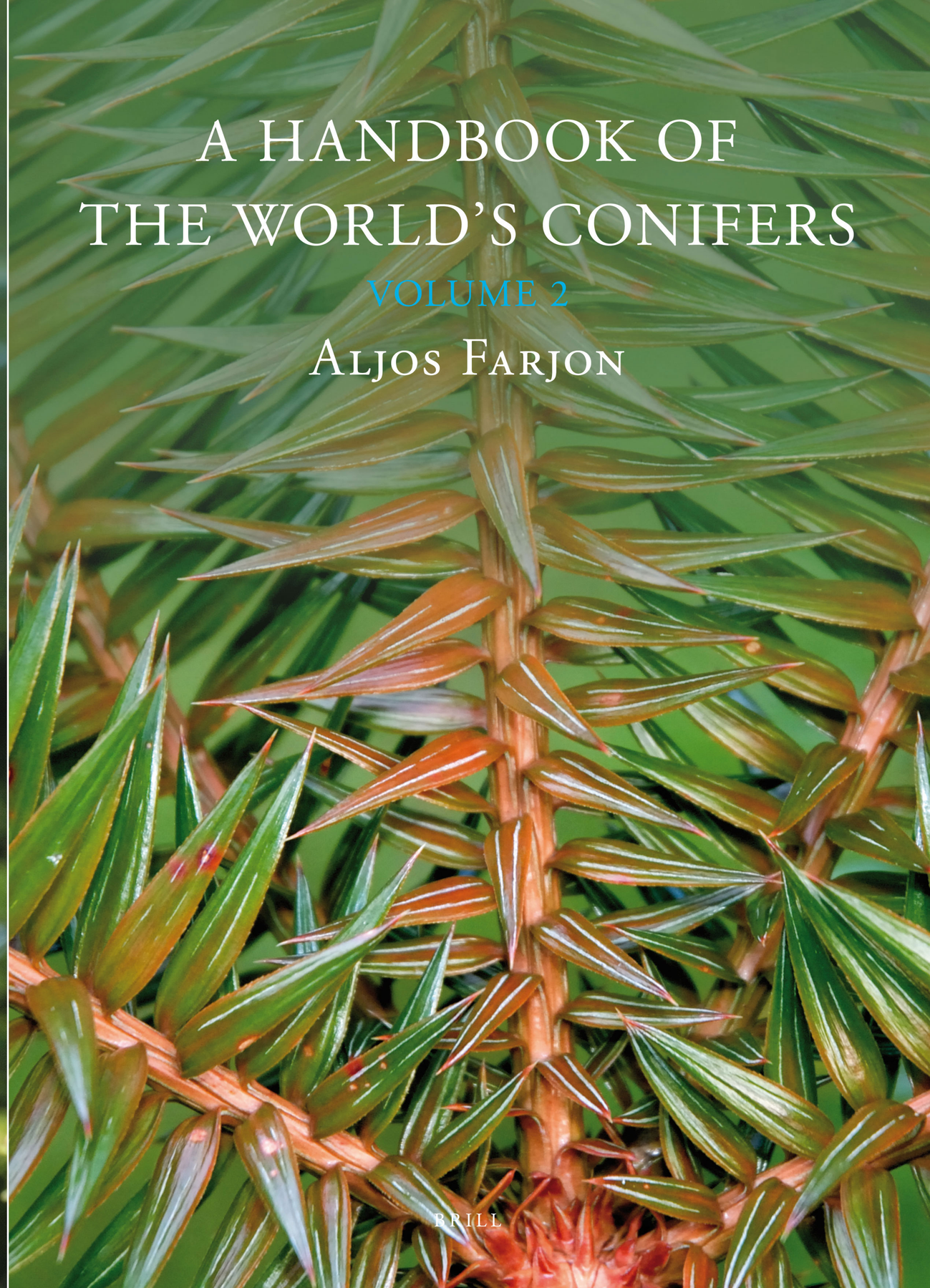
VOLUME 2

ALJOS FARJON



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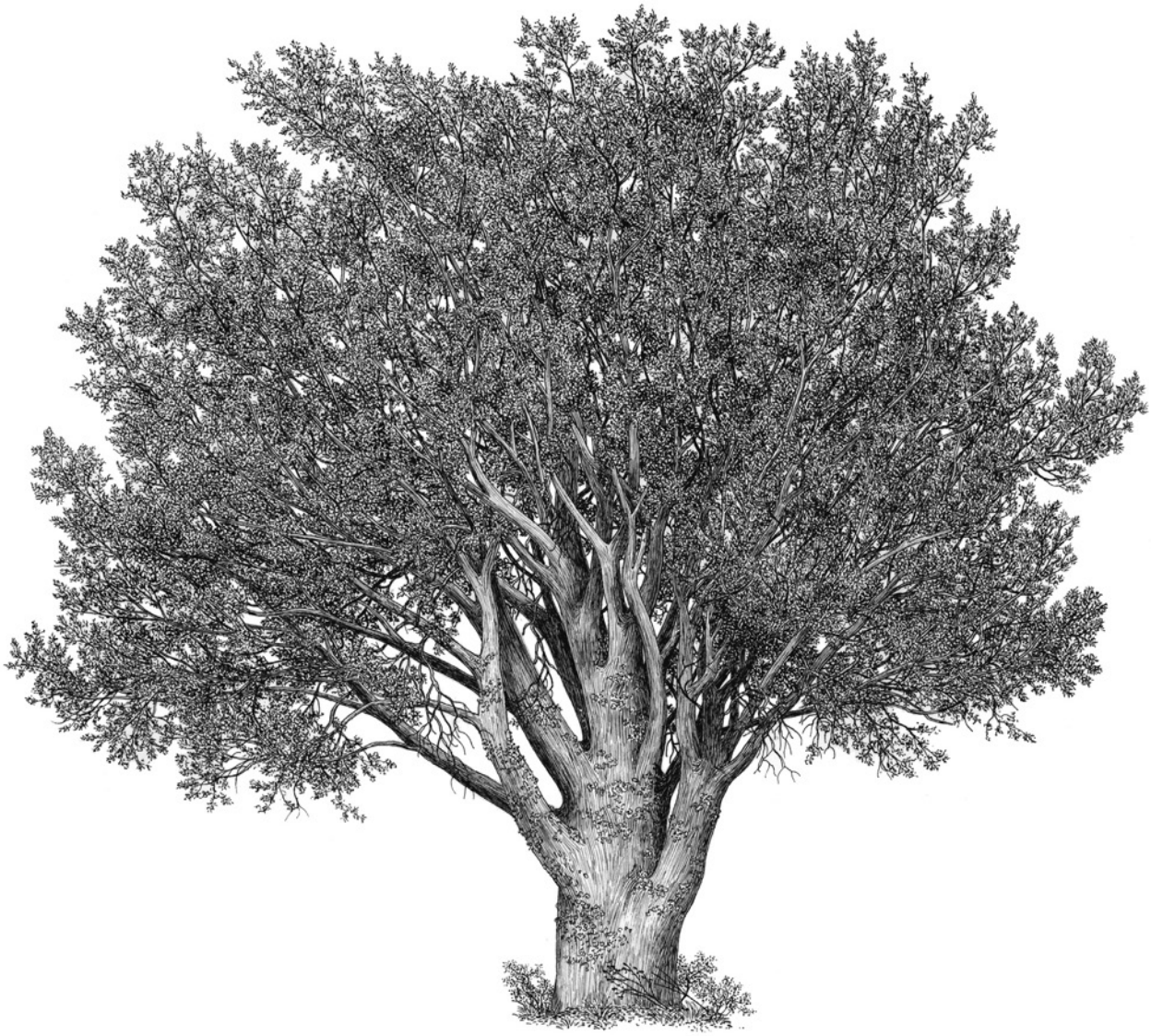

Cupressus guadalupensis Drawing by Aljos Farjon

A HANDBOOK OF THE WORLD'S CONIFERS

BY

ALJOS FARJON

VOLUME I

SECOND, REVISED EDITION

BRILL
LEIDEN-BOSTON
2017

This book is printed on acid-free paper.

Library of Congress Cataloging-in-Publication Data

The Library of Congress Cataloging-in-Publication Data is available from the Publisher.

front cover:
Abies fabri young seed cones

back cover:
top left: *Dacrycarpus kinabaluensis* seed cones
bottom right: *Picea likiangensis* young seed cones

VOLUME ISBN: 978 90 04 32449 7
SET ISBN: 978 90 04 32442 8
E-ISBN: 978 90 04 32451 0

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TABLE OF CONTENTS

Foreword *7*

Preface *9*

Preface to the second edition *13*

The conifers of the world, an introduction *15*

The distribution and ecology of conifers *23*

The economic importance of conifers *27*

The conservation of conifer diversity *31*

Synopsis of families and genera *35*

Taxonomic treatment of families, with keys to families and genera *45*

Taxonomic treatment of genera and species *57*
(in alphabetical order), with keys to sections, subsections and species

Appendix *1071*

Glossary *1073*

References *1093*

Lists of illustrations *1105*

Index to botanical names of conifers *1113*

FOREWORD

With the Handbook of the World's Conifers, its author Aljos Farjon has given us a wonderful aid to learn almost all there is to know about this ancient lineage of woody plants. In true Handbook tradition all 614 species of extant conifers are concisely described, with user-friendly identification keys to families, genera and species and invaluable additional information on uses, conservation status, and much more. Unlike earlier books on conifers that are heavily skewed towards temperate conifers from the northern hemisphere, the present Handbook does equal justice to the 200 tropical species and 415 temperate ones; this attention to tropical species makes the Handbook truly unique.

In the very informative introduction the evolution, classification, ecology, biology, economic uses, and conservation status of the conifers are discussed. This handbook thus combines the virtues of a comprehensive taxonomic monograph of the conifers, with that of a true *vademecum* on the morphological attributes, uses, and conservation of all species of the order. The information on the ecology of each species in its natural habitat is particularly welcome, because it gives us the keys to designing effective conservation measures for each endangered species and also defines the scope and limitations of where one could introduce a species successfully in tropical or temperate horticulture.

With his lifelong dedication to the study of the taxonomy of conifers at Utrecht, Oxford and Kew, and his strong involvement in the conservation of many red-listed conifer species throughout the world, Aljos Farjon is arguably the only plant scientist in the world to complete the colossal task of producing this comprehensive handbook single-handedly and authoritatively. I hope and am confident that it will give as much pleasure and satisfaction to a wide audience of tree enthusiasts, foresters, botanists, ecologists and conservationists as it has given me.

Pieter Baas
Emeritus Professor of Systematic Botany, Leiden University
Former Director of the National Herbarium of the Netherlands

PREFACE

Many books have been written about conifers during the 19th and 20th centuries, the majority of these with emphasis on horticulture in Europe. Those that are mostly compilations of species and their cultivars found to be grown in gardens and parks, with descriptions, illustrations and information about their cultivation, are known as handbooks or manuals. A conifer handbook as traditionally compiled is therefore a comprehensive guide to the conifers that are grown or could be grown in cultivation in a certain part of the world and includes, besides species and botanical varieties, cultivated varieties or forms (since 1953 universally known as cultivars). All such works, even the most comprehensive, emphasise conifers adapted to a cool temperate climate as experienced in Europe. Several have made this explicit in the title of the book, but even those that have not done this invariably treat 'hardy' conifers more fully than other species, which are at best only mentioned briefly. The scope, content and presentation are aimed at the horti- or silvicultural users. Some of the better-known conifer handbooks were reviewed in Chapter 1 of my Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a). Most conifer handbooks are now out-of-print, but some new books have recently been added to the bibliography of conifers, while others are being compiled. The emphasis on the temperate conifers in cultivation has remained strong in these works, as far as I know.

The present Handbook is very different from these predecessors. There is no particular emphasis on conifers that can be grown in Europe. Of the 614 species known in the world at present, about 200 occur in the tropics. They receive here equal cover with the species that grow in temperate climates. In this respect, the present book more closely resembles a taxonomic monograph, as it includes all the currently known and accepted taxa, from the ranks of family down to variety and forma. However, it is not a monograph purely for taxonomists. Its content aims at a much wider audience. To achieve this, strictly taxonomic information has been limited to what is more or less essential, while other information has been included that may not even have been considered for a taxonomic monograph. There are paragraphs on ecology, uses and conservation with all species accounts. This handbook does not describe or illustrate conifers that are only known in cultivation. With some 15,000 conifer cultivars known, no comprehensive coverage could have been achieved. Instead, a separate volume now covers these, authored by Aris Auders in Latvia and Derek Spicer in England, entitled Conifers – A Comprehensive Guide to the Conifer World, published under the auspices of the Royal Horticultural Society. It follows the taxonomy in this Handbook of the World's Conifers for families, genera and species and these two handbooks are therefore complementary and can (and should) be used side-by-side.

The need for a comprehensive and modern handbook concentrating on the species of conifers is clear. Awareness of the obligation to manage and protect the biological resources of this planet and use these resources sustainably has created a demand for accurate, up-to-date information. Conifers occur worldwide and are major or minor components of nearly all major forest and woodland types, as well as many timber plantations and numerous gardens and parks. They are of high economic value, but also play major roles in the ecology of many natural and semi-natural ecosystems. They are an integral part of many landscaped estates and parks from the subtropics of Australia and New Zealand to the temperate regions of Europe and North America. This handbook of conifers has been compiled to address this need for relevant information and should therefore be useful to botanists, conservationists, dendrologists, ecologists, foresters, horticulturists, land resource managers and, I should add, all those with an interest in the trees and forests of the world. Knowledge is not only useful, it is a pleasure that enhances the quality of life.

The introductory chapters have deliberately been kept brief, often merely touching on interesting aspects of conifer biology, evolution and taxonomy, as well as ecology, economics and conservation. For a recently published full introduction I refer to my book *A Natural History of Conifers* (Farjon, 2008), where all these issues are treated in much more detail. After these short chapters, the book moves to

the families, genera and species and becomes the handbook referred to above. For the general user it may be useful to outline and explain the conventions and format followed throughout for all genera and species. To identify a completely unknown conifer, one should start with the key to families on p. xxx; then the key to genera under the family determined, and the key to species under the genus arrived at. Genera with numbers of species greater than 15–20 have been divided, formally or informally, and keys to these groups are first to be consulted. Under species may follow subspecies and/or varieties; these are usually not included in keys. Not more than six infraspecific taxa are accepted under any one species in this book, and their descriptions are brief and diagnostic. These descriptions should primarily be compared with the relevant species description and the character states mentioned therein, and less with each other. No attempt has been made to create varieties within subspecies and, unless such ranking has been established by other authors and is followed here, the two ranks are treated as equal. In the taxonomic literature, the use of either subspieces or variety appears to derive more often from tradition than from explicit taxonomic concepts. I believe that botany would be well advised to follow zoological practice and use only a single infraspecific rank in future. After using the keys, reading the description of a species is recommended as a check to find out if the determination is correct. Also, as it is almost impossible to construct keys that use any and every feature of a specimen in hand, the reading of the description helps with the identification. An extensive glossary is provided to help explain much of the terminology used in this handbook.

Botanical names are given in full as in a taxonomic monograph, i.e. with (abbreviated) author name(s), abbreviated reference to the place of first publication, synonymy and type citation. The accepted names are followed by synonyms if these apply. Among synonyms, basionyms are always cited as types refer to these; other synonyms are cited selectively. In most cases, synonyms no longer in use as accepted names have been omitted. Most recently published names have been included, but not all, for instance new names resulting from a mere change of rank, such as variety to subspecies. When several synonyms are cited, homotypic synonyms are grouped together in one continuous line; heterotypic synonyms are separated by a blank line from the accepted name (and its homotypic synonyms) or begin on a new line. Where relevant, the (aberrant) status of synonyms under the Botanical Code (ICBN) is given after the citation of the place of publication. Types (i.e. herbarium specimens designated to fix the application of a botanical name) are only given here for accepted names, including their synonyms if based on the same type. Types of genera are cited as names of species. The opportunity to designate types where it was appropriate and possible has been taken; but in several cases typification is complicated and then it has been left to future research. This is what is meant with the phrase "type not designated" under several species. Type specimens are deposited in institutional herbaria, abbreviated by an acronym and these can be found at www.sciweb.nybg.org/science2/IndexHerbariorum.asp.

Under species, subspecies, varieties and forms may be recognized. While these ranks are hierarchical in that order and species have been subdivided in that way, I am no advocate of this. A single rank under species would suffice in botany as well as it does in zoology. Leaving the rare use of forms aside as a special case, I am agnostic as to whether this should be the rank of subspecies or variety. In botanical taxonomy, we have an unavoidable historical legacy: both ranks have been used in the literature, often for the same taxon. In some countries one rank was preferred over the other. In this Handbook, therefore, I have used what ranks were available in validly published names under species where infraspecific taxa merited recognition; under a few species I have accepted two ranks if these appear to be widely used. Unfortunately, the same notion of one rank under species has induced the publication of numerous new combinations, some have changed subspecies to variety and others *vice-versa* depending on preferences. I have not seen fit to increase the number of pages by including all of these mostly superfluous name changes, nor by adding new combinations if none existed in the desired rank. If infraspecific taxa are recognized, the species name in the inclusive sense is given first (with authority and place of publication) and the description is similarly inclusive, i.e. it encompasses all subspecies and/or varieties. Synonyms and types are given with the latter and the short descriptions given there are exclusive. Botanical descriptions immediately follow the names of taxa and are not headed, but all other information is given under its

specific head (in bold type face) for clarity and ease of reference. The descriptions of species follow the conventional sequence for descriptions of trees; i.e. from size and habit to trunk, bark, branches, foliage, leaf details, male and female reproductive structures and ending with seeds. Despite the relative detail in some descriptions, it should therefore not be difficult to find particular parts and I have therefore not marked these with a different font or type. The botanical names of species are followed by the *etymology* of the accepted name and by *vernacular names*. Etymology is also explained for genus names but not for subspecies and varieties and only occasionally vernacular names are mentioned with the latter two. The vernacular names do not provide a comprehensive listing, especially not for species with a very large natural distribution, covering an area in which many languages may be spoken. Vernacular names may not be specific; if referring to the genus rather than the species and if more than one species occur in the area, such names are not listed. Some published vernacular names seem contrived; if these are not actually in use locally or regionally, they are not cited here. *Taxonomic notes* may follow the descriptions; they are usually comments on different taxonomic treatments or notes on typification of the species or mention similarities of taxa. In the concise format necessary in this Handbook, comments and discussions are limited to the essential and are kept brief. Not every name placed in synonymy can be discussed here; the reader can rest assured that due scientific consideration has been given, some of which has been published elsewhere. *Distribution* of taxa is given in two formats and these are often complementary. The first is descriptive, mentioning regions as well as countries, provinces, areas and localities, as appropriate. The second format uses the TDWG codes (Brummitt, 2001). These codes provide geographical information at three levels defined by geographically and politically delimited areas, e.g. 42 = Malesia (a geographical region) BOR = Borneo (an island) and SB = Sabah (a politically delimited area): 42 BOR-SB means therefore that the species occurs (also) in Sabah. The meaning of these codes can be found at www.catalogueoflife.org/search.php. For species with large ranges the TDWG codes provide more detailed information than the descriptive statement, but for species with very limited distribution the latter is often more precise because TDWG codes often do not go down to such detail. When entered in a database, the TDWG codes linked to names can provide easy and quick listings of species per country, state or province. This information is available for conifers at www.catalogueoflife.org/search.php.

Ecology describes the habitat of a species and its altitudinal range (in meters above sea level: m a.s.l.) is given here. For many species, especially in the tropics, their habitat remains poorly documented, while much has been written on many species in the temperate northern hemisphere. Some information could be assembled from notes on herbarium specimen labels and has been recorded in the conifer specimen database available at dps.plants.ox.ac.uk/bol//home/default.aspx under "Online Groups". As indicated above, a balanced approach has meant that not all that is known can be mentioned here and for such species the information on ecology (and other subjects) is indicative rather than comprehensive. *Conservation* is usually concerned with species survival issues as defined by the World Conservation Union's (IUCN) Species Survival Commission (SSC). Information was gathered and the conservation status of taxa (species to varieties) has been assessed by members of a Specialist Group (SG) resorting under the SSC. In the case of conifers this is the Conifer Specialist Group (CSG) which is currently chaired by this author. Almost all conifers have been assessed under IUCN Red List criteria, the resulting categories of threat are given under the heading IUCN. For the abbreviated categories of threat see the introductory chapter Conservation; for definitions and decoding of the criteria used visit www.iucnredlist.org/static/categories_criteria. The listings given here are as in the 2008 IUCN Red List of Threatened Species™ [www.iucnredlist.org] including the criteria of either version 2.3 (1994) or 3.1 (2001) as applied. *Uses* mentions commercial as well as other human uses of species. The two main categories are wood (timber) and its applications and horticulture, but other uses, including 'traditional', have been mentioned when known. As with ecology, much more is known about uses of species in the temperate zones than in the tropics. Often, timber is traded under a 'generic' name which may even include different genera, as in the family *Podocarpaceae*, which makes distinctions of use among species extremely difficult. Horticultural use is also unevenly distributed along similar lines of geographical demarcation, but uses in the subtropics

and tropics are picking up and therefore mentioned when known. This book does not include cultivars but if such exist under a species, that information is given. Plantation in a forestry context is usually mentioned with the uses of timber; for several species plantations have become the main source of that commodity.

The glossary in this Handbook is the most inclusive I have yet compiled. I have made use of several published in my earlier works, but added numerous entries specifically for this book. In particular, I have attempted to explain terms used by plant taxonomists, because this book is meant to be used and consulted by many others, amateur as well as professional. I hope it will be found useful, but I am aware of the difficulty of finding a balance between explaining commonly understood terms and thereby underestimating my readers and using unexplained terms for which one might need to consult a large dictionary. Finally, I have only included botanical names of conifers in the index. Numerous other species names occur in the texts on the ecology of conifer species, but giving information about these other species is obviously beyond the scope of this Handbook. Vernacular names, while cited under many species, are incomplete (especially in the tropics), use several languages besides or in lieu of English, and are often ambiguous. The reader is therefore encouraged to use (and learn) the botanical names of species. Both in the library and on the Internet, nearly all information is available under these identifiers. Because the information in this book is arranged by species, finding the species (they are arranged in alphabetical order as well as indexed) is all that is needed to obtain all the information about them given in this Handbook.

The compilation and writing of the Handbook of the World's Conifers has been a task which started some time after my official retirement from the Royal Botanic Gardens, Kew in 2006. Certain conditions had to be met before I could seriously embark on this project, because it required access to resources, to enable me to devote full working time to it. I was very fortunate that the Royal Botanic Gardens appointed me an Honorary Research Associate after my retirement, to be based in the Herbarium where I had worked before (now the Herbarium, Library, Arts & Archives Department). It was there that much of the work on this book was done and I am grateful to RBG Kew for this invaluable support. Funds had to be raised for this project, and when money was being pledged, I had to find a registered charity to administer these funds. This was generously undertaken by the Linnean Society of London and I am grateful for the trust the Society has placed in one of their Fellows to fulfil the commitments thereby generated. The Treasurer of the Society, Prof. Grenville Lucas, guided me through this whole process in his capable and incomparable manner and I am most indebted to him for this generous support. Most importantly, my gratitude goes to all the generous donors to this project, who together have made this book possible. I have permission to name them here and shall do so in alphabetical order. They are the Arboricultural Association (UK), Mr. Lawrence Banks (UK), The Dendrology Charitable Company and the International Dendrology Society, Dr. Barry Denyer-Green (UK), the Lord Devonport Charitable Trust (UK), Mrs. Francine von Finck (Germany), Mrs. Arabella Killander (UK), the Samuel Storey Family Charitable Trust (UK) and the Stanley Smith Horticultural Trust (UK). This Handbook is the synthetic product of 25 years of research into conifers by its author. To give detailed acknowledgement to all persons and organisations who have assisted me in that research would be next to impossible. Research is often a collaborative effort, even if the resulting published output appears to have a single author. My thanks are therefore here expressed to all I have been in touch with on conifers from time to time, on field trips around the world as well as at my and their various home institutes during those years. Dr. Christopher N. Page reviewed the texts on *Podocarpaceae* and the smaller families and his supportive comments were much appreciated. Michael Frankis commented on common names and corrected errors therein. The entire text was copy-edited by Dr. Hans Kruijer, whose helpful corrections much improved consistency and clarity of presentation. Prof. Pieter Baas wrote a thoughtful foreword, for which I am most grateful. Finally, coming closer to the end product now before you, I wish to thank the publisher, Brill and their helpful staff (especially Michiel Thijssen, Sabine Steenbeek and Frits Fritschy) for their professional work and helpful patience with the author. They have turned a huge and complicated manuscript into a beautiful book.

Aljos Farjon, FLS
[Kew, 27 November 2009]

PREFACE TO THE SECOND EDITION

Since the publication of this Handbook in 2010 rapid and substantial developments in conifer research and publication have occurred. Those that have caused many necessary corrections and amendments to the first edition are connected with two projects led by the author; the compilation of *An Atlas of the World's Conifers* published by Brill in 2013 and the reassessment for the IUCN Red List of all conifers in 2010–2013. As a consequence, new and often more detailed information on distribution and conservation status of species became available and had to be incorporated in the new edition. Proposed taxonomic changes have been treated cautiously but those considered 'unavoidable' have been presented in an Appendix so as not to disrupt the alphabetical sequence adopted in the Handbook.

AF
[Kew, 30 November 2016]

THE CONIFERS OF THE WORLD, AN INTRODUCTION

To most of us who live in the temperate zone of the northern hemisphere, conifers are among the most familiar trees and indeed an everyday sight. Not only do they naturally occupy vast areas of northern lands such as Canada, Scandinavia and Russia, as well as many mountain regions further south, we have also extensively planted them in forestry while gardens and parks of even moderate size are hardly conceivable without them. Far less widely known are the conifers of the southern hemisphere and still fewer people will associate conifers with the tropics. True, neither of these major parts of the world have extensive conifer forests similar to those in the north; conifers in these latitudes are more often than not a relatively minor component of forests, often confined to rather inaccessible areas, or inconspicuously mixed with more numerous angiosperm trees. But if we were to regard diversity rather than sheer quantity as a criterion, the north would lose its primacy as the realm of conifers to more southern latitudes. In the present Handbook of the World's Conifers I have recognized 614 species in 70 genera belonging to 8 families. Of the genera, 35 are restricted to the northern hemisphere, 25 occur only south of the equator and 10 are found both north and south of that line. Since, with the exception of *Podocarpus*, which is largely tropical, most large genera occur in the northern hemisphere, that half of the globe (with by far the greater land mass) has more species than the southern hemisphere. But in the northern hemisphere, diversity of species, especially in the larger genera, increases markedly towards the equator, with for instance only 9 species of *Pinus* in Canada and 43 in Mexico. More or less limited regions with more than 40 species or 50 taxa (species and lower ranks) defined as centres of diversity for conifers (Farjon & Page, 1999) are now eight in number, seven are situated on or north of the equator and one south of it, but all except Japan are at latitudes below 40° and two, Borneo and New Caledonia, are entirely in the tropics. That last island is the most diverse and remarkable conifer centre of all; covering an area the size of Wales, it has 43 species and all are endemic to the island.

But, such criteria of appeal to biologists aside, the sheer number and volume of conifer trees growing in the temperate north makes them of prime economic and ecological importance throughout the entire world. With an estimated value of $100 billion per annum, wood products stand foremost and conspicuous at the top of the economic shopping list, but especially at more southern latitudes other products, e.g. resins and derivatives, and even seeds for food, are also economically important. And then, as already indicated, there is the significant contribution conifers have made to horticulture as ornamental trees, a trade which has given rise to numerous cultivars some of which are among the most popular shrubs and trees planted almost the world over in gardens and parks. I venture the statement that, although being a relatively small group of species of woody plants – there are about as many species of oak (*Quercus*) and twice as many species of wattle (*Acacia*) – conifers far exceed any other group of woody plant species in economic and ecological importance. We would have to look at the major food crop plants to find species that generate more income than some of the pines and spruces. But, as with cereals and beans, only a tiny minority of species diversity within conifers is accountable for this prominence today, while the majority shares in the fame only by merit of kinship. Having said this, the question may be asked, what constitutes this 'kinship' in conifers? In other words, what are conifers? It is not as straightforward a question to answer as it may seem.

In the early days of systematic botany, the 'conifers' were often thought of as a natural family of plants, in a similar fashion as botanists referred to e.g. *Rosaceae* or *Compositae* and, indeed, the name *Coniferae* prevailed well into the early 20th century. Are conifers a family of plants, or at a rank higher, an order *Coniferales*? Modern classifications classify groups of organisms in monophyletic groups, i.e. organisms or groups of organisms that in evolutionary history share a common ancestor (usually an ancestral species). Monophyletic groups may include more recently formed monophyletic groups and belong to other monophyletic groups of more distant

pasts. We must discuss the term 'conifer' in this context of monophyly to answer these questions. No such discussion makes any sense without looking at the origin of conifers as (imperfectly) revealed in the fossil record. The fossil story is a complicated tale which can only be very summarily related here, but I shall nevertheless try to answer these questions; for more on this topic, see my book *A natural history of conifers* (Farjon, 2008). The word 'conifer', meaning 'cone-bearer', suggests that plants bearing 'cones' could be called conifers. Cones are reproductive organs consisting of fertile scales (simple cones) or sterile and fertile scales (compound cones) that are spirally arranged at a central axis; the fertile scales of a cone contain either pollen sacs or ovules. However, although the majority of conifers are characterized by having cones, it is problematic to define the conifers as plants bearing cones. Even if the term 'cone' would be restricted to the ovulate organ of its description, a definition of conifers based on that organ is problematic, because we will then find that, among the gymnosperms, pines are considered conifers but cycads are not. Conversely, *Cephalotaxus*, with a mature ovulate organ reduced to a single seed is still a conifer, but *Ginkgo*, seemingly similar in that respect, is not (despite its inclusion in many books on conifers). The key to the difference here is partly revealed in the ontogeny of both taxa, but it ultimately has to do with phylogeny, i.e. how these taxa are related in an evolutionary sense.

The term 'gymnosperm' has fallen, and we need to explain what is meant by it first. In the course of the early evolution of land plants, adaptations to water stress – i.e. dry conditions – gradually led to the origin of the 'seed habit', with the evolution of ovules with an envelope (integument) to protect the vulnerable gametophyte phase from desiccation, coupled with devices to catch pollen in a suitable micro-environment and to conduct the growing pollen tube to the megagametophyte for fertilization. As these ovules were borne variously on branching systems, leaves or other appendages, but otherwise exposed to air and not enclosed in a capsule (ovary), like in angiosperms, they were 'naked' as denoted by the term 'gymnosperm' which is thus merely a denominator for a 'less advanced' mode of seed habit. All seed plants were by definition gymnosperms until the angiosperm 'seed habit' evolved from a gymnospermous seed. By sharing the evolutionary novelty of having ovules and seeds enclosed in capsules, angiosperms form a natural group. The term gymnosperm, on the other hand, does not specify a 'natural group' by any modern criterion. Conifers are characterized by 'naked' ovules, for sure, and are thus gymnosperms, but they share this one feature of early seed plants with other groups of primitive seed plants, e.g. *Ginkgo* and cycads. Taxa are defined by evolutionary novelties. It is, however, often difficult to determine which characters represent such evolutionary novelties. Taxa, therefore, need to be defined by diverse and structurally unrelated characters to increase the likelihood of representing 'natural groups' and for conifers several of such characters can be identified. Farjon (2008) characterized conifers as "shrubs or trees with secondary wood build of tracheids with large bordered pits in their walls and narrow rays. The leaves are simple and single or parallel veined. Resin is produced in the wood or in the leaves and is conducted through resin canals. The reproductive organs are separated into male and female, with male cones (pollen cones) simple and female cones (seed cones) compound or reduced. Conifers have only one copy of a large inverted repeat in the chloroplast DNA, whereas all other plants studied so far have two copies." If the DNA observation holds true, it may well turn out to be the single character state that is unique to conifers. But the group is exclusively circumscribed by this plus the other characters, each not unique, but in combination only present in conifers. Such characters are sometimes called 'traits'. The seeds of certain coniferous taxa occurring in the Carboniferous, when the earliest seed-bearing plants became apparent, tended to be borne on appendages axillary to leaves. Reduction of these appendages in size and/or number, planation, movement of ovules towards the base of the appendage and transformation of the subtending leaf to a bract as well as reduction of the fertile shoot to a determinate axis led to the formation of the conifer cone. By these transformations the female reproductive organs were aggregated in compound cones, which later again became reduced in various ways but the homology is often still discernible in ontogeny. The male reproductive organs (pollen cones) remained, or became early on, a simple axis bearing microsporophylls with dehiscent microsporangia (pollen sacs). Pollen cone morphology is rather uniform throughout the conifers. All these (and other) transformations are well

documented in the fossil record. They can generally be understood as adaptations to increasing aridity and seasonality with cold winters, which indeed marked the end of the Carboniferous and beginning of the Permian in large sections of the supercontinent Pangea. Out of perhaps a single ancestor (but which one?) plants we now call conifers evolved, spread across much of the ancient supercontinent, were dominant almost everywhere when this was divided by the Thetys Ocean into Gondwana and Laurasia, and prevailed even when these two continents broke up and the present continents started to drift further and further apart. But then, in the early Cretaceous, the first angiosperms evolved and spread to all continents eventually dominating most of the ecosystems suitable for vascular plants.

In the Late Carboniferous and Permian a group of conifers known as *Voltziales* or 'Walchian' conifers was widespread in Laurasia. Several had foliage leaves remarkably similar to some extant conifers, but the ovuliferous cones and especially the seed-bearing structures in these cones were very different. The famous studies of Rudolf Florin in the 1940's and 1950's solved once and for all the century old debate over the homology of the conifer cone and demonstrated how the conifer cone has evolved, at least in broad terms, from these Permian ancestors to, e.g., present day pines. 'Modern' conifers appear in the Triassic with *Podocarpaceae* and *Araucariaceae*, of which some remains show traits that did hardly or not at all change during all the ensuing millions of years, for instance the structure of conifer wood. Conifer wood is well preserved in numerous permineralized fossils allowing detailed study of cell walls. The wood of many conifers is anatomically relatively simple in structure and often hardly distinguishable between families. The famous remains of Late Triassic (ca. 210 million years ago) conifer tree trunks of the Petrified Forest in Arizona, USA could have belonged to *Araucariaceae, Podocarpaceae, Cupressaceae* (*Taxodiaceae*) or more likely an extinct family. The big logs of these Triassic trees were transported by ancient rivers from a considerable distance upland where they once grew to the place where they now lay. Yet, these and other fossils demonstrate abundantly how important and widespread conifers have been throughout the Mesozoic. Of particular interest is the conifer history on the Indian subcontinent, which is now almost devoid of conifers (with exception of the Himalayan region which had a different geological history), but rich in conifer fossils and those of other gymnosperms. On its long journey from southern latitudes as a disconnected chunk of Gondwana, going through the hot tropics and one or two arid zones it must have lost them all. On the collision with Asia, thrusting up the Himalayas, northern conifers spread southward to occupy the mountains. India has but a single southern conifer today: *Nageia wallichiana*, which is in fact an Indo-Malesian element spread from Southeast Asia. Another remarkable case is Antarctica. This continent has been glaciated for more than 20 million years, perhaps completely for 15 million years. But prior to that it was vegetated and in the Mesozoic is was a major centre for plant evolution, the pivotal piece in the Gondwanan puzzle of a fragmented continent of which the pieces started to drift apart just when 'modern' conifers evolved. Palaeobotanists are discovering more and more fossil sites in Antarctica and other Gondwanan continents, yielding important remains especially for the understanding of southern hemisphere taxa. A third phenomenon is the discovery of diverse conifer forests that existed at very high Arctic latitudes such as Axel Heiberg Island in Canada and Spitsbergen from the Cretaceous into the early Tertiary where now even tundra plants are few and very small. In a warm temperate climate there existed mixed conifer forests reminiscent of those occurring in, e.g., China today, but which had to adapt to four or five months without daylight in winter. Many of these conifers were the deciduous ones we know today from far more southern latitudes, such as *Metasequoia, Taxodium, Pseudolarix*, and even *Larix*; the latter does occur in part within the Arctic circle today.

Conifer phylogenetic systematics is marked by one predominant factor: extinction. Even the extant conifers reflect this very clearly, with 30 genera (43%) represented by just a single species and a further 11 genera with only two or three species, comprising 59% of the total of genera. Further analysis of their relationships, as well as the fossil record, are strong indicators that this lack of diversity at species level is the result of extinction, not a reflection of incipient speciation. Take for example the Dawn Redwood (*Metasequoia glyptostroboides*), first found as a Miocene fossil in Japan, then as a very restricted living tree in China, and subsequently (described as

several species) from Late Cretaceous and Tertiary deposits across the northern hemisphere even as far north as the arctic islands of Canada. In 1994, a conifer recognized as a third living genus in *Araucariaceae, Wollemia nobilis*, was discovered some 100 km northwest of Sydney in a remote, deep canyon; it has almost certainly near relatives in the fossil record of Australia and beyond, but no more than 100 mature trees survive 'miraculously' in the wild today. Similar stories abound in conifers, and while the popular press hailed both examples as 'living fossils' when they were first discovered, that label would be appropriate to scores of other species. The fossil record of conifers is comparatively rich and very diverse, with numerous extinct species (Stewart & Rothwell, 1993; Anderson *et al.*, 2007). Once important groups or families have become extinct long ago, others are at present merely represented by a few scattered species, but some, even though they evolved long ago in the Mesozoic, are still with us and thriving. Although Florin (1951) considered the Carboniferous *Cordaitales* to be ancestral to conifers based on demonstrated homologies, more recent analyses have cast doubts on this hypothesis (Rothwell & Serbet, 1994; Rothwell & Mapes, 2001). Modern cladistic analyses based on molecular data (DNA) assessing extant gymnosperms usually conclude on the monophyly of conifers (e.g. Stefanović *et al.*, 1998; Rai *et al.*, 2008), but these studies often suffer from undersampling of taxa. As a consequence of this, some extant taxa have been found to be closely related using molecular data (not available in fossils) while they appeared unrelated when morphological data from the fossil record were included with those from living taxa. The most controversial case of this lack of agreement in cladistic analyses of diverse data sets involves the conifers and a group of gymnosperms known as *Gnetales*. The molecular evidence often indicates a close relationship of conifers and *Ephedra, Gnetum* and *Welwitschia*, the three rather disparate and relict genera constituting the extant order *Gnetales*. Despite seriously conflicting results among several of these studies (e.g. Rai *et al.*, 2008; see for this conclusion also Mathews, 2009), some analysts have boldly stated: "Gnetophytes are derived conifers" and 'found' them to be a sister group to *Pinaceae* (e.g. Hajibabaei *et al.*, 2006). Such conclusions are superficial because they ignore the fossil record and thereby crucial evolutionary information (Farjon, 2007). Indeed, cladistic analyses based on morphology that sampled the fossil record did not give these results (Crane, 1985 and all subsequent studies) and appear to be much more consistent (Rothwell *et al.*, 2009). There are perhaps analytical problems inherent in the use of molecular data derived from organisms that only represent hugely disparate lineages due to extinction. These difficulties will be only partly overcome with more comprehensive sampling of extant taxa (Mathews, 2009). The inclusion of *Gnetales* in *Coniferales* (*Pinales* in Mabberley, 2008; *Pinophyta* of other authors) is, therefore, premature at best and is not accepted in this book. Nearly all recent molecular analyses of the phylogenetic relationships among extant conifers divide them into two clades: the *Pinaceae* in one clade and the remainder of the families in the other ('Cupressophyta'). *Araucariaceae* and *Podocarpaceae* are placed in the latter clade as sister groups (e.g. Rai *et al.*, 2008). In the fossil record, however, these two and not *Pinaceae* are oldest (Farjon, 2008) and so we have again a conflict of evidence, albeit less serious than the 'gnepine' controversy. Without consideration of the fossil record the relationships of the few remaining families of conifers are of only limited 'academic' interest.

The 614 species of extant conifers are classified in 8 families of which 541 belong to the three largest families *Pinaceae* (231), *Podocarpaceae* (174) and *Cupressaceae* (135). Conifers are here considered to include *Cephalotaxaceae* and *Taxaceae*; the *Taxodiaceae* are subsumed in the *Cupressaceae* with the exception of *Sciadopitys* ('Japanese umbrella pine') which is assigned to its own monospecific family. Then there is the ancient family *Araucariaceae*, since the discovery of *Wollemia* with three genera, and finally the still somewhat debatable family *Phyllocladaceae* (by some included in *Podocarpaceae*). Within the species, subspecies and varieties are also recognized, which brings the total to around 800 different conifers living today. Although such a figure is not fixed, it gives a plausible estimate of the diversity at this level. As has already been hinted at above, behind this rather moderate number of taxa lies a biological diversity far greater than in any other natural group of plants of comparable size. A long evolutionary history and ecological marginalization by the generally more competitive angiosperms since

the middle Cretaceous have led to numerous adaptations to cope with extreme environments, some examples will be mentioned under the brief outlines of families below.

The *Pinaceae*, with 11 genera and 232 species are an exclusively northern hemisphere family. No fossils are known from the southern hemisphere or from parts that once were situated south of the equator. They are the ubiquitous pines, spruces, firs and larches of northern boreal forests and mountain forests extending further south into cool to warm temperate climatic zones. The pines (113 species) exhibit the greatest diversity within a genus of this family, both taxonomically and biologically. They range from 'creeping' shrubby species like *Pinus pumila* from NE Asian mountains with a cold maritime climate and *P. culminicola* on a few isolated mountain summits of NE Mexico to 60 or 80 meters tall, straight pines like *P. ayacahuite* in Mexico and *P. lambertiana* in California and Oregon. They occur on the Arctic tree line of Canada and Russia (*P. banksiana, P. sylvestris*), with a winter of 8 months and -50° C temperatures, but also in steaming hot 'pine savannas' on lowland coasts of the Caribbean and in Thailand and Cambodia (*P. caribaea, P. kesiya*), where tropical rainstorms in the wet season alternate with frequent grass fires in the dry season. Growth rates can vary in pines as much as size. There are amazingly fast growers, such as *P. palustris* in the warm SE of the United States, adding 2–3 m of height per year, and pines that grow so slow that annual increment rings cannot be discerned without a magnifying lens. Some of the latter, notably *P. longaeva*, carry on for millennia. The oldest still living specimen tree in the world growing in the White Mountains of California is more than 4806 years old (Lanner, 2007). It is the tree's minimum age, an unknown number of years must be added for the young tree to have attained about 1.3 m height. It was a young vigorous sapling of a few centuries when the pyramids of Gizeh were being built during the 4th Dynasty of ancient Egypt. While most pines disperse their seeds by dropping them from opening cones, to be carried away by wind aided by wings, some have evolved a strategy dependent on mutualism with birds which carry the seeds to caches for winter storage, where many of them germinate. There are even one pine-one bird relationships, such as *P. cembra* with the Eurasian Nutcracker (*Nucifraga caryocatactes*) in Europe and *P. albicaulis* with Clark's Nutcracker (*Nucifraga columbiana*) in North America. Seeds of these pines are 'wingless' and will not fall out of the cones but have to be pried out by a bird's bill. Pine cones range enormously in size, from 2 cm to 60 cm in length and weights of a few grams to more than 2 kg in the amazing species *P. maximartinezii* of Zacatecas, Mexico. This pine has a similar seed morphology as the known 'bird pines' and the enormous cones open their hard scales not enough to release the seeds either. Which are the dispersing birds? We don't really know, but when I was once on the one mountain in the world where this pine occurs, I saw some sinister ravens hopping about…could they have been the ones helping the tree regenerate?

Firs (*Abies*) are by comparison with pines much more alike, but this book recognizes 46 species. They are in many respects more 'demanding' ecologically, needing better soils and growing under climatic conditions with less moisture stress and more equitable, cool temperatures. Hence, they have to be able to out-compete angiosperms, or be codominant in mixed forest. The seed cone bearing branches are situated in the top of the tree, where the beautiful erect cones can freely receive windblown pollen and later disperse scales and winged seeds to the winds that sweep through the crowns. Firs are mountain trees, which are rarely extending to lowlands like in the northern taiga and there they are restricted to more favorable sites for tree growth than other local conifers. Spruces (*Picea*), with 38 species, are better adapted to acidic soils and harsh climate than firs, although there are exceptions, such as *Picea sitchensis* which occurs within a narrow coastal strip with much rainfall and moderate temperatures from Alaska to California. It reaches enormous sizes in the area around Vancouver and Seattle. Spruces can form dense, uniform forests over very large areas, a quality used to advantage in plantation forestry. Larches (*Larix*) with 11 species are deciduous, light demanding pioneers that colonize areas after disturbance, or occupy the most extreme habitats in peat bogs of the boreal zone or the Arctic tree line, where on the Taymir Peninsula in Siberia at 75° N *Larix gmelinii* is the northernmost tree in the world. Other genera have a limited number of species, e.g. *Pseudotsuga* and *Tsuga*, or only one, like *Pseudolarix*, a true relict now very rare in China (and not closely

related to *Larix*) and the enigmatic *Cathaya*, also in China.

The *Podocarpaceae*, by contrast, are a largely tropical family, outside the tropics they occur mostly in mountains of the southern hemisphere. At present, 18 genera are recognized, with the largest, *Podocarpus*, with 98 species nearly as speciose as the pines (*Pinus*). Next is *Dacrydium*, with 22 species. The other genera all have fewer than 10 species. The family is undoubtedly of Gondwanan origin, with fossils going back to the Triassic found on all southern land masses including Antarctica. In the *Podocarpaceae*, taxonomic research is far from complete. On the one hand, more detailed observations of morphology, now often backed-up by molecular evidence, has led to the recognition of more genera to accommodate species formerly classified under *Podocarpus* and to a lesser extend *Dacrydium*. On the other, quite a number of species in *Podocarpus* are only known from a few herbarium collections, often with insufficient material and little or no knowledge of the biology of the plant. A comprehensive revision of this genus, and of the entire family, is wanting. A critical taxonomic revision will most likely lead to a reduction of the number of species recognized, but there may also be new discoveries in under-collected regions, such as western New Guinea and southern Venezuela. For this book, only a preliminary revision of the family was possible, so some relatively recently described species have here been retained 'with the benefit of the doubt'. The *Podocarpaceae* are characterized by specialized seed cones, in which in most cases during ontogenesis the number of seeds is reduced to one, which becomes variously enclosed or subtended with soft, often colourful and at any rate to certain animals tasteful tissue. As a result, these conifers are adapted to dispersal of seeds by animals (zoochory). However, as in other conifers, the *Podocarpaceae* are wind pollinated. Hence, the pollen cones of the *Podocarpaceae* do not differ from types found in the *Pinaceae*, but their seed cones are profoundly different. With few exceptions, a compound cone structure, with an axis beset with bracts and axillary ovuliferous scales, can only be discerned in the initial (pre-fertilization) phase. As soon as the first ovule, e.g. in *Podocarpus*, has been fertilized, the other ovules are aborted and the bracts swell and fuse together to form a juicy and colourful (often red or purple) receptacle to attract birds. The initial cup-like seed scale grows around the seed to form the epimatium, which in some genera (*Afrocarpus, Nageia, Prumnopitys*) swells to a succulent 'fruit' with the same attraction, taking over the function of the receptacle. When a bird eats the 'fruit', the seed is swallowed with the rest, but is protected from digestion by a hard seed coat and dropped somewhere away from the parent tree. In some species, like the diminutive *Microcachrys tetragona*, a creeping dwarf shrub from the highlands of western Tasmania, most ovules develop after fertilization; the bracts of the cone swell up and turn bright red so that a ripe seed cone resembles a little raspberry. Few studies are known that have dealt with the question of what animals act as dispersers; looking at these studies and what is known from pines, it is obvious that in *Podocarpaceae* mutualisms are likely to abound and much is still to be discovered here. That is not easy, because so many podocarps are scattered in tropical montane forests and there are so many species of bird and other fruit eaters around to be suspected! As in *Pinaceae*, diversity of life forms is great in this family, not only ranging from dwarfs like *Microcachrys* to giants like *Podocarpus totara* of New Zealand, but even including a true parasite, the only one in gymnosperms. *Parasitaxus usta*, from New Caledonia, lives on the root bases of another podocarp, *Falcatifolium taxoides*. Some species are shrubs well adapted to nutrient-poor and harsh environments, such as the 3 species of *Lepidothamnus*, one of which grows in peat bogs in southernmost South America, the two others in the mountains of New Zealand. There is also a true rheophyte, the dwarf tree *Retrophyllum minus* from New Caledonia, with thick spongy bark, perhaps to protect it from rocks and other debris smashing against it in flash floods. Others are emergent trees in tropical montane rain forests, such as many species of *Podocarpus*, or shrubs to dominant trees in the moss-forests of high tropical mountains, like species of *Dacrydium* in New Guinea.

The *Cupressaceae* are the only cosmopolitan family of conifers at present. The family is currently recognized to have 30 genera and 135 species. This count includes the former, well-known family *Taxodiaceae*, a family concept which cannot be maintained when all the information now available, including phylogeny,

is considered. The species accomodated in the *Taxodiaceae* were in fact a loose assembly of relict taxa having retained a few 'primitive' traits, such as spiral arrangement of leaves *Metasequoia*, with decussate leaf arrangement (phyllotaxis) is by many other characters related to *Glyptostrobus, Sequoia* and *Taxodium* with spiral phyllotaxis. Decussate and whorled phyllotaxis, as well as other leaf characters, appear to have evolved more than once from a presumably ancestral spiral arrangement. While in the *Podocarpaceae* extreme reduction of parts has led to a single-seeded 'cone', in *Cupressaceae* reduction of another kind has taken place. Here, the seed scale itself has been lost or, in some cases, e.g. in *Cryptomeria japonica*, vestiges in the form of seemingly functionless appendages of what may have been a scale, remain. The erect ovules (most other conifers have inverted ovules) originate on the apex of a shoot in the axils of transformed leaves (bracts). These bracts enlarge in various ways and ultimately form the cone scales, covering the seeds.

The worldwide distribution of *Cupressaceae* is reflected in the great ecological diversity among its species, although only a few are tropical such as some species of *Callitris* and *Libocedrus* from northern Australia and New Caledonia and *Papuacedrus papuana* from New Guinea and the Moluccas. The other species occupy all the major environments that conifers thrive in generally, but in addition have many species well adapted to semi-arid conditions. Especially diverse in semi-arid environments, which occupy large parts of the land masses of four continents, are *Cupressus* and *Juniperus* in the northern hemisphere and *Callitris* in Australia; some of the species even occur in true deserts. Other extremes are altitude records, e.g. *Juniperus indica* found at 5100 m altitude on the moraines of Tibetan glaciers coming from Mt. Everest. Other *Cupressaceae* thrive in ecosystems that can hardly be more different than these: the wet, oceanic forests of giant conifers along the Pacific coast of North America from central California to Alaska. *Sequoia sempervirens* from California is the tallest tree in the world, reaching up to 117 m. *Sequoiadendron giganteum*, confined to the western slopes of the Californian Sierra Nevada a little further inland, is a living 'fossil' of gargantuan proportions. Compare this with the dwarfed species *Microbiota decussata* from the Russian Far East and *Diselma archeri* from Tasmania, both important components of subalpine scrub communities, and the diversity in this family, and that of the conifers in general, will become clear.

The smaller families, except the *Taxaceae*, have a more limited distribution. The *Araucariaceae* occur in South America, with two species, one of which is the well known 'Monkey puzzle' *Araucaria araucana*, but is more abundant in Borneo, New Guinea, NE Australia, and New Caledonia and other SW Pacific islands. The genus *Araucaria* was in the Mesozoic nearly cosmopolitan, and hence the typical conifer with which to depict the dinosaurs, but became increasingly restricted in its distribution. It does not mean that all the 19 species currently recognized are 'living fossils'; it is more likely that most of the species in New Caledonia, where at present the genus has its centre of diversity with 13 species, evolved there more recently. Yet others, such as *A. araucana* and *A. angustifolia* from South America and *A. bidwillii* from Queensland, Australia, may have changed little since the Jurassic. In contrast with *Araucaria, Agathis*, with 17 species, is restricted to Malesia, NE Australia and islands of the SW Pacific. It is not yet known in the fossil record prior to the Tertiary, nor from other land masses. The most famous member of this genus is the Kauri, *Agathis australis*, of the northern part of North Island, New Zealand. The third genus, *Wollemia*, was discovered in 1994 in a hidden canyon in Wollemi National Park, New South Wales, Australia, and is one of the most interesting of recent conifer discoveries. It is considered to be another 'living fossil' and true fossils are indeed now being assigned to this new genus.

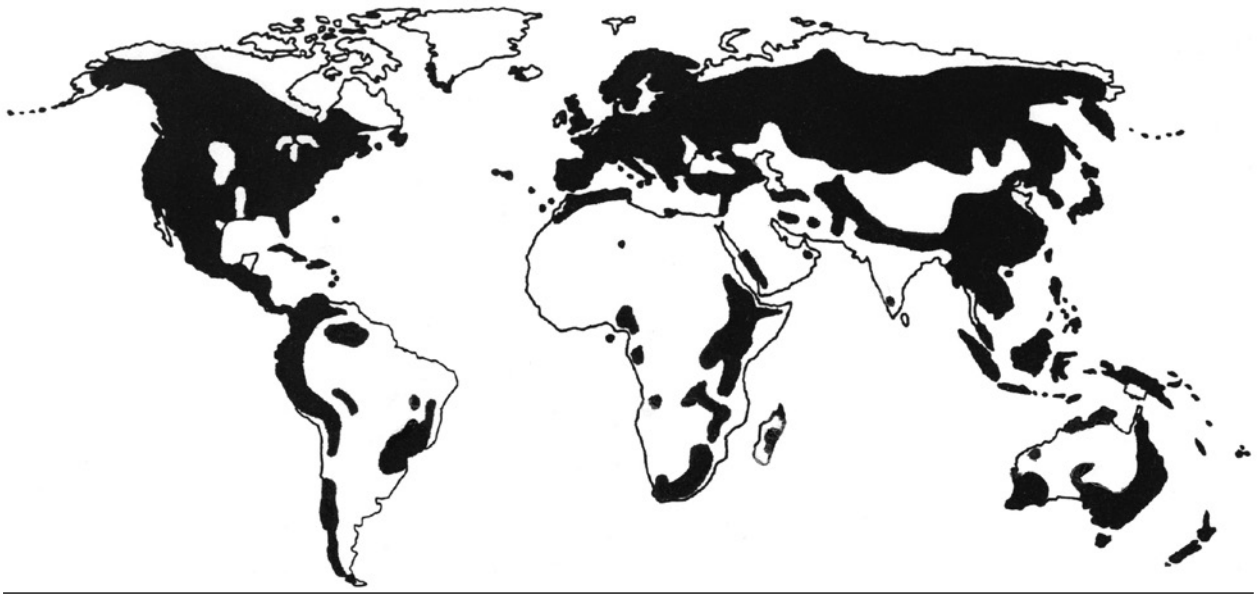
The *Phyllocladaceae* are distinguished by greatly reduced true leaves and 'phylloclades', representing planated shoots, taking on the tasks of assimilating leaves. They also have a distinct system of pollen capture by the ovule, which sets them apart from most, but not all podocarps, as does the formation of a true aril around the seed, as in the *Taxaceae*. However, molecular evidence appears to indicate that they are very closely related to the *Podocarpaceae*. The *Phyllocladaceae* are from a Gondwanan ancestry and greatly reduced. The four species of its single genus are now scattered in Malesia, New Zealand and Tasmania. The *Sciadopityaceae* are represented by a single species, *Sciadopitys verticillata* from a few

localities in Japan. This conifer has until recently been misunderstood; it is not a pine and although related to the *Cupressaceae* it has a whole suite of unique characters. It is a prime example of a relict taxon and deserves more intensive study by all disciplines relevant to its taxonomy. The *Cephalotaxaceae*, with a single genus as recognized by most taxonomists, accommodates 8 species, all eastern Asian, ranging from Korea and Japan to Malaysia. In some DNA-based analyses, this family has been proposed for synonymy with *Taxaceae*, but I think there are arguments to retain it as a separate family. Several species are cultivated widely and the taxonomy is still somewhat unsettled, in part because some species are based on cultivated plants, in part because species have been based on variable foliage characters due to the extremely reduced ovuliferous cones. A similar difficulty besets the *Taxaceae*, and especially its largest genus *Taxus*, here recognized with 10 species, but recently again the subject of debate, when a long-time student of the genus raised the number of species to 24, with 55 varieties (Spjut, 2007). In the *Taxaceae*, 4 other genera are recognized, of which *Amentotaxus* and *Torreya* have 6 species. All are evergreen shrubs or small trees adapted to live in the understorey of tall forests and have developed a single arillous seed of which the aril is either partly covering the seed and soft and juicy and colorful red or yellow, or wholly covering it and more fleshy and bluish green to purple. The aril is eaten by birds which disperse the seeds undamaged. In recent years, the discovery of chemical compounds (taxanes), which have proven to be in certain cases effective against cancer in humans, have focused a lot of research on the species of *Taxus*. This event has also demonstrated how much we can still learn about conifers.

THE DISTRIBUTION AND ECOLOGY OF CONIFERS

The 614 species of conifers cover a large proportion of the land surface of the earth. The map on p. xxx shows that the greatest covering of land by conifers is clearly to be seen in the northern hemisphere. This is due to the extensive conifer forest of the boreal zone in Eurasia and North America. There are only few species occurring there and the diversity increases dramatically further south, while the areas being covered decrease. The area indicated to be covered by conifers on the map is, of course, not uniformly covered with conifers, they usually occur together with angiosperms or grow in patches too small to separate on this scale. There are already big gaps at around 30º North, which continue across the equator into the southern hemisphere. In the far south there is much less land, but except Antarctica – which has been omitted from the map for obvious reasons – it is quite well covered with conifers, with few big gaps.

Conifers are present in nearly all the major vegetation types of the world. They are absent from only a few and are very rare in some others. In the far north, a few conifers occur in tundra vegetation, mostly in the transition zone from boreal forest to tundra. In the High Arctic of northern Canada and northern Siberia (cold deserts) they are left behind, while the Greenland icecap prevents any form of vegetation. The steppes of North America, Central Asia, Tibet and Mongolia, parts of Africa, and Patagonia in South America can have some conifers here and there, but are also largely without them. Although a few conifers occur in deserts, most of the world's deserts, i.e. the deserts of central and western Asia, Arabia, North Africa (Sahara), and Australia, are devoid of conifers. Another vegetation type mostly devoid of conifers is lowland tropical rainforest, such as the Amazon Basin in South America and the Congo Basin in Africa but also in smaller areas like the Yucatán Peninsula in Mexico and the southern lowlands of New Guinea. Other large areas without conifers have been stripped of their natural vegetation and are now occupied by agriculture and urbanization, especially in Western Europe, India, Bangladesh and northern China. However, some of the remaining areas devoid of conifers cannot be resolved with an ecological explanation. Large parts of South America and larger parts of Africa and the Indian subcontinent are the major gaps in conifer distribution that have no explanation in terms of unsuitable climate or soils. Did these parts ever have conifers, and if so, why did they loose them?



The global distribution of conifers shown on a world map with approximate equal area projection. The black areas on the map are not uniformly covered with conifers; they occur together with angiosperms or in patches too small to separate on this scale.

Discounting the Mediterranean coastal areas, which biogeographically belong to Eurasia, Africa is the poorest continent for conifers today. In Sub-Saharan Africa we only have *Widdringtonia* (*Cupressaceae*) with four species, *Afrocarpus* (*Podocarpaceae*) with five species and *Podocarpus* with four species. Vast areas of Sub-Saharan Africa have no conifers at all. The Indian subcontinent south of the Himalaya and adjacent hills has only a single indigenous conifer: *Nageia wallichiana* (*Podocarpaceae*). There are plenty of suitable areas for conifers in both, as the successful plantation of conifers for forestry in Africa and India demonstrates. The causes are most likely of a historical kind, having had effect over time spans on a geological scale. It appears that isolation, caused by the break-up of the southern supercontinent Gondwana and the increasing separation of its constituent land masses, is a major factor behind the gaps in conifer distribution of land masses of Gondwanan origin. Connections between land masses remained much longer in place with the break-up of Laurasia, the northern super-continent, which also became less fragmented. Both dispersal and vicariance played a part in the history of conifer distribution leading to the present situation. However, due to the size, proximity, and orientation of land masses of Laurasian origin, all situated in the northern hemisphere, dispersal accounts for much of the distribution of genera and species. Losses in the past could often still be made up for by new arrivals.

The long history of the assemblage and subsequent fragmentation of the two super-continents, Laurasia in the north and Gondwana in the south, is apparently still reflected in the distribution patterns of conifers across the globe. If we look at the different taxa this is even more clearly demonstrated. At the family level, *Cephalotaxaceae, Pinaceae, Sciadopityaceae* and *Taxaceae* are Laurasian, whereas *Araucariaceae, Phyllocladaceae* and *Podocarpaceae* are Gondwanan, although *Araucaria* once extended into Laurasia. *Cupressaceae* as a family are cosmopolitan, but the 30 genera that make up this family today are divided in northern and southern hemisphere groups, with a few 'trespassers', some only known from the fossil record. Some of these exceptions are intriguing enough, though. The South African genus *Widdringtonia* has been found in the Upper Cretaceous of North America and *Austrosequoia wintonensis* from the Cretaceous of Australia is very similar to *Sequoia* or *Sequoiadendron* of Laurasian origin. Such widely distant occurrences of taxa in the *Cupressaceae* seem to throw the separation of extant conifers into northern and southern origins into doubt. *Araucaria* may have originated before the separation of Pangea into two super-continents, but as far as we know, the *Cupressaceae* evolved after that event.

One final, intriguing observation about present-day conifer distribution is that more than half (ca. 330) of all species occur on the Pacific Rim. All families and 83% of all 70 genera are represented. The Pacific Rim is the system of mountain ranges and islands around the Pacific Ocean in both hemispheres, mostly forming part of so-called subduction zones where oceanic crust plates slide beneath the continents, causing volcanism and thrusting up of mountains and islands in the process. Going clock-wise an starting at 10 o'clock the diversity centres for conifers are Japan, the Pacific North-west of the United States and Vancouver Island, California, southern Mexico and Guatemala, southern Chile, New Zealand, Tasmania, New Caledonia, Fiji, the coast of New South Wales and Queensland, New Guinea, Borneo, the Philippines, and Taiwan. All of these areas have many species in several genera and families. In contrast the coastal areas of the Atlantic and Indian Oceans do not have such diversity of conifers, with the exception of Morocco, which has a moderate diversity of 12 species, and Florida, with 10. The explanation is probably again historical: none of the other oceans are nearly as old as the Pacific Ocean, which has therefore provided coastal mountains and islands suitable for well moisturized montane forests from well before the origin of the angiosperms.

In the north, around the Arctic Circle, the conifer forest or taiga begins where the tundra ends. The taiga is not entirely homogeneous. It is interrupted by lakes and swamps and dissected by large rivers. There are few conifer species and most of them belong to the family *Pinaceae*. In some areas two or three of these conifer species may occur together, but very often the forest is formed by only a single species. The environment of these conifers is dynamic. Disturbance by fire and flooding is an integral part of the taiga ecosystem, and natural disturbance, mostly in the form of fires, often covers large areas. Storms, however, are rare. The air burst of a large meteoroid or comet fragment in June 1908 in Siberia, known as

the Tunguska Event, destroyed large tracts of taiga forest. Outbursts of defoliating insect plagues, often associated with freak weather conditions, can lay waste to the forest as well. However, usually within a few decades the conifer forest is coming back from abundant seed. It was their capacity to conquer new land in great numbers that enabled conifers to return and to occupy the vast northern regions during the relatively short interglacial phases between the ice ages of the Pleistocene. But the present conditions are still harsh, the growing season is very short, and only a few species have been able to adapt to these.

Conifers predominantly occur on soils or in climates that are sub-optimal for plant growth. However, as we know well from plantation forestry and horticulture, there is no evidence that conifers prefer nutrient-poor soils or harsh climates. Many species that are restricted to these poor conditions in their natural habitat grow exceedingly well if planted on fertile soils. Monterey or Radiata pine (*Pinus radiata*) has been planted on a large scale especially in the southern hemisphere and is one of the most productive trees in the industry. Yet its natural habitat is nutrient-deficient podzolic sand in the salty winds of the Pacific Ocean right on the Californian coast. Many species of conifer are more or less restricted to ultramafic soils derived from serpentine or similar rocks, where phosphorus is almost absent. It appears that conifers, in order to survive in nature, have often adapted to such poor sites. It is the strategy of evasion. What are these conifers trying to escape from that they have adapted to put up with such poor conditions? The answer is competition from angiosperms, in particular fast growing, large-leaved herbs, shrubs and trees. While conifers, once they are full-grown trees, can often outgrow angiosperm trees, they often have a slower start. It has long been assumed that the evolution leading to weedy herbaceous angiosperms has caused the decline of conifers. Grasses are particularly effective in suppressing juvenile conifers and have excluded conifers from the steppes in Asia and the Americas and probably from the grasslands of Africa. That conifers can grow well there is again demonstrated by plantation forestry. Overgrazing and fire prevention, suppressing the grasses, can lead to the return of conifers; this happens at present with junipers (*Juniperus*) on the rangelands of the American West. However, if site conditions are poor for any plant growth, the conifers have a natural chance. Once they are mature, they will persist because they now can compete with any angiosperm. One of the key factors for the success of conifers on poor soils must be the extensive development of mycorrhizal symbiosis with certain fungi, which is especially prevalent in conifers. This form of collaboration between entirely different organisms enables conifers to cope with very low levels of essential minerals such as phosphorus and nitrogen in the soil, because the fungal hyphae greatly expand the surface and thereby uptake of water and nutrients by the plant root system. It is now even being thought that plants would not have succeeded to come onto dry land permanently without the assistance of these fungi; conifers were among the first to succeed in leaving the lakes and swamps behind them.

Although it is the most widely applied strategy, not all conifers are escapists. Especially in areas on the Pacific Rim, there are many conifers that grow very tall, rising well above the general forest canopy. Most of them can live very long, some even thousands of years. These giant trees appear to be scattered in the forest as veteran trees, or they occur in cohorts of more or less even-aged trees when still of a lesser age. These forests grow on the whole on mineral-rich, young soils, often of volcanic and sometimes of glacial origin. Competition among abundant trees of many species is fierce. The ecological strategy here is closely tied in with localized forest disturbance. Fires, land slides and destructive storms in these places occur infrequently, sometimes with intervals of several centuries. The old, big trees are the survivors of such disturbances. The bigger the tree, the more resistant it becomes; the bark of huge trees of *Sequoiadendron giganteum* from the western slopes of the Sierra Nevada in California is up to 60 cm thick and a very effective protection against forest fires. Nearly all of these giants among the conifers are light demanding and would not successfully regenerate under the canopy of other trees, being either angiosperms or conifers. These trees have to be removed first. On open sites, regeneration of the big tree conifers is often abundant, but soon competition starts and a struggle for space, light and water begins. Since some of the big conifers can grow taller, they have a chance to become dominant above the canopy of the other trees. The giant ultimate survivors are the insurance policy of the species.

There are many mutually beneficial relationships between animals and plants, almost all of which have developed with angiosperms on the plant's side of the deal. Pollination provides numerous examples and it is the single reason why flowering plants developed their almost endless variation of flower designs. Not a single conifer has ever managed this as far as we know, they are all wind pollinated, which is, lacking precision in pollen delivery, a wasteful process. Wind pollination has, however, not prevented them from becoming abundant and widespread, and some wind pollinated angiosperms, like grasses, have done well, too. Many conifer species have been more successful with seed dispersal aided by animals. In general, there are two scenarios for seed dispersal: (i) the animal transports and eats a fruit containing seeds, which pass through the animal undigested, and (ii) the seeds are transported and hidden to be eaten later and not all hidden seeds are eaten. Conifers have adapted to both scenarios and the first one is more common than the second. The families *Podocarpaceae, Taxaceae, Phyllocladaceae, Cephalotaxaceae* and *Cupressaceae* all have many species in which the seed cone, or the seed, has evolved to resemble a fruit. In all cases, the cone has been extremely reduced, in some cases it effectively disappeared. With few exceptions, the number of seeds has been reduced to one only. In many ways, the *Podocarpaceae*, the second largest family of conifers, has been the most innovative as well as the most successful family to adopt this strategy of seed dispersal. Probably all 174 extant species in the family have their seeds dispersed by birds. In the *Cupressaceae*, it is the genus *Juniperus* in which the cone, in a very different way, has become fruit-like. Birds are again the main dispersers of the seeds, in many species reduced to one large seed per cone; quite a reduction in number if the evidence is correct that the genus may have arisen from an ancestral species of *Cupressus*, of which many species have well over 100 seeds per cone. The seeds of all species in the *Taxaceae* arise at the apex of dwarf shoots, a seed cone does not even develop to become 'aborted' in a later stage as in some species of the *Podocarpaceae*. An aril, arising from the initial seed integument, takes on the fruit function. The imitation of angiosperm fruits has proved very successful in dispersing the seeds of conifers with a minimal waste of resources. In the second scenario of seed dispersal by animals, some species of pine (*Pinus*) have developed mutualistic relationships with birds of the crow family (*Corvidae*) to effect seed dispersal. The birds remove the seeds from the specially adapted cones and hide them in the surrounding terrain for later consumption. Large quantities of seeds are involved and invariably not all seeds get eaten. Where their close relatives have winged seeds, the seeds of these pines are wingless; wings would be useless and a waste to produce. In this way, the pines can travel upslope independent of prevailing wind conditions, which for some of the subalpine species may turn out to be an advantage during a warming climate.

THE ECONOMIC IMPORTANCE OF CONIFERS

The economic uses of conifers can be conveniently divided in those centring on wood, other derivative products, and horticulture. The first two are mostly industrial. Horticulture does not generally manufacture products but focuses on the cultivation and trade of the whole plant and has a strong element of non-commercial interest. However, there are manifestations of both applications evident in all three categories of economic use of conifers, so that the demarcation between industry and leisure is not an absolute one. It could even be argued that these distinctions have become less clear in recent times than they were in the past, and examples will be given in this chapter.

Today the world trade in coniferous wood is huge. Conifers provide about 60% of all wood used for industrial purposes. They dominate industrial wood supply because of both technical and economic advantages over wood from angiosperms. The vast reserves of natural conifer forest in the boreal zone of the northern hemisphere play an important part in this supply, but plantations, especially in the southern hemisphere, of particularly pines take up an increasing proportion of this. Nearly all this mass production goes into pulpwood for the paper industry, although about ⅔ of conifers in plantations in the world are destined for timber. The more specialized, high quality woods used for all the versatile applications mentioned in this chapter come from forests that can be allowed to grow older. In the trade, the wood of conifers is known as softwood and that of angiosperms as hardwood. These terms are misleading if applied to all conifers, because many species produce very hard wood indeed, while some of the softest woods in use do not come from conifers but from angiosperms. By far the greatest volume of industrial wood is produced by species in the family *Pinaceae*, which occur naturally in the northern hemisphere only, but have been widely planted for this purpose in the southern hemisphere. In particular, the genus *Pinus* stands out, with several species being among the fastest growing plantation trees producing pulpwood on short-term rotations. Several other species, especially 'white pines' (*Pinus* subsect. *Strobi*), are providing wood of higher quality with properties such as high dimensional stability, straight grain, softness and workability together with large, straight dimensions especially when taken from 'old growth' forests. These timbers are applied in the building industry for, e.g. doors and windows, in furniture making and even for musical instruments such as organ pipes and piano keys. Firs (*Abies*) produce lightweight, relatively soft, creamy white to pale brown wood; the high grade timber from forests with these species is sawn for framing material and for plywood and veneer. The wood of spruces (*Picea*) differs markedly from that of firs and is consequently used for different, mostly less refined purposes. In northern lands, it was and often still is the principal tree for the construction of log houses. In Norway, the ancient village churches were entirely made of wood, often a mixture of spruce (*Picea abies*) and pine (*Pinus sylvestris*); some date from nearly 1000 years ago and are still intact. In the Alps similar uses in construction are made of larch (*Larix decidua*), as its wood is particularly resistant to weather and rot. All three genera also provide pulpwood for the paper industry; the transparent windows in envelopes are a paper made from larch wood. In some genera of conifers, various circumstances have caused only one of the species to become of high economic importance. An example is the Douglas fir (*Pseudotsuga menziesii*), which has become the most important timber tree in North America. It has consequently been introduced by foresters in many temperate regions around the world. Douglas fir grows rapidly, is straight and tall and produces large volumes of wood per hectare, especially in managed forests where competing species are excluded or suppressed. Its wood is used for plywood and construction, both exterior and interior, and it has a reasonable durability for outdoor applications such as telephone poles and railway sleepers. The wood of the *Cupressaceae* differs markedly from that of *Pinaceae*. It is more fibrous and contains less resin; it is also mostly very decay-resistant and many species have fragrant properties due to volatile chemical compounds. These properties

make it highly desirable in China and Japan, where it was traditionally used in the construction of temples and other ceremonial buildings. Some species have been over-exploited and good sized trees are now rare. Other species, like *Cryptomeria japonica*, have been widely planted, in plantations in Japan, where it is native, as well as in China and Taiwan. Some of this cupressaceceous wood splits easily into shingles, and its rot-resistance was noted by people in regions as far apart as the Pacific coasts of Canada and the northwestern United States, Chile, Japan and Viet Nam, where these shingles were traditionally used to cover the roofs of houses. Durability has also been the major property that made juniper (*Juniperus*) the tree of preference for fence posts, but metal is pushing it out of the market. Some species in the *Cupressaceae* produce wood with beautiful patterns and are therefore prized for the making of cabinets and other pieces of furniture. In particular, the large, ancient coppice stools of the North African species *Tetraclinis articulata* are valuable and were already sought after by the Romans. Few conifers have this coppicing capacity, i.e. re-growth from a stem base after repeated cutting. Another source for this type of wood, suitable also for wood turning, is yew (*Taxus*), which is hard, dense, heavy and resistant to decay. Perhaps most famous were the English yew longbows of the Middle Ages; the arrows shot from these bows could penetrate a knight's armour at 200 meters and helped the English win the battles of Crécy, Poitiers and Agincourt in the Hundred Years' War (1337–1453).

The most tropical of the conifer genera, *Agathis* (*Araucariaceae*) is one of the most valued timber trees in Australasia. The wood known as kauri in the timber trade is light and soft, pale yellow or straw-coloured, often with darker heartwood ranging from pink to dark red brown. The wood of *Agathis* has many uses, from indoor construction, panelling, boat masts, joinery, furniture, pencils, matches and matchboxes, rulers, and piano parts. Naturally it is excellent for plywood and veneer, while more industrial uses of lower grade wood are pulp for paper manufacturing and high grade charcoal. In Indonesia and Malaysia *Agathis* is exploited heavily for export of raw timber (round logs); in the Philippines this has already led to a total ban on further cutting, while export is banned from Papua New Guinea. In tropical countries the wood of the *Podocarpaceae* is usually highly valued and trees belonging to this family are often selectively logged for timber. The most important genus, *Podocarpus*, is also the most widespread; of regional importance are *Afrocarpus* (Southern Africa), *Dacrydium* and *Dacrycarpus* (Australasia) and *Nageia* (Southeast Asia). All yield light to medium-weight, pale coloured wood, known as podo in the trade, with a straight grain and even texture that is easy to saw and plane but is often brittle. It is not durable when exposed to the weather, so its building applications are for indoor construction only. High grade timber can used for door and window frames, panelling, veneer, cupboards, furniture, cabinet work, joinery, household utensils and engineering instruments like drawing boards and rulers. The New Zealand species *Podocarpus totata* provides the only softwood that is resistant to attack by marine borers, so it was used for ship and boat building as well as wharf building and harbour construction until a ban on further logging stopped it. The Maori built their famously long war canoes with the wood of this large indigenous tree.

Of second industrial importance to wood of conifers is their resin. Resin is present in all conifers, albeit not in equal quantities. Resin in leaves can be distilled from them, resin in wood can be tapped as well as distilled, and there is even resin to be mined. The resins of conifers are mostly terpenoid, with some phenolic resins (Langenheim, 2003). Only two families, *Araucariaceae* and *Pinaceae*, produce copious amounts in the wood, where the resin is stored in resin ducts or canals. The genus *Agathis* (*Araucariaceae*) is the most copious producer of resin; over centuries, resin has flowed from the trunks of large trees onto the ground where it has accumulated, forming large deposits of copal which can be excavated. Its use is mostly for varnishes. More commonly, resin is tapped from the trunks of pines. Major resin producing species are, or were, *Pinus kesiya* in Southeast Asia, *P. massoniana* in China, *P. pinaster* in Europe, especially France, and *P. palustris* and *P. elliottii* in the Southeastern United States. The resin tapped forms the basis of many products in industry, such as turpentine, rosin and pitch – together known as naval stores – oils, varnishes, printing inks, sealing wax, soap, plastics, and fireworks. Coarser products are obtained by destructive distillation of resinous wood. In the age of wooden ships, pitch and tar were indispensable to keep them seaworthy by caulking the seams with pitch and by tarring the

rigging. The term naval stores for these and similar products dates back to the 17th century, when the English navy required large quantities of these for an expanding fleet.

The value of conifers for human food is marginal and consists almost exclusively of the seeds of several species of pine (*Pinus*) and three species of *Araucaria*, two in South America and one in Australia. Pine seeds are nutritious and sometimes tasteful food and some are of commercial value today. In Europe, it is mainly the Mediterranean species *P. pinea* or umbrella pine which yields seeds of good size and taste for the food market (Italian pignolia), used in processed food as well as sold as whole seeds. The distantly related Asian pine *P. koraiensis* produces similar kernels and has become the leading species in the export market. *Pinus gerardiana*, or chilgoza, and *P. bungeana*, or lace-bark pine, are other Asian pines with good edible seeds. In the United States and Mexico there are several species with edible seeds, of which *P. cembroides, P. edulis* and *P. monophylla* are the most widespread, which are commonly known as piñon or pinyon pines. In Russia, *P. sibirica* produces seeds which are harvested for oil extraction. The seeds of *Araucaria*, although delicious when roasted, are more of traditional value to indigenous people than commercialized for the food or delicatessen markets. The rarity of the trees of *A. araucana* and *A. bidwillii* due t o past over-exploitation prevents large scale seed harvesting. Flavouring is probably best known from the use of juniper 'berries' (seed cones) in producing gin. The Dutch words for gin and for the shrub *Juniperus communis* are, respectively, 'jenever' and 'jeneverbes', in the latter the Dutch word for berry is added. This species, together with its varieties, is the most widespread conifer in the world and the various brands of gin, like aquavit, gin, jenever and Schnaps, are all made with it. The resin of the Mediterranean pine *Pinus halepensis* is used to flavour retsina, a Greek white or rosé wine popular with locals as well as tourists. Scent is close to flavour. The typical fragrance of a northern conifer forest is due to the volatile components of the terpenoid resins of the conifers and these are being used in the cosmetics industry. The volatile components were and are also used in religious ceremonies, as fragrance and scent play a major role in imagination. The Aztecs called teocote pine (*Pinus teocote*) the pine of the gods; to burn its rosin as incense was a privilege of priests and kings. Religious or symbolic use also lies at the root of the Christmas tradition to decorate a room in the house with an evergreen tree and the growing of several species of conifer for this purpose has developed in the last 150 years or so to a significant industry.

Conifers in horticulture certainly started as a pastime, not as a business. Its earliest roots lie undoubtedly in China and Japan, where planting of trees for aesthetic reasons antedates that activity in Europe by centuries. In that tradition, form, shape and colour were of greatest importance as part of a reconstruction *in situ* of idealized pictorial land- and townscapes. By contrast, in Europe the planting of (exotic) conifers in gardens and parks mostly resulted from a curiosity about the natural world of distant lands and the products these brought forth. This developed in the 19th century to a rage among the landed gentry of Europe to obtain species, which led them to employ 'plant hunters' to travel to America and Asia to obtain suitable tree seeds that could be grown in Europe. Horticulture developed in part from the demand that this trade generated, with nurseries in e.g. England and Germany specializing in trees, including conifers, for large gardens, parks and estates. This again fed into plantation forestry, when some land owners saw potentials for planting timber trees on their estates. By the middle of the 19th century, conifers from North America were well established and common, while the first introductions from China and Japan had just arrived. About 60–70 years later, these had become common, too. It was this widespread planting of exotic conifers and other trees which caused a demand for descriptive literature and gave rise to a number of 'manuals' or 'handbooks', particularly in England and Germany. Naturally, these books concentrated on the species, and soon also cultivars, that were grown in Europe. The British Isles, due to a relatively mild but varied climate and varied geology and topography, as well as widespread private landownership that has continued to the present, are the world's 'centre of diversity' for introduced conifers. Current membership of the International Dendrology Society (which was established on the continent) reflects this. However, in recent decades other parts of the world have been catching up, such as the United States, Australia and New Zealand. With parts of these countries in a warmer and either wetter or drier climate than most

of Europe, the range of species that can be grown extends beyond the more or less common assortment used in Europe. There is no good reason why tropical conifers should not be planted in gardens and parks of tropical countries, which is one reason why this book includes all species. While the planting of conifers in gardens and private parks remains 'pastime' activity, horticulture with conifers has developed into a substantial business aiming at a different and wider market. In recent years the trade appears to have been emphasising dwarf conifers, but the fashion is not new. One of the many garden crazes in the Victorian age was building rock gardens in parks with plantings in it that ought to grow slow and remain moderate in size. In Britain, dwarf conifers became popular for a time from the 1850's onward. Interest was renewed in the 1960's but this time it was a fashion to plant heathers in suburban gardens and it affected Europe as well as the United States. Consequently, many arboreta and pineta followed suit and established heather gardens with small or medium size, preferably columnar or fastigiate conifers. When people began to be bored with this, the heather garden went out of fashion again, although it may still have its adherents. One reason for the disillusion may have been that 'dwarf' conifers often grow bigger after a slow start than they were promised to do when planted. The methods and practices of growing dwarfs only slowly developed into what professional nurserymen can achieve in this métier today. The trade is, of course, influenced by the demand but also creates it by making new and better cultivars available. Many good dwarf and colour cultivars have been developed in the last decade or so. A major development has been the utilization of witches' brooms occurring as a result of DNA mutations in buds or shoots. Unlike those resulting from a tree's reaction to parasites or pathogens, these genetic mutations alter growth of any shoot taken from the witches' broom, resulting in clones with identical, permanent dwarf growth characteristics. Although they were first used as long ago as 1836, in recent times selections derived from witches' brooms have become a major source of dwarf conifers in cultivation, and a constant stream of new cultivars is entering the market. With a growing knowledge of causes and processes, especially genetics, and improved techniques in propagation and cultivation, we can see this develop in future into an industry where conifer cultivars are being 'made' as well as grown.

THE CONSERVATION OF CONIFER DIVERSITY

Extinction is an apparent fate of all species. What concerns conservationists is the current high rate of extinction, well above what is believed to be a 'background' rate. Different estimates of these rates exist and are debated, but what is undisputed is that the current rate is abnormally high and that humans are causing it. "The primary cause of the decay of organic diversity is not direct human exploitation or malevolence, but the habitat destruction that inevitably results from the expansion of human populations and human activities." This is how Paul Ehrlich, a well known American ecologist and writer on the biodiversity crisis, has summed up the cause of the present mass extinction of species (Ehrlich & Ehrlich, 1981). He called the destruction inevitable and that is what it is under those circumstances. He later calculated that by the end of the 1980's humans had consumed, directly and indirectly, up to 40% of the total net primary production of stored biological energy produced by plants from solar energy. So, one species is using two fifths of all biological production on the planet. He warned that when the human population doubles again, that could become as much as 80%. Logically, if human activities and economic growth also continue to rise, we will one day have to use it all, and there will be no room for vegetation not in the service of humanity. If everyone in the world today enjoyed a lifestyle similar to the one people have in Europe and the United States we would need at least three planets to sustain ourselves; with a world population double that of today, we would need six planets. Edward Wilson, a leading writer on evolution and extinction, has put the ecological absurdity of our numbers succinctly, noting that we are now 100 times more numerous than the most abundant species of large animals that has ever existed. "There is no way that we can draw upon the resources of the planet to such a degree without drastically reducing the state of most other species." (Wilson, 1992). That state for most species means extinction. The prospect that within a few decades far more people will live in cities than in the countryside (the 50–50 balance line has recently been crossed) threatens to detach humanity further from its biological resources, with dire consequences.

Against this rather overwhelming perspective, it could appear to be next to hopeless to take action for the conservation of conifer diversity in the natural habitats in which they occur. The real big issue is human demography, but to address that is both complicated and difficult. It has to be addressed, or else the size of the population will be 'corrected' naturally, which will be disastrous. Meanwhile, we can and should buy time, although there is not much time left. This is why the conservation of species in their natural habitats is very important, and even more urgent when certain species are 'keystone' in the ecosystem. Many conifers perform that role, because they are large, long living trees providing habitat for numerous other species. Conservation of these conifer species in functioning ecosystems in the wild means the conservation of many other species. It is therefore a good strategy to concentrate conservation efforts on conifers. Especially in the tropics, however, our knowledge of the role of conifers in ecosystems is rudimentary. Where natural, undisturbed forests are formed by many tree species, conifers often occupy restricted localities and occur there in numbers. The ecosystem will be different in such places, in which the conifers are likely to act as keystone species. Research is urgently needed where logging and deforestation threaten the existence of such tropical conifers with local abundancy, e.g. the species of *Agathis* in Borneo and *Afrocarpus* in eastern Africa. Conifers are also important in nature because all trees are providers of ecological services to a more stable environment. Climate regulation is one; watershed protection preventing erosion and assuring a steady supply of clean water in streams are other important functions of forests. In valleys with human habitation, the prevention or limitation of the effects of snow avalanches in mountainous areas is obviously important. On slopes where avalanche stopping conifer forests have been removed it is nearly impossible to restore them and in populated valleys artificial avalanche barriers will have to be erected. They are expensive and not as effective as the natural conifer forests. That conifers provide these services in many parts of the world is the logical corollary of their dominant distribution in the

northern hemisphere. The environmental services of natural conifer forests, coupled with the creation of habitat to numerous species of animals, fungi and plants and the provision of material and immaterial goods to human society are increasingly understood as vital. The proper management of these forests aims at the perpetuation of the original ecosystem on large spatial and temporal scales and at least in the temperate climate zones of the world utilization is moving in the direction of such true sustainability. However, recent Food and Agriculture Organisation of the United Nations (FAO) figures are showing that subtropical and tropical coniferous forests are declining faster than any other forest types. Outside a limited number of reserves, exploitation not utilization is still the rule in much of the tropics. Intrinsic values to conifers may provide incentives to make sure they do not become extinct due to our activities. These can be aesthetic, cultural, emotional and scientific. People in all cultures show a remarkable veneration for individual trees, especially if these are old, large, or grow in special places. Thomas Pakenham, writer, photographer and planter of trees on his estate in Ireland, gives many examples from many countries in his books on remarkable trees, quite a number of which are conifers. The popularity of his books, illustrated with his similarly remarkable photographs, amply demonstrates the fascination people still have with large and ancient individual trees. Many conifer species are apparent relicts of a geological past when they, or their closest relatives, were still abundant. When introduced by man to other continents, sometimes returning to where they once grew, some have done well. Perhaps therein lies the main reason to conserve them, it offers the opportunity to restore something of a lost world. There is also an obvious scientific interest, a curiosity value if you like, in these distinct species representing the past. Given the threat of extinction to so many species, prioritization of the species in need of conservation may be necessary to save at least some of them. Phylogenetic distinction might be a criterion that is well worth using to shortlist species for conservation action.

The first task before us if we want to address the increasing threats of extinction of conifer species is to assess the conservation status of these species. Types of threat need to be identified, with their causes if known. And finally, we would have to recommend action and work to ensure these conservation measures are implemented and maintained. The assessment of conservation status of species on a global scale is largely undertaken by the International Union for the Conservation of Nature (IUCN). This Non-Governmental Organisation (NGO), based in Gland, Switzerland but operating worldwide, works on this through its Species Survival Commission (SSC) and numerous Specialist Groups, made up of biologists and other specialists with special knowledge of certain groups of animals, plants, or other defined groups. The Conifer Specialist Group is responsible for conifers in this context; it has a membership of around 40 individuals and is currently chaired by the author of this Handbook. The conservation status of a species involves knowledge of the extent of occurrence (EOO) in nature (excluding all introduced, planted and naturalized occurrences) and the area of occupancy (AOO) within the natural range, both calculated in square kilometers. These two factors determine how widespread (EOO) and how common (AOO) a species is. Population size is measured as numbers of mature (reproducing) individuals in total, or in subpopulations when occurring in scattered or fragmented groups of individuals. Counting individuals of trees is only practicable if there are not too many, so many estimates are based on EOO and AOO plus numbers of subpopulations. The conservation status is also influenced by trends in the population: are the numbers of individuals declining, stable or increasing? Past, present, as well as projected future trends are of concern and can be used in a conservation assessment. IUCN has developed criteria for conservation assessment of this kind, which gives a species a rating on a categorical scale of conservation status. An assessed and evaluated species is then added to the IUCN Red List™ with its category of threat and the criteria used. The development of these criteria has taken considerable time because a single system had to be made to work for all organisms. As a result, there have been two versions (dated 1994 and 2001) which are currently both valid in terms of having added species to the Red List. The Conifer Specialist Group assessed most of the (now) 614 recognized conifer species in the period between 1994 and 2001 and only about 100 since then, some of the latter a second time. These assessments are cited in this book. Re-assessment of the ca. 500 earlier

assessments is urgent, but was still in progress at the time of publication of this Handbook. The categories are now as follows:

Extinct (EX)
Extinct in the Wild (EW)
Critically Endangered (CR)
Endangered (EN)
Vulnerable (VU)
Near Threatened (NT)
Least Concern (LC)
Data Deficient (DD)
Not Evaluated (NE)

The abbreviations are used with all species, subspecies, and varieties treated in this Handbook. The coded (abbreviated) criteria are also given, but their full explanation would be too extensive to repeat here and the reader is referred to the originals (IUCN, 1994, 2001). Taxa assessed and evaluated to be in any of the three categories printed in bold are the taxa threatened with extinction in a foreseeable future if trends of decline continue and if no adequate measures are taken to alleviate the situation. As calculated when writing this in April 2009, 230 of 794 accepted taxa (species, subspecies and varieties) or 29% were threatened with extinction. It is slightly more complicated to calculate how many species would fall in this broad category, because a species may have one variety at risk and another variety not at risk. The categories of threat are therefore assigned to the lowest rank in case of a subdivided species. Only if all varieties recognized in a species are at risk, the entire species is at risk. This is true for ca. 180 or 30% of all conifer species. These figures are likely to change as species are re-assessed, partly due to more and better data, but also due to real changes in their status. If these two causes are separated, it will be possible to see a trend in the overall conservation status of conifer diversity. This will then result in a Red List Index for conifers, which will be a measure of success, or failure, of conservation action because it will tell us in what direction this diversity is moving. It is very important that several non-related taxonomic groups of organisms with worldwide distributions, geographically aa well as ecologically, are being assessed as completely as possible and as soon as possible. The Convention on Biological Diversity (CBD) has recommended to develop a number of indicators, including one based on changes in status of threatened species, to be able to monitor progress towards the target of reducing the rate of loss of biological diversity (Baillie *et al.*, 2004). IUCN has therefore developed Red List Indices for two such groups: Birds and Amphibians. More taxonomic groups with repeated complete assessments are urgently needed in order to provide data for the investigation of trends in the conservation status of biodiversity. The only taxonomic groups of plants with suitable baseline data at present (2009) are the Cycads and the Conifers. Conifers are more valuable for this purpose than Cycads, of which the distribution, although wide, is much more restricted both in terms of geography and of ecology. Conifers occur indeed worldwide and occupy nearly all the major biomes of the terrestrial world. It is hoped that the attention this Handbook may bring to the plight of conifers in the world will help to put adequate and sufficient conservation policies and action in place to indeed slow down their extinction rate.

SYNOPSIS OF FAMILIES AND GENERA

This synopsis gives brief character sketches of taxa in the ranks of genus to family. Only those characters are mentioned which together would suffice to identify the taxon; these are not necessarily the same for all taxa, and comparisons between them are therefore limited to those necessary for identification. In this Handbook 8 families and 70 genera are recognized within the order *Coniferales*, or conifers. The families are here given in alphabetical order, as no satisfactory classification at this level based on all necessary evidence seems possible (Farjon, 2007, 2008). The hypothetical relationships of genera within families are indicated by their groupings; some of these groupings have been named at the rank of subfamily, others are here presented as informal and separated from each other by a double space only. The relationships in *Podocarpaceae* are most tentative, as they are based on phylogenies derived from recent cladistic analyses of molecular and morphological data, which are not in agreement for several clades. The DNA-based analyses tend to place *Phyllocladaceae* within *Podocarpaceae*. Perhaps it could be assumed that the former arose from the latter. The names of families and genera are given with their abbreviated authorities following Brummitt & Powell (1992). For more detailed recent classifications down to species see for *Cupressaceae* Farjon (2005a), for *Pinaceae* excluding *Pinus* Farjon (1990), for *Pinus* Richardson (ed., 1998) and Farjon (2005b) and for *Taxaceae* Cope (1998).

Araucariaceae Henkel & W. Hochst.

Dioecious or monoecious evergreen, highly resinous trees. Tree architecture according to Massart's and Rauh's models. Leaves in helical arrangement or subopposite to opposite; lamina broad and flat, or scale-like. Pollen cones catkin-like, sometimes large. Seed cones large, globose, mostly disintegrating. Seed cone scales predominantly consisting of the bract, but with a fused seed scale bearing a single seed.

Agathis Salisb.

Monoecious trees. Leaves subopposite to opposite, leaf lamina broad and flat, with distinct petiole. Pollen cones solitary, relatively small. Seed cone scales with an imbricate, rounded margin. Seeds with a single broad wing, becoming detached from the scale.

Wollemia W. G. Jones *et al.*

Monoecious trees. Leaves helically attached, sessile, adult leaves arranged in 4 rows (tetrastichous), linear. Pollen and seed cones terminal on primary branches, relatively small. Seed cone scales with an apical free extension. Seeds circumferentially winged, remaining attached to the scale; wing(s) narrow.

Araucaria Juss.

Dioecious or monoecious trees. Leaves in helical arrangement, sessile, lamina broad and flat, or scale-like, persistent on falling branches. Pollen cones solitary or in small clusters, relatively small to very large. Seed cone scales with an apical free extension. Seeds without wings, remaining attached to the scale.

Cephalotaxaceae Neger

Cephalotaxus Siebold & Zucc. ex Endl.

Dioecious evergreen shrubs or small trees. Leaves pectinately arranged becoming subopposite, linear-lanceolate, with two prominent stomatal bands on the abaxial side. Pollen cones aggregated in capitulae. Seed cones reduced, with opposite fertile bracts. Seeds 1–2 per cone, exposed, large, completely surrounded by a fleshy aril.

Cupressaceae Gray

Aromatic, evergreen or deciduous, monoecious or dioecious shrubs or trees. Leaves on (pen)ultimate

branchlets linear, needle- or scale-like, spirally arranged, ternate or decussate (rarely quadrate) in mature plants. Pollen cones small, terminal, rarely axillary, solitary or sometimes clustered in groups of 2–7. Seed cones terminal, simple or semi-compound, globose, ovoid or conical. Seed cone scales consisting of transformed bracts, true seed scales absent or sometimes rudimentary. Seeds 1-many axillary to each cone scale, with or without wings.

***Cunninghamioideae* (Zucc. *ex* Endl.) Quinn**

Cunninghamia R. Br.

Evergreen, monoecious trees, capacity to coppice profound. Leaves helically arranged, linear-lanceolate; leaf margin serrulate. Pollen cones numerous in clusters. Seed cones subterminal, persistent (falling with foliage branches), with thin, coriaceous scales. Seeds 2–3 per fertile scale, with 2 marginal wings 1 mm wide.

***Taiwanioideae* L. C. Li**

Taiwania Hayata

Evergreen, monoecious trees. Leaves helically arranged, imbricate, in young trees falcate-subulate, ultimately scale-like. Pollen cones in terminal clusters on branchlets with scale leaves. Seed cones terminal, solitary, small, with thin, coriaceous scales. Seeds usually 2 per fertile scale, each with 2 small wings.

***Athrotaxoideae* L. C. Li**

Athrotaxis D. Don

Evergreen, monoecious trees. Leaves helically arranged, small and appressed or longer than 6 mm and spreading gradually or abruptly. Pollen cones solitary, small. Seed cones terminal, solitary, globose or subglobose when opened, with clavate-peltate, thin or thick woody scales. Seeds with two slightly unequal wings.

***Sequoioideae* Saxton**

Deciduous or evergreen, monoecious trees. Leaves helically arranged or opposite, linear or scale-like. Pollen cones solitary or numerous in spike-like shoot systems. Seed cones barrel-shaped or ovoid, with peltate bract-scale complexes. Seeds axillary to cone scales, with 2 marginal wings.

Metasequoia Hu &W. C. Cheng

Deciduous, monoecious trees, dropping foliage branchlets, not individual leaves. Leaves opposite, linear, spreading at nearly right angles to the shoot. Pollen cones numerous in spike-like shoot systems. Seed cones terminal on 2–5 cm long, scale-leaved shoots, subglobose, barrel-shaped or fusiform. Seeds numerous, with 2 marginal wings.

Sequoia Endl.

Evergreen, monoecious (very tall) trees, often sprouting from lignotubers. Leaves alternate, mostly linear, pectinate on shaded shoots. Pollen cones on the same branches as seed cones, solitary. Seed cones terminal on short branchlets, more or less ovoid, 15–30 mm long. Bract-scale complexes helically arranged, parting to release the marginally winged seeds.

Sequoiadendron J. Buchholz

Evergreen, monoecious (giant) trees. Leaves helically arranged in 3 ranks, imbricate, scale-like. Pollen cones on the same branches as seed cones but well above them, solitary. Seed cones terminal on short branchlets, 30–70(–95) cm long. Bract-scale complexes helically arranged, parting to release the flattened, unequally winged seeds.

***Taxodioideae* Endl. *ex* K. Koch**

Deciduous or evergreen, monoecious trees. Leaves alternate to helically arranged, of various types but linear leaves present. Pollen cones crowded or arranged in spike-like to paniculate systems, solitary. Seed cones terminal, solitary or clustered; bract-scale

complexes with or without small teeth below the apex. Seeds with 1–2 wings, or almost wingless.

Cryptomeria D. Don

Evergreen, monoecious trees. Leaves helically arranged in 5 ranks, decurrent, free for 1/2–3/4 of leaf length, linear-subulate. Pollen cones numerous, axillary and crowded towards the ends of branchlets. Seed cones terminal, often aggregated; bract-scale complexes helically arranged, spreading, with a number of small teeth below the bract apex. Seeds with 2 narrow, unequal wings.

Glyptostrobus Endl.

Semi-evergreen, monoecious trees. Leaves alternate to helically arranged, consisting of three types, scale-like, subulate, and linear. Pollen cones terminal, solitary. Seed cones terminal, solitary, pyriform to obovate; bract-scale complexes obovate-oblong, connate but parting slightly at maturity, with many tiny, subapical tooth-like lobes. Seeds with a single wing.

Taxodium Rich.

Deciduous or semi-deciduous, monoecious trees, dropping foliage branchlets, not individual leaves. Leaves helically arranged, spreading in 2 ranks or in 5–8 ranks, linear or (short) acicular. Pollen cones arranged in spike-like to paniculate systems. Seed cones terminal and often clustered, subglobose or more or less ovoid; bract-scale complexes breaking away to release the almost wingless seeds.

Cupressoideae **Rich. *ex* Sweet**

Evergreen, dioecious or monoecious trees. Adult leaves scale-like or acicular; scale leaves dimorphic or monomorphic mostly dependent on plagiotropic or orthotropic branching, often with a gland. Pollen cones terminal or sometimes axillary, very small, solitary or sometimes 2–3 together. Seed cones terminal on foliage branchlets or on dwarf shoots, variable in size and shape; bract-scale complexes 3–4 whorled or decussate, valvate, peltate, or fused. Seeds 1–many per cone, winged or wingless.

Thujopsis Siebold &Zucc. ex Endl.

Evergreen monoecious trees. Leaves decussate, imbricate, scale-like, dimorphic at least on plagiotropic branchlets, lustrous green, with broad, white stomatal bands on the underside of branchlets. Pollen cones ovoid-globose, reddish purple. Seed cones subglobose, markedly umbonate, 8–16(–20) mm long; bract-scale complexes decussate, apically thickened. Seeds with 2 wings.

Thuja L.

Evergreen, monoecious shrubs or trees. Leaves decussate, imbricate, scale-like, dimorphic on lateral branchlets. Pollen cones oblong, yellowish green. Seed cones ovoid-globose, narrowly ovoid or elliptical, partly opening; bract-scale complexes decussate, the lowest pair reduced, the 2–3 following pairs enlarged and spreading, the apical pair often connate. Seeds with 2 wings.

Calocedrus Kurz

Evergreen, monoecious trees. Leaves decussate, appearing in whorls of 4, imbricate, scale-like, dimorphic, decurrent. Pollen cones solitary, cylindrical. Seed cones solitary; bract-scale complexes in 3(–4) decussate pairs. Seeds 1–2 per fertile scale, with 2 very unequal wings.

Chamaecyparis Spach

Evergreen, monoecious trees. Leaves decussate, imbricate, scale-like, dimorphic. Pollen cones solitary, short cylindrical, with yellow or red pollen sacs. Seed cones solitary, globose to ellipsoid-ovoid, small, with ± peltate, parting scales. Seeds with 2 lateral, narrow wings.

Cupressus L.

Evergreen, monoecious shrubs or trees. Leaves decussate, scale-like, monomorphic or dimorphic. Pollen cones solitary, short cylindrical, with yellow pollen sacs. Seed cones often grouped close together or clustered, globose to ovoid-oblong with parting woody scales, caducous or persistent; bract-scale complexes decussate, peltate. Seeds numerous, angular, with rudimentary wings.

Fokienia A. Henry & H. H. Thomas

Evergreen, monoecious trees. Leaves decussate, imbricate, scale-like, (strongly) dimorphic, decurrent. Pollen cones solitary, subglobose to oblong. Seed cones subglobose; bract-scale complexes decussate, spreading at maturity. Seeds with 2 very unequal wings.

Juniperus L.

Evergreen, monoecious or dioecious shrubs or trees. Leaves decussate or ternate, scale-like or acicular, decurrent or articulate. Pollen cones terminal or axillary. Seed cones terminal on axillary (dwarf) shoots, globose, semiglobose or ovoid, indehiscent, usually red, glaucous or blue; bract-scale complexes in 1–4 decussate or ternate whorls, entirely fused, usually soft. Seeds 1–8 per cone, wingless.

Microbiota Kom.

Evergreen, monoecious, decumbent shrubs. Leaves decussate, imbricate, scale-like, weakly dimorphic, turning copper-brown or purplish brown in winter. Pollen cones axillary. Seed cones hidden in shoot axils, minute, reduced to 2 pairs of bract-scales, the upper enclosing a single, ovoid, wingless seed.

Platycladus Spach

Evergreen, monoecious trees. Leaves decussate, scale-like, decurrent, on lateral branchlets dimorphic. Pollen cones solitary, subglobose. Seed cones erect, ampulliform, opening widely; bract-scale complexes 6–8, decussate. Seeds ovoid; wings absent or rudimentary.

Tetraclinis Mast.

Evergreen, monoecious shrubs or small trees. Leaves decussate, scale-like, long decurrent, adnate to shoot except the apex, weakly dimorphic. Pollen cones solitary, ovoid-globose, reddish. Seed cones (sub)tetragonal; bract-scale complexes 4, decussate, nearly equal in size, thick woody. Seeds with 2 large, thin membranous wings.

Xanthocyparis Farjon &Hiep

Evergreen, monoecious trees. Leaves scale-like (adult) and acicular-linear (juvenile), in one species both occur in mature trees; adult leaves decussate, dimorphic, juvenile leaves in whorls of 4, monomorphic. Pollen cones solitary, yellow. Seed cones opening wide; bract-scale complexes 4 (or 6) in decussate pairs. Seeds flattened, with 2 lateral wings.

Austrocedrus Florin &Boutelje

Evergreen, dioecious shrubs or trees. Leaves decussate, in opposite ranks, scale-like, dimorphic; facial leaves very small. Pollen cones solitary, small. Seed cones on ultimate branchlets with non-modified leaves, ovoid-oblong; bract-scale complexes 4, decussate, the upper scales twice as large as the lower. Seeds with 2 wings, one rudimentary, the other well developed.

Libocedrus Endl.

Evergreen, monoecious shrubs or trees. Leaves decussate, imbricate, scale-like, decurrent, strongly dimorphic. Seed cones terminal on flattened or quadrangular branchlets, subtended by 4–5 decussate, transitional leaf pairs; bract-scale complexes in 2 decussate pairs, the upper fertile pair of scales spreading at maturity, with a long subapical bract tip. Seeds 1–4 per cone, with 2 very unequal wings.

Papuacedrus H. L. Li

Evergreen, monoecious trees, often appearing dioecious. Leaves in whorls of 4 or decussate, on lateral branchlets scale-like, strongly dimorphic. Pollen cones solitary, cylindrical. Seed cones (sub)terminal, thin woody; bract-scale complexes consisting of 2 decussate pairs, the lower curved, the upper much larger, elliptic. Seeds 2–4 per cone, with 2 very unequal wings.

Pilgerodendron Florin

Evergreen, dioecious trees. Leaves decussate, occasionally in whorls of 3, imbricate, forming 4(6) rows, scale-like, monomorphic. Seed cones terminal, subtended by 2 decussate, transitional leaf pairs, with

distally spreading scales; bract-scale complexes in 2 decussate pairs, elliptic to obtrullate, the upper pair twice as large as the lower pair; columella conspicuous. Seeds 3–4 per cone, with 2 very unequal wings.

Actinostrobus Miq.

Evergreen, monoecious shrubs or trees. Leaves in whorls of 3, decurrent; juvenile acicular leaves on young plants only or also on mature plants; adult leaves mostly shorter than 5 mm, linear-lanceolate. Seed cones persistent along branches and stems; bract-scale complexes in two whorls of 3, of nearly equal size at maturity, subtended by 4–6 alternating whorls of 3 broad, imbricate scale leaves; columella a strong, acute spike. Seeds with 3 wings.

Callitris Vent.

Evergreen, monoecious shrubs or trees. Leaves in alternate whorls of 3 (in one species also with acicular, spreading leaves in whorls of 4), scale-like, decurrent, appressed, linear. Pollen cones solitary or with 2–3 together at the tips of branchlets. Seed cones solitary, opening soon and deciduous, but more often clustered and persistent and often serotinous; bract-scale complexes in two alternate whorls of 3 (or 4), the upper whorl usually the largest; columella distinct, often trimerous. Seeds with 2–3 wings.

Diselma Hook. f.

Evergreen, dioecious shrubs, or very small trees. Leaves opposite-decussate, occasionally in whorls of 3, scale-like, imbricate. Pollen cones numerous, solitary. Seed cones terminal, maturing in one season to small cones of 3 × 2 mm, consisting of 2 pairs of decussate cone scales surrounding a central columella. Seeds 2 (or 1), with 2(-3) marginal wings.

Fitzroya Lindl.

Evergreen, dioecious trees. Leaves in alternate near-whorls of 3, imbricate, scale-like, decurrent. Seed cones formed by 2–3 whorls of slightly modified scale leaves, followed by 2 alternate whorls of 3 fertile, wide spreading scales; columella variably shaped, trigonal to tripartite. Seeds with 2–3 narrow wings.

Neocallitropsis Florin

Evergreen shrubs or small trees (distribution of sexes uncertain). Leaves in alternate whorls of 4, seemingly in 8 rows, short decurrent or nearly sessile with broad base, lanceolate, incurved, thick. Pollen cones 10–12 × 6–7 mm, subglobose to ovoid. Seed cones with spreading bract-scale complexes; columella short pyramidal. Seeds with 2(-3) marginal wings.

Widdringtonia Endl.

Evergreen, monoecious shrubs or trees. Leaves decussate on smallest branchlets, becoming more or less spirally arranged (bijugate) on thicker branchlets, scale-like. Pollen cones solitary. Seed cones usually clustered (to 50 mature cones); bract-scale complexes 4 (rarely 6), valvate, in two pairs of slightly unequal size and shape, thick woody; columella short, sometimes double. Seeds numerous, with or without 2 wings.

Phyllocladaceae **Bessey**

Phyllocladus Rich. ex Mirb.

Evergreen shrubs or trees, usually dioecious, occasionally monoecious. Lateral branches of highest order transformed to simple or compound (pinnate) phylloclades functioning as leaves, arranged spirally or in pseudo-whorls. True leaves rudimentary. Seed cones on petiolate or foliate parts of phylloclades, arranged in rows, in pairs or solitary. Seeds ovoid, partly embedded by the fused, swollen and succulent bract scales of the cone and subtended by a filmy white aril leaving the apical part of the seed free.

Pinaceae **Spreng. *ex* F. Rudolphi**

Monoecious evergreen or deciduous, resinous trees or shrubs. Leaves spirally inserted on long or short shoots and solitary or arranged in fascicles of 1–8 surrounded by a sheath on dwarf shoots (*Pinus*), acicular-linear to long linear. Pollen cones often grouped close together on long shoots, axillary, solitary or clustered from a single bud, catkin-like,

deciduous. Seed cones compound, small to very large. Bracts free, well developed or rudimentary. Seed scales persistent or deciduous, woody; bearing 2 inverted seeds. Seeds with 1 wing or wingless.

Pinoideae Pilg.

Evergreen trees or shrubs. Leaves spirally inserted on long shoots or in fascicles of 1–8 on dwarf shoots (*Pinus*), acicular or (long) linear. Pollen cones grouped close together on long shoots (*Pinus*) or solitary in leaf axils. Bracts of seed cones small but conspicuous or rudimentary. Seed scales persistent, thin or thick woody. Seeds winged or wingless. Number of cotyledons in seedlings high (4–≥20).

Pinus L.

Trees or shrubs. Leaves in fascicles of 1–8 (commonly 2, 3 or 5) on dwarf shoots, long linear. Pollen cones grouped close together in helical arrangement on long shoots. Seed cones at base of new shoots, small to very large, persistent or deciduous. Bracts rudimentary. Seed scales usually thick woody, sometimes remaining soft, with a distinct apophysis and umbo. Seeds winged or wingless, wing adnate or easily detached.

Cathaya Chun &Kuang

Trees. Leaves on short shoots seemingly in tufts, on long shoots more remote, linear, flattened, longitudinally grooved above. Pollen cones lateral, near the shoot apex, pendant. Seed cones lateral, ovoid oblong, with acute apex, 3–5 cm long. Bracts triangular, with a long point. Seed scales 13–16, thin woody, orbicular or ovate. Seeds ovoid, winged; wing 2 × length of seed, adnate.

Picea A. Dietr.

Trees. Leaves inserted (adnate) on pulvini on long shoots, acicular. Pollen cones lateral, numerous but solitary in leaf axils. Seed cones becoming pendant, deciduous. Bracts rudimentary. Seed scales numerous, thin woody. Seeds winged; wing usually 3 × length of seed, easily detached.

Laricoideae Melchior &Werdermann

Evergreen or deciduous trees. Leaves on long shoots and/or short shoots, linear. Pollen cones lateral in leaf axils, or terminal and clustered on short shoots. Seed cones pendant or erect, deciduous or falling attached to branches. Bracts well developed, often exserted. Seed scales thin woody. Seeds winged; wing 2 × length of seed, adnate.

Larix Mill.

Deciduous trees with pronounced shoot dimorphism. Leaves on long shoots but predominantly on short shoots, linear, lax. Pollen cones terminal and clustered on short shoots. Seed cones remaining erect, persistent and separated from the tree while still attached to short shoots and branches. Bracts exserted or included, not or only slightly longer than seed scales.

Pseudotsuga Carrière

Evergreen trees. Leaves on long shoots, leaving small scars when falling. Pollen cones solitary in axils of leaves. Seed cones becoming pendant at maturity, falling entire from branches with the peduncle attached. Bracts exserted, longer than seed scales, with trilobate apex. Seed scales with a rounded upper margin. Seeds winged; wing short.

Abietoideae Pilg.

Evergreen or deciduous trees. Leaves on long shoots and/or on short shoots, linear or acicular. Pollen cones solitary or clustered, in axils of leaves or terminal on short shoots. Seed cones erect and disintegrating when fully mature, or becoming pendant and falling intact. Bracts well developed, small, or rudimentary. Seed scales with narrowed, pedicellate base. Seeds winged, with resin vesicles in seed coat.

Abies Mill.

Evergreen trees. Leaves on long shoots, linear, leaving a round scar when falling. Pollen cones solitary in axils of leaves of ultimate branchlets. Seed cones

erect, yellowish green to deep purple or dark blue, often exuding resin. Bracts exserted or included. Seed scales falling with the broadly winged seeds, leaving the erect rachis on the tree.

Cedrus Trew*

Evergreen trees with pronounced shoot dimorphism. Leaves on long shoots but predominantly on short shoots, acicular. Pollen cones solitary at the apex of short shoots, with anthesis in autumn. Seed cones remaining erect, maturing in second year. Bracts rudimentary. Seed scales falling with the broadly winged seeds, leaving the erect rachis on the tree.

* The genus *Cedrus* has come out as basal (sister group) to all other genera of the *Pinaceae* in some recent DNA-based cladistic analyses; morphological evidence however places it firmly within *Abietoideae*. A basal position is not corroborated by the fossil record. Its position is tentative.

Keteleeria Carrière

Evergreen trees. Leaves on long shoots, broadly linear to lanceolate-linear. Pollen cones solitary in leaf axils. Seed cones remaining erect, breaking up by disintegration of the rachis. Bracts well developed, often exserted. Seed scales persistent. Seeds with broad wing dispersed separately; seed germination hypogeal.

Nothotsuga Hu ex C. N. Page

Evergreen trees with weakly developed shoot dimorphism. Leaves linear. Pollen cones in umbellate clusters from a single bud. Seed cones remaining more or less erect, falling entire or disintegrating. Seed scales persistent. Seeds with small wing dispersed separately.

Pseudolarix Gordon

Deciduous trees with pronounced shoot dimorphism. Leaves on long shoots but predominantly on short shoots, linear, lax. Pollen cones in umbellate clusters from the apex of a short shoot. Seed cones terminal on short shoots, remaining erect, disintegrating. Seed scales persistent, narrowly deltoid-triangular, subtended by a small bract. Seeds with a large, narrow wing.

Tsuga (Endl.) Carrière

Evergreen trees with weakly developed shoot dimorphism. Leaves on long shoots (some rather small), linear, with a bent and twisted petiole. Pollen cones axillary, solitary, small. Seed cones pendulous, falling entire without branchlets or peduncles attached. Seed scales thin, with rounded margin. Seeds with a relatively large, oblique wing.

Podocarpaceae **Endl.**

Dioecious or sometimes monoecious, evergreen trees or (dwarf) shrubs (one species parasitic on another member of the family). Leaves helically arranged, rarely decussate (*Microcachrys*), appressed and imbricate to spreading and remote, shapes highly variable, ranging from small, appressed scale leaves, via thin acicular leaves, to dorsiventrally flattened, linear-lanceolate to broadly lanceolate, large leaves (up to 34 × 9.5 cm). Pollen cones mostly simple, axillary or terminal, solitary or clustered. Seed cones axillary or terminal, solitary, mostly much reduced and often swelling to form a succulent receptacle; fertile bracts 1-many. Seeds of most species surrounded by a coriaceous or succulent epimatium.

Saxegothaea Lindl.

Monoecious trees. Leaves pectinate, short decurrent, linear or falcate. Pollen cones axillary, solitary or sometimes in pairs, 4–6 mm long. Seed cones terminal, globular, 9–12 mm diam. Cone scales 15–20 per cone, spirally arranged, swelling at maturity. Seeds 1 per scale (from 2 inverted ovules), enclosed.

Podocarpus L'Hér. ex Pers.

Dioecious or rarely monoecious shrubs or more commonly trees. Leaves relatively broad, usually linear-lanceolate or linear-elliptic, coriaceous, with a single raised, flat or sunken midrib and stomata in two broad bands on the abaxial side. Pollen

cones axillary, solitary or clustered, catkin-like. Seed cones swelling to form a smooth, succulent, coloured receptacle. Seeds 1(–2) per cone, completely exposed, drupe-like, completely covered by a fleshy epimatium.

Retrophyllum C. N. Page

Dioecious, dwarfed to large trees. Leaves spirally inserted, lanceolate to narrowly ovate, obliquely directed into subopposite and decussate apparent pairs by twisted petioles in opposite directions, amphistomatic. Pollen cones axillary or terminal. Seed cones rudimentary, with a single large seed covered by a fleshy, drupe-like epimatium.

Afrocarpus (J. Buchholz & N. E. Gray) C. N. Page

Dioecious trees. Leaves twisted in opposite directions, narrowly lanceolate-elliptic to linear-lanceolate, coriaceous, with a single midrib, amphistomatic. Pollen cones axillary, solitary or in groups of 2–3, catkin-like. Seed cones much reduced, not transformed into a receptacle. Seeds 1 per cone, subtended by small, withering scales, entirely enclosed by a swollen, drupe-like epimatium.

Nageia Gaertn.

Dioecious or monoecious trees, rarely shrubs. Leaves large, flat, broadly ovate-elliptic to lanceolate, lacking a midrib and with many parallel, converging veins. Pollen cones single or in small, spicate groups of 2–6 on axillary peduncles, ovoid-cylindric. Seed cones much reduced, or forming a weakly developed, fleshy receptacle. Seeds 1 per cone, exposed, entirely enclosed by a swollen, drupe-like epimatium.

Acmopyle Pilg.

Dioecious (or sometimes monoecious?) small trees. Leaves dimorphic, small and scale-like on leading and fertile shoots, larger and falcate-linear on lateral, vegetative shoots. Pollen cones cylindrical, more or less erect. Seed cones solitary or occasionally grouped, when mature forming an irregular, fleshy and verrucose receptacle. Seeds single, enclosed by a fleshy epimatium.

Dacrycarpus (J. J. Bennett) de Laub.

Dioecious or rarely monoecious shrubs or trees. Leaves trimorphic, with small scale leaves, acicular leaves and flattened, linear-falcate leaves. Pollen cones single or in pairs on axillary short shoots, cylindrical. Seed cones solitary, when mature forming an irregular, fleshy and verrucose receptacle. Seeds single, enclosed by a fleshy epimatium.

Dacrydium Sol. ex G. Forst.

Dioecious or rarely monoecious shrubs or trees. Leaves dimorphic, scale-like and subulate or acicular. Pollen cones small, cylindrical. Seed cones small, forming a red receptacle. Seeds 1–2(–3) per cone, becoming more or less erect, protruding from a cup-like epimatium covering basal part of seed only, lustrous brown or nearly black.

Falcatifolium de Laub.

Dioecious shrubs or trees. Leaves dimorphic, with scale leaves on leading and fertile shoots, alternating with more or less distichously spreading, bilaterally flattened, obliquely lanceolate-falcate leaves on vegetative shoots. Pollen cones cylindrical and catkin-like. Seed cones forming an irregular, red receptacle. Seeds erect, surrounded at the base by a swollen epimatium, with two lateral ridges.

Halocarpus Quinn

Dioecious shrubs or trees. Leaves dimorphic, radially spreading, lanceolate-linear to linear ones alternating with appressed, rhombic scale leaves. Pollen cones solitary or with 2–3 together at the apex of scale-leaved branchlets, small. Seed cones reduced to a few reddish bracts at the apex of scale-leaved branchlets. Seeds 1–5 per cone, erect, at base surrounded by a swollen epimatium forming a white or yellow collar, lustrous black.

Lagarostrobos Quinn

Predominantly dioecious trees, with lower branches frequently layering. Adult leaves imbricate and appressed, rhomboid in appearance, 1–1.5 × 1 mm. Pollen cones terminal, sessile. Seed cones terminal

on decurved short branchlets, 4–5 mm long. Seeds up to 5–8 per cone, usually fewer, light brown, enclosed at base by a dry, papery epimatium.

Lepidothamnus Phil.

Dioecious or sometimes monoecious, creeping or erect shrubs or trees. Leaves dimorphic, with linear, spreading juvenile ones usually gradually giving way to appressed, ovate-rhombic and gibbous scale leaves. Pollen cones terminal or sometimes lateral. Seed cones terminal, solitary, very small, consisting of 3–5 yellow or reddish bracts. Seeds 1 per cone, purplish brown or black, surrounded at base by a membranous epimatium.

Manoao Molloy

Predominantly dioecious trees; 'sucker' shoots from horizontal underground stems prolific. Adult leaves imbricate and appressed, rhomboid in appearance, 1–1.5 × 1 mm. Pollen cones terminal, sessile. Seed cones terminal on distally curved short branchlets, 3–4 mm long. Seeds 1–3(-5) per cone, dark purple to black, the basal half or more enclosed by a swollen, fleshy epimatium.

Microcachrys Hook. f.

Monoecious or (temporarily) dioecious, prostrate shrubs. Leaves on lateral branchlets decussate, imbricate, appressed, short triangular in appearance, 1–1.5 × 1 mm. Pollen cones terminal, more or less recurved. Seed cones terminal, with ca. 20 helically arranged, fleshy, red bracts. Seeds 1 per fertile bract scale, at base partly covered by an epimatium.

Parasitaxus de Laub.

Small erect monoecious shrubs, parasitic on the roots of *Falcatifolium taxoides*. Leaves spirally arranged, imbricate, scale-like, decurrent, reddish. Pollen cones usually on the same branching systems as seed cones, terminal, solitary. Seed cones reduced to a few bracts with a single seed surrounded by a hard, glaucous white epimatium.

Pherosphaera W. Archer

Dioecious shrubs. Adult and juvenile leaves similar, spirally arranged, 2–4(–6) mm long and mostly scale-like. Pollen cones terminal, globose to ovoid. Seed cones terminal, with (3–)5–8 spreading, fertile scales, not fleshy at maturity. Seeds usually 1–4 per cone, exposed, erect.

Prumnopitys Phil.

Dioecious trees or shrubs. Leaves small, in lateral shoots pectinately arranged, flattened, falcate-linear. Pollen cones aggregate on relatively long, leafless branchlets, cylindrical. Seed cones reduced to a few bracts. Seeds enclosed in a drupe-like, fleshy, yellow, red or black epimatium.

Sundacarpus (J. Buchholz & N. E. Gray) C. N. Page

Dioecious trees. Adult leaves broadly linear, 5–15 cm long, 6–15 mm wide, petiolate, with a single midvein. Pollen cones axillary, often 3–7 on a stalk, cylindrical. Seed cones much reduced, not forming a receptacle. Seeds 1 per cone, large, covered by a glaucous purple, fleshy but firm epimatium.

Sciadopityaceae **Luerss.**

Sciadopitys Siebold &Zucc.

Evergreen, monoecious trees. Foliage consisting of linear cladodes ('needles') in pseudo-whorls on shortened terminal sections of long shoots. True leaves much reduced, scale-like. Pollen cones in terminal or sublateral clusters. Seed cones terminal or sublateral, ovoid to cylindrical, often exuding resin. Bract-scale complexes helically arranged, consisting of a partly fused bract and exceeding seed scale. Seeds basal to seed scales, inverted, with 2 wings.

Taxaceae **Gray**

Dioecious or rarely monoecious evergreen shrubs or trees. Leaves helically or decussately inserted, usually

pectinately arranged, linear to lanceolate with a single midrib, hypostomatic, with two bands of stomata. Pollen cones axillary to foliage leaves and solitary or aggregated in umbellate clusters of racemes. Seed bearing structures consisting of axillary dwarf shoots with terminal, erect ovules. Seeds surrounded by a fleshy or succulent aril; aril partially or entirely enclosing the seed, becoming red, purple or yellow when ripe.

Amentotaxus Pilg.

Dioecious shrubs or small trees. Leaves usually opposite-decussate, pectinately arranged by twisted petiolate leaf bases, linear-lanceolate, straight or slightly falcate, large. Pollen cones aggregated in umbellate clusters of racemes. Seed-bearing structures usually in groups near the apex of vegetative shoots. Aril surrounding the ripe seed greatly enlarged, ellipsoid or ovoid, fleshy and succulent, red or purple, completely hiding the small seed.

Austrotaxus R. H. Compton

Dioecious trees. Leaves alternate (helical), spreading forward at 30–60° to the shoot axis, narrowly lanceolate, large. Pollen cones axillary, solitary. Seed aril almost entirely enclosing the seed and only leaving the seed apex free, ovoid, smooth, at first glaucous green ripening to orange.

Pseudotaxus W. C. Cheng

Dioecious shrubs. Leaves helically arranged, distichous, spreading, linear. Pollen cones axillary, solitary. Seed aril cupular, only partly enclosing the seed, succulent and white when ripe.

Taxus L.

Dioecious shrubs or trees. Leaves helically inserted, twisted at petiolate base and becoming pectinate or distichous, linear or falcate. Pollen cones axillary, solitary. Seed aril cupular, only partly enclosing the seed, succulent and red, orange or yellow when ripe.

Torreya Arn.

Dioecious or rarely monoecious trees or sometimes shrubs. Leaves helically inserted, pectinately arranged, linear-lanceolate, rigidly coriaceous, acuminate or pungent. Pollen cones axillary, solitary. Aril almost completely surrounding the large seed, fleshy, purplish green to bluish black when ripe.

TAXONOMIC TREATMENT OF FAMILIES

Key to the families

This Handbook recognizes eight families within the conifers (currently with 70 genera and 614 species); some of their diagnostic characters are here used in the key to families. If the family to which a species has been assigned is not known to the user, it is necessary to start with this key and then proceed to the key to genera under the family determined. If the family is known, one can proceed directly to the latter key to determine the genus. Keys to species within genera are provided under each genus; the species are arranged in alphabetical order (A-Z) throughout using the Latin binomials, which enables the user to find the genus determined using the keys with ease.

1a. Seed cones with seed scales in the axils of bracts (bracts can be much reduced in mature, woody cones but are conspicuous in immature cones at early stages of development); i.e. cones clearly compound and never reduced; seeds two on the adaxial (upper) side of each fertile scale; adult green leaves acicular-linear ***Pinaceae***

1b. Seed cones with seed scales fused with bracts (bracts make up the bulk of the cone), or with bracts only (which may be much enlarged, swollen and/or woody at maturity), or with scales obscure, much reduced or absent; seeds either single or more than two per fertile scale; adult green leaves scale-like, or acicular, or with a distinct lamina, or replaced by phylloclades (phyllodes) **2**

2a. Seed cones with seed scales fused with bracts, or with bracts only which are much enlarged and often swollen at maturity and may then form a compact, globose cone **3**

2b. Seed cones with seed scales fused with bracts; bracts forming the largest part of the cone scales; a single inverted seed per scale ***Araucariaceae***

3a. Seed cones consisting of bracts forming the cone scales only (sometimes with rudimentary seed scales only visible at very early stages of development); seeds 1-many, axillary or on the base of each bract (rarely only a single seed per cone) **4**

3b. Seed cones either with much reduced, obscure scales (whether bracts or seed scales, in a few instances with many very small bracts) or lacking any kind of scales and reduced to a single, terminal seed with a surrounding epimatium or arillus **5**

4a. True leaves scale-like or acicular (needle-like), cataphylls absent, phyllodes absent ***Cupressaceae***

4b. True leaves reduced to tiny cataphylls (usually brown scales); phyllodes (pseudo-leaves) in the axils of these green, needle-like, growing rhythmically in pseudo-whorls on shoots ***Sciadopityaceae***

5a. Seed cones reduced to a single seed; seed terminally placed at a scaly dwarf shoot, partly or completely surrounded by a succulent or fleshy aril ***Taxaceae***

5b. Seed cones apparent, with much reduced, obscure scales (usually bracts; if these are seemingly absent, seed on a stout or fleshy 'peduncle') or in a few instances with many, very small bracts **6**

6a. Pollen cones aggregated in more or less globose capitulae ('heads'); bracts of (reduced) seed cones decussate ***Cephalotaxaceae***

6b. Pollen cones solitary or clustered but not in globose capitulae; bracts of (reduced) seed cones alternate or helically arranged (but sometimes seemingly absent being enveloped by a swollen receptacle) **7**

7a. True leaves scale-like, acicular or with a distinct lamina, always simple; cataphylls absent; phylloclades absent; cones arising in the axils of leaves ***Podocarpaceae***

17b. True leaves reduced to tiny cataphylls, usually soon deciduous; phylloclades (pseudo-leaves) leaf-like, green, simple or compound; cones arising on the edges of phylloclades or on separate determinate shoots (axillary to bracts) ***Phyllocladaceae***

Araucariaceae Henkel & W. Hochst., Syn. Nadelhölz.: xvii, 1. 1865. (*nom. cons.*). Type: *Araucaria* Juss.

Description

Dioecious or monoecious evergreen, highly resinous trees. Tree architecture according to Massart's and Rauh's models. Resin canals in bark, leaves and seed cones. Bark hard and smooth, exfoliating with rounded or irregular flakes (*Agathis*), rough and exfoliating in horizontal strips and eventually deeply fissured (*Araucaria*), or forming many irregular pustules (*Wollemia*). Branches in rhytmic pseudowhorls, spreading and plagiotropic (Massart's model) or ascending to become orthotropic (Rauh's model), sometimes profusely reiterating or sprouting from dormant buds in roots near the base of stems. Foliage branchlets with or without terminal buds. Leaves spirally arranged or subopposite, scale-like and adnate or laminar and sessile or short petiolate, imbricately covering the shoot or free and more or less distichously spreading, sometimes forming 4 ranks (*Wollemia*), more or less coriaceous, with numerous parallel veins originating from basal dichotomies and few to numerous resin canals. Pollen cones axillary to leaves, solitary or in small clusters, small or large, much elongating after anthesis and becoming cylindrical; microsporophylls numerous, helically inserted, crowded, with imbricate or tesselate heads, each with 4–20 oblong pollen sacs containing non-saccate pollen. Seed cones terminal on long shoots (*Wollemia*) or lateral on short, pedunculate, leafy shoots, solitary, erect, ovoid or subglobose, sometimes massive (*Araucaria bidwillii* has the heaviest cones of all conifers), usually disintergrating leaving the rachis on the tree. Bracts helically inserted on the rachis, much developed, flattened, with a thickened distal margin and with or without a terminal elongated cusp, forming the bulk of the cone. Seed scales much reduced, axillary to and almost entirely fused with the bract, with or without a small, free apical ligule, more or less enclosing a single, inverted seed, concrescent with the seed scale or free, wingless or with a single wing or 2 unequal wings. Seedlings with 2, sometimes deeply divided, cotyledons. Number of chromosomes (diploid) 2n = 26.

Three genera: *Agathis* (17 spp.), *Araucaria* (19 spp.) and *Wollemia* (1 sp.); total 37 species.

Distribution

Malesia: all major islands except Jawa and Lesser Sunda Islands; Australia: New South Wales, Queensland. SW Pacific: New Caledonia, Vanuatu, Fiji, Norfolk Island, New Zealand (North Island). South America: SE Brazil, NE Argentina; S Chile, SW Argentina (Andes).

Key to the genera

1a. Bark hard and smooth, exfoliating with rounded or irregular flakes; leaves distinctly petiolate; seed cones globose, with imbricate scales lacking an extended apex ***Agathis***

1b. Bark rough, exfoliating in horizontal strips or forming many irregular pustules; leaves sessile; seed cones ovoid-globose to globose; cone scales with an extended, free apex **2**

2a. Bark forming many irregular pustules in mature trees; leaves opposite or subopposite, mostly linear, distichous or tetrastichous (in 2 or 4 ranks); pollen and seed cones terminal on first-order branches ***Wollemia***

2b. Bark exfoliating in horizontal strips; leaves spirally arranged, scale-like or triangular to lanceolate, mostly equally divided around the shoot; pollen and seed cones lateral on higher order foliage branches ***Araucaria***

Cephalotaxaceae Neger, Nadelhölzer: 23, 30. 1907 (*nom. cons.*). Type: *Cephalotaxus* Siebold & Zucc. *ex* Endl.

Description

See the genus description.

One genus: *Cephalotaxus*, with 8 species.

Distribution

As for the genus.

Taxonomic Notes

The family *Cephalotaxaceae* has been variously circumscribed by different authors, or included in the Taxaceae *s. l.* This situation led Page (1990) to remark that "obscurity is probably the only aspect of the generic and family affinities.... about which we can be totally sure." He included *Amentotaxus* and *Cephalotaxus* in *Cephalotaxaceae*, but his circumscription has not been generally accepted. Florin (1948) excluded *Taxaceae s. str.* from 'true' conifers, but included *Cephalotaxus*, which he considered to "occupy an isolated position among the recent representatives of this class." *Cephalotaxus* appeared to Florin to have several ovules aggregated into a cone, while the other genera lacked evidence of a cone, or the reduction of one. A number of morphological studies of both male and female reproductive organs have brought the two groups more closely together, often inferring a more primitive state in *Cephalotaxus* compared with *Taxaceae s. str.* The male cones in *Taxaceae* were interpreted by Wilde (1975) as reduced structures derived from more clearly compound systems in *Cephalotaxaceae*. These differences were confirmed in an elaborate study by Mundry (2000). The structure and ontogeny of the female reproductive organs however, are essentially similar in *Cephalotaxus* and *Taxaceae*. The 'cone' Florin observed in *Cephalotaxus* results from a swelling of the bracts subtending the ovules, of which more in a single reproductive unit are retained, at least to the pollination stage, in this genus than in the others. Other similarities are evident, but there are also some marked differences; Chen & Wang (1990) found the numbers of free nuclei in the female gametophyte to be extremely high but variable (1024–4096) in *Cephalotaxus*, and relatively low and constant (256) in 4 of the 5 genera of *Taxaceae* (*Torreya* was not investigated). Phylogenies reconstructed from molecular data (DNA nucleotide sequences) tend to place *Cephalotaxus* basal (as sister to) a clade with *Taxaceae s. str.* (e.g. Cheng *et al.*, 2000; Quinn *et al.*, 2002), but in the latter study the consensus tree shows a polytomy within a single clade. This can be interpreted as evidence that *Cephalotaxus* is best placed within *Taxaceae* (Quinn *et al.*, 2002), but the 'total' evidence is still ambiguous. A solution of sorts could be to recognize this genus as a subfamily *Cephalotaxoideae*, but until its relationships are unambiguously resolved, it seems advisable to retain a monogeneric family *Cephalotaxaceae*.

Cupressaceae Gray, Nat. Arr. Brit. Pl. 2: 222, 225. 1821. (*nom. cons.*), ["*Cupressideae*"]. Type: *Cupressus* L.

Description

Aromatic, resinous, evergreen or sometimes deciduous, monoecious or dioecious shrubs or trees, ranging from diminutive prostrate shrubs to trees exceeding 100 m. Bark fibrous or brittle, exfoliating in longitudinal strips or small plates. Branches erect or spreading; foliage branches erect to pendulous, initially covered with (decurrent) leaf bases until secondary growth replaces these with bark, terete, (quadr)angular or more or less flattened, orthotropic or in more or less plagiotropic and often frond-like sprays. Buds mostly absent; (seasonal) abscission of (pen)ultimate branchlets, not of single leaves. Foliage leaves simple, usually polymorphic dependent on life phase, with juvenile, transitional and mature forms, and on growth of foliage branches. Leaves on (pen) ultimate branchlets linear, needle- or scale-like, spirally arranged, ternate or decussate (rarely quadrate) in mature plants, also in whorls of 4 in juvenile plants and in some mature plants; decussate scale leaves pairwise dimorphic on flattened branchlets. Leaf resin duct or cavity mostly single, often with a dorsal gland in scale leaves. Leaf vascular bundle single. Pollen cones small, terminal, rarely axillary, solitary or sometimes clustered in groups of 2–7, sessile on foliage branchlets or on dwarf shoots, simple, deciduous. Microsporophylls spirally arranged, ternate or decussate in congruence with leaf phyllotaxis on the cone-bearing shoot, small and thin, (sub)peltate. Pollen sacs (microsporangia) abaxial, free, 2–10(-14) per microsporophyll, in one or two rows, longitudinally dehiscent, containing spheroidal, non-saccate pollen. Seed cones terminal, solitary or sometimes secondarily clustered, sessile or pedunculate, simple or semi-compound, globose, ovoid or conical, deciduous or persistent. Bract-scale complexes spirally arranged, in whorls of 3–4 or decussate in congruence with leaf phyllotaxis on the cone-bearing shoot, consisting of transformed

bracts enlarged with subsidiary intercalary growth, rarely with elements of ovuliferous scales, forming (semi-)woody or soft, imbricate or valvate, free or (partially) fused, (sub)peltate, ovate or oblong cone scales with or without an abaxially protruding bract tip. Ovules at base of bracts, axillary or sometimes terminal, erect (or secondarily inverted), single to numerous. Seeds winged or unwinged, wings 1–3 per seed, often unequal in size and shape, derived from thin or thick and hard seed coat, seed often with resin pits. Seedlings with 2–6(-9) cotyledons; germination epigeal. Chromosome number (diploid) = 22, sometimes tetra- or hexaploid (*Sequoia sempervirens*).

30 genera: *Actinostrobus* (3 spp.), *Athrotaxis* (3 spp.), *Austrocedrus* (1 sp.), *Callitris* (15 spp.), *Calocedrus* (4 spp.), *Chamaecyparis* (5 spp.), *Cryptomeria* (1 sp.), *Cunninghamia* (2 spp.), *Cupressus* (15 spp.), *Diselma* (1 sp.), *Fitzroya* (1 sp.), *Fokienia* (1 sp.), *Glyptostrobus* (1 sp.), *Juniperus* (53 spp.), *Libocedrus* (5 spp.), *Metasequoia* (1 sp.), *Microbiota* (1 sp.), *Neocallitropsis* (1 sp.), *Papuacedrus* (1 sp.), *Pilgerodendron* (1 sp.), *Platycladus* (1 sp.), *Sequoia* (1 sp.), *Sequoiadendron* (1 sp.), *Taiwania* (1 sp.), *Taxodium* (2 spp.), *Tetraclinis* (1 sp.), *Thuja* (5 spp.), *Thujopsis* (1 sp.), *Widdringtonia* (4 spp.) and *Xanthocyparis* (2 spp.); total 135 species.

Distribution

Cosmopolitan. Northern hemisphere: Macaronesia; N Africa (including one locality in Central Sahara). Eurasia: Europe (including Iceland), SW Asia (excl. driest deserts), Central Asia, Mongolia, Siberia, Russian Far East (including Kamchatka), Hindu Kush, Himalaya, China, Taiwan, Japan, Korea, Lao PDR, Viet Nam. Australasia: New Guinea, Maluku (Moluccas), Australia (including Tasmania). SW Pacific: New Caledonia, New Zealand. North America: Canada, S Greenland, USA (including Alaska), Mexico. Central America S to Honduras. Caribbean Islands. South America: S Chile and S. Argentina (Andes) to Tierra del Fuego.

Taxonomic notes

The family *Cupressaceae* here includes the former *Taxodiaceae*. The initial full description of *Taxodiaceae* by Warming (1884) included spiral phyllotaxis as a distinctive character; at that time *Metasequoia* (with opposite phyllotaxis but in other characters similar to e.g. *Sequoia* and *Taxodium* in *Taxodiaceae*) was unknown. Another distinction claimed in earlier works was the position of ovules in developing cones: axillary to bracts (*Cupressaceae*) or basal upon them (*Taxodiaceae*). In reality, as has now been shown in detailed observations of ontogeny of cones using scanning electron microscopes (SEM), there is no clear cut distinction, but a grade through both families. If there is a line of demarcation between the two positions, it lies within the traditional *Taxodiaceae* (see Farjon, 2005a for an overview). It was Eckenwalder (1976) who first demonstrated in a comprehensive phenetic analysis of morphological and other characters, that apart from *Sciadopitys* (formerly classified in *Taxodiaceae*), no taxon assigned to *Taxodiaceae* was separable from a larger group including taxa classified in the *Cupressaceae*. Phylogenetic analyses, both of morphological data and of molecular (DNA) data, and of combined data, all demonstrate that the genera of traditional *Taxodiaceae* constitute not a coherent clade (group), but a 'grade' of taxa with on the whole less advanced character states. These genera are also predominantly monospecific, with in several cases more species known from the fossil record. They therefore constitute a loose assembly of relict species with more or less basal positions in the phylogeny of the *Cupressaceae*. It is interesting to note that palaeobotanists, who have been more hesitant than other systematists to abandon the concept of *Taxodiaceae*, are now also beginning to interpret *Cupressaceae* in the here accepted circumscription (e.g. Stockey *et al*. in Farjon, 2005a; Anderson *et al*., 2007). This is undoubtedly due to the fact that more fossil remains are coming to light that appear to fill in the gaps created by the extinctions.

Key to the genera

1a. Leaves linear-lanceolate; margins serrulate; seed cones > 15 mm wide, composed of helically arranged, coriaceous scales each with 2–3 seeds ***Cunninghamia***

1b. Leaves of a different shape, entire if linear; seed cones if with helically arranged coriaceous scales, then <15 mm wide and 2 seeds per scale

2a. Leaves on lateral, short branchlets all linear, flat and entire **3**

2b. Leaves on lateral, short branchlets at least in part scale-like or subulate, or a mixture of scale-like and linear leaves present on the same mature plant **5**

3a. Leaves on lateral branchlets and cone scales decussate, lateral branchlets deciduous ***Metasequoia***

3b. Leaves on lateral branchlets and cone scales helically arranged **4**

4a. Leaves scale-like on leading branches, linear and flat on lateral branchlets, lateral branchlets evergreen; all cones near or at the end of foliage branchlets ***Sequoia***

4b. Leaves (almost) all linear, flat or short acicular to subulate in one variety; lateral branchlets (semi-)deciduous; pollen cones numerous on leafless branchlets; seed cones on thicker branches, often aggregate ***Taxodium***

5a. Leaves on lateral foliage branchlets and cone scales all helically arranged **6**

5b. Leaves on lateral foliage branchlets and cone scales decussate, opposite or whorled **10**

6a. Leaves on lateral foliage branchlets scale-like as well as linear, lateral branchlets deciduous ***Glyptostrobus***

6b. Leaves on lateral foliage branchlets scale-like or subulate or lanceolate, lateral branchlets evergreen **7**

7a. Leaves on lateral branchlets mostly scale-like; seed cones ovoid, > 30 mm long with 30 or more peltate scales; bark on trunk thick and soft fibrous ***Sequoiadendron***

7b. Leaves on lateral branchlets scale-like, appressed, or subulate or lanceolate; seed cones < 30 mm long with less than 30 scales; bark relatively thin and scaly **8**

8a. Leaves on lateral branchlets of cone-bearing trees all subulate, distinctly keeled; seed cones squarrose; cone scales cuneate, with small teeth above the recurved bract tip ***Cryptomeria***

8b. Leaves on lateral branchlets scale-like, subulate or lanceolate; seed cone scales without small teeth above the bract tip **9**

9a. Leaves subulate in younger trees only, eventually changing to scale leaves; seed cones ellipsoid to cylindrical, with thin cone scales; pollen cones aggregate ***Taiwania***

9b. Leaves subulate or scale-like on different mature trees; seed cones (sub)globose, with ± thickened cone scales; pollen cones solitary ***Athrotaxis***

10a. Seed cones berry-like, ± soft, indehiscent; cone scales (almost) entirely fused; leaves scale-like or acicular-linear ***Juniperus***

10b. Seed cones not berry-like, (eventually) dehiscent; cone scales at least partly integer; leaves on lateral branchlets scale-like, rarely acicular or linear **11**

11a. Leaves on lateral branchlets decussate, dimorphic, with differently shaped facials and laterals **12**

11b. Leaves on lateral branchlets decussate or whorled (3–4), monomorphic or at least not clearly divided in facials and laterals **23**

12a. Seed cones (sub)globose when closed, with cone scales of more or less equal length **13**

12b. Seed cones oblong when closed, with some paired cone scales longer than other scales **18**

13a. Seed cones with 4(-5–6) subpeltate scales in decussate pairs **14**

13b. Seed cones with 8 or more peltate or subpeltate scales in decussate pairs **16**

14a. Leaves weakly dimorphic, appressed; columella in seed cone absent **15**

14b. Leaves strongly dimorphic, lateral leaves with free apex, or monomorphic linear leaves present; columella present ***Xanthocyparis***

15a. Small tree or shrub; leaves long decurrent, adnate to branchlets except for the small apex; seed cones woody, > 10 mm, with 4–6 winged seeds ***Tetraclinis***

15b. Decumbent shrub; leaves short decurrent; seed cones < 5 mm, with a single, wingless seed ***Microbiota***

16a. Leaves on lateral branchlets lustrous green above, with conspicuous, white stomatal bands below; seed cones > 11 mm **17**

16b. Leaves green above, with ± obscure, greenish white stomatal bands below; seed cones < 12 mm ***Chamaecyparis***

17a. Seed cones with 2(-3) pairs of larger scales and 2–3 pairs of reduced scales; leaves thick, facials and laterals equally long ***Thujopsis***

17b. Seed cones with at least 4 pairs of larger, peltate scales, only the upper 1–2 pairs reduced; leaves thin, laterals exceeding facials ***Fokienia***

18a. Seed cones with 3 decussate pairs of scales, the proximal pair reduced, the middle pair spreading and fertile, the long distal pair fused and sterile ***Calocedrus***

18b. Seed cones with 2 or 3–6 decussate pairs of scales, the middle and distal pairs spreading and fertile, or the distal pair reduced and sterile **19**

19a. Seed cones with 2 decussate, fertile pairs of scales **20**

19b. Seed cones with 3–6 decussate pairs of fertile and sterile scales **22**

20a. Seed cone scales with a large bract apex ***Libocedrus***

20b. Seed cone scales with a small bract apex **21**

21a. Facial leaves minute in comparison to laterals in all stages; bract apex nearly central on the seed cone scale ***Papuacedrus***

21b. Facial leaves slightly smaller than laterals; bract apex subapical ***Austrocedrus***

22a. Seed cone scales thin, the distal pair reduced and connate; seeds winged ***Thuja***

22b. Seed cone scales thickened, the distal pair well developed and spreading; seeds unwinged ***Platycladus***

23a. Leaves on lateral branchlets decussate **24**

23b. Leaves on lateral branchlets whorled, usually ternate **27**

24a. Seed cones globose to ovoid, with > 6 peltoid scales; seeds numerous, small, winged ***Cupressus***

24b. Seed cones with a different shape and/or fewer scales; seeds few to numerous, winged or nearly wingless **25**

25a. Shrub to very small tree (to 6 m); seed cones tiny, ca. 3 mm long, with 2 pairs of scales; maximal 2 seeds per cone ***Diselma***

25b. Shrub to tall tree, seed cones > 10 mm long, with 2 or more pairs of scales; > 2 seeds per cone **26**

26a. Seed cones subglobose when closed, with thick woody scales and numerous seeds per cone; leaves on older branchlets more or less spirally arranged ***Widdringtonia***

26b. Seed cones ovoid-oblong when closed, with thin woody scales and 3–4 seeds per cone; all leaves decussate ***Pilgerodendron***

27a. Leaves all in alternate whorls of 4, seemingly in 8 rows, lanceolate; seed cones rare, with 8 only 2–3 mm wide scales ***Neocallitropsis***

27b. Leaves usually in alternate whorls of 3, scale-like or sometimes acicular (juvenile form); seed cones common, with 6, rarely with 8, > 3 mm wide scales **28**

28a. Mature type leaves long decurrent, adnate to branchlets except for the (small) apex; seed cones with thick woody, valvate scales and a ± conical, hard columella **29**

28b. Mature type leaves short decurrent, loosely appressed or spreading; seed cones with thin woody, widely spreading scales and a trigonal to tripartite, soft columella ***Fitzroya***

29a. Valvate, thick cone scales subtended by appressed, thin sterile scales; leaf apices on ultimate branchlets spreading and acute ***Actinostrobus***

29b. Valvate, thick cone scales not subtended by sterile scales; leaf apices on ultimate branchlets usually appressed or just free. ***Callitris***

Phyllocladaceae Bessey, Nebraska Univ. Stud. 7: 325. 1907. Type: *Phyllocladus* Rich. *ex* Mirb.

Description

See the genus description.

One genus: *Phyllocladus*, with 4 species.

Distribution

As for the genus.

Taxonomic notes

The genus *Phyllocladus* was placed within the *Podocarpaceae* as a subfamily *Phyllocladoideae* by Pilger (1903), but elevated to family rank by Bessey (1907), a publication apparently overlooked by Keng (1973), who proposed the family again. Since then, this family status has been controversial. Keng, in a series of papers re-published in Taipei (Taiwan) as 'A monograph of the genus *Phyllocladus* (Coniferae)' (Keng, 1963–79), emphasised the peculiar phylloclades which function as true leaves and, erroneously, believed they were homologous with progymnospermous dichotomous branching systems, e.g. those of the Devonian genus *Archaeopteris*. We now know that they are adaptive

structures of much more recent origin, unique in conifers but evolved independently in some angiosperms. Keng's interpretation was criticised by Quinn (1987) and in a series of subsequent papers (Chaw *et al.*, 1997; Conran *et al.*, 2000; Quinn *et al.*, 2002; Quinn & Price, 2003) researchers analysed various DNA sequence data to address the question of the phylogenetic relationship of *Phyllocladus*. The presented cladograms predominantly show a clade '*Podocarpaceae*' consisting of selected representative taxa, with *Phyllocladus* in a basal position (sister to the other genera). The implication inferred by Quinn and co-workers is that *Phyllocladus* "is a true podocarp despite its highly distinctive morphology." If retained in the *Podocarpaceae*, its phylogenetic relationship as inferred from these molecular data would obviously warrant status as a subfamily. Whether one recognizes it instead as a family then depends on two criteria. One is the acceptance or rejection of paraphyletic taxa: when *Phyllocladus* and the *Podocarpaceae* are recognized in equal rank (both as family) and given the results of these analyses (phylogeny represented by cladograms), the *Podocarpaceae* would be paraphyletic (i.e. a group not including all its descendants) instead of monophyletic (including all its descendants). But the analyses remain limited; not all possible relatives were included. Based on the current information it is therefore appropriate to conclude that *Phyllocladus* is closely related to *Podocarpaceae*, but because of the limitations of the molecular studies thusfar undertaken and the morphology, the *Phyllocladaceae* are for the present retained as a separate family. The other criterion is the evolution of morphological and biological characters. Apart from the phylloclades (which, being unique within conifers, provide no information about phylogenetic relationships of members of that group), there are some quite fundamental differences that would warrant recognition at a higher taxonomic rank. These are seen in the reproductive morphology (Tomlinson *et al.*, 1989), where *Phyllocladus* has an aril instead of an epimatium, and in the different pollination mechanisms (Tomlinson *et al.*, 1997). There are a suite of other characters which either "unite" *Phyllocladus* with *Podocarpaceae* (Quinn *et al.*, 2002) or "separate" them (Page, 1990), and each author tends to emphasize those in favour of their respective views on the matter. Taxon recognition, despite claims to the contrary, is not a matter to be decided in a purely formalized way (e.g. cladistic analysis) and more evidence is needed to resolve this question to the satisfaction of all.

Pinaceae Spreng. *ex* F. Rudolphi, Syst. Orb. Veg.: 35. 1830. Type: *Pinus* L.

Description

Monoecious evergreen or deciduous, resinous trees or shrubs, sometimes to 100 m tall. Resin canals in wood, bark, leaves and seed cones. Wood with adaxial parenchyma, with normal (non-traumatic) resin canals and ray tracheids. Branching in rhytmic pseudo-whorls on main stem and branches, with apical dominance maintained or restored and limited reiteration (Massart's and Rauh's models); branches terminating in seasonally dormant buds. Leaves spirally inserted on long or short shoots and solitary, or in fascicles of 1–8 surrounded by a sheath on dwarf shoots (*Pinus*), acicular-linear to long linear, amphistomatic or hypostomatic, sometimes epistomatic. Leaf anatomy in cross section with 1–2 vascular bundles encapsulated in a stele and 1-many resin canals variously positioned in the mesophyll; palisade parenchyma present or absent; hypodermis and epidermis usually well developed and differentiated. Pollen cones lateral on long shoots or apical on short shoots, often grouped close together on long shoots, axillary, solitary or clustered from a single bud, catkin-like, deciduous. Microsporophylls numerous, spirally arranged, (sub)peltate, with 2 abaxial, free pollen sacs (microsporangia) which are longitudinally dehiscent, containing bisaccate or monosaccate or non-saccate pollen. Seed cones woody, small to very large, erect or becoming pendulous, lateral on long shoots or apical on short shoots, often grouped together on long shoots, solitary in leaf axils, sometimes long persistent. Bracts spirally arranged on a woody and integer rachis (breaking up in *Pseudolarix*), remaining small or growing with the cone; growing bracts apically differentiated and often exserted. Seed scales axillary to and free from bracts, both persistent or deciduous (*Abies, Cedrus*); seed scales flattened; apex rounded, more or less acute (*Pseudolarix*), or differentiated (*Pinus*). Ovules 2 per scale, inverted; seeds slightly flattened, usually winged (with 1 wing) but in some species of *Pinus* effectively wingless due to rudimentary wings

remaining attached to the seed scale. Seedlings with varying numbers of cotyledons (2–24, the highest number in all plants). Germination epigeal (hypogeal in *Keteleeria*); young taproot of the seedling with 1–2 resin canals in the vascular cylinder (stele). Diploid number of chromosomes (2n) = 24 (in *Pseudolarix* 44 and in *Pseudotsuga menziesii* 26).

11 genera: *Abies* (47 spp.), *Cathaya* (1 sp.), *Cedrus* (3 spp.), *Keteleeria* (3 spp.), *Larix* (11 spp.), *Nothotsuga* (1 sp.), *Picea* (38 spp.), *Pinus* (113 spp.), *Pseudolarix* (1 sp.), *Pseudotsuga* (4 spp.) and *Tsuga* (9 spp.); total 231 species.

Distribution

Northern hemisphere (with one equatorial crossover in N Sumatera). Eurasia & N Africa: Canary Islands, Mediterranean coast of N Africa, Europe (excl. Iceland & Ireland), Turkey, Syria, Lebanon, Caucasus, Central Asia, Siberia, Russian Far East (including Kamchatka), Korea, Japan, Hindu Kush, Himalaya, NE India, China, Taiwan, Indochina, N Sumatera, Philippines. North America: Canada, USA (including Alaska, excl. some midwestern states), Mexico. Central America S to Nicaragua; Caribbean Islands (excl. Lesser Antilles).

Key to the genera

1a. Adult green leaves bundled with 2–5(-8) together on dwarf shoots (1 species with a single leaf on a dwarf shoot); seed cones biennial (rarely triennial), with distinction between each year's growth apparent as an umbo and apophysis on each scale; seed held to the wing in a pair of claws ***Pinus***

1b. Adult green leaves either solitary or in pseudo-whorls of more than 10 together on short shoots; seed cones mostly annual (if biennial without umbo); seed held to the wing in a cup **2**

2a. Seeds without resin vescicles; seed scales with a broad basis, persistent **3**

2b. Seeds with resin vescicles; seed scales with a narrow, petiolate basis, persistent or deciduous **6**

3a. Seeds easily separated from relatively large, narrow seed wing; pulvini on shoots very strongly developed; leaves mostly amphistomatic or sometimes epistomatic; seed cones with rudimentary (or small) bract scales and with rudimentary scales on the pedunculate base, pendulous at maturity ***Picea***

3b. Seeds not separable from relatively small, broad seed wing; pulvini on shoots weakly developed or absent; leaves epi/hypostomatic or epi-amphistomatic with distinct primary stomatal bands; seed cones with small to very large bract scales and distinct, leaved peduncles, erect, spreading or pendulous at maturity **4**

4a. Shoots strongly dimorphic; leaves spirally and remotely arranged on long shoots, in dense pseudo-whorls on short shoots, deciduous; seed cones erect from mostly pendulous branches ***Larix***

4b. Shoots monomorphic or weakly dimorphic; leaves spirally arranged, remote or dense, evergreen; seed cones spreading or pendulous from mostly plagiotropic branches **5**

5a. Shoots weakly dimorphic, with (alternate) long and short growth; leaves in short growth parts of shoots in dense tufts; bract scales of seed cones small, included and simple acuminate ***Cathaya***

5b. Shoots monomorphic; leaves equally distant on all (segments of) shoots; bract scales of cones large, exserted and trilobate at apex ***Pseudotsuga***

6a. Mature seed cones pendulous ***Tsuga***

6b. Mature seed cones erect **7**

7a. Pollen cones in (umbellate) clusters from a single bud; seed cones on mostly long, leaved peduncles; cone rachis (slowly) disintegrating **8**

7b. Pollen cones solitary; seed cones on short, bare peduncles or sessile; cone rachis persistent **10**

8a. Shoots strongly dimorphic; leaves spirally and remotely arranged on long shoots, in dense pseudo-whorls on short shoots, deciduous; seed scales deciduous by rapid disintegration of the cone rachis ***Pseudolarix***

8b. Shoots monomorphic or weakly dimorphic; leaves spirally arranged on long shoots, evergreen; seed scales (longer) persistent **9**

9a. Seed cones large, (usually) more than 6 cm long and 3 cm wide; leaves with narrowed, twisted base, 2–4.5 mm wide, on weakly developed pulvini, leaving circular leaf scars after falling ***Keteleeria***

9b. Seed cones small, (usually) 2.5–5 × 1.5–2.5 cm; leaves with oblique, petiolate base, 1–2 mm wide, on more developed pulvini, leaving no distinct leaf scars after falling ***Nothotsuga***

10a. Shoots strongly dimorphic; leaves spirally and remotely arranged on long shoots, in dense pseudo-whorls on short shoots; seed cones maturing in two years, disintegrating on tree with deciduous seed scales ***Cedrus***

10b. Shoots monomorphic; leaves spirally arranged on long shoots; seed cones maturing in one season, with deciduous bracts and seed scales ***Abies***

Podocarpaceae Endl., Syn. Conif.: 203. 1847. (*nom. cons.*). Type: *Podocarpus* L'Hér. *ex* Pers.

Description

Dioecious or sometimes monoecious, evergreen, slightly resinous trees or (dwarf) shrubs (one parasitic on another member of the family). Bark of trees thin, usually becoming scaly and exfoliating in flakes or strips. Tree trunks monopodial, commonly with orthotropic branching (Rauh's model). Foliage branches terminating in buds with small, leaf-like or more specialized scales (*Podocarpus*), or terminating in reduced leaves. Leaves helically arranged, rarely decussate (*Microcachrys*), appressed and imbricate to spreading and remote, shapes highly variable, ranging from small, appressed scale leaves, via thin acicular leaves, to dorsiventrally flattened, linear-lanceolate to broadly lanceolate, large leaves (up to 34 × 9.5 cm); venation a single median strand or multiple parallel veins; texture soft and flexible to coriaceous and more or less stiff; leaves amphistomatic or hypostomatic. Pollen cones mostly simple, axillary or terminal, solitary or clustered, in some genera (*Nageia, Prumnopitys*) forming compound, racemose units (spikes), sessile or pedunculate, very small to long cylindrical; microsporophylls spirally arranged, with 2 abaxial, longitudinally dehiscent pollen sacs; pollen bisaccate or trisaccate (rarely 4–6), or non-saccate (*Saxegothaea*). Seed cones axillary or terminally, solitary on naked or scaly peduncles, or sessile, composed of 2-many alternate or helically arranged bracts; fertile bracts 1-many. Sterile and fertile bracts either fusing and forming a fleshy or succulent, often brightly coloured receptacle, or remaining small as part of a small, compound cone and either becoming succulent and coloured (*Microcachrys*) or leathery and dry (*Pherosphaera, Saxegothaea*). Seed scales single in the axil of a bract, bearing a single initially erect but at pollination more or less inverted ovule, in most genera (not in *Pherosphaera*) much expanding after fertilization to enclose the seed partly or entirely, forming the epimatium. Epimatium leathery or fleshy, thin or very thick, becoming succulent in some genera that do not develop (or only imperfectly develop) a succulent receptacle, remaining green or variously coloured. Seeds (except *Microcachrys, Pherosphaera* and *Saxegothaea*) single or sometimes 2, protruding well outside the transformed or reduced cone proper. Seeds proper ovoid, slightly flattened, with a hard, sclerified seed coat and wingless. Seedlings with 2 cotyledons, germination epigeal. Chromosome numbers (diploid) 2n = 18 to 38 (but not 28 and 32).

18 genera: *Acmopyle* (2 spp.), *Afrocarpus* (5 spp.), *Dacrycarpus* (9 spp.), *Dacrydium* (22 spp.), *Falcatifolium* (6 spp.), *Halocarpus* (3 spp.), *Lagarostrobos* (1 sp.), *Lepidothamnus* (3 spp.), *Manoao* (1 sp.), *Microcachrys* (1 sp.), *Nageia* (5 spp.), *Parasitaxus* (1 sp.), *Pherosphaera* (2 spp.), *Podocarpus* (97 spp.), *Prumnopitys* (9 spp.), *Retrophyllum* (5 spp.), *Saxegothaea* (1 sp.) and *Sundacarpus* (1 sp.); total 174 species.

Distribution

Pantropical, extending in the southern hemisphere to cool temperate and in the northern hemisphere to warm temperate latitudes. Africa: Sub-Saharan Africa only, in W Africa from Sâo Thomé, S Nigeria and Cameroon to Angola; in E and S Africa from Ethiopia along the Afromontane system to the Cape; Madagascar. Asia: S India (disjunct in Kerala) and from the E Himalaya and Assam through S China to Japan; Taiwan, Indochina, Andaman and Nicobar Islands, and Malesia. Australasia and SW Pacific: Australia (excl. the dry interior and NW), Solomon Islands, New Caledonia, Vanuatu, Fiji, Tonga, and New Zealand. Americas: From Mexico to Panama, Caribbean Islands (excl. Bahamas & Turks Caicos Islands); South America along the Andean Cordillera from Venezuela to S Chili, Venezuelan Highlands, SE and SW Brazil.

Key to the genera

1a. Leaves monomorphic, forming a distinct lamina (blade) wider than thick **2**
1b. Leaves monomorphic or dimorphic, at least in part scale-like or more or less acicular, these not or only slightly wider than thick **8**
2a. Leaves with multiple parallel veins ***Nageia***
2b. Leaves with a single (sometimes inconspicuous) midvein **3**
3a. Seed cones forming an inflated, coloured, succulent receptacle below the seed(s) when ripe ***Podocarpus***
3b. Seed cones much reduced, not or rarely slightly inflated, or consisting of numerous small, fertile scales **4**
4a. Seed cones consisting of numerous small, fertile scales ***Saxegothaea***
4b. Seed cones much reduced, not or rarely slightly inflated **5**
5a. Pollen cones aggregated in spikes ***Prumnopitys***
5b. Pollen cones in clusters, sessile or very short pedunculate, or solitary **6**
6a. Leaves in apparent opposite and decussate pairs due to twisted petioles turning the leaves in opposite directions ***Retrophyllum***
6b. Leaves alternate, not twisted in opposite directions **7**
7a. Leaves with stomata on both surfaces (amphistomatic ***Afrocarpus***
7b. Leaves with stomata only on the abaxial (lower) surface (hypostomatic) ***Sundacarpus***
8a. Leaves monomorphic (only one type present) **9**
8b. Leaves dimorphic (two distinct types present) **14**
9a. Small shrubs or dwarf trees with reddish scale leaves and purple (pen)ultimate branchlets; seeds terminal, glaucous white ***Parasitaxus***
9b. Shrubs or trees with green scale leaves on foliage branchlets; seeds lateral or (sub)terminal, usually not glaucous white **10**
10a. Dwarf shrubs, usually creeping, with decussate scale leaves ***Microcachrys***
10b. Shrubs or trees with spirally arranged scale leaves **11**
11a. Seed cones very small, consisting of multiple fertile (and some infertile) scales and ovules (seeds) **12**
11b. Seed cones much reduced, usually with only one fertile scale producing a single seed **13**
12a. Always shrubs, trailing or upright ***Pherosphaera***
12b. Trees (sometimes appearing shrubby with multiple stems, especially when in cultivation) ***Lagarostrobos***
13a. Epimatium forming a yellowish green collar around the erect seed; always trees ***Manoao***
13b. Epimatium basal, hidden from view by inverted ripe seed; (dwarf) shrubs or sometimes trees ***Lepidothamnus***
14a. Leaves acicular, rarely scale-like, never with a distinct lamina ***Dacrydium***
14b. Leaves scale-like and/or with a distinct lamina, never acicular **15**
15a. Epimatium forming a collar around the base of the seeds **17**
15b. Epimatium surrounding the seeds completely, becoming swollen and succulent **16**
16a. Leaves with well developed lamina always present and dominant on all foliage branchlets ***Acmopyle***
16b. Laminar leaves present or absent, not dominant (i.e. scale leaves predominate on some or most foliage branchlets) ***Dacrycarpus***
17a. Leaves with well developed lamina always present and dominant on all foliage branchlets, mostly falcate; seed cones forming a swollen receptacle ***Falcatifolium***
17b. Leaves with well developed lamina absent or present, but not dominant (i.e. scale leaves predominate on some or most foliage branchlets); seed cones much reduced ***Halocarpus***

Sciadopityaceae Luerss., Grundz. Bot.: 265. 1877, ["*Sciadopityeae*"]. Type: *Sciadopitys* Siebold & Zucc.

Description

See the species description.

One genus: *Sciadopitys*, with 1 species.

Distribution

As for the species.

Taxaceae Gray, Nat. Arr. Brit. Pl. 2: 222, 226. 1822. (*nom. cons.*). Type: *Taxus* L.

Description

Dioecious or rarely monoecious evergreen shrubs or trees, slightly resinous with resin in leaves (with or without resin canals) and arils. Bark thin, exfoliating in strips. Branches spreading or ascending, often with much reiteration; foliage branches terminating in buds with small, imbricate scales. Leaves helically or decussately inserted, usually pectinately arranged on plagiotropic branchlets, linear to lanceolate, bifacially (dorsiventrally) flattened, with a single median vascular bundle (midrib), coriaceous, hypostomatic, with two separate bands of stomata. Pollen cones lateral on foliage shoots and axillary to foliage leaves, or aggregated in umbellate clusters of (1-)3–6 racemes at or just below the apex of vegetative shoots (*Amentotaxus*), subtended by small or large perular scales, short pedunculate, (sub)globose to short cylindrical. Microsporophylls helically or decussately arranged (with secondary displacement forming 8 ranks), few in number (but up to 60 in *Torreya*), radially symmetric (peltate) or dorsiventrally compressed, with 2–8 pendulous, oblong pollen sacs either in radial placement or abaxially, containing spherical, inaperturate pollen. Seed bearing structures consisting of axillary dwarf shoots with decussate scales, branching 1–2 times, usually strongly reduced, with terminal, erect ovules of which only a single one matures. Ovules at pollination time around the base of the integument with a ring-like structure. Aril partially or entirely enclosing the seed, fleshy or succulent, becoming red, purple, or yellow when ripe. Seeds oval to ovoid, slightly flattened, with a hard, sclerified seed coat. Seedlings with 2 cotyledons, germination epigeal. Number of chromosomes (diploid) 2n = 22 (*Amentotaxus, Torreya*) or 24.

Five genera: *Amentotaxus* (6 spp.), *Austrotaxus* (1 sp.), *Pseudotaxus* (1 sp.), *Taxus* (10 spp.) and *Torreya* (6 spp.); total 24 species.

Distribution

Western Eurasia & North Africa: Madeira; Atlas Mountains; Europe from Ireland and Portugal to S Scandinavia, European Russia and the Caucasus; Turkey, N Iran. Asia: Hindu Kush, Himalaya, Assam; China, Korea, Russian Far East (Primorye), Japan, Taiwan; Indochina; Malesia (Sumatera, Sulawesi, Philippines). SW Pacific: New Caledonia. North & Central America: British Columbia, Washington, Idaho, W Montana, Oregon, California; E Canada, E USA to Florida; Mexico, Guatemala, Honduras, El Salvador.

Key to the genera

1a. Leaves opposite-decussate; pollen cones in umbellate clusters of (1-)3–6 racemes at or just below the shoot apex ***Amentotaxus***

1b. Leaves alternate (spirally inserted); pollen cones solitary in the axils of leaves along the shoot (proximally, along the entire length or distally) **2**

2a. Leaves usually not longer than 3.5 cm (rarely to 4.5 cm); aril surrounding the seed incompletely when mature, leaving the seed well visible **3**

2b. Leaves usually longer than 4 cm and up to 12(-17) cm; aril surrounding the seed (almost) completely when mature, leaving the seed (virtually) invisible **4**

3a. Foliage branchlets sub-whorled or subopposite; stomatal bands white; aril of seeds white when ripe ***Pseudotaxus***

3b. Foliage branchlets irregularly alternate; stomatal bands pale greyish green or pale yellow; aril of seeds red or sometimes orange to yellow when ripe ***Taxus***

4a. Midrib forming a narrow groove on the adaxial (upper) face of leaves; pollen cones aggregated near the base of new foliage shoots; arils surrounding the seeds 12–15 × 7–9 mm, leaving the seed apex visible ***Austrotaxus***

4b. Midrib on the adaxial face of leaves more or less prominently raised; pollen cones forming double rows along the foliage shoots; arils 15–40 × 10–25 mm, completely surrounding the seeds ***Torreya***

Abies Mill., Gard. Dict., Abridg. Ed. 4, vol. 1. 1754. Type: *Abies alba* Mill. [*Pinus picea* L.] (*Pinaceae*).

Abies is the classical Latin name for firs.

Description

Evergreen monoecious trees with a monopodial, straight, columnar trunk. Resin canals in bark, leaves, and seed cones, normally not in wood unless traumatic. Branching in rhythmic pseudo-whorls on the trunk (Massart's model), spreading horizontally, with a dorsiventral symmetry (plagiotropic), branching again with opposite shoots of lesser potential. (Sub-) terminal buds often extremely resinous. Leaves linear, more or less flattened, spirally arranged and usually twisted at the petiolate base, set on small, circular depressions on the shoot which are clearly visible after detachment; with two conspicuous white stomatal bands abaxially and sometimes scattered stomata also on the adaxial side. Pollen cones usually below seed cones in the tree, axillary, pendulous, solitary, catkin-like, with spirally arranged, peltate microsporophylls; bearing two pollen sacs with bisaccate pollen. Seed cones restricted to the upper part of the crown, axillary, solitary, sessile or short pedunculate, erect, disintegrating at maturity when drying. Bracts and seed scales helically attached to a stout or slender rachis which remains on the branches. Bracts in mature cones exserted or sometimes hidden, with a central cusp; cusp elongated or not. Seed scales cuneate to reniform, with a pedicellate base. Seeds held in a membranous cup, covering about 0.7 part of the seed; membrane continued in a well developed, cuneate-triangular, persistent wing. Seedlings with (3–)4–8(–10) cotyledons.

46 species

Distribution

North America: (disjunct) from Yukon to Arizona and California into Mexico to Honduras; from Great Slave Lake to Newfoundland and Appalachian Mountains in North Carolina. Eurasia and N Africa: from Morocco through S and Central Europe to Turkey and Lebanon; NE Russia, Siberia and Central Asia to Sakhalin and Japan; Sino-Himalayan mountain system and isolated spots in China, Taiwan.

Taxonomic notes

The genus *Abies* is the second largest in *Pinaceae* (after *Pinus*). Liu (1971) recognized 39 species, while Rushforth (1987) came to a total of about 55. In Farjon (1990) 46 species were recognized. The World Checklist & Bibliography of Conifers (Farjon, 1998, [2001]) recognized 49, resp. 48 species. Since the monographic work of Liu, several new species have been described, mainly from China; furthermore, his treatment of several SW Chinese taxa failed to recognize differences on the species level. On the other hand, a number of species mentioned by Rushforth have been given infraspecific status here, mainly at the subspecies level. Recently, a few new species were described from Mexico, but it appears that we have arrived at a phase where these reflect narrower circumscriptions rather than truly new discoveries.

Synopsis

The classification of the genus into sections and subsections used here to key out the species in the genus *Abies* is essentially that of Farjon & Rushforth (1989), also used in my book Pinaceae (Farjon, 1990), but with a few emendations. Most notable of these is the removal of *Abies kawakamii* from Taiwan in section *Balsamea* (subsection *Laterales*) and its tentative placement in section *Momi* (subsection *Homolepides*) as a result of a molecular (nuclear DNA) analysis by Xiang *et al.* (2004). This molecular analysis broadly supported the classification given

by Farjon & Rushforth based on morphological data, but it has demonstrated the anomaly of their placement of this species. The other changes made here involve a few additions and subtractions of species. The classification given below is arranged according to hypothetical phylogenetic relationships, but in the keys to the species the sections and subsections are presented in alphabetical order, with sections first and subsections under these.

Genus *Abies* Mill.

Sect. *Abies*
Species *A. alba, A. cephalonica, A. nordmanniana, A. nebrodensis, A. cilicica*, *A.* ×*borisii-regis*

Sect. *Piceaster* Spach emend. Farjon & Rushforth
Species *A. pinsapo, A. numidica*

Sect. *Bracteata* Engelm. emend. Sargent
Species *A. bracteata*

Sect. *Momi* Franco
Subsect. *Homolepides* (Franco) Farjon & Rushforth, emend.
Species *A. homolepis, A. kawakamii, A. recurvata*
Subsect. *Firmae* (Franco) Farjon & Rushforth
Species *A. firma, A. beshanzuensis*
Subsect. *Holophyllae* Farjon & Rushforth
Species *A. holophylla, A. chensiensis, A. pindrow, A. ziyuanensis*

Sect. *Amabilis* (Matzenko) Farjon & Rushforth
Species *A. amabilis, A. mariesii*

Sect. *Pseudopicea* Hickel emend. Farjon & Rushforth
Subsect. *Delavayianae* Farjon & Rushforth
Species *A. delavayi, A. fabri, A. forrestii, A. densa, A. spectabilis, A. fargesii, A. fanjingshanensis, A. yuanbaoshanensis*
Subsect. *Squamatae* E. Murray
Species *A. squamata*

Sect. *Balsamea* Engelm. emend. Farjon & Rushforth
Subsect. *Laterales* Patschke emend. Farjon & Rushforth, emend.
Species *A. balsamea, A. lasiocarpa, A. sibirica*
Subsect. *Medianae* Patschke emend. Farjon & Rushforth
Species *A. sachalinensis, A. fraseri, A. koreana, A. nephrolepis, A. veitchii*

Sect. *Grandis* Engelm. emend. Farjon & Rushforth
Species *A. grandis, A. concolor, A. durangensis, A. guatemalensis*

Sect. *Oiamel* Franco
Subsect. *Religiosae* (Matzenko) Farjon & Rushforth
Species *A. religiosa, A. vejarii*
Subsect. *Hickelianae* Farjon & Rushforth
Species *A. hickelii, A. hidalgensis*

Sect. *Nobilis* Engelm.
Species *A. procera, A. magnifica*

Key to the sections and subsections

1a. Bract cusps more than 2.5 cm long. Vegetative buds fusiform, 1–2 cm long, not resinous **Sect. *Bracteata: A. bracteata***

1b. Bract cusps much shorter than 1.5 cm. Vegetative buds not fusiform, usually much less than 1 cm long, often resinous **2**

2a. Seed cones very large (14–30 × 5–10 cm). Leaves on vegetative shoots usually carinate, imbricate at base, lower leaves curving sideways, upper leaves strongly assurgent **Sect. *Nobilis***

2b. Seed cones smaller, if longer than 15 cm then less than 6 cm wide. Leaves on vegetative shoots usually flattened **3**

3a. Seed cones narrowly cylindrical (ratio of length to width greater than 2.5); rachis of cone conical, slender **4**

3b. Seed cones ovoid, conical or broad cylindrical; rachis of cone conical, cylindro-conical or fusiform, stout **8**

4a. Seed cones (10–)12–25(–30) cm long, ratio of length to width usually 3 or more **5**

4b. Seed cones 3–12 cm long, ratio length to width usually less than 3 **6**

5a. Bracts exserted and reflexed (usually included in *A. cilicica*), with elongated cusp; cone apex obtuse or acutish (sometimes papillionate) **Sect. *Abies***

5b. Bracts always included, cusp short; cone apex papillionate **Sect. *Piceaster***

6a. Seed cones small, (3–)4–8 × (1.5–)2–3(–4) cm, purplish (rarely greenish); bracts yellow-brown. Leaves emarginate **Sect. *Balsamea*** **7**

6b. Seed cones larger, (5–)7–12 × 3–5 cm, green, olive green or rarely bluish during the growing season. Leaves obtuse, acute or emarginate **Sect. *Grandis***

7a. Bracts exserted and reflexed; seed scales reniform **Subsect. *Medianae***

7b. Bracts included; seed scales cuneate-flabellate **Subsect. *Laterales***

8a. Seed cone rachis thick, fusiform or cylindro-conical; seed scales usually apically thickened. Shoots usually stout **Sect. *Pseudopicea*** **9**

8b. Seed cone rachis less thick, conical; seed scales thickest at or below the middle. Shoots usually thin **10**

9a. Bark exfoliating in large papery flakes **Subsect. *Squamatae:* *A. squamata***

9b. Bark different **Subsect. *Delavayianae***

10a. Bracts usually exserted with a broad cusp (but not in *A. vejarii* subsp. *mexicana*). Branchlets purplish brown **Sect. *Oiamel*** **11**

10b. Bracts included with a small cusp (which may be slightly exserted) or if exserted, cone oblong-conical and green **12**

11a. Leaves emarginate or obtuse; resin canals in the leaves 4–10(–12) **Subsect. *Hickelianae***

11b. Leaves acute; resin canals in the leaves 2 **Subsect. *Religiosae***

12a. Young shoots uniformly pubescent; leaves densely crowded above the shoot, directed forward **Sect. *Amabilis***

12b. Young shoots glabrous or weakly pubescent in grooves; leaves not dense, more pectinate **Sect. *Momi*** **13**

13a. Seed cones oblong-conical; bracts strongly exserted **Subsect. *Firmae***

13b. Seed cones ovoid-oblong to cylindrical; bracts included or cusps just exserted near the base of the cone **14**

14a. Leaves 1.5–3(–3.5) cm long. Seed cones violet-blue or purple, oblong –cylindrical to ovoid-oblong, 2.5–3.5(–4) cm wide **Subsect. *Homolepides***

14b. Leaves 2–5(–9) cm long. Seed cones yellowish green to violet-blue, cylindrical or ovoid-cylindrical, 3.5–6 cm wide **Subsect. *Holophyllae***

Key to the species of Section *Abies*

1a. Bracts included or only slightly exserted. Shoots mostly glabrous; leaves 2.5–4 cm long, with obtuse or slightly emarginate apex ***A. cilicica***

1b. Bracts strongly exserted and reflexed **2**

2a. Leaves 1–2.2 cm long, 2–3.5 mm wide, rigid; apex acute or obtuse, not emarginate. Seed cones small, 7–12 × 3–4 cm ***A. nebrodensis***

2b. Leaves (usually) longer than 2 cm, up to 2.5 mm wide, acute to emarginate. Seed cones usually larger **3**

3a. Seed cones long and narrow (ratio length to width 3–4), width 3–5 cm. Leaves acute or emarginate **4**

3b. Seed cones large, (10-)12–20 × 4–6 cm (ratio length to width up to 3 at most). Leaves emarginate, on shaded, vegetative shoots pressed forward, covering them ***A. nordmanniana***

4a. Leaves on shaded shoots emarginate, mostly in pectinate arrangement with overlapping ranks. Young shoots pubescent **5**

4b. Leaves acute, rarely obtuse, more radially spreading. Young shoots glabrous ***A. cephalonica***

5a. Leaves on the adaxial (upper) side lustrous green, without any stomata; apex of leaves on non-coning shoots slightly emarginate ***A. alba***

5b. Leaves on the adaxial side with a few stomata; apex of all leaves entire ***A. ×borisii-regis***

Key to the species of Section *Amabilis*

1a. Cones large, 9–15 × 5–8 cm. Leaves 2–3 cm long; buds ca. 5 × 4 mm ***A. amabilis***

1b. Cones smaller, 4–9 × 2–4.5 cm. Leaves shorter (usually 1–2 cm long); buds small, 2–3 mm long ***A. mariesii***

Key to the species of Section *Balsamea*, Subsection *Laterales*

1a. Leaves on vegetative shoots mostly pectinate, a few above the shoot directed forward, short and stiff. Seed cones (2.5-)5–8 × 2–3 cm ***A. balsamea***

1b. Leaves on vegetative shoots mostly assurgent, short or longer, flexible. Seed cones mostly larger **2**

2a. Leaves strongly assurgent, densely covering the shoot; buds usually larger than 3 mm ***A. lasiocarpa***

2b. Leaves slightly assurgent, the lower leaves spreading laterally, more remote, leaving the shoot visible; buds 2–3 mm long ***A. sibirica***

Key to the species of Section *Balsamea*, Subsection *Medianae*

1a. Seed cones with large, strongly exserted, reflexed and light coloured bracts **2**

1b. Seed cones with smaller, less exserted and reflexed, usually darker coloured bracts **3**

2a. Seed cones very numerous, even on the lower branches, often crowded together, appearing soon on young trees; bracts leaving the apex of the seed scales mostly free. Leaves on vegetative shoots emarginate ***A. koreana***

2b. Seed cones absent from the lower branches, less numerous; bracts very broad, covering most of the seed scales. Leaves on vegetative shoots mostly obtuse ***A. fraseri***

3a. Young shoots red-brown or brown, rarely grey-brown. Leaves often strongly twisted at base; cones usually ellipsoid-cylindrical. Bracts variously exserted ***A. sachalinensis***

3b. Young shoots yellowish- or greenish brown. Leaves less twisted; cones cylindrical. Bracts slightly exserted **4**

4a. Young shoots densely yellowish pubescent. Leaves dark green above. Bracts slightly exserted ***A. veitchii***

4b. Young shoots minutely pubescent in grooves. Leaves light green above. Bracts entirely included or only the cusps of the bracts exserted ***A. nephrolepis***

Key to the species of Section *Grandis*

1a. Leaves very thin, less than 2 mm wide, very flexible **2**

1b. Leaves thicker, 2–3 mm wide, more rigid **3**

2a. Young shoots (light) greenish to reddish brown. Leaves 1.2–2 mm wide, emarginate or obtuse. Bracts slightly exserted ***A. guatemalensis***

2b. Young shoots dark purplish red or red-brown. Leaves 1–1.6 mm wide, slightly acute or obtuse. Bracts included ***A. durangensis***

3a. Leaves green or glaucous green, stomata on both sides, leaf apex entire ***A. concolor***

3b. Leaves dark glossy green above, stomata on one side only, leaf apex emarginate ***A. grandis***

Key to the species of Section *Momi*, Subsection *Firmae*

1a. Bracts oblanceolate, slightly exserted and not reflexed. Buds large (max. 10 × 5 mm). Leaves light green ***A. firma***

5b. Bracts spathulate, exserted and reflexed at the upper margin. Buds smaller. Leaves dark green ***A. beshanzuensis***

Key to the species of Subsection *Holophyllae*

1a. Leaves on vegetative shoots entire **2**

1b. Leaves on vegetative shoots emarginate or bifid **3**

2a. Seed cones oblong-cylindrical, 3–4.5 cm wide. Leaves on leading and coning shoots strongly assurgent, acute or mucronate ***A. holophylla***

2b. Seed cones broader, 5–6(–7) cm. Leaves slightly assurgent and bifid, emarginate or sometimes obtuse ***A. pindrow***

3a. Leaves 3–3.5 mm wide, 2–4.8 cm long, obtuse or rarely slightly emarginate. Ripe seed cones dark brown; bracts spathulate, with 9–10 mm wide apex ***A. ziyuanensis***

3b. Leaves 2.5–3 mm wide, when wider, then longer than 4.5 cm, at least on vegetative shoots emarginate. Ripe seed cones (light) cinnamon-brown; bracts not spathulate ***A. chensiensis***

Key to the species of Subsection *Homolepides*

1a. Leaves spreading pectinately or at least parted above the shoot ***A. homolepis***

1b. Leaves crowded and curved upwards or sometimes reflexed above the shoot **2**

2a. Leaves on vegetative shoots 1.5–2 mm wide, curved upwards ***A. kawakamii***

2b. Leaves on vegetative shoots 1.9–2.5 mm wide, recurved or reflexed ***A. recurvata***

Key to the species of Section *Nobilis*

1a. Bark of old trees (in their native habitat!) greyish brown. Bracts of seed cones far exserted and strongly reflexed, covering much of the seed scales. Leaves partly grooved above ***A. procera***

1b. Bark of old trees (dark) red-brown. Bracts of seed cones included or slightly exserted and reflexed. Leaves not grooved ***A. magnifica***

Key to the species of Section *Oiamel*, Subsection *Hickelianae*

1a. Bracts of seed cones exserted ***A. hickelii***

1b. Bracts of seed cones included ***A. hidalgensis***

Key to the species of Section *Oiamel*, Subsection *Religiosae*

1a. Seed cones (8–)10–16 × 4–6 cm; bracts strongly reflexed, partly covering the seed scales. Leaves pectinately arranged, usually 1.5–3 cm long, leaving the shoot visible from above ***A. religiosa***

1b. Seed cones 6–12(–15) × 4–6(–7?) cm; bracts not reflexed. Leaves spreading but not pectinate, usually 1–2 cm long, covering the shoot above ***A. vejarii***

Key to the species of Section *Piceaster*

1a. Leaves carinate, obtuse or slightly acute, amphistomatic,very rigid and radial. Buds resinous. Seed cones 9–14 × 3–4 cm ***A. pinsapo***

1b. Leaves flattened, weakly amphistomatic, on shaded shoots less radial. Buds not resinous. Seed cones usually larger, 12–18 × 4–6 cm ***A. numidica***

Key to the species of Section *Pseudopicea*, Subsection *Delavayianae*

1a. Seed cones large, usually 10–17 × 4–7 cm; bracts included. Leaves pectinately arranged, 2.5–6 cm long, 2.2–3.5 mm wide, bifid or emarginate, with slightly recurved margins ***A. spectabilis***

1b. Seed cones smaller, if larger than 10 × 5 cm usually with exserted bracts. Leaves spreading more radially, shorter or with strongly revolute margins **2**

2a. Leaves with (strongly) revolute margins; stomatal bands (partly) hidden, niveous white **3**

2b. Leaves not revolute or with only very slightly recurved leaf margins, stomatal bands entirely visible, white or greyish white **4**

3a. Bracts abruptly ending in an elongated, awl-like cusp, usually exserted (at least with the long cusp). Young shoots dark red-brown ***A. delavayi***

3b. Bracts gradually ending in a short cusp, not or slightly exserted. Young shoots yellowish brown ***A. densa***

4a. Seed cones green or yellowish green in the growing season; bracts exserted and reflexed ***A. yuanbaoshanensis***

4b. Seed cones purple or purplish blue in the growing season; bracts exserted or sometimes included, not reflexed **5**

5a. Young shoots usually purplish, reddish, or dark orange-brown **6**

5b. Young shoots yellowish brown, mostly glabrous ***A. fabri***

6a. Seed cones small, 5–9 × 3–4 cm; bracts with rounded or emarginate apex ending in a small, abrupt cusp **7**

6b. Seed cones 6–10(–14) × 4–5(–6) cm, or if less than 8 × 4 cm, with differently shaped bracts ***A. forrestii***

7a. Leaves 1–2.5 cm long, rarely up to 4.3 cm, very densely set in overlapping, pectinate rows. Bracts mostly included or slightly exserted, with very short cusps ***A. fanjingshanensis***

7b. Leaves (1–)1.5–3(–4.5) cm long, especially on shaded shoots, less dense. Bracts exserted, with much longer cusps ***A. fargesii***

Abies alba Mill., Gard. Dict., ed. 8: Abies No. 1. 1768. Type: "Habitat in Alpinus Helvetiae, Sueviae, Bavariae, Scothiae", *Herb. Clifford 449 Abies 2* (lectotype BM). Fig. 1

Abies alba Mill. subsp. *apennina* Brullo, Scelsi & Spampinato, La Vegetazione dell' Aspromonte: 41. 2001.

Etymology

The species epithet means 'white' and perhaps refers to the light grey bark.

Vernacular names

Silver fir; Sapin pectiné (French); Weisstanne (German)

Description

Trees to 55(–60?) m tall, d.b.h. to 2–2.5 m; trunk monopodial, straight, columnar, terete; crown conical, but flat topped ("stork's nest") in most old trees. Bark in young trees greyish, smooth, in old trees greyish brown, light or dark, becoming scaly and fissured below. Branches of first order horizontal, descending, ascending towards the top of the tree; branches of second order slender, spreading horizontally. Branchlets slender, flexible, stout and firm on cone bearing branches, yellowish grey or grey, nearly smooth, striated, with short, yellowish or brown pubescence or occasionally glabrous; leaf scars broadly elliptic or circular. Vegetative buds ovoid or conical, ca. 6 × 4 mm, not resinous or slightly resinous especially on cone bearing branches; bud scales broadly ovate, obtuse, brown, persisting several years. Leaves spirally arranged, on vegetative branches pectinate in two lateral sets, on leading shoots radial, on coning shoots radial and assurgent, (1.2–)1.5–3(–3.5) cm long, 1.5–2.6 mm wide, (slightly) twisted at base, linear, flattened, grooved and lustrous dark green on the adaxial (upper) face, whitish green below; apex slightly emarginate (obtuse or acute on coning shoots). Stomata in two bands separated by a midrib on the abaxial leaf face. Pollen cones lateral, crowded, 2 cm long, greenish yellow with purple red microsporophylls. Seed cones lateral, erect; peduncles short, slightly curved, cylindrical, with conical or obtuse apex, 10–15(–20) cm long, 3–5(–6) cm wide, yellowish green when immature, sometimes with purple tinge, ripening to light brown or reddish brown; cone rachis persistent, narrowly conical, dark brown. Seed scales cyathiform, the upper ones more cuneate, length × width at midcone 2.5–3 × 2.5–3.5 cm; surface smooth, pulverulent especially on the exposed part; upper margin entire; base long pedicellate. Bracts linear-spathulate, with long, caudate cusp, 2.5–3.5(–4) cm long, exserted, slightly recurved at maturity. Seeds cuneate, angular, 7–9 mm long, yellowish brown; seed wings cuneate, 10–15 mm long, reddish yellow.

Distribution

Europe: From the Pyrenees to the Carpathians, Italy (Apennines) and in the Balkan Peninsula to Bulgaria and N Greece.

TDWG codes: 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER HUN POL SWI 12 COR FRA-FR SPA-AN SPA-SP 13 ALB BUL GRC ITA-IT ROM YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 UKR-UK

Ecology

Primarily a montane species, occurring between 500 and 1500 m a.s.l., but as low as 300 m in the Bavarian Forest and up to 1950 m in the Pyrenees. Soils are usually well drained sandy loams from silicate rocks or limestone derivatives. The climate is cool temperate, comparatively humid (precipitation often >1000 mm/year), with abundant snowfall but moderately low temperatures in the winter. The species often forms large forests, either pure, mixed with other conifers (*Picea abies*, locally *Pinus sylvestris*) or mixed with broad-leaved trees (*Fagus sylvatica*), in a belt between deciduous forest in the valleys and coniferous forest composed of other species of *Pinaceae* towards the tree limit. Of the European native conifers, *Abies alba* is most capable of competing with Beech (*F. sylvatica*) at altitudes where the latter becomes less vigorous and is the first of the conifers to appear among them (Ellenberg, 1988).

Conservation

IUCN: LC

Uses

White fir is an important timber tree in western and central Europe, where most forests are semi-natural and managed with a view to encourage fir regeneration and growth at the expense of competitors. It is not very successful as a plantation forestry tree outside its natural areas of occurrence; one cause of this may be damage done by insect pests, which may be more prolific in monocultures and in areas with mild

winters such as in the British Isles. Its most famous use in the past was for the masts of 17th century ships. Most of its wood today is used for plywood and veneer as it is evenly grained, light, and easily worked. Minor uses are for soundboards in musical instruments, boxes, wood carving, and sometimes for joinery. Distillation of the leaf essential oils has in the past been used to produce remedies for sprains and bruises. In Britain it was used as a Christmas tree in the 19th century when Prince Albert popularized the tradition; its use has declined since in favour of the more quickly and cheaply produced Norway spruce. In horticulture White fir is uncommon and mostly restricted to arboreta; a number of cultivars are known but few are common in the trade.

Abies amabilis Douglas *ex* J. Forbes, Pinetum Woburn.: 125, t. 44. 1839. *Picea amabilis* Douglas *ex* Loudon, Arbor. Frut. Brit. 4: 2342. 1838.
Type: A collection made by David Douglas, not designated. Fig. 2

Etymology

The species epithet means 'lovely' and was coined by its discoverer David Douglas.

Vernacular names

Pacific silver fir, Lovely fir, Cascades fir

Description

Trees to 45–80 m tall, d.b.h. to 2–3 m; trunk monopodial, straight, columnar, massive, terete; crown narrowly conical or irregular in old trees. Bark in young trees smooth, ash grey or whitish, with resin blisters, in old trees deeply furrowed, brown, divided into small plates. Branches of first order horizontal, relatively short, thick, curved downward on lower part of the trunk; branches of second order short, curved, spreading. Branchlets slender, light greenish brown or greyish, changing to reddish brown, ridged and grooved, remotely or more densely pubescent with light hairs; leaf scars circular, reddish. Vegetative buds subglobose, ca. 5 × 4 mm, very resinous; bud scales dark purple, persisting several years. Leaves spirally arranged, on vegetative branches the lower ones pectinate, the upper ones directed forward, covering the branches, on coning shoots radial, curved, the upper ones assurgent, 2–3 cm long, 1.5–2 mm wide, twisted at base, linear, flattened, grooved and dark lustrous green above, two silvery white lines below; apex slightly notched or obtuse. Stomata in two bands separated by a midrib on the abaxial (lower) leaf face, none or a few on the adaxial side. Pollen cones lateral in leaf axils mostly solitary but numerous, 1–1.5 cm long, with red microsporophylls. Seed cones lateral, erect, mostly towards the ends of branches on short peduncles, ovoid-cylindrical or oblong, with obtuse or papilliform apex, 9–15 cm long, 5–8 cm wide; purple or rarely greenish when immature, purplish brown when maturing, turning brown when ripe; cone rachis persistent, cylindric conical, dark or light brown. Seed scales cyathiform-flabellate or cuneate, recurved when ripe, length × width at mid-cone 2–2.8 × 2.5–3.5 cm; surface smooth, often densely covered with resin, puberulous on both surfaces; upper margin entire, strongly incurved; base long pedicellate. Bracts obovate-oblong, 1–1.5 cm long, included, with very short cusps. Seeds oblong, 10–12 mm long, light brown; seed wings quadrangular, broad, 18 × 20 mm, yellow or pale brown.

Distribution

Pacific coast region of W North America, from extreme SE Alaska to N California.
TDWG codes: 70 ASK 71 BRC 73 ORE WAS 76 CAL

Ecology

Abies amabilis occurs from sea level near the coast to 330 m a.s.l. in SE Alaska, in Oregon from 250 m to 1830 m a.s.l. on the western slopes of the Cascade Range. It grows on different mountain soils, usually of glacial origin and acidic. The climate is extremely wet maritime, with 1500 to 4000 mm annual precipitation, much of it as snow. It is a constituent of the mixed coniferous forests with among other conifer tree species *Tsuga heterophylla, Picea sitchensis, Pseudotsuga menziesii, Thuja plicata, Chamaecyparis nootkatensis, Abies grandis, A. magnifica*; and with *A. lasiocarpa* and *Tsuga mertensiana* at higher elevations, but unlike the latter two not reaching the tree line.

Conservation

IUCN: LC

Uses

In the timber industry no distinction is made between this species and Western hemlock as both conifers have similar wood properties. This wood is in use for various construction applications such as plywood, veneer, sub-flooring and sheathing. It contains little or no resin and is light in colour and easily worked. Together with Western hemlock, substantial quantities of wood go to the kraft pulp industry. As an ornamental tree it is uncommon, performing only in cool and wet maritime climate such as prevails in the west of Scotland.

Abies balsamea (L.) Mill., Gard. Dict., ed. 8: Abies No. 3. 1768.

Etymology

The species epithet refers to the 'balsam' i.e. its cortical resin which has medicinal properties.

Vernacular names

Balsam fir, Canadian fir; Sapin balsamier (French)

Description

Trees to 25 m tall, d.b.h. to 1 m; trunk monopodial, straight, columnar, terete; crown conical. Bark in young trees pale grey, smooth, with prominent resin blisters, in old trees dark greyish brown or blackish, flaking. Branches of first order long and slender, in whorls and horizontally spreading; branches of second order spreading horizontally. Branchlets slender, pale yellowish green, becoming ash grey tinged with red, smooth, shortly pubescent with dark grey hairs; leaf scars circular to ellipsoid. Vegetative buds ovoid globose, ca. 5 × 4 mm, resinous, with resin covering the scales entirely; bud scales dark green with purple tinge, persisting several years. Leaves spirally arranged, mostly pectinate on sterile branches, the upper ones directed forward, assurgent on coning shoots, 1.5–2.5 cm long, 2 mm wide, twisted at base, linear, flattened, dark green above, two white bands separated by green midrib below; apex obtuse or emarginate (acute or acuminate on cone bearing branches). Stomata on the adaxial (upper) surface scattered along a medial groove, increasing towards apex, on lower surface in two bands separated by a midrib. Pollen cones lateral, in leaf axils, pendant, crowded and numerous, 0.6 cm long, yellow, with purple microsporophylls. Seed cones lateral, erect; peduncles very short; shape cylindrical, narrowing towards an obtuse apex, (2.5–)5–8 cm long, (1.5–)2–3 cm wide, green, tinged with purple, or violet-purple when immature, ripening to (purplish) brown; cone rachis persistent, narrowly conical, blackish brown. Seed scales cuneate, flabellate or rhombic-orbicular, length × width at mid-cone 1.2–1.4 × 1.4–1.7 cm; surface smooth, striate on lower part, pubescent with brown hairs on exposed part; upper margin entire, strongly curved inward; base pedicellate. Bracts broad ligulate, with a short cusp, 0.6–1 cm long, entirely included or sometimes exserted and recurved. Seeds cuneate, 3–4 long, dark grey; seed wings cuneate, oblique at apex, 7–10 mm long, greyish brown.

Distribution

Canada, North Central and NE USA: south to Virginia.

TDWG codes: 71 ABT MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT QUE 74 IOW MIN WIS 75 CNT MAI MAS MIC NWH NWJ NWY PEN VER WVA 78 VRG

Ecology

Abies balsamea occurs from lowland plains to upland hills and mountains in the vast boreal forest of North America, from sea level to 1200 m a.s.l. in West Virginia. It is most common on usually podzolized moderately acid soils in silt or sand. In some areas it may also grow on wet, peaty soil. The climate is cold continental in the interior, cool maritime in the eastern part of the range, with precipitation between 250 and 1250 mm and very cold winters. The growing season ranges from 80 days in the interior of Canada to 180 days in the Appalachian Mountains. It is a constituent of coniferous forests with *Picea* spp., *Pinus strobus, Tsuga canadensis* and sometimes

Pinus banksiana, or it grows mixed with broad-leaved trees such as *Populus tremuloides, Betula* spp. and, further south, *Acer* spp., *Fagus grandifolia* and *Betula alleghaniensis*. *Taxus canadensis* is the most common conifer shrub in these mixed forests.

Uses

Balsam fir is an economically important conifer. Its wood, although of modest size, is used in light-frame construction and for pulpwood. It is also popular as a Christmas tree and is one of the top three species grown for this purpose in E North America. The fragrant needles are partly responsible for this popularity, they are also used to stuff pillows sold as souvenirs in New England. Canada balsam, the aromatic and soft terpenoid resin collected from blisters in the bark, is especially important in Quebec. Its medicinal properties were known to Native Americans, who used it as an antiseptic wound dressing as well as internally for various ills. Lewis and Clark had it in their medicine box on their famous overland expedition to the Pacific Ocean in 1804–05. In modern Western society its medicinal use has been replaced by other salves; the resin is now used to seal microscopic glass slides with biological preparates. In horticulture, Balsam fir is less valued; this fir is apparently short lived when planted in gardens and only a few dwarf cultivars are known.

2 varieties are recognized:

Abies balsamea (L.) Mill. var. ***balsamea***. *Pinus balsamea* L., Sp. Pl. 2: 1002. 1753. Type: "Habitat in Virginia, Canada", *leg. ign. LINN 1135.14* (lectotype LINN).

Description

Seed cones 5–8 cm long, 2–3 cm wide, green with a purplish tinge when young, brown at maturity; bracts included or only the cusps exserting.

Distribution

Canada, North Central and E USA: south to Virginia.
TDWG codes: 71 ABT MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 74 IOW MIN WIS 75 CNT MAI MAS MIC NWH NWJ NWY PEN VER WVA 78 VRG

Conservation

IUCN: LC

Abies balsamea (L.) Mill. var. ***phanerolepis*** Fernald, Rhodora 11: 201. 1909. *Abies intermedia* Fulling, Castanea 1: 93. 1936; *Abies balsamea* (L.) Mill. f. *phanerolepis* (Fernald) Rehd., Man. Cult. Trees, ed. 2: 16. 1940; *Abies* ×*phanerolepis* (Fernald) T. S. Liu, Monogr. Gen. Abies: 316. 1971; *Abies balsamea* (L.) Mill. subsp. *phanerolepis* (Fernald) E. Murray, Kalmia 12: 18. 1982. Type: Canada, Quebec, Percé Mt., *M. L. Fernald & J. F. Collins 860* (holotype GH).

Description

Seed cones 2–5.5 cm long, 1.5–2 cm wide, violet-purple when young, greyish or blackish brown at maturity, brown pubescent; bracts exserting, with long, reflexed cusps.

Taxonomic notes

This fir has been interpreted by Liu (1971) as a hybrid between *A. balsamea* and *A. fraseri*; this taxonomy was accepted in my book Pinaceae (Farjon, 1990) but is here rejected in favour of an infraspecific taxon under *A. balsamea*, with which it shares more character states. Only the smaller cones with exserting but small bracts remind of *A. fraseri* and a hybrid origin of this variety has not been demonstrated genetically.

Distribution

Canada: Quebec, Percé Mt., Mont Blanc (Matane Co.); USA: Virginia, West Virginia.
TDWG codes: 72 QUE 75 WVA 78 VRG

Conservation

IUCN: LC

Abies beshanzuensis M. H. Wu, Acta Phytotax. Sin. 14 (2): 16, t. 1, f. 1. 1976. *Abies fabri* (Mast.) Craib var. *beshanzuensis* (M. H. Wu) Silba, Phytologia 68: 13. 1990. Type: China: Zhejiang, Tung-Kung Mts., Baishan-zu, *M. H. Wu 7511* (holotype PE).

Etymology

The epithet refers to the name of the mountain on which it was found.

Vernacular names

Baishan fir; Baishanzu lengshan (Chinese)

Description

Trees to 15 m tall, d.b.h. to 0.5 m; trunk monopodial, straight, columnar, terete; crown broad, conical or flat topped. Bark of young trees whitish grey, smooth, of old trees longitudinally fissured and scaly. Branches of first order long, spreading horizontally, ascending towards the top of the tree; branches of second order spreading and overlapping. Branchlets stout, firm, light yellow, turning to greyish brown, ridged and grooved between the leaves, glabrous or sparsely pubescent; leaf scars circular or ovate oblong. Vegetative buds ovoid or conical, (slightly?) resinous; bud scales triangular ovate, light yellowish brown, slightly keeled, persisting several years. Leaves spirally arranged, the lower ones pectinate, the others directed obliquely forward, the shortest upper leaves recurved, parting above, on coning shoots crowded and assurgent, (1–)1.5–3.5(–4.2) cm long, 2.5–3.5 mm wide, twisted at base, ligulate linear or oblanceolate, flattened, shining dark green above, two silvery white bands below; apex emarginate or bifid. Stomata absent on the adaxial (upper) surface, in two broad bands divided by a midrib below. Pollen cones lateral, in leaf axils, 2–2.5 cm long, yellowish with red microsporophylls. Seed cones lateral, erect; peduncles short and thick; shape oblong-conical, narrowing towards a truncate apex, (6–)7–11(–12) cm long, (3–)3.5–4(–4.5) cm wide, pale yellowish green when immature, turning light yellowish brown, ripening to light brown. Seed scales flabellate, auricled at base, length × width at midcone 1.8–2.5 × 2.5–3 cm; surface striate, sparingly pubescent (?); upper margin entire or slightly erose; base pedicellate. Bracts spathulate, with reflexed upper margin, 2–2.5 cm long (cusps ca. 1 mm), exserted, recurved. Seeds oblong-obovate, length × width 6–9 × 3–4 mm; seed wings cuneate, oblique, length × width 6–10 × 5–9 mm, light brown.

Taxonomic notes

This species resembles *A. firma* in several characters. Wu (1976) related this species to *A. fabri* on the grounds of its recurved cone bracts, but both colour and shape of the cones are quite different and resemble the cones of *A. firma*, as do the broad, flat and emarginate leaves. Hence, Farjon & Rushforth (1989) classified it in the section *Momi*, subsection *Firmae*.

Distribution

China: Zhejiang (Mt. Baishan-zu NE of Qingyuan in the Tung-Kung Range at 27° 45' N, 119° 11' E).
TDWG codes: 36 CHS-ZJ

Ecology

On a medium high mountain in the maritime SE of China, with warm summers and cool, moist winters (annual precipitation ca. 1250 mm), where it is found between 1500–1700 m a.s.l. It grows there with other conifers, such as *Tsuga chinensis, Cephalotaxus chinensis* and *Taxus chinensis*, and broad-leaved trees, e.g. *Castanopsis* spp., *Fagus lucida, Quercus* spp., *Acer* spp., *Magnolia cylindrica* and *Lithocarpus hancei*. The angiosperm trees are dominating the present site of *Abies beshanzuensis*. Also reported is *Cryptomeria fortunei*; this is an invalid name for *C. japonica* and not indigenous in China (Farjon, 1999). Its presence indicates secondary forest, as is also borne out by the photographs I have seen of the area.

Conservation

Known from only a few mature individuals in the wild, without natural regeneration, in degraded angiosperm woodland. According to an account by Dudley (1988), in 1987 only three individual trees were left (after three other specimens had been removed to Beijing Botanic Gardens and subsequently died there) of a population at discovery in

1963 of only seven individuals, of which four were flowering and coning at that time. This species was taken into cultivation from cuttings at a forestry station in Qingyuan, S Zhejiang, China, as a graft on *Abies firma* rootstock.
IUCN: CR (D)

Uses

No uses other than recent attempts to grow it in cultivation have been reported.

Abies* ×*borisii-regis Mattf., Notizbl. Bot. Gart. Berlin-Dahlem 9: 235. 1925. *Abies cilicica* (Antoine & Kotschy) Carrière var. *borisii-regis* (Mattf.) Silba, Phytologia 68: 11. 1990; *Abies alba* Mill. subsp. *borisii-regis* (Mattf.) Kozuharov & N. Andreev, Opred. Vissh. Rast. Bulg.: 785. 1992. Type: Greece, Mt. Olympus, Monastery Hagios Dionysius, 1899, *P. E. E. Sintenis 1870* (lectotype, B).

Abies alba Mill. var. *acutifolia* Turrill, Kew Bull. Misc. Inf. 1925: 34. 1925.
Abies×*borisii-regis* Mattf. var. *pungenti-pilosa* Viguié & Gaussen, Bull. Soc. Hist. Nat. Toulouse 58: 279. 1929.

Etymology

This species was named after King Boris of Bulgaria (reigned 1918–1943).

Vernacular names

King Boris fir, Bulgarian Fir, Macedonian fir

Description

Trees to 40 m tall, d.b.h. to 1.5 m; trunk monopodial, straight, columnar, terete; crown conical, but flat topped ("stork's nest") in most old trees. Bark of young trees greyish, smooth, in old trees greyish brown, light or dark, becoming scaly and fissured below. Branches of first order horizontal, descending, ascending towards the top of the tree; branches of second order slender, spreading horizontally. Branchlets slender, flexible, stout and firm on cone bearing branches, yellowish grey or grey, nearly smooth, striated, with short, yellowish or brown pubescence; leaf scars broadly elliptic or circular. Vegetative buds ovoid or conical, ca. 6 × 4 mm, not resinous or slightly resinous especially on cone bearing branches; bud scales broadly ovate, obtuse, brown, persisting several years. Leaves spirally arranged, on vegetative branches pectinate in two lateral sets, on leading shoots radial, on coning shoots radial and assurgent, (1.2–)1.5–3(–3.5) cm long, 1.5–2.6 mm wide, (slightly) twisted at base, linear, flattened, grooved and lustrous dark green above, whitish green below; apex entire in all leaves. Stomata in two bands separated by a midrib below, often also a few stomata on the adaxial (upper) side. Pollen cones lateral, crowded, 2 cm long, greenish yellow with purple red microsporophylls. Seed cones lateral, erect; peduncles short, slightly curved; cone shape cylindrical, with conical or obtuse apex, 10–15(–20) cm long, 3–5(–6) cm wide, yellowish green, sometimes with purple tinge when immature, ripening to light brown or reddish brown; cone rachis persistent, narrowly conical, dark brown. Seed scales cyathiform, the upper ones more cuneate, length × width at midcone 2.5–3 × 2.5–3.5 cm; surface smooth, pulverulent especially on the exposed part; upper margin entire; base long pedicellate. Bracts linear spathulate, with a long, caudate cusp, 2.5–3.5(–4) cm long, exserted, slightly recurved at maturity. Seeds cuneate, angular, 7–9 mm long, yellowish brown; seed wings cuneate, 10–15 mm long, reddish yellow.

Taxonomic notes

This taxon was originally described as a species from the Rhodope Mountains in Bulgaria and Mt. Olympus in Greece, and it is treated as such in several handbooks of conifers. Liu (1971) was of the opinion that these trees can be best regarded as natural hybrids between *A. alba* and *A. cephalonica*. Although often more similar to *A. alba*, most trees do share minor characters of both. More recent research into hybridization (Mitsopoulos & Panetsos, 1987) has shown that introgression of *A. alba* genes into ancient populations of *A. cephalonica* in the southern Balkans, due to southward migration of the former during glacial stadia of the Pleistocene, is the likely origin of *A.* ×*borisii-regis*. This process has led to more or less stable, true-breeding populations, but has also reduced *A. cephalonica* to its last remaining

refugia in southern Greece. These closely related firs will, unsurprisingly, hybridize readily, and the more dominant genome will in due course prevail, obliterating the other species. This process may not have reached its conclusion, and to reflect this history it seems appropriate to recognize this taxon as of hybrid origin in the way we write its name.

Distribution

S Albania, Bulgaria (Rhodope Mts.), Greece (Macedonia to N Peloponnisos).
TDWG codes: 13 ALB BUL GRC

Ecology

Abies ×borisii-regis is a montane species occurring in the Balkan mountains at middle elevations between 700 m and 1500 m a.s.l. It can grow mixed with *Picea abies* or occur in more or less pure stands; at lower elevations it can occur in broad-leaved forest.

Conservation

IUCN: NE

Uses

The timber of this fir is valuable and used for interior construction, mostly as plywood or veneer. It is similar to European fir (*Abies alba*) in all its properties and uses. It has been planted in European arboreta especially in the 19th century and many of these trees still remain alive; it apparently grows to a better shape in the British Isles than *A. alba*.

Abies bracteata (D. Don) A. Poit., Rev. Hort., sér. 2, 4: 7. 1845. *Pinus bracteata* D. Don, Trans. Linn. Soc. London 17: 443. 1836. Type: USA: California, Monterey Co., Santa Lucia Mts., *D. Douglas s.n.* (holotype K). Pl. 1, Fig. 3

Etymology

The species epithet refers to the exceptionally long bract tips spreading out from the seed cones.

Vernacular names

Bristlecone fir, Santa Lucia fir

Description

Trees to 30–40(–50) m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown pyramidal, regular, with narrowly tapering top. Bark of young trees smooth, grey or whitish, later blackish grey to brown, fissured below. Branches of first order long, slender, becoming gradually shorter towards the top, horizontal, pendulous below; branches of second order spreading, then pendant. Branchlets firm but slender, the lowest long and pendulous, greenish brown or reddish- to purplish brown, turning grey green or olive green, smooth or slightly ridged, glabrous; leaf scars circular. Vegetative buds fusiform or conical, with acute apex, ca. 1.2–2 × 0.5–0.8 cm, not resinous; bud scales triangular, obtuse or acute, opening when dry, light brown, only the lower ones persistent for a few years. Leaves spirally arranged, forming two lateral rows, on shaded shoots relatively wide apart, loosely pectinate, curved or straight, on coning shoots slightly assurgent, 2.8–6 cm long, 2–3.5 mm wide, strongly twisted at base, linear, narrowed towards both ends, often curved, flattened, acuminate with callous tips, shallowly grooved above, lustrous dark or grey green above, with two broad, greenish white bands separated by a prominent green midrib below. Stomata in two bands below. Pollen cones lateral, pedunculate, with reflexed involucral scales, yellow brown with purplish microsporophylls. Seed cones lateral, erect; peduncles up to 1 cm; cones ovoid-globular to ovoid, 4–5 10 cm long, 4–6 cm wide, with obtuse apex, greenish with purple tinge when immature, turning pale purplish brown to brown when ripe; cone rachis persistent, cylindric conical, blackish brown. Seed scales ovate or broadly reniform, length × width at mid-cone 1.5–1.7 × 2–2.2 cm; surface smooth or slightly rough, glabrous; upper margin entire, incurved; base short pedicellate. Bracts strongly attached to seed scales, obovate-oblong, with twisted, extremely elongated cusps, (2.5–)3–5(–6) cm long, exserted, cusps twisted or spreading. Seeds obovate-cuneate, 8–10 mm long, pale brown; seed wings (oblique) obovate or cuneate, 10 mm long, pale brown.

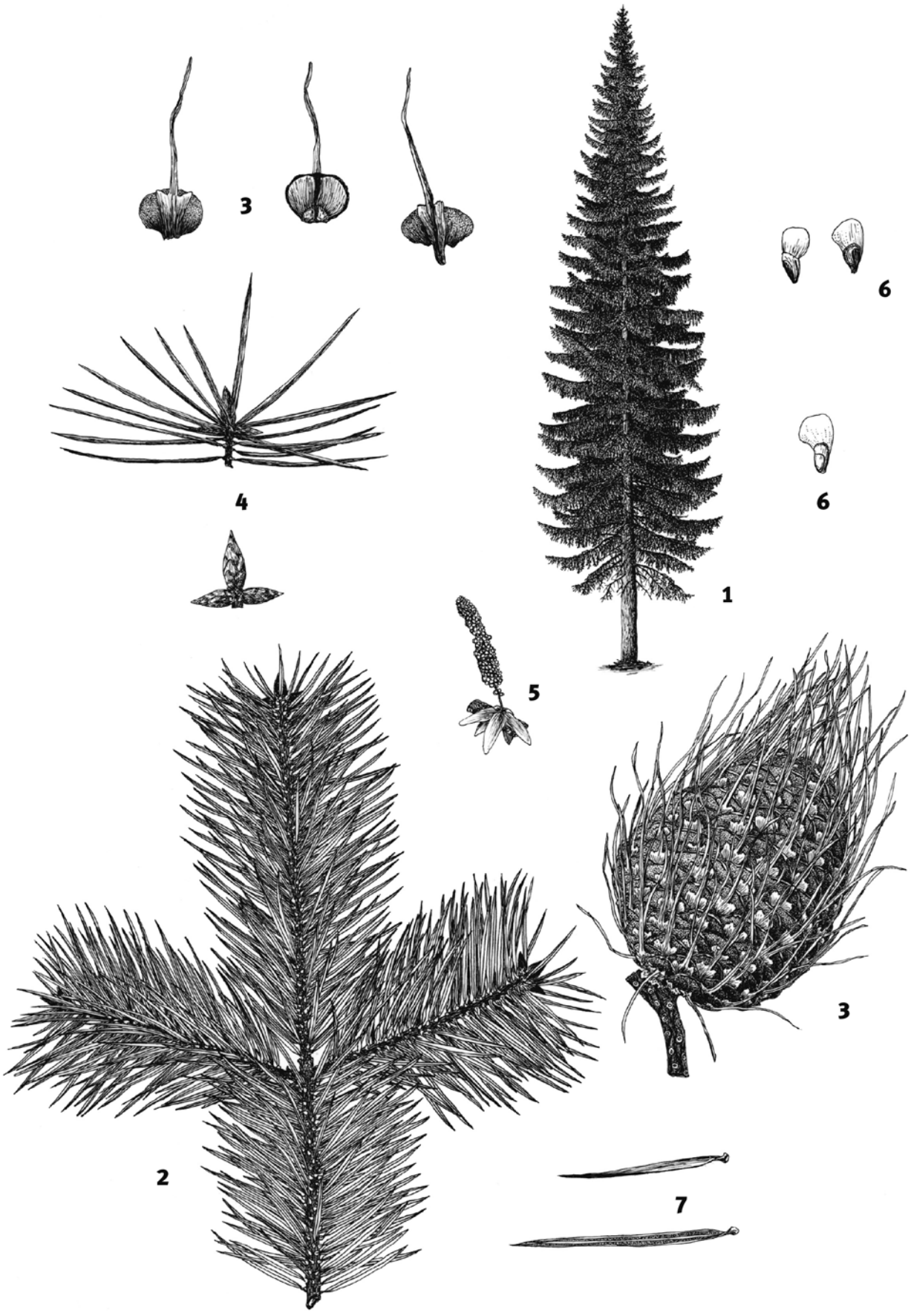


PLATE 1. *Abies bracteata*. **1.** Habit of tree. **2.** Foliage branch. **3.** Seed cone; seed scales with bracts. **4.** Detail of buds and leaves. **5.** Pollen cone. **6.** Seeds. **7.** Leaves.

Distribution

USA: California (Santa Lucia Mts.).
TDWG codes: 76 CAL

Ecology

This fir species occurs in the Upper Sonoran and Transition Life Zones of the coastal Santa Lucia Mountains, in canyon bottoms and on rocky slopes at elevations between (180–)600 and 1570 m a.s.l. It grows on rocky, clay or loam rich mountain soils, which can be very dry in summer. It usually grows within reach of ground or seepage water or near intermittent canyon bottom streams. The climate is warm, with dry summers and moderate, moist winters, the precipitation ranges from 500 to 1300 mm annually. It is a constituent of a mixed forest with *Pinus coulteri, P. ponderosa, Pseudotsuga menziesii, Quercus* spp., *Lithocarpus densiflorus, Acer macrophyllum*, and other species.

Conservation

Abies bracteata has a limited range, consisting of a reasonably large number of small and often quite disjunct subpopulations, each containing from a few score to several hundred trees. No commercial exploitation threatens this species and most populations are within protected areas or on public lands where the management is aimed at preserving these remarkable trees. However, they are susceptible to forest fires, which in much of central and southern California have increased in intensity and extent due to a complex of largely anthropogenic factors. A hot forest fire at the wrong time in the wrong location could wipe out an entire subpopulation. However, it appears that nearly all stands are in situations where a fire would not reach or have limited destructive power.
IUCN: NT

Uses

Santa Lucia fir is not used for timber but it is an attractive and unusual species much valued in collections for botanic gardens and arboreta. It was successfully introduced and raised by the famous tree nursery of Veitch & Son near Chelsea in England in 1853, but it only became more common in horticulture later in the 20th century when renewed seed collecting was undertaken. Trees in cultivation often grow much faster and taller than in their natural habitats in the Santa Lucia Mountains.

Abies cephalonica Loudon, Gard. Mag. & Reg. Rural Domest. Improv. 14: 81. 1838 [Arbor. Frutic. Brit.]. *Abies alba* Mill. var. *cephalonica* (Loudon) Richt., Pl. Europ. 1: 5. 1890. Type: not designated. Fig. 4

Etymology

The species epithet denotes its *locus classicus*, the island of Cephalonia in Greece.

Vernacular names

Greek fir, Grecian fir; Kukunaria (Greek)

Description

Trees to 30–35 m tall, d.b.h. to 1.5–2 m; trunk monopodial, straight, columnar, terete; crown pyramidal, old trees flat topped. Bark of young trees greyish, tinged with pink or brown, smooth, finally in old trees fissured below. Branches of first order long, spreading horizontally, pendant below; branches of second order spreading or pendant. Branchlets stout, shaded ones slender, shining pale brown or reddish brown, rarely yellowish, prominently grooved, glabrous; leaf scars circular. Vegetative buds ovoid or conical, ca. 6 × 4–5 mm, with yellowish resin; bud scales ovate, acute, reddish brown and persistent for several years. Leaves spirally arranged, spreading radially, more or less pectinate below, assurgent and curved on coning shoots, (1.5–)2–3(–3.5) cm long, 2–2.5 mm wide, twisted or curved at base, linear, curved and flattened, shining dark green above, with two whitish green stomatal bands separated by a midrib below; apex acute, rarely obtuse. Stomata few on the adaxial (upper) surface near the apex, two bands separated by a midrib below. Pollen cones lateral, crowded on the underside of branches, 1.2–1.8 cm long, yellow with red microsporophylls. Seed cones lateral, erect; peduncles short; cone shape cylindrical, 10–16(–20?) cm long, 3.5–5 cm wide; apex obtuse or papilliform, greenish brown when

immature, maturing to light brown; cone rachis persistent, narrowly conical, brown; seed scales cuneate near the top, cyathiform at mid-cone, length × width at mid-cone 2.5–3.5 × 2–3 cm; surface smooth, with yellowish brown pubescence on the exposed part; upper margin undulate or entire, convex; base short pedicellate. Bracts linear-spathulate, with long cusp, 3–4 cm long, exserted and recurved. Seeds narrowly cuneate, 8 × 5 mm, brown; seed wings cuneate or oblong, 15–20 × 8–10 mm, lustrous light brown.

Taxonomic notes

The genetic purity of *A. cephalonica* is apparently lacking in much of the presumed former range of this species (Mitsopoulos & Panetsos, 1987). There appears to be a north-south cline of character states, reflecting introgression with *A. alba* genes with decreasing influence on morphological traits. Pure *A. cephalonica* populations occur on Cephalonia (the locus classicus), Euboea and in the far south of Peloponnesos, but individual trees with genuine characters of this species occur mixed with intermediate forms well into Macedonia. Variation is considerable in much of the area where these hybrid forms are supposed to occur. This hybrid has been formally named as *Abies* ×*borisii-regis* Mattf. and was originally described from the Rhodope Mountains in Bulgaria. Other botanists described the hybrid as a variety or subspecies of *A. alba* (*A. alba* var. *acutifolia* Turrill).

Distribution

Greece (Cephalonia, Euboea, Sterea Hellas, Peloponnisos).
TDWG codes: 13 GRC

Ecology

Abies cephalonica is a montane species, occurring from (600–)800–2000(–2100) m a.s.l. in the high mountains of Greece. Soils are usually well drained and calcareous, but in the north, where introgression with *A. alba* seems to have occurred, also on siliceous soils, which may be slightly acid. The climate has relatively dry summers and wet winters, with annual precipitation from 700 to 1500 mm. At lower elevations *A. cephalonica* mixes with *Fagus orientalis, Quercus* spp., *Castanea sativa*, and also *Pinus nigra*, but higher in the mountains it usually forms pure forests with occasional *Juniperus oxycedrus*.

Conservation

Abies cephalonica has a limited distribution, but its actual extent of occurrence (EOO) is difficult to establish due to inferred past and perhaps present hybridization with *A. alba*. Where it is considered genetically pure, the introduction of firs from other sources would potentially threaten this species; it is therefore imperative for foresters to refrain from such introductions among or near such populations. The situation becomes more obscure in the northern Peloponnisos and in Sterea Hellas where it is found that both *A. cephalonica* and *A.* ×*borisii-regis* already occur. Climate change may influence this situation, with drier conditions presumably benefiting *A. cephalonica* and wetter conditions *A. alba*, and therefore ongoing introgression of the genes of *A. alba* into the remaining populations of *A. cephalonica*.
IUCN: LC

Uses

Greek fir, due to its rarity, is of limited commercial value as a timber tree. Crosses with other European firs (*A. nordmanniana, A. pinsapo*) have been established and tried or used in plantation forestry as well as the natural hybrid *A.* ×*borisii-regis*. The latter is more widespread and, together with European fir (*A. alba*), exploited for timber in its natural range. *Abies cephalonica* was widely planted as an ornamental tree in Europe during the 19th century, distributed from seed collected on Cephalonia. Such trees are now becoming rare because seedlings from them will not be genetically pure and new collections are seldom made. A few cultivars are known but these, too, are rare.

Abies chensiensis Tiegh., Bull. Soc. Bot. France 38: 413. 1892.

Etymology

The species epithet refers to the Chinese province (now spelled Shaanxi) from where this species was first described.

Vernacular names

Shensi fir; qin ling leng shan (Chinese)

Description

Trees to 50(–70?) m tall, d.b.h. to 2–2.5 m; trunk monopodial, straight, columnar, terete; crown pyramidal, becoming flat topped in old trees. Bark of young trees dark grey, smooth, fissured in old trees. Branches of first order short, massive; branches of second order stout, spreading. Branchlets stout, firm, yellowish or grey, shining, ridged between leaf scars, glabrous or slightly pubescent at first; leaf scars roundish with a light centre. Vegetative buds conical or ovoid, 10 × 6 mm or larger on some leading shoots, (slightly) resinous; bud scales triangular or broadly ovate, brown or reddish, persisting several years. Leaves spirally arranged, the lower ranks pectinate at right angles to shoot, the upper leaves shorter and directed forward, assurgent or nearly erect on coning shoots, (1.3–)2–4.5(–7.5) cm long, 2.5–3 mm wide, twisted at base, ligulate linear, flattened, grooved and shining green above, whitish green below, emarginate or obtuse, occasionally acute (coning shoots). Stomata in two broad bands divided by a midrib below. Pollen cones lateral, crowded, 1 cm long. Seed cones lateral, erect on short peduncles, oblong-ovoid or cylindrical, with a truncate apex, (7–)8–11(–14) cm long, (3–)4–5 cm wide, green when immature, ripening to cinnamon brown; cone rachis persistent, cylindric-conical, dark brown. Seed scales broadly ovate-cuneate to cyathiform, length × width at mid-cone 2.5–3 × 3–3.5 cm; surface smooth, tomentose-puberulent; upper margin rounded, obscurely serrate; base pedicellate. Bracts short, 2-laminated, with short cusp, length 1–1.5 cm, entirely included. Seeds obovoid, 10 × 5 mm, brown; seed wings obdeltoid, 20 × 10 mm, pale brown.

Distribution

China: SE Gansu, Henan, W Hubei, Shaanxi, W Sichuan, NW Yunnan, SE Xizang [Tibet]; NE India: Arunachal Pradesh.

TDWG codes: 36 CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHS-HE CHT 40 EHM-AP

Ecology

This species occurs in high mountain ranges of the SW Plateau of China between 2100 and 3000 m a.s.l., on grey-brown mountain podzols, brown earth or lithosols. The climate is cold and moist, with annual precipitation between 1000 and 2000 mm. It is a rare species, usually mixed with *Picea* spp., *Abies fargesii* var. *sutchuenensis, Tsuga chinensis, Larix potaninii* at high elevations, and *Betula* spp. at lower elevations; also as a pure forest in Tsin-ling Shan (Wang, 1961).

Uses

This fir has been logged heavily for timber in northern China. As of most tall firs, the wood is soft, even-grained and suitable for many applications in construction, veneer, panelling etc. The species is uncommon in cultivation outside China and mostly restricted to botanic gardens and arboreta.

Three subspecies are recognized:

Abies chensiensis Tiegh. subsp. ***chensiensis***. Type: China, Shaanxi, Qinling Shandi, *Abbé David 918* (holotype P).

Description

Leaves (1.3–)2–4.5(–5) cm long; resin canals in leaves of coning shoots medial. Seed cones (7–)8–11(–12) cm long.

Distribution

China: SE Gansu, Henan (Nexiang), W Hubei, S Shaanxi, W Sichuan.

TDWG codes: 36 CHC-HU CHC-SC CHN-GS CHN-SA CHS-HE

Conservation

Logging and deforestation have depleted this most common and widespread subspecies, but to an unknown extent. A logging ban imposed by the central government applies to all native forest with this and other conifer species.

IUCN: LC

Abies chensiensis Tiegh. subsp. ***salouenensis*** (Bordères & Gaussen) Rushforth, Notes Roy. Bot. Gard. Edinburgh 41: 539. 1984. *Abies salouenensis* Bordères & Gaussen, Trav. Lab. Forest. Toulouse T. 1 (4, 15): 4. 1947; *Abies ernestii* Rehd. var. *salouenensis* (Bordères & Gaussen) W. C. Cheng & L. K. Fu, Fl. Reipubl. Pop. Sin. 7: 93. 1978; *Abies recurvata* Mast. var. *salouenensis* (Bordères & Gaussen) C. T. Kuan, Fl. Sichuan. 2: 48. 1983; *Abies chensiensis* Tiegh. var. *salouenensis* (Bordères & Gaussen) Silba, Phytologia 68: 10. 1990. Type: China: Yunnan, Hengduan Shan, Atuntze, *T. T. Yü, 7952* (holotype TLF).

Description

Leaves 4–7.5 cm long; resin canals in leaves of coning shoots marginal.

Taxonomic notes

In Flora of China 4: 52 (1999) this taxon is classified as *Abies ernestii* Rehd. var. *salouenensis* (Bordères & Gaussen) W. C. Cheng & L. K. Fu; *A. ernestii* Rehd. is treated as a variety of *A. recurvata* in Farjon (1990, 1998, [2001]).

Distribution

SW. China: NW. Yunnan, SE Xizang [Tibet]; NE. India: Arunachal Pradesh.
TDWG codes: 36 CHC-YN CHT 40 EHM-AP

Conservation

IUCN: LC

Abies chensiensis Tiegh. subsp. ***yulongxueshanensis*** Rushforth, Notes Roy. Bot. Gard. Edinburgh 41: 539. 1984. *Abies chensiensis* Tiegh. var. *yulongxueshanensis* (Rushforth) Silba, Phytologia 68: 10. 1990. Type: China: Yunnan, Lijiang Xian, Yulongxue Shan, *T. T. Yü, 15050* (holotype E).

Description

Seed cones 10–14 cm long. Resin canals in leaves of coning shoots marginal.

Taxonomic notes

Rushforth (1984) described this subspecies from the main massif of the Lijiang Shan (Yulongxue Shan, 5596 m) in NW Yunnan. It has somewhat larger cones than the type subspecies and marginal resin canals in the leaves of cone-bearing shoots. In Flora of China 4 (1999) where no subspecies of *A. chensiensis* are recognized, this taxon has been instead treated under *Abies ernestii* Rehd. var. *salouenensis* (Bordères & Gaussen) W. C. Cheng & L. K. Fu as a synonym.

Distribution

China: Yunnan (Lijiang Shan).
TDWG codes: 36 CHC-YN

Conservation

This subspecies is only known from one mountain range in NW Yunnan and is believed to count fewer than 1000 mature trees. Parts of this mountain are a National Park and at least some of the population occurs within this protected area.
IUCN: VU (D2)

Abies cilicica (Antoine & Kotschy) Carrière, Traité Gén. Conif.: 229. 1855.

Etymology

The species epithet means 'from Cilicia' the classical name for a part of the Mediterranean coast of Turkey.

Vernacular names

Cilician fir

Description

Trees to 30 m tall, d.b.h. to 0.75–1 m; trunk monopodial, straight, columnar, terete; crown (narrowly) conical. Bark of young trees grey, smooth, of old trees scaly and fissured. Branches of first order spreading horizontally, the upper ones ascending; branches of second order spreading horizontally. Branchlets stout and firm, yellowish or greenish brown, turning

grey later, shallowly grooved, faintly pubescent or glabrous on first year shoots, all soon glabrous; leaf scars circular, dark. Vegetative buds ovoid conical, acute, small, 3–4 × 2–3 mm, not or slightly resinous; bud scales broadly ovate, light brown or orange brown, persisting several years. Leaves spirally arranged, directed forward especially on vegetative shoots, the lower ranks pectinate, on coning shoots radially and assurgent, more or less forward, 2.5–4 cm long, 1.5–1.8 mm wide, twisted and abruptly narrowed at base, linear, flattened, bright green or glaucous above, greenish white with green midrib below; apex obtuse or slightly emarginate. Stomata in two broad bands separated by a midrib below. Pollen cones lateral, axillary, short pedunculate, 1–1.5 cm long, yellowish with red microsporophylls. Seed cones lateral, erect, often in pairs, with short peduncles or sessile, cylindrical, with obtuse, retuse or papilliform apex, 16–20(–30) cm long, 4–6 cm wide, greenish when immature, turning reddish brown (often resinous) and brown with age; cone rachis persistent, narrowly conical, dark brown. Seed scales broadly flabellate, length × width at mid-cone 2.5–3 × 3–4 cm; surface smooth, pubescent on exposed parts; upper margin thin and entire; base pedicellate. Bracts narrowly spathulate, 1.5–2.5 cm long, usually included, sometimes slightly exserted. Seeds obovate-triangular, 10–12 × 5 mm, light brown; seed wings cuneate, broad, 14–17 mm long, light brown.

Taxonomic notes

The minor and probably variable differences between *A. cilicica* subsp. *cilicica* and subsp. *isaurica* are considered by some specialists in the genus to be insignificant, but because the latter subspecies was recognized in Vol. 1 of the Flora of Turkey (Davis *et al.*, 1965), and as it occurs only in the Isaurian Taurus Mountains, it is here separated from subsp. *cilicica*.

Distribution

Lebanon, Syria, Turkey.
TDWG codes: 34 LBS-LB LBS-SY TUR

Ecology

Abies cilicica is a species of the high mountains around the eastern Mediterranean Basin, occurring at elevations between 1200 m to 2100 m a.s.l. (subsp. *cilicica*) and 1000 m to 2000 m a.s.l. (subsp. *isaurica*). The soils are often shallow and rocky, well drained, calcareous, and dry in the summer. The climate is characterized by warm, dry summers and wet, mild winters, the annual precipitation is 1000 to 1500 mm. In its lowest reaches *Quercus* spp. and *Taxus baccata* are mixed in, but higher on the mountains it forms pure stands or mixed forests with *Cedrus libani; Pinus nigra* and *Juniperus excelsa* occur more rarely.

Uses

Cilician fir is an important timber tree in Turkey, where it is relatively abundant. Its wood is used for indoor construction mainly as plywood. It is rare in cultivation despite its alleged horticultural merits because of its susceptibility to 'late' frost damage which can occur in much of western Europe due to erratic cold and warm spells in early spring.

Abies cilicica (Antoine & Kotschy) Carrière subsp. ***cilicica***. *Pinus cilicica* Antoine & Kotschy, Oesterr. Bot. Wochenbl. 3: 409. 1853. Type: Turkey: Bulgar Daglari, *K. G. T. Kotschy 49611* (holotype G).

Abies cilicica (Antoine & Kotschy) Carrière var. *pyramidalis* Boydak & Erdogrul, Istanbul Univ. Orman Fak. Dergisi, A, 49 (2): 21. [1999] 2000.

Description

New shoots faintly pubescent, soon glabrous; buds not resinous.

Distribution

Lebanon, Syria, Turkey (Anti-Taurus, Cilician Taurus).
TDWG codes: 34 LBS-LB LBS-SY TUR

Conservation

IUCN: LC

Abies cilicica (Antoine & Kotschy) Carrière subsp. ***isaurica*** Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 26: 167. 1965. Type: Turkey: Antalya, Gebiz, Bozburun Dag, ["Bozburun Dag, between Bogarz Azzi & Tozlu Cukur yoyla"(?)], *P. H. Davis 15505* (holotype E).

Description

New shoots glabrous; buds slightly resinous.

Distribution

Turkey: Prov. Antalya and Konya (Isaurian Taurus).
TDWG codes: 34 TUR

Conservation

This subspecies (if distinct) has a limited distribution and therefore, dependent on trends in its abundancy which are currently unknown, it could in the near future qualify for a category of threat. The region has experienced substantial forest depletions in the past.
IUCN: NT

Abies concolor (Gordon) Lindl. *ex* Hildebr., Verh. Naturhist. Vereines Preuss. Rheinl. Westphalens 18: 261. 1861. *Picea concolor* Gordon, Pinetum: 155. 1858. Type: USA: New Mexico, *A. Fendler 828* (holotype MO).

Picea lowiana Gordon, Pinetum Suppl.: 53. 1862; *Abies lowiana* (Gordon) A. Murray bis, Proc. Roy. Hort. Soc. London 1863 (3): 317. 1863; *Abies grandis* (Douglas *ex* D. Don) Lindl. var. *lowiana* (Gordon) Hoopes, Book Evergr.: 212. 1868; *Abies concolor* (Gordon) Lindl. *ex* Hildebr. var. *lowiana* (Gordon) Lemmon, Cone-Bear. Trees Pacif. Slope, ed. 3: 64. 1895; *Abies concolor* (Gordon) Lindl. *ex* Hildebr. subsp. *lowiana* (Gordon) E. Murray, Kalmia 13: 3. 1983.
Abies concolor (Gordon) Lindl. *ex* Hildebr. f. *atroviolacea* Cinovskis, Introd. Rast. Bot. Sad. Pribaltiki: 48. 1974.
Abies concolor (Gordon) Lindl. *ex* Hildebr. var. *bajacalifornica* Silba, Phytologia 68: 11. 1990.
Abies concolor (Gordon) Lindl. *ex* Hildebr. var. *martinezii* Silba, Phytologia 68: 12. 1990.
Abies lowiana (Gordon) A. Murray bis var. *viridula* Debreczy & Rácz, Phytologia 78 (3): 13. 1995.

Etymology

The species epithet refers to the similar colour on both sides of the leaves.

Vernacular names

White fir, Colorado fir, Low's fir, California white fir; pino real blanco (Spanish)

Description

Trees to 60–70 m tall, d.b.h. to 2–2.5 m; trunk monopodial, straight, columnar, terete; crown narrowly conical, with flat domed top in old trees. Bark of young trees smooth, grey to whitish with conspicuous resin blisters; in old trees dark grey, tinged with yellowish brown, scaly, deeply fissured below. Branches of first order relatively short, in regular, horizontal whorls in young trees, the lower ones later drooping, curved; branches of second order spreading. Branchlets slender, yellowish green, soon becoming grey brown, smooth or with shallow grooves, glabrous or with minute pubescence on first year shoots; leaf scars circular, light. Vegetative buds globose or globular, 3–5 mm long, resinous; bud scales ovate triangular, brown, persistent for 2–3 years. Leaves spirally arranged, in irregular ranks, spreading, more or less pectinate in some trees, curved upward and forward in others, assurgent or nearly erect on coning shoots, (1.5–)4–6(–7) cm long, 2–3 mm wide, curved or (strongly) twisted at base, linear, usually curved, or the shortest leaves falcate, flattened or slightly carinate, green or glaucous green; apex obtuse or acute. Stomata in a few or more lines above, two bands divided by a midrib below. Pollen cones in the axils of leaves, pendulous, 1.2–2 cm long, with red or roseate microsporophylls. Seed cones lateral, erect, sessile or very short pedunculate, cylindrical or elliptical, with obtuse or retuse apex, 7–12(–15) cm long, 3–4.5 cm wide, colour variable when immature, usually light (yellowish)green,

sometimes purple violet, maturing to (light) brown; cone rachis persistent, narrowly conical, blackish brown. Seed scales flabellate, sometimes much wider than long, length × width at mid-cone 2.5–3 × 3–3.5 cm; surface smooth, puberulent, especially on exposed parts; upper margin entire; base pedicellate, often curved. Bracts ovoid-oblong, with two lateral wings and short cusp, 1–1.5 cm long, included. Seeds cuneate, 8–10 mm long, dull light brown; seed wings oblong-cuneate, 15–20 mm long, light, lustrous brown.

Taxonomic notes

Investigation of herbarium specimens from locations covering much of the range of *A. concolor* revealed a great variety in arrangement and length of leaves. It has been concluded that var. *lowiana* (Gord.) Lemmon falls entirely within the variation of var. *concolor* as found in specimens from Rocky Mountain locations (Farjon, 1988). There is consequently no taxonomically sound basis upon which to recognize this perceived entity as a distinct species or as an infraspecific taxon.

Distribution

USA: from Oregon and Idaho through the Rocky Mountains and Californian mountains to Arizona and New Mexico. Mexico: Baja California Norte, Chihuahua, Sonora.
TDWG codes: 73 COL IDA ORE WYO 76 ARI CAL NEV UTA 77 NWM 79 MXE-CU MXN-BC MXN-SO

Ecology

Abies concolor occurs in the Transition and Canadian Life Zones of high mountains, often restricted to N-facing slopes, at elevations between 600 to 3000 m in the western part of its range, from 1800 m to 3350 m a.s.l. in the Rocky Mountains. It grows in a variety of mountain soils on granitic or basaltic rocks or occasionally sandstone. The climate is moderately humid (500 to 1875 mm annual precipitation), with relatively warm and dry summers and cold winters. It grows in pure stands, or mixed with various other conifers, e.g. *Pinus* spp., *Abies magnifica, A. procera, A. grandis, Pseudotsuga menziesii* var. *glauca*, and also with *Populus tremuloides*.

Conservation

IUCN: LC

Uses

White fir provides timber for general construction applications and plywood; its market value has improved in recent decades relative to other species of fir. In California it is grown for Christmas trees in plantations or harvested from natural regeneration in forests managed for timber production. The natural variation in leaf colour from green (recognized as var. *lowiana* in horticulture) to glaucous green can be enhanced by selection and has been used both in the Christmas tree trade and in horticulture. A number of cultivars, including dwarfed forms, are commonly used in gardens.

Abies delavayi Franch., J. Bot. (Morot) 13 (8): 255. 1899.

Etymology

This species was named after the French missionary P. J. M. Delavay, who collected plants in Yunnan, China, during the last quarter of the 19th century.

Vernacular names

Delavay's fir; cang shan leng shan (Chinese)

Description

Trees to 30–40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown (broad) pyramidal, flat topped in old trees. Bark of young trees grey or brownish grey, smooth, in old trees deeply fissured and flaking off in small fragments. Branches of first order massive, spreading, ascending near the top; branches of second order spreading, assurgent. Branchlets stiff, terete, maroon or brown, usually dull, sometimes shining dark red brown or purplish brown, becoming grey, smooth or slightly grooved, glabrous, puberulent or ferruginous pubescent in grooves on 1st year shoots; leaf scars angular circular. Vegetative buds ovoid-globular, small, or up to 8 mm long on leading shoots, very resinous;

bud scales broadly ovate, obtuse, reddish or greenish brown, persisting several years. Leaves spirally arranged, in several radially spreading, overlapping ranks of different length, more or less forward, on coning shoots more assurgent, (1.2–)1.5–3(–4.3) cm long, 1–2(–2.8) mm wide, twisted at base, linear, often curved or S-shaped, above lustrous dark green, below niveous white, often also with white wax on the midrib; margins strongly revolute; apex emarginate or obtuse; stomata in two bands below. Pollen cones laterally on the lower side of branches, pendant from the leaf axils, 2–3.5(–4) cm long, yellow with violet microsporophylls. Seed cones lateral, erect; peduncles short, with many scales; shape cylindrical or ovoid-oblong, with truncate or slightly umbilicate apex, 6–11(–14) cm long, 3–4.5 cm wide, dark violet blue when immature, turning purplish black or blackish brown with blue bracts, dull (reddish) brown when ripe; cone rachis persistent, thick, conical to fusiform, purplish brown. Seed scales obtriangular-flabellate to flabellate-reniform, auriculate, length × width at mid-cone 1.2–2 × 1.5–2.5 cm; surface smooth, puberulent; apical part thickened, with rounded, slightly recurved, entire margin, lateral margins erose; base pedicellate. Bracts oblong-spathulate, straight or recurved at apex, with small or long, narrow cusps, 1–2 cm long, entirely included or exserted, usually with spreading cusps. Seeds obovate, 5–8 mm long, brown (mostly covered with a blackish wing membrane); seed wings cuneate-dolabriform, 10 × 6 mm, (light) brown with a black or purplish blue tinge.

Distribution

SW China: W Yunnan, SE Xizang [Tibet]; NE India: Arunachal Pradesh; N Myanmar [Burma]; N Viet Nam.
TDWG codes: 36 CHC-YN CHT 40 EHM-AP 41 MYA VIE

Ecology

This is a species of high elevations in the great mountain ranges of SW China, occurring between 2400 m and 4300 m a.s.l., but usually between 3000 m and 4000 m, commonly on N-facing slopes. The soil is a grey brown mountain podzol. The climate is extremely wet, with cool summers and cold, snowy winters (annual precipitation ranges from 1000 mm to 3000 mm and more). It grows mixed with other conifers, such as *Picea likiangensis, P. brachytyla* var. *brachytyla*, or in pure stands towards the tree limit. At lower elevations it is sometimes mixed with *Tsuga chinensis, T. dumosa, Juniperus formosana* and broad-leaved trees, e.g. *Betula albosinensis, Betula platyphylla* var. *szechuanica*, and *Quercus semecarpifolia*. *Abies delavayi*, however, is less common with these trees than *A. forrestii*.

Uses

This high altitude species is not an important timber tree, but it has been logged in several areas together with other conifers with which it occurred. Measures to reduce or even stop logging these high mountain forests are being put in place by the Chinese government. This species, and some of its forms or varieties, have been introduced to cultivation in Europe, in particular the UK and France, but are still mostly restricted to arboreta and botanic gardens, as they are slow growing.

Three varieties and one subspecies are recognized:

Abies delavayi Franch. var. ***delavayi***. Type: China, Yunnan, Tsang Shan, near Dali, *P. J. M. Delavay 1210* (holotype P). Fig. 5, 6

Description

Shoots glabrous or puberulent in grooves; leaves (1.2)1.5–3(–3.5) cm long, 1–2 mm wide, strongly revolute. Seed cones ovoid-oblong to cylindrical, 6–11(–14) cm long; bracts (slightly) exserted, with a long, narrow cusp.

Distribution

SW China: W Yunnan, SE Xizang [Tibet]; NE India: Arunachal Pradesh; N Myanmar [Burma].
TDWG codes: 36 CHC-YN CHT 40 EHM-AP 41 MYA

Conservation

IUCN: LC

Abies delavayi Franch. subsp. ***fansipanensis*** (Q. P. Xiang) Rushforth, Int. Dendrol. Yearb. 1998: 62. 1999. *Abies fansipanensis* Q. P. Xiang, Acta Phytotax. Sin. 35 (4): 356. 1997. Type: Viet Nam, Lao Cai Prov., Mt. Fan Si Pan, *Sino-Vietnamese Exped. s.n.* (holotype PE)

Description

Trees 15–20 m tall. Seed cones cylindrical, 8–14 cm long; bracts bilobed, with small cusp, entirely included.

Distribution

Viet Nam: Lao Cai Prov. (Mt. Fan Si Pan).
TDWG codes: 41 VIE

Ecology

Abies delavayi subsp. *fansipanensis* is endemic on Mt. Fan Si Pan, the highest mountain in Viet Nam in the extreme NW of the country. It is an outlier of a widespread species with a typical Sino-Himalayan distribution. It grows on the highest slopes and ridges of this granitic mountain at altitudes between 2600 m and 3000 m a.s.l. as an emergent tree in primary evergreen tropical high montane forest. Rainfall is very high, to 3,500 mm or more per year and clouds cover the summit region of the mountain for most of the time. It is associated with *Tsuga dumosa* (which has a similar geographical distribution as *A. delavayi*) and *Rhododendron* spp.; the understorey is often dominated by bamboos.

Conservation

At present, there are no direct threats from logging due to its remote habitat, but if plans to build a road on the mountain were to materialize this may change, despite the fact that the entire population occurs within the Hoang Lien National Park. Increasing tourism on the mountain could heighten the risk of fires in dry spells.
IUCN: CR (D)

Abies delavayi Franch. var. ***motuoensis*** W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975. Type: China, SE Xizang [Tibet], Motuo, *Chinese collector 1011* (holotype PE)

Description

Shoots densely ferruginous pubescent; leaves 2–3.2 cm long.

Distribution

China: SE Xizang [Tibet] (Motuo).
TDWG codes: 36 CHT

Conservation

IUCN: LC

Abies delavayi Franch. var. ***nukiangensis*** (W. C. Cheng & L. K. Fu) Farjon & Silba, Phytologia 68: 13. 1990. *Abies nukiangensis* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975. Type: China: Yunnan, Hengduan Shan, Nu Jiang, *K. M. Feng 8025* (holotype PE). Fig. 7

Description

Shoots glabrous, purplish brown; leaves 1.2–4.3 cm long, 1.5–2.8 mm wide, sometimes only slightly revolute. Cone bracts with a short cusp, mostly included.

Distribution

China: NW Yunnan (Nukiang River).
TDWG codes: 36 CHC-YN

Conservation

IUCN: NT

Abies densa Griff., Notul. Pl. Asiat. 4: 19. 1854. *Abies spectabilis* (D. Don) Spach var. *densa* (Griff.) Silba, Phytologia Mem. 7: 10. 1984. Type: not designated.

Abies fordei Rushforth, Int. Dendrol. Soc. Yearb. 2008: 42. 2009.

Etymology

The species epithet refers to the crowded leaves.

Vernacular names

Sikkim fir; gobria, gobra, salla (Nepal); dhunsing (Bhutan)

Description

Trees to 50–60 m tall, d.b.h. to 2.5 m; trunk monopodial, straight, columnar, terete; crown broad, pyramidal or columnar, in old trees flat topped. Bark soon scaly, grey, in old trees fissured towards base, breaking into large plates. Branches of first order thick, long, assurgent near the top, horizontally spreading, or lower branches bent down; branches of second order assurgent. Branchlets thick in leading shoots, lateral shoots firm but slender, yellowish to reddish brown, becoming grey, prominently ridged and grooved, glabrous or with slight pubescence in grooves; leaf scars circular ovate. Vegetative buds ovoid-conical, 8 × 6 mm, resinous; bud scales ovate, obtuse, orange brown and persistent for several years. Leaves spirally arranged, more or less pectinate, on leading and coning shoots more radially arranged, with the upper leaves curved forward, (1.5–)2–4(–5) cm long, 1.5–2.5 mm wide, twisted or curved at base, linear, straight or slightly curved, flattened; margins slightly revolute; upper surface of leaves light or mid green, lower surface with two white bands; apex emarginate. Stomata in two bands separated by a midrib below. Pollen cones lateral, radially arranged around the shoot, 2–4.5 cm long, yellow with purplish blue microsporophylls. Seed cones lateral, erect, sessile or on very short peduncles, (ovoid-)cylindrical with obtuse or umbilicate apex, 8–12 cm long, 4–5.5 cm wide, purplish blue when immature, becoming blackish purple with some brown when ripe. Seed scales flabellate-cuneate, length × width at mid-cone 1.5–2 × 2–2.5 cm; surface smooth or slightly striated, pubescent on exposed parts; upper margin entire, incurved; base pedicellate. Bracts ligulate-spathulate, 2–2.5 cm long, slightly or not exserted. Seeds cuneate, 8 × 4 mm, brown; seed wings cuneate, 10 × 5 mm, brown.

Taxonomic notes

This species has been included with *A. spectabilis* (Liu, 1971; Cheng & Fu, 1978; Sahni [in part], 1990), but it is distinct both morphologically and geographically. It has somewhat smaller cones with slightly exserting bracts and leaves with slightly revolute margins, which are arranged more radially around the shoots, especially on coning branches. In these characters it is intermediate between *A. spectabilis* and *A. delavayi*, the latter a species occurring from NE India to Yunnan, China, and also disjunct in N Viet Nam. Rushforth (2009) described a new species, *A. fordei*, from S Xizang [Tibet] ocurring on the northern side of the Himalayan crest in the Yarlung Zangbo drainage. Apart from its flat, not revolute, leaf margins, it is similar to *A. densa* and is here treated as synonymous. It thus appears that at high elevation in the Himalaya, we find from west to east, with partly overlapping distributions, first *A. spectabilis*, then *A. densa*, and finally *A. delavayi*, which extends into the adjacent mountains of western China and as far as Viet Nam.

Distribution

E Himalaya: from E Nepal to the Great Bend of the Brahmaputra.

TDWG codes: 36 CHT 40 ASS-AS EHM-AP EHM-BH EHM-DJ EHM-SI NEP

Ecology

Abies densa occurs in the high mountains of the eastern Himalaya, from 2450 m to 4000 m a.s.l., on rocky, often steep slopes in the cloud belt, where it grows on a variety of alpine lithosols. The climate is extremely wet, with well marked monsoons and an annual precipitation of more than 2000 mm. The summers are relatively warm, the winters are cold at high altitudes and bring heavy snowfall. The species occurs in a wide altitudinal range from mixed deciduous coniferous forest at lower elevations to stands with *Betula utilis* at tree line. Deciduous trees are e.g. *Acer caudatum, A. pectinatum, Prunus* spp., *Sorbus* spp. and many large *Rhododendron* spp. Most of these disappear above 3000 m to make place for conifers. *Picea spinulosa* and *Tsuga dumosa* occur

generally in a belt below *Abies; Larix griffithiana* and/or *Juniperus squamata* above it, the latter at tree line.

Conservation

IUCN: LC

Uses

Sikkim fir is a timber tree of importance in the eastern Himalaya, where it is used in construction (house building), in particular for interior work such as floor boards, ceilings and stairs, while shingles are used for roofing. This species has been introduced in Europe only relatively recently from Bhutan, Nepal and Sikkim. It is still uncommon in gardens and parks but has more attractive characters than *A. spectabilis*, with very white leaf undersides and deep purplish blue, nearly black seed cones. It undoubtedly requires ample precipitation, judging from its natural habitat.

Abies durangensis Martínez, Anales Inst. Biol. Univ. Nac. México 13 (2): 621. 1942.

Etymology

The species epithet refers to the Mexican state of Durango.

Vernacular names

Durango fir

Description

Trees to 30–40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown narrowly pyramidal or more rounded, lower half of trunk often bare of branches. Bark of young trees smooth, greyish or reddish brown, in old trees dark blackish brown and deeply fissured below. Branches of first order long, spreading horizontally; branches of second order spreading or ascending. Branchlets firm, slender, dark purplish red or red-brown, turning brown with age, prominently ridged and grooved between the leaves, glabrous or sparsely to densely pubescent in grooves; leaf scars circular or somewhat ovate. Vegetative buds oblong-ovoid, 4–5 mm long, very resinous; bud scales dark brown (but covered with yellowish resin), persisting 2–3 years. Leaves spirally arranged, more or less pectinate, curved slightly backward or forward, on coning shoots the same or weakly assurgent, (1.4–) 2–3.5(–4.5) cm long, 1–1.6 mm wide, twisted at base, narrowly linear, tapering towards an acutish or obtuse apex, (dark) green or light green; none or with a few lines of stomata above, two bands separated by a midrib below. Pollen cones lateral, in leaf axils, 1–2 (?) cm long (according to Liu, 1971, 5 mm, but likely longer when mature), with resinous perular scales; microsporophylls red. Seed cones lateral, erect, on very short peduncles, cylindrical with obtuse apex, 5.5–10 cm long, 3–4.5 cm wide; pale brown or ochraceous when immature, ripening to pale brown; cone rachis persistent, narrowly conical. Seed scales flabellate-cuneate, usually wider than long, length × width at mid-cone 1.5–2 × 2–2.8 cm; surface smooth, pubescent on exposed parts; upper margin entire, slightly reflexed; base pedicellate. Bracts spathulate, with short cusps, 1–1.5 cm long, included. Seeds cuneate-oblong, 7–8 mm long, yellowish brown; seed wings cuneate to more or less rounded, 8–10 × 6–8 mm, pale yellowish.

Distribution

Mexico: Chihuahua, Coahuila, Durango, N Jalisco, Sinaloa.

TDWG codes: 79 MXE-CO MXE-CU MXE-DU MXN-SI MXS-JA

Ecology

Abies durangensis occurs in high mountain valleys and steep canyons on the western side of the divide of the Sierra Madre Occidental, at elevations between (1600–)2000–3550 m a.s.l. and usually on well drained talus or lithosols. The climate is moist and cool, especially on N-facing slopes. It is a relatively rare constituent of coniferous forests in the Canadian Life Zone, with *Pseudotsuga menziesii* var. *glauca, Pinus strobiformis, P. leiophylla* var. *chihuahuana, Cupressus lusitanica, C. arizonica* in the north of its range, *Picea chihuahuana* (only near El Salto, Durango), *Pinus durangensis* (in the south), *Juniperus deppeana* (locally) and some broad-leaved trees like *Quercus castanea, Q. rugosa, Prunus serotina*.

Uses

Durango fir is not a commercially important timber tree and is extremely rare in cultivation. Trees from high altitude provenances are being grown with some success, but mostly slowly, in the south of England and in Belgium.

2 varieties are recognized:

Abies durangensis Martínez var. ***durangensis***. Type: Mexico, Chihuahua, Pinos Altos, Dec 1939, *J. H. Faull s.n.* (holotype MEXU)

Abies neodurangensis Debreczy, Rácz & Salazar, Phytologia 78 (3): 7. 1995.

Description

Shoots glabrous or sparsely pubescent in grooves; leaves 2–3.5(–4.5) cm long, with bands of stomata wider than the midrib, usually a few lines of stomata on the upperside.

Distribution

Mexico: Chihuahua, Durango, N Jalisco, Sinaloa.
TDWG codes: 79 MXE-CU MXE-DU MXN-SI MXS-JA

Conservation

IUCN: LC

Abies durangensis Martínez var. ***coahuilensis*** (I. M. Johnst.) Martínez, Pinaceas Méxic., ed. 3: 139. 1963. *Abies coahuilensis* I. M. Johnst., J. Arnold Arbor. 24: 332. 1943. Type: Mexico: Coahuila, Charretera Canyon, *I.M. Johnston 9010* (holotype A).

Description

Shoots densely pubescent; leaves 1.4–3 cm long, with bands of stomata narrower or as wide as the midrib, few or no stomata on the upperside.

Distribution

Mexico: Coahuila.
TDWG codes: 79 MXE-CO

Ecology

Var. *coahuilensis* has been found in steep canyons at 2100 m to 2300 m a.s.l. and on mountain summits above 3500 m, in dense forest with *Pseudotsuga menziesii* var. *glauca, Pinus strobiformis* and *Cupressus arizonica*.

Conservation

IUCN: VU (D2)

Abies fabri (Mast.) Craib, Notes Roy. Bot. Gard. Edinburgh 11: 278. 1919.

Etymology

This species was named after Ernst Faber (1839–99), who collected plants in China, among which the type specimen of this species.

Vernacular names

Faber's fir; leng shan, pao shan (Chinese)

Description

Trees to 40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown often open, broad pyramidal or flat topped in old trees. Bark of young trees smooth, grey, deeply fissured below in old trees. Branches of first order long, spreading horizontally, ascending near the top; branches of second order spreading and assurgent. Branchlets stiff, terete, shiny, light yellow or brown, grooved and ridged between the leaves, glabrous or with a few dark hairs in the grooves; leaf scars circular. Vegetative buds ovoid-conical, small, resinous; bud scales ovate, with obtuse apex, greenish purple, persisting several years. Leaves spirally arranged, spreading sideways, pectinate below, parted above, on coning shoots more radially, 1.5–3(–4) cm long,

2–2.5 mm wide, twisted or curved at base, linear, straight or slightly curved, flattened, with revolute margins; green above, two white stomatal bands separated by a midrib below; apex emarginate or bifid (obtuse or acute on coning shoots). Stomata in two bands separated by a midrib below. Pollen cones lateral, axillary, pendant, 2–3.5 cm long, yellow with violet or purplish blue microsporophylls. Seed cones lateral, erect; peduncles 0.5 cm; shape ovoid-oblong or more barrel-shaped, with obtuse or umbilicate apex, 5–10 cm long, 3.5–5 cm wide, purplish blue when immature, ripening to brownish blue; cone rachis persistent, fusiform, purplish brown. Seed scales flabellate, auriculate, length × width at mid-cone 1.4–1.8 × 1.6–2 cm; surface smooth, puberulent on exposed parts, apical end thickened; upper margin entire, incurved; base pedicellate. Bracts oblong-spathulate, 1–1.5 cm long, only the cusps exserted and recurved or reflexed. Seeds oblong-ovate, 8 × 4 mm, light brown (partly covered by the blackish wing membrane); seed wings cuneate-dolabriform, 10 × 6 mm, blackish brown.

Distribution

China: W Sichuan.
TDWG codes: 36 CHC-SC

Ecology

The type location of *Abies fabri* is on Mt. Emei (Emei Shan), a mountain SW of Chengdu in Sichuan. The species occurs there at elevations between 2500 m and 3100 m a.s.l. [K. D. Rushforth, pers. comm.; Craib (1919) has given a range between 3000 m and 3600 m a.s.l.] in a humid, cool climate (mean temp. in Jan. -4°C, in July +12.6°C, annual precipitation >2000 mm). There are some nearly pure stands and scattered trees on Mt. Emei, but elsewhere in W Sichuan the species occurs mixed with *Picea likiangensis, Tsuga chinensis* and occasionally *Larix potaninii*.

Uses

This species is not known to be a commercially important timber tree, presumably due to its restricted occurrence (protected from exploitation on the 'holy' mountain Emei Shan). It is uncommon in cultivation and mostly restricted to arboreta and botanic gardens.

Two subspecies are recognized:

Abies fabri (Mast.) Craib subsp. ***fabri***. *Keteleeria fabri* Mast., J. Linn. Soc., Bot. 26: 555. 1902; *Abies delavayi* Franch. var. *fabri* (Mast.) D. R. Hunt, J. Roy. Hort. Soc. London 92: 263. 1967. Type: China: Sichuan, Emei Shan, *E. Faber 984* (holotype K).

Description

Shoots light brown, with a few dark hairs in the grooves or glabrous; leaves 1.5–3 cm long.

Distribution

China: W Sichuan.
TDWG codes: 36 CHC-SC

Conservation

IUCN: VU (A2cd)

Abies fabri (Mast.) Craib subsp. ***minensis*** (Bordères & Gaussen) Rushforth, Notes Roy. Bot. Gard. Edinburgh 43: 273. 1986. *Abies minensis* Bordères & Gaussen, Trav. Lab. Forest. Toulouse T. 1 (4, 15): 10. 1947. Type: China: Sichuan, Min River, Songpan, *T. T. Yü 8586* (holotype TLF).

Description

Shoots yellowish, glabrous; leaves (1.8–)3–4 cm long.

Taxonomic notes

In Flora of China 4: 47 (1999) this taxon is treated as a synonym of *Abies fargesii* var. *faxoniana*. Its new shoots are there described as light brown or grey-brown and being densely rusty brown pubescent on lateral branchlets, but usually glabrous on leading branches.

Distribution

China: W Sichuan
TDWG codes: 36 CHC-SC

Conservation

IUCN: VU (A2cd)

Abies fanjingshanensis W. L. Huang, Y. L. Tu & S. Z. Fang, Acta Phytotax. Sin. 22 (2): 154. 1984. *Abies fargesii* Franch. var. *fanjingshanensis* (W. L. Huang) Silba, Phytologia 68: 15. 1990. Type: China: Guizhou, Yinjiang Tujiazu Miaozu Zizhix, Fanjing Shan, *L. Yang 83–427* (holotype Herb. Dept. Geogr. Guiyang Teach. Coll., isotype PE).

Etymology

The species epithet refers to Mt. Fanjing (Fanjing Shan) on which it occurs.

Vernacular names

fan jing lengshan (Chinese)

Description

Trees to 22 m tall (or more), d.b.h. to 0.65 m (or more); trunk monopodial, straight, columnar, terete; crown (narrowly) pyramidal or oblong cylindrical. Bark of young trees grey, smooth, becoming dark grey or greyish brown, scaly and fissured on lower part of trunk. Branches of first order large, massive, spreading horizontally; branches of second order spreading or ascending. Branchlets stout, firm, light or dark reddish brown, in 2–3 years becoming dark brown, ridged and grooved, glabrous or with pubescence in the grooves; leaf scars circular. Vegetative buds ovoid-globular, 5 × 4 mm, resinous; bud scales broadly triangular ovate, reddish brown, persisting several years. Leaves spirally arranged, crowded, the lower more or less pectinate, in two lateral rows, the others more radially spreading or assurgent and directed obliquely forward, often recurved near shoot apex, 1–4.3 cm long (but mostly less than 2.5 cm), 2–3 mm wide, twisted or curved at base, linear, or the shorter leaves ligulate linear, flattened, longitudinally grooved and light green above, two whitish bands below; apex (slightly) emarginate, also of leaves on coning shoots. Stomata in two bands separated by a narrow midrib below. Pollen cones lateral, axillary, crowded, oblong, 1–1.5 cm long, yellow, with red microsporophylls. Seed cones lateral, erect; peduncles 0.8–1 cm; oval cylindric or barrel shaped, with truncate or umbilicate apex, 5–6(–7) cm long, 3.5–4 cm wide, bluish purple when immature, maturing to dark purplish brown, becoming dark brown when ripe; cone rachis persistent, fusiform, blackish brown. Seed scales broadly cuneate or reniform, length × width at mid-cone 1.5 × 1.8–2.2 cm; surface smooth, or slightly striated, exposed part densely puberulent, apically thickened; upper margin entire, rounded, incurved; base pedicellate ('pedicels' 8–10 mm long, curved). Bracts spathulate-obcordate, with a tiny cusp; upper margin with irregular fine teeth, 1–1.2 cm long, included or slightly exserted. Seeds ovoid-conical, slightly flattened, length × width 6–8 × 3–4 mm, dark brown; seed wings trapezoid-cuneate or dolabriform, 6–8 × 4–6 mm, light brown or reddish brown.

Taxonomic notes

This species is closely related to *Abies fargesii* and is possibly only a subspecies, even though it occurs at least 500 km to the south of the nearest occurrence of *A. fargesii* in the NW of Hubei. Both Farjon (1990) and Flora of China 4: 46 (1999) have recognized it as a distinct species.

Distribution

China: NE Guizhou (Fanjing Shan, near Jiangkou).
TDWG codes: 36 CHC-GZ

Ecology

This rare species has been found on Mt. Fanjing (Wuling Shan) at 2100–2300 m a.s.l. The climate on this mountain is cool and moist, with only a short summer season at this altitude. The species occurs there in a mixed forest with, among other species, *Tsuga chinensis, Acer flabellatum, Rhododendron hypoglaucum, Enkiartnus chinensis* and *Prunus serrulata*. Only a few *Abies* trees are found scattered in the forest.

Conservation

Only known from a single locality with a small population (the number of mature trees is below 2500) in forest dominated by other tree species.

Mt. Fanjing is a forest reserve and the entire population of this species is in the reserve. There is substantial dieback in parts of the population that are exposed to air pollution (acid rain).
IUCN: EN [B1ab(v); C2a(ii)]

Uses

Although potentially a timber tree, this species does not appear to be exploited at present.

Abies fargesii Franch., J. Bot. (Morot) 13 (8): 256. 1899.

Etymology

This species commemorates the French abbé P. G. Farges, who collected it in 1893.

Vernacular names

Farges fir; Bashan lengshan (Chinese)

Description

Trees to 40 m tall, d.b.h. to 1.5–2 m; trunk monopodial, straight, columnar, terete; crown narrowly pyramidal or conical. Bark of young trees smooth, finely flaking, grey, of old trees fissured, brown grey. Branches of first order massive, short, sparse; branches of second order spreading, assurgent, or lower branches pendant. Branchlets slender, firm, reddish brown, purplish or 'mahogany' (variable), shallowly grooved, glabrous, minutely pubescent (in grooves) or densely pubescent on 1st year shoots; leaf scars circular. Vegetative buds ovoid-oblong, (4–)5–8 × 4–5 mm, slightly resinous; bud scales triangular ovate, yellowish brown, persistent for several years. Leaves spirally arranged, crowded in several overlapping ranks of unequal length, the lower leaves pectinate, on coning shoots assurgent, (1–)1.5–3(–4.5) cm long, 2–3.5 mm wide, twisted at base, ligulate-linear or linear, flat or margins slightly revolute; shining green above, whitish or glaucous green below; apex entire, emarginate or bifid, obtuse or acute on cone bearing shoots. Stomata in two bands divided by a midrib on the lower side of leaves. Pollen cones crowded, axillary near shoot apex, small, yellow with red microsporophylls. Seed cones lateral, erect; peduncles very short; cones ovoid-oblong or oval-cylindrical, with obtuse or umbilicate apex, 5–9 cm long, 3–4 cm wide; bluish purple when immature, maturing to purplish or reddish brown. Seed scales cuneate-flabellate, length × width at mid-cone 0.8–1.2 × 1.5–2 cm; surface smooth, puberulent; upper margin rounded, entire; base pedicellate. Bracts obovate-cuneate, 1–1.5 cm long, slightly exserted, straight or with recurved cusps. Seeds oblong, 5–6 × 3–3.5 mm, light brown or blackish; seed wings cuneate, oblique, 6–7 × 4–5 mm, light purplish to nearly black.

Distribution

Western China: S Gansu, W Hubei, Shaanxi, NW Sichuan, N Chongqing, W Henan.
TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHN-GS CHN-SA CHS-HE

Ecology

Abies fargesii occurs in the high montane to subalpine zones of N Central China, at elevations between 2000 m and 4000 m a.s.l. (*A. fargesii* var. *faxoniana* at elevations between 2600 m and 4000 m, with an optimum between 3400 m and 3800 m according to Wang, 1961). Soils are mostly grey brown mountain podzols. The climate is cold and moist. At its lowest elevation broad-leaved trees (e.g. *Fagus engleriana, Davidia involucrata*) are important, but *A. fargesii* mostly forms either pure forests or mixed coniferous forests with among other species *Picea purpurea, P. asperata, P. neoveitchii, P. brachytyla, Larix potaninii, Abies chensiensis, A. recurvata, Tsuga chinensis* and *Taxus chinensis*. Some broad-leaved trees are usually present: *Betula* spp., *Populus* spp., and many shrubs: *Cotoneaster, Ribes, Spiraea, Rhododendron* and *Berberis* are among the common genera (except in dense *Picea-Abies* forest).

Uses

Being the most widespread of firs in the high mountains of western China, this species has been subject to extensive exploitation for its timber. The wood, if of high grade, is used in construction (mainly indoor flooring, framing and joinery), otherwise it is applied in the paper pulp industry. Most botanical collectors active in western China in the first decades

of the 20th century encountered it or its varieties and the species has been introduced to Europe and the USA from these collections. Most trees still in cultivation date from these introductions and are generally confined to botanical gardens and arboreta.

3 varieties are recognized:

Abies fargesii Franch. var. ***fargesii***. Type: China: Chongqing Municipality, Chengkou Xian, Daba Shan, ["Tsjen-keou-tin" (district)], *P. G. Farges 908bis* (holotype P).

Abies fargesii Franch. var. *hupehensis* Silba, Phytologia 68: 15. 1990.

Description

New shoots glabrous or minutely pubescent; buds 6–8 mm long, 4–5 mm wide; leaves with flat margins, apices of leaves on non-coning shoots emarginate to bifid. Seeds dark brown to blackish; wings nearly black.

Distribution

China: S Gansu, W Hubei, Shaanxi, NW Sichuan, N Chongqing, W Henan.
TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHN-GS CHN-SA CHS-HE

Conservation

IUCN: LC

Abies fargesii Franch. var. ***faxoniana*** (Rehd. & E. H. Wilson) T. S. Liu, Monogr. Gen. Abies: 151. 1971. *Abies faxoniana* Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 42. 1914; *Abies delavayi* Franch. var. *faxoniana* (Rehd. & E. H. Wilson) A. B. Jacks., in Chittenden, Cult. Conif.: 246. 1932. Type: China: Sichuan, Min River, Songpan, Ne of Songpan, *E. H. Wilson 4060* (holotype A).

Description

New shoots densely pubescent with ferruginous short hairs; buds 4–5 cm long, 4 mm wide; leaves with flat margins and emarginate apex. Seeds light brown, wings pale, tinged purple.

Distribution

China: NW Sichuan, Gansu.
TDWG codes: 36 CHC-SC CHN-GS

Conservation

Past logging has reduced the population by circa 20+%. Possible on-going risk from acid rain in parts of the population.
IUCN: VU (A2c)

Abies fargesii Franch. var. ***sutchuenensis*** Franch., J. Bot. (Morot) 13 (8): 256. 1899. *Abies sutchuenensis* (Franch.) Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 48. 1914. Type: China: Sichuan, Jiange Xian, Chengkou, *P. G. Farges s.n.* (holotype P).

Abies kansouensis Bordères & Gaussen, Trav. Lab. Forest. Toulouse T. 1 (4, 5): 6. 1944.

Description

New shoots glabrous or minutely pubescent; buds 6–8 mm long, 4–5 mm wide; leaves with slightly revolute margins, apices of leaves on non-coning shoots entire to acute.

Distribution

China: S Gansu, NW Sichuan.
TDWG codes: 36 CHC-SC CHN-GS

Conservation

IUCN: LC

Abies firma Siebold & Zucc., Fl. Japon. 2 (2): 15, t. 107. 1842. Type: Japan: ["in Japonia"], *P. F. von Siebold* comm. 1842 ex herb. Zuccarini No. 284 (lectotype M).

Etymology

The species epithet (Latin: *firmus* = firm, stable) refers to the rigidity of the leaves.

Vernacular names

Momi fir; momi, momi-noki (Japanese)

Description

Trees to 50 m tall, d.b.h. to 2 m; trunk monopodial, massive, straight, columnar, terete; crown open, broad pyramidal, domed or flat topped in old trees. Bark of young trees smooth, with horizontal resin blisters, pinkish grey, in old trees thick, corky, rough, fissured at base. Branches of first order long, spreading horizontally or, especially in young trees, ascending; branches of second order thick, spreading horizontally or ascending. Branchlets firm, yellowish grey, buff grey brown or light brown, grooved, usually quite glabrous or with fine pubescence in grooves of 1st year shoots; leaf scars circular or angular. Vegetative buds ovoid to conical, maximal 10 × 5 mm, not or only slightly resinous; bud scales broad conical, pale (reddish) brown with green margins, persisting several years. Leaves spirally arranged, pectinate in 2–3(–4) ranks of different length, on coning shoots spreading, the upper leaves assurgent, (1–)1.5–3.5(–5) cm long, 2–4 mm wide, narrowed and curved or twisted at base, linear, flattened; lustrous (light) green above, whitish green below; apex obtuse or emarginate (bifid in young trees). Stomata in two broad bands separated by a midrib below, none or a few in a central groove above. Pollen cones solitary in leaf axils, pendulous, 2.5–3 cm long, yellow. Seed cones lateral, erect; peduncles short, with many scales at base; shape ovoid-oblong or conical, with obtuse apex, 8–15 cm long, 3–5 cm wide; yellowish green or green with yellow bracts when immature, maturing to greyish green and becoming yellowish brown when ripe; cone rachis persistent, narrowly conical, brown. Seed scales broad flabellate, length × width at mid-cone 2–2.5 × 2.8–3.2 cm; surface smooth or longitudinally striated, glabrous or sparingly pubescent on exposed parts; upper margin thinner than the rest of the scale, incurved, entire or obscurely denticulate; base short pedicellate. Bracts oblanceolate, 2 cm long, exserted, especially on lower part of cone, straight. Seeds obovate-cuneate, 6–8 mm long, light brown; seed wings broad cuneate, 10–15 mm long, yellowish brown.

Distribution

Japan: Honshu, Kyushu, Shikoku, Yakushima.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Ecology

Abies firma occurs on hills and in mountains of southern and central Japan, at elevations between 50 m and 1200 m a.s.l. (commonly 300 m and 1000 m). The soils are various mountain soils of volcanic origin or alluvial, and mesic. The climate is moist or wet, cool in the north of its range and warm temperate in the south, with annual precipitation above 1000 mm. This species is a constituent of mixed forests (rarely in pure stands on dry sites) with e.g. *Fagus crenata, F. japonica, Castanea crenata, Carpinus laxifolia, Quercus* spp., *Tsuga sieboldii, Pinus parviflora, P. densiflora, Pseudotsuga japonica, Abies homolepis, Cryptomeria japonica, Sciadopitys verticillata, Chamaecyparis obtusa, Torreya nucifera* and *Picea jezoensis* subsp. *hondoensis*.

Conservation

IUCN: LC

Uses

Momi is the most common and widespread fir in southern Japan and there regarded as an important timber tree. Its wood is light, soft and straight-grained and easily worked, but requires careful seasoning to prevent warping. It is used for carpentry making indoor framing, flooring, joinery, crates, boxes etc., but the greatest quantities of its timber are converted to paper pulp. In plantation forestry it is only common in Japan, where old growth stands of this large fir have mostly been logged. Elsewhere, it is only used as an ornamental tree or planted in collections in arboreta and botanic gardens, requiring a climate with mild winters and abundant rainfall.

Abies forrestii Coltm.-Rog., Gard. Chron., ser. 3, 65: 150. 1919.

Etymology

This species was named after the English plant hunter George Forrest (1873–1932).

Vernacular names

Forrest fir; chuandian lengshan (Chinese)

Description

Trees to 40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown broad conical, flat topped in old trees. Bark in young trees smooth, brown grey, in old trees dark brown, fissured at base. Branches of first order long, spreading horizontally, ascending near the top; branches of second order assurgent. Branchlets thick, purplish, reddish or orange brown, often turning grey, smooth or finely grooved, glabrous or (ferruginous) pubescent; leaf scars circular or oval. Vegetative buds globular to ovoid, 4–10 × 3–7 mm, very resinous; bud scales ovate, red brown (covered with white resin), persisting several years. Leaves spirally arranged, dense, covering shoot in several ranks, parting in the middle, assurgent on coning shoots, (1.5–)2–3(–4) cm long, 2–2.5 mm wide, curved or twisted at base, linear or ligulate-linear, flattened; margins flat or slightly revolute; lustrous dark green or bluish green above, two white (sometimes tending to greenish white) bands below; apex emarginate, or acuminate on coning shoots. Stomata in two bands separated by a green midrib below. Pollen cones lateral, 3–4.5 cm long, yellowish, with purple microsporophylls. Seed cones lateral, erect on short peduncles, thick, barrel shaped or cylindrical, with obtuse or retuse apex, 6–10(–14) cm long, 4–5(–6) cm wide, purplish blue with blue bracts when immature, ripening to purplish brown or dark brown; cone rachis persistent, massive, cylindro-conical or fusiform, purplish brown. Seed scales cuneate-obovate, length × width at mid-cone 2 × 1.8 cm; surface smooth or somewhat rough, puberulent; upper margin entire or slightly erose; base pedicellate. Bracts oblong or broadly cuneate-spathulate, 2–3 cm long, with long cusps (–10 mm), much exserted, included or only the cusps exserted, with straight or recurved cusps. Seeds obovate, ca. 8 mm long, lustrous brown; seed wings cuneate-dolabriform, 10 × 8 mm, light brown.

Taxonomic notes

Abies chengii Rushforth was described from cultivated trees in the British Isles, derived from seed collected by George Forrest "somewhere in Yunnan" and was accepted as a species in my book Pinaceae (Farjon, 1990). It is more probably another variety (or a mere form not deserving a botanical name) of *A. forrestii*. A hybrid origin with this species and *A. chensiensis* subsp. *salouenensis* has also been suggested, but without supporting evidence. *Abies forrestii* is evidently a variable species.

Distribution

China: SW Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHT

Ecology

This species (and its varieties) occurs in the high mountains of SW China at elevations between 2400 m and 4300 m a.s.l. (commonly 3000–4000 m), on grey-brown mountain podzols. The climate is cold and wet, annual precipitation ranges from 1000 mm to 2000 mm. The species forms forests in pure stands near the tree limit, or is mixed with *Picea likiangensis, Larix potaninii, Tsuga dumosa* and some broad-leaved trees, e.g. *Betula albo-sinensis, Acer* spp. and *Sorbus* spp. at lower elevations. An ericaceous lower shrub layer with *Rhododendron* spp. is often prominent.

Uses

Forrest fir and and its several varieties occur at high altitudes, often up to the tree line and consequently only yield timber suitable for saw mill processing from larger trees at its lowest altitudinal range. Exploitation has (at least officially) ceased with Chinese forest conservation law now prohibiting logging in old growth forest in the western provinces. Having been collected on numerous occasions by the famous European plant hunters of the early 20th century it was introduced to Europe and the

United States where it is still quite common in arboreta and private large gardens. Most trees labeled *A. delavayi* actually belong to this species (*A. delavayi* has narrow leaves with revolute margins and dark violet-blue or purplish black seed cones). Renewed collecting in recent decades has brought in some new stock on a limited scale. *Abies forrestii* is one of the most attractive species of fir in horticulture and deserves to be made much more widely available. Perhaps China could do some alternative business now that they have ceased logging?

4 varieties are recognized:

Abies forrestii Coltm.-Rog. var. ***forrestii***. *Abies delavayi* Franch. var. *forrestii* (Coltm.-Rog.) A. B. Jacks., in Chittenden, Cult. Conif.: 245. 1932. Type: China: Yunnan, Lijiang Shan, eastern slopes at 27° 25' N, *G. Forrest 6744* (holotype E).

Abies chengii Rushforth, Notes Roy. Bot. Gard. Edinburgh 41: 333. 1983; *Abies forrestii* Coltm.-Rog. var. *chengii* (Rushforth) Silba, Phytologia 68: 17. 1990.

Description

Shoots glabrous. Resin canals in leaves marginal, small. Bracts slightly exserted, or only the cusps exserted, or sometimes entirely included.

Distribution

China: SW Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHT

Conservation

IUCN: LC

Abies forrestii Coltm.-Rog. var. ***ferreana*** (Bordères & Gaussen) Farjon & Silba, Phytologia 68: 17. 1990. *Abies ferreana* Bordères & Gaussen, Trav. Lab. Forest. Toulouse T. 1 (4, 15): 8. 1947. Type: China: Yunnan, Chungtien, Yua-Tse, *T. T. Yü 12326* (holotype TLF).

Abies chayuensis W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975; *Abies forrestii* Coltm.-Rog. var. *chayuensis* (W. C. Cheng & L. K. Fu) Silba, Phytologia 68: 16. 1990.

Abies ferreana Bordères & Gaussen var. *longibracteata* L. K. Fu & Nan Li, Novon 7 (3): 261. 1997.

Description

Shoots pubescent. Resin canals in leaves medial. Seed cones 6–8 cm long.

Distribution

China: NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-YN CHT

Conservation

Logging, especially when followed by grazing (as at Zhongdian where there are yaks), by fire and by the planting of "other" conifer species present an identifiable threat. A past reduction of ca. 50% seems to be a reasonable estimate.
IUCN: EN (A2cde)

Abies forrestii Coltm.-Rog. var. ***georgei*** (Orr) Farjon, Pinaceae (Regnum Veg. 121): 59. 1990. *Abies georgei* Orr, Notes Roy. Bot. Gard. Edinburgh 18: 1, t. 236. 1933; *Abies delavayi* Franch. var. *georgei* (Orr) Melville, Bull. Misc. Inf. R.B.G. Kew 1958: 533. 1959. Type: China: Yunnan, Jinsha-Mekong Divide, *G. Forrest 22547* (holotype E).

Description

Shoots densely pubescent with ferruginous, short hairs; leaves 1.5–3 cm long; margins slightly revolute. Bracts of seed cones exserted, broad and gradually tapering to a short cusp, with erose-denticulate, light brown margins.

Taxonomic notes

In Flora of China 4: 49 (1999) this taxon is treated as a species, as originally described by M. Y. Orr.

Distribution

China: SW Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHT

Conservation

IUCN: LC

Abies forrestii Coltm.-Rog. var. ***smithii*** Viguié & Gaussen, Trav. Lab. Forest. Toulouse T. 1 (2, 1): 177. 1929. *Abies delavayi* Franch. var. *smithii* (Viguié & Gaussen) T. S. Liu, Monogr. Gen. Abies: 143. 1971; *Abies georgei* Orr var. *smithii* (Viguié & Gaussen) W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 63. 1975. Type: China: Yunnan, Lijiang Shan, E slope, *J.F. Rock 10673* (holotype A).

Description

Shoots pubescent. Bracts of seed cones exserting, broad and abruptly narrowing to a long cusp.

Distribution

China: NW Yunnan.
TDWG codes: 36 CHC-YN

Conservation

IUCN: NT

Abies fraseri (Pursh) Poir. in Lamarck, Encycl. Suppl. 5: 35. 1817. *Pinus fraseri* Pursh, Fl. Amer. Sept. 2: 639. 1814; *Abies balsamea* (L.) Mill. subsp. *fraseri* (Pursh) E. Murray, Kalmia 12: 18. 1982. Type: not designated.

Etymology

This species was named after John Fraser (1750–1811) who collected plants in eastern North America, among which was this fir.

Vernacular names

Fraser fir, Fraser's fir

Description

Trees to 15 m tall, d.b.h. to 0.5 m; trunk monopodial, straight, columnar, terete; crown narrowly conical, often open and irregular on exposed sites, broader in solitary trees. Bark of young trees smooth, brown, with numerous horizontal resin blisters, becoming rough, scaly and grey in old trees. Branches of first order long, spreading horizontally or ascending near the top; branches of second order slender, spreading horizontally or assurgent. Branchlets slender, stiff, pale yellowish brown, becoming darker brown in the second year, slightly grooved, densely and rather persistently pubescent with short, reddish hairs; leaf scars circular. Vegetative buds broadly ovoid, 4 × 3 mm, very resinous; bud scales dark reddish brown, but covered with yellowish resin, persistent several years. Leaves spirally arranged, the lower ones pectinate, the upper ones spreading upward and forward, incurved and assurgent especially on coning shoots, 1–2(–2.3) cm long, 2–2.2 mm wide, twisted or curved at base, linear or falcate linear, widest near the obtuse or acute (rarely emarginate) apex, dark green above, two whitish bands below. Stomata in two bands separated by a midrib below, a few in the central groove above. Pollen cones crowded on the lower side of branches, pendulous, 1 cm long, yellow, with red microsporophylls. Seed cones lateral, erect, often crowded, on short peduncles, oblong-conical, with narrowed, obtuse apex, 4–8 cm long, 2.5–4 cm wide, dark purple with yellowish bracts when immature, ripening to purplish brown with pale brown bracts; cone rachis persistent, narrowly conical, dark brown. Seed scales broadly flabellate to reniform, length × width at mid-cone 0.8–1.2 × 1–1.5 cm; surface smooth, puberulent on exposed parts; upper margin entire and incurved; base long pedicellate. Bracts oblong or obovate-oblong, with obcordate apices and short cusps, 1.5–2 cm long, much exserted and reflexed, covering most of the seed scales. Seeds obovate-cuneate, 5–6 mm long, dark purplish black; seed wings obliquely cuneate or dolabriform, 5–6 × 5 mm, purplish brown.

Distribution

USA: W North Carolina, E Tennessee, SW Virginia (Appalachian Mts.).
TDWG codes: 78 NCA TEN VRG

Ecology

On the highest slopes and summits of the Appalachian Mountains, between 1200 m and 2150 m

a.s.l., usually best developed on N-facing slopes. The soils are commonly podzolized and moderately acid. The climate is humid, with cool summers and cold winters with heavy snowfall, annual precipitation varies between 850 mm and 2000 mm. Fraser fir occurs in scattered populations, sometimes pure at the highest elevations, but more often mixed with *Picea rubens* and *Betula papyrifera* above 1500 m, at lower elevations also with *Tsuga caroliniana, Betula alleghaniensis, Sorbus americana, Acer saccharum* and *Fraxinus caroliniana*. *Ericaceae* and various herbs are common in the understorey, often thick moss carpets (*Hylocomium splendens*) cover the forest floor.

Conservation

The disjunct populations of this fir, restricted to the mountain tops and their north-facing slopes of the southern Appalachians, are susceptible to destruction by windfall and fire. However, by far the most damaging agent is an insect, the Balsam woolly adelgid (*Adelges piceae*), discovered in 1957 in *Abies fraseri* on Mt. Mitchell. This alien pest has spread quickly to all populations causing massive dieback through impairment of translocation flow in the cambium. Millions of trees had died by the 1980's and only one substantial population (Mt. Rogers, Virginia) remained largely unaffected. Methods to control this introduced insect are still being researched but none have been fully effective; some small scale protection can be provided by chemical insecticides.
IUCN: EN [B2 (ii, iv, v)]

Uses

The remaining stands of Fraser fir have very limited commercial value as timber trees. The most important use is growing this species for Christmas trees; it is considered the best conifer available in the USA for this purpose. It has a natural 'Christmas tree shape' and retains its fragrant, dark green leaves well for this indoor use. It is also widely used as an ornamental tree for gardens with several cultivars named. At least in the UK it does not usually have a very long life as a garden tree.

Abies grandis (Douglas *ex* D. Don) Lindl., Penny Cyclop. 1: 30. 1833. *Pinus grandis* Douglas *ex* D. Don, in Lambert, Descr. Pinus, ed. 8°, 2: *p. s.n. inter* 144 *et* 145 Type: not designated.

Abies excelsior Franco, Bol. Soc. Brot., ser. 2, 23: 162. 1949.
Abies grandis (Douglas *ex* D. Don) Lindl. var. *idahoensis* Silba, Phytologia 68: 19. 1990.

Etymology

The species epithet is a reference to the great stature this species can attain in its natural habitat.

Vernacular names

Grand fir, Lowland fir, Giant fir

Description

Trees to 80–100 m tall, d.b.h. to 2–3 m; trunk monopodial, straight, columnar, terete; bole often free of branches to considerable height; crown narrowly conical. Bark of young trees thin, smooth and grey brown, with many resin blisters, braking up into many small plates in old trees. Branches of first order long, spreading horizontally, the lower ones curved downward; branches of second order spreading, or ascending near the end of the main branches. Branchlets slender, firm, olive green to reddish brown, with narrow, straight ridges between the leaves, minutely pubescent, but glabrous by the 3rd year; leaf scars small, circular. Vegetative buds globose, 1.5–2 × 1.5 mm, slightly resinous; bud scales triangular, obtuse, red-brown, persisting 2–3 years. Leaves spirally arranged, pectinately spreading in a more or less horizontal plane, the upper ranks shorter than the lower, on coning shoots assurgent, (2–)3–5(–6) cm long, 2–3 mm wide, strongly twisted at base, narrowly linear, flattened with slightly revolute margins, dark glossy green above, greenish white below; apex emarginate or obtuse on coning shoots. Stomata only on the abaxial (lower) surface in two bands separated by a midrib. Pollen cones lateral on the lower sides of branches, axillary, 1.2–1.8 cm long, yellowish green. Seed cones lateral, erect; peduncles very short (cones nearly sessile); shape oblong-cylindrical, with obtuse apex, (5–)7–12 cm long, 3–4 cm

wide, light green or purple tinged when immature, ripening to dull grey-brown, usually very resinous; cone rachis persistent, narrowly conical, brown. Seed scales broad flabellate, length × width at mid-cone 2–2.5 × 2.5–3 cm; surface smooth, in immature cones pubescent; upper margin entire, incurved; base pedicellate. Bracts short, rectangular, with very small cusps, 1–1.5 cm long, entirely included. Seeds cuneate, 8 × 5 mm, pale brown; seed wings cuneate-dolabriform, 10–15 mm long, pale brown with a purple tinge.

Distribution

SW Canada, NW USA: south to N California.
TDWG codes: 71 BRC 73 IDA MNT ORE WAS 76 CAL

Ecology

Grand fir has its optimum in lowland coastal areas of the Pacific Northwest, but occurs also in the Cascade Range and the northern Rocky Mountains, to the west of the Continental Divide. It grows from near sea level to ca. 1800 m a.s.l., on a variety of soils derived from granitic or basaltic rock, best development is on alluvial soils with a relatively high ground water table. In the Pacific Northwest the climate is moist maritime to wet, with annual precipitation from as low as 500 mm to 2500 mm, in the upland interior the winters are snowy and cold, the precipitation ranges from 500 mm to 1250 mm. It grows pure in some areas in Idaho, but is usually mixed with *Pseudotsuga menziesii, Abies amabilis, Picea sitchensis, Calocedrus decurrens, Thuja plicata, Tsuga heterophylla* or *Larix occidentalis* (in the interior). Broad-leaved associated trees are e.g. *Acer macrophyllum, Alnus rubra* (along streams), and *Fraxinus latifolia*, while the shrub layer is formed by *Acer circinatum* in coastal areas and *Amelanchier alnifolia* and *Rosa* spp. in the interior.

Conservation

IUCN: LC

Uses

Rapid growth and great size make this species an important timber tree. The wood is soft and white and an excellent source of pulpwood. For construction timber it is considered less desirable due to its relative weakness and limited durability. In the Pacific Northwest young trees are valued as Christmas trees because they tend to grow up very symmetrically and have lustrous green foliage. Grand fir is commonly grown as an amenity tree in large gardens and city parks and, as another David Doulas introduction, it was planted in nearly all landscape gardens laid out in the 19th century in Europe, where some trees have now attained impressive sizes. In horticulture it is much in use and a substantial number of cultivars have been selected for garden planting.

Abies guatemalensis Rehd., J. Arnold Arbor. 20: 285. 1939.

Etymology

The species epithet refers to Guatemala, from where it was first described.

Vernacular names

Guatemalan fir

Description

Trees to 35–40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown broad conical or dome shaped and open in old trees. Bark in young trees smooth, grey brown, becoming scaly in old trees. Branches of first order long, spreading horizontally, the lower ones curved downward; branches of second order spreading. Branchlets slender, greenish to reddish brown or purplish red, turning dark purple, finally dark grey, ridged and grooved, with minute pubescence or glabrous; leaf scars ovate or circular. Vegetative buds globose to ovoid, 4–5 × 3–3.5 mm, resinous; bud scales broadly triangular ovate, with obtuse apex, reddish brown, persisting 2–3 years. Leaves spirally arranged, in two lateral sets, pectinate to subdistichous, at right angles to shoot or obliquely forward, on coning shoots the upper (shorter) leaves assurgent, (1.2–)1.5–5(–7) cm long, 1.2–2 mm wide, twisted at base, narrowly linear, flattened, with emarginate or sometimes obtuse apex, shining green, with two white bands below.

Stomata absent above or a few near apex, in two bands separated by a midrib below. Pollen cones lateral, 2–2.5(–3.5?) cm long, yellowish. Seed cones lateral, erect, subsessile, oblong-cylindrical, with obtuse or truncate apex, 8–12(–16) cm long, 4–5.5 cm wide, purple when immature, becoming dark brown when ripe; cone rachis persistent, narrowly conical, blackish brown. Seed scales transversely oblong to reniform, length × width at mid-cone 2–2.5 × 3 cm; surface smooth, puberulent; upper margin erose-denticulate or entire, slightly revolute; base pedicellate. Bracts cuneate-obovate, with short triangular cusps, 1.2–1.7 cm long, included or slightly exserted. Seeds cuneate-obovoid, 8–9 mm long, light brown; seed wings broad, obliquely obovate, 10–15 × 10–15 mm, light brown.

Distribution

El Salvador; Guatemala; Honduras; S Mexico along the Sierra Madre del Sur to Jalisco and Zacatecas.
TDWG codes: 79 MXE-TA MXS-GR MXS-JA MXS-MI MXS-OA MXT-CI 80 ELS GUA HON

Ecology

Abies guatemalensis is the southernmost species of the genus: it reaches 14° 49' N in the Guatemalan highlands. It grows from 1800 m to 3700 m a.s.l. on the Pacific side of the Sierra Madre del Sur, in Guatemala usually between 3300 m and 4100 m, on well drained mountain soils of volcanic origin. The climate is cool, moist oceanic, with most precipitation as rain in the winter, or as fog the year round in Guatemala. Var. *guatemalensis* occurs between 3500 m and 3800 m a.s.l. in the mountains of Chiapas, at a greater distance from the ocean than the other varieties. Guatemalan fir is usually associated with several highland pines, e.g. *Pinus ayacahuite, P. montezumae, P. hartwegii, P. pseudostrobus* and *P. devoniana*, also with *Abies religiosa* in W Guatemala and with *Cupressus lusitanica* in Chiapas. At lower elevations *Juniperus* spp., *Quercus* spp. and *Arbutus* spp. become more important.

Conservation

Listed on CITES Appendix I.

Uses

Guatemalan fir occurs in scattered stands on high mountains, often in quite inaccessible places, and is therefore only of limited importance as a timber tree. Like *A. hickelii*, it is locally worked in sawmills for domestic use in carpentry, plywood and veneer. In Guatemala, there is trade in the foliage branches for semi-natural Christmas trees and the species is also grown in plantations for that purpose. Its southern distribution has made it an unlikely tree to be tried in horticulture in Europe and North America, but provenances from the highest altitudes could be more or less hardy, certainly in the SW USA and southern Europe, where it is, however, still rarely seen even in botanical collections. A few trees grow in botanic gardens in England and in California.

2 varieties are recognized:

Abies guatemalensis Rehd. var. ***guatemalensis***.
Type: Guatemala: Huehuetenango, Las Cumbres del Aire, *J. H. Faull 13104* (holotype A).

Abies tacanensis Lundell, Amer. Midl. Naturalist 23: 175. 1940; *Abies guatemalensis* Rehd. var. *tacanensis* (Lundell) Martínez, Pinaceas Méxic., ed. 3: 129. 1963.
Abies zapotekensis Debreczy, Rácz & Ramírez, Phytologia 78 (3): 9. 1995.
Abies guatemalensis Rehd. var. *longibracteata* Debreczy & Rácz, Phytologia 78 (3): 11. 1995.

Description

New shoots at first purple, turning dark grey. Leaves (1.2–)1.5–4(–5.5) cm long. Pollen cones 2–2.5 cm long when shedding pollen. Seed cones 8–12 cm long, 4–5.5 cm wide; bracts shorter or as long as the seed scales, minutely cuspidate.

Distribution

El Salvador; W Guatemala; Honduras; Mexico from Chiapas to Nayarit and Tamaulipas.
TDWG codes: 79 MXE-TA MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 ELS GUA HON

Conservation

IUCN: EN [A2acd; B2ab(i, ii, iii, iv, v)]

Abies guatemalensis Rehd. var. ***jaliscana*** Martínez, Anales Inst. Biol. Univ. Nac. México 19: 73. 1948.
Type: Mexico: Jalisco, Talpa de Allende, Cuale, Las Mesas, *M. Martínez 28000* (holotype MEXU).

Abies religiosa (Kunth) Schltdl. & Cham. var. *emarginata* Loock *ex* Martínez, Anales Inst. Biol. Univ. Nac. México 19: 60. 1948.
Abies flinckii Rushforth, Notes Roy. Bot. Gard. Edinburgh 46: 101. 1989.

Description

New shoots initially greenish, turning light reddish brown. Leaves 3.5–7 cm long. Seed cones 9–14(–16) cm long, (3–)4–5 cm wide; bracts or bract cusps exserted. Pollen cones possibly longer than in var. *guatemalensis*, but insufficiently known.

Distribution

Mexico: Jalisco, Michoacán.
TDWG codes: 79 MXS-JA MXS-MI

Conservation

IUCN: VU (A2acd)

Abies hickelii Flous & Gaussen, Trav. Lab. Forest. Toulouse T. 1 (1, 17): 1. 1932.

Etymology

This species was named after the French botanist and dendrologist R. Hickel.

Vernacular names

Hickel's fir; oyamel, pinabete (Mexican Spanish)

Description

Trees to 30 m tall, d.b.h. to 1–1.3 m; trunk monopodial, straight, columnar, terete; bole often bare of branches to a considerable height; crown narrowly conical, or wider and more open in old trees. Bark of young trees smooth, grey, of old trees thick, breaking into quadrangular plates. Branches of first order spreading horizontally; of second order spreading or ascending. Branchlets slender, purplish or reddish brown, ridged and grooved between the leaves, glabrous or with minute pubescence in the grooves; leaf scars small, ovate or circular. Vegetative buds ovoid or globular, 5 × 4 mm, very resinous; bud scales triangular ovate, brown, but covered in yellowish resin, persisting several years. Leaves spirally arranged, pectinate, in two lateral sets at about right angles to shoot, of about equal length or the upper ranks shorter, on coning shoots the upper leaves assurgent, (1.2–)1.8–3.5 cm long, 1–1.8 mm wide, twisted or curved at base, shining light green above, glaucous below; apex emarginate or sometimes obtuse. Stomata in two bands separated by a midrib below, none or a few near apex above. Pollen cones lateral, short, yellow with red microsporophylls. Seed cones lateral, erect, short pedunculate, oblong-cylindrical, with obtuse apex, 6–8(–12) cm long, 2.5–3.5(–5) cm wide, purple when immature, ripening to dark brown; cone rachis persistent, cylindric-conical, blackish brown. Seed scales cuneate-flabellate, length × width at mid-cone 1.3–1.5 × 1.8–2 cm; surface smooth, hirsute-puberulent; upper margin rounded, entire; base pedicellate. Bracts oblong-lanceolate, 2 cm long, exserted, straight. Seeds obovate-cuneate, 6–7 mm long, light brown; seed wings broad cuneate, 10 × 8 mm, light brown.

Taxonomic notes

In a recent paper Strandby *et al.* (2009) presented a morphometric study of the genus *Abies* in Mexico and Central America. They proposed to reduce *A. hickelii* to a subspecies of *A. religiosa* on the basis of their results. This paper came too late for these results to be thoroughly considered (or tested) and therefore this new taxonomy is merely noted here.

Distribution

Mexico: Chiapas, Guerrero, Oaxaca, Puebla, Veracruz.
TDWG codes: 79 MXC-PU MXG-VC MXS-GR MXS-OA MXT-CI

Ecology

Both varieties of this species occur in high mountains of sub-tropical S Mexico, at elevations between 2500 m and 3400 m a.s.l. The soils are of volcanic origin. The climate is cool, moist oceanic, with rain mostly in the winter. There are some pure stands at the highest elevations, but this species is usually mixed with highland pines, e.g. *Pinus montezumae, P. pseudostrobus*, and *P. ayacahuite*, and also with *Cupressus lusitanica* and *Quercus* spp. Shrubs are e.g. *Vaccinium* spp., *Andromeda* spp., *Ribes* spp. and *Fuchsia* spp.

Uses

Hickel's fir is a rare species and its two varieties occur in more or less disjunct, limited stands. Exploitation for timber is minor and its use is local, mainly worked in sawmills for domestic purposes. In cultivation it is extremely rare and limited to some dendrological collections in countries with mild climate, e.g. southern France.

2 varieties are recognized:

Abies hickelii Flous & Gaussen var. ***hickelii***. Type: Mexico: Oaxaca, Sierra de San Felipe (?), 1900, *C. Conzatti s.n.* (holotype LY).

Description

Seed cones 6–8(–9) cm long, 2.5–3.5 cm wide.

Distribution

Mexico: Chiapas, Oaxaca, Puebla, Veracruz.
TDWG codes: 79 MXC-PU MXG-VC MXS-OA MXT-CI

Conservation

IUCN: EN [B2ab (ii, iii, v)]

Abies hickelii Flous & Gaussen var. ***oaxacana*** (Martínez) Farjon & Silba, Phytologia 68: 20. 1990. *Abies oaxacana* Martínez, Anales Inst. Biol. Univ. Nac. México 19: 39. 1948. Type: Mexico: Oaxaca, *M. Martínez 29000* (holotype MEXU).

Abies hickelii Flous & Gaussen var. *macrocarpa* Martínez, Anales Inst. Biol. Univ. Nac. México 13 (2): 621. 1942.

Seed cones 9–12 cm long, ca. 5 cm wide.

Distribution

Mexico: Guerrero, Oaxaca.
TDWG codes: 79 MXS-GR MXS-OA

Conservation

IUCN: EN [B2ab (ii, iii, v)]

Abies hidalgensis Debreczy, Rácz & Guízar, Phytologia 78 (3): 4. 1995. Type: Mexico: Hidalgo, Metepec, 4–5 km N of the village, *Z. Debreczy et al. DAPC 40323* (holotype BP).

Etymology

This species was named after the Mexican State of Hidalgo; the name also recalls Miquel Hidalgo y Costilla (1762–1811), after whom the State was named.

Vernacular names

No common name has been given to this species.

Description

Trees monopodial; trunk columnar, straight (max. height and diam. not given); crown columnar-conical. Bark smooth, light grey in young trees, on large trunks breaking into irregular, large plates, thick; inner bark red. Branches spreading and ascending, higher orders descending in lower part of the tree. Foliage branchlets robust, smooth or ridged and grooved on leading shoots, new shoots

densely pubescent with short, yellowish brown hairs. Vegetative buds small, partly hidden by short, incurving leaves, slightly resinous; bud scales triangular. Leaves pectinately arranged, distichous, shortest on the upperside of branchlets, (1–)3–5(–6) cm long, 1.5 mm wide, linear, curving slightly downward or forward, shortly bifid or emarginate at apex, lustrous dark green or dull greyish green, with white stomatal bands on the abaxial side; stomata in few to several lines on the upperside, in two white bands below separated by a green midrib; resin canals 2–5, medial, in leaves on coning branches up to 7. Pollen cones lateral, crowded, 10–12 mm long, yellow, with puberulent microsporophylls. Seed cones lateral, erect, short pedunculate, cylindrical, 6.5–8 cm long, 3.5–4 cm wide, pruinose green at maturity, with obtusely rounded or slightly umbilicate apex; cone rachis narrowly conical. Seed scales flabellate to wide cyathiform, green to greyish green, densely velutinous with very short, white, appressed hairs. Bracts short, 5–8 mm long, spathulate, with serrate margins, without a protruding cusp, entirely included. Seeds narrowly triangular with resin blisters (size not given); seed wings yellowish grey (not fully developed at time of description).

Taxonomic notes

The type collection, Debreczy *et al.* DAPC 40323 (holotype BP, isotypes A, E, K, MEXU) was gathered 4.5 km N of the village of Metepec. The number of resin ducts in the leaves, given as 5–7 in the protologue, is highly unusual in the genus, but *A. hickelii* has 4–12. *Abies hidalgensis* could be nothing more than a variety of *A. hickelii* with included bracts in the seed cones. It is only known from the type specimens deposited in the herbaria cited above. More material is needed to establish its taxonomic position, the species is here given the benefit of the doubt.

Distribution

Mexico: Hidalgo (canyon near village of Metepec).
TDWG codes: 79 MXE-HI

Ecology

This species occurs in a steep canyon in the Sierra Madre Oriental at an altitude of ca. 2000–2300 m a.s.l. on the moist, eastern slopes in cloud forest. It is associated with *Cupressus lusitanica, Pinus patula, P. pseudostrobus* and *P. teocote*; among broad-leaved trees *Quercus laurina, Ternstroemia pringlei* and *Cestrum* sp. dominate, with *Alnus firmifolia, Buddleia cordata, Ptelea trifoliata* and *Sambucus mexicanum* as frequent understorey trees and shrubs.

Conservation

This species was described and named as new in 1995 from a single location in Hidalgo, Mexico. Its distribution beyond the type locality remains unknown and no subsequent collections have been assigned to this new species.
IUCN: VU (D2)

Uses

No uses are known, or likely, of this species. It has not been taken into cultivation.

Abies holophylla Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 10: 487. 1866. Type: China: ["Manchuria"], 8 Sep 1869, *C. J. Maximowicz s.n.* (holotype LE).

Abies holophylla Maxim. var. *aspericorticea* Y. Y. Sun, Bull. Bot. Res. (China) 25 (3): 264. 2005.

Etymology

The species epithet means 'entire leaf' and refers to the undivided leaf apex.

Vernacular names

Needle fir, Manchurian fir; shansong (Chinese)

Description

Trees to 30–50 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown shape broad pyramidal, young trees with narrowing top. Bark of young trees smooth, grey to buff orange, in old trees shallowly fissured, scaly and brown. Branches of first order long, spreading horizontally; branches of second order spreading horizontally or assurgent.

Branchlets stout, firm, yellowish to grey-brown or buff orange, with ridges and grooves between the leaves, glabrous, or with only minute pubescence in grooves of 1st year shoots; leaf scars oval circular, light coloured. Vegetative buds ovoid-conical, 4–8 × 3–5 mm, more or less resinous; bud scales triangular with blunt apices, prominently keeled, light brown or reddish brown, persisting several years. Leaves spirally arranged, radial and assurgent on leading and coning shoots, subdistichous and/or more or less pectinate in shaded shoots, 2–4.5 cm long, 2–2.5 mm wide, twisted or curved at base, linear, tapering towards an acute or mucronate apex, flattened, lustrous light green above, pale whitish green with a green midrib and margins below. Stomata in two bands divided by a midrib below, none or a few near apex above. Pollen cones lateral, clustered, 1–1.5 cm long, yellow with reddish microsporophylls. Seed cones lateral, erect; peduncles 0.5–1 cm, scaly; shape oblong-cylindrical, with obtuse or truncate apex, 6–14 cm long, 3–4.5 cm wide, pale green when immature, sometimes with a purple tinge, maturing to yellowish green and ripening to light yellowish brown; cone rachis persistent, narrowly conical, brown. Seed scales flabellate, length × width at mid-cone 2 × 3 cm; surface smooth, puberulent on exposed parts, often very resinous; upper margin entire, slightly incurved; base pedicellate. Bracts oblong-spathulate, with small cusps, 0.8–1 cm long, included. Seeds cuneate, ca. 6 × 4 mm, light brown; seed wings cuneate, with a truncate, oblique end, ca. 13 × 10 mm, light brown.

Distribution

NE Asia: from mountains N of Vladivostok to South Korea, also in Heilongjiang, Jilin and Liaoning Prov., China.

TDWG codes: 31 PRM 36 CHM-HJ CHM-JL CHM-LN 38 KOR-NK KOR-SK

Ecology

Abies holophylla occurs in NE China in low to medium high mountains, in SE Siberia and N Korea also in hills and on lowland plains. Its elevational range is from 10 m to 1200 m a.s.l. in the north, to 500–1500 m a.s.l. in the south of its range. It grows on lithosols of granitic origin. The climate is cold, with wet summers and arid winters with long periods of snow. At higher elevations or in the NE of its range it forms pure stands, or more commonly mixed coniferous forests with *Pinus koraiensis*, especially in the coastal mountains near the Sea of Japan. In other areas it is a constituent of the northern mixed coniferous deciduous forests, with *Abies nephrolepis, Picea obovata, Larix gmelinii* (var. *olgensis*) and broad-leaved trees, such as *Populus* spp., *Quercus mongolica, Fraxinus mandshurica, Ulmus* spp., and *Betula ermanii*.

Conservation

IUCN: NT

Uses

Manchurian fir is a valuable timber tree in its native area and is exploited mainly in managed forests in much of the region. Most of its wood today is used for plywood and veneer as it is evenly grained, light and easily worked. Minor uses are for soundboards in musical instruments, boxes and sometimes for joinery. In Europe it was introduced around 1905, but, although perfectly hardy and ornamental, remains an uncommon tree mainly seen in arboreta and botanic gardens of the northern hemisphere's cooler regions.

Abies homolepis Siebold & Zucc., Fl. Japon. 2 (2): 17, t. 108. 1842. Fig. 8

Etymology

The species epithet (Greek/Latin: *homo* = equal, the same; *lepis* = scale) refers to the similar length of seed scales and bracts.

Vernacular names

Nikko fir; dake-momi, nikko-momi (Japanese)

Description

Trees to 35–40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown broad pyramidal, in old trees often flat topped. Bark of young trees smooth, with papery flakes, grey with pinkish hues, of old trees rough and broken into plates, dark

grey-brown. Branches of first order long, spreading horizontally; branches of second order spreading horizontally or assurgent. Branchlets stout, firm, lustrous light yellowish brown, ridged and deeply grooved, glabrous; leaf scars circular or ovate. Vegetative buds ovoid-conical, 3–5 × 2–4 mm, resinous; bud scales triangular, keeled, reddish brown, persisting several years. Leaves spirally arranged, more or less distichous, but pectinate on shaded shoots, assurgent to recurved on coning shoots, but usually parted above, (1–)1.5–3(–3.5) cm long, 2–3.5 mm wide, slightly twisted or curved at base, linear or ligulate-linear, flattened, deeply grooved and lustrous green above, two whitish bands below; apex obtuse or emarginate. Stomata in two broad bands separated by a midrib below. Pollen cones lateral, crowded, pendulous, yellow. Seed cones lateral, erect, often several together; peduncles 0.5 cm; shape oblong-cylindrical, with obtuse or umbilicate apex, 7–10(–14) cm long, 2.5–3.5(–5) cm wide, violet blue or greenish when immature, violet-brown or brown when ripe; cone rachis persistent, narrowly conical, blackish brown. Seed scales broadly flabellate to flabellate, length × width at mid-cone 1.5–2 × 2.5–3 cm; surface smooth, puberulent, often very resinous; upper margin entire, incurved; base pedicellate. Bracts rectangular-oblong, 1 cm long, included. Seeds cuneate, 6 × 4 mm, light brown; seed wings cuneate-dolabriform, 10 × 8 mm, yellowish brown.

Distribution

Japan: central Honshu, Shikoku.
TDWG codes: 38 JAP-HN JAP-SH

Ecology

Abies homolepis is a species of high mountains in the central parts of the Japanese islands Honshu and Shikoku. In the south it occurs from 1100 m to 1800 m a.s.l., in Honshu between 700 m and 2000 m. The soils are mesic, derived from volcanic rock and usually well drained. The climate is cool and humid. Near the tree limit it forms either pure stands, or mixtures with *A. veitchii* and/or *Larix kaempferi*, but at lower elevations it occurs in the mixed coniferous deciduous forests, with e.g. *Fagus crenata, Quercus crispula, Betula grossa, Tsuga diversifolia, Thuja standishii* and *Pinus densiflora; A. firma* replaces *A. homolepis* below 1100 m.

Uses

Nikko fir is not an important timber tree as its range is limited and it occurs at high altitudes. It is fairly widely planted as an ornamental tree in Japan as well as in Europe, where it appears to be one of the least demanding species in the genus. A few cultivars are known in Japan as well as in Europe (independently derived), mostly being dwarfed forms suitable for Japanese gardens or rockeries.

2 varieties are recognized:

Abies homolepis Siebold & Zucc. var. ***homolepis***. Type: Japan: ["in Japonia"], *P. F. von Siebold* comm. 1842 ex herb. Zuccarini No. 290 (lectotype M).

Abies brachyphylla Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 10: 488. 1866; *Abies firma* Siebold & Zucc. var. *brachyphylla* (Maxim.) Bertrand, Bull. Soc. Bot. France 18: 380. 1871.

Description

Seed cones 7–10 cm long, 2.5–3.5 cm wide, violet-blue; apex obtuse.

Distribution

Japan: central Honshu, Shikoku.
TDWG codes: 38 JAP-HN JAP-SH

Conservation

IUCN: NT

Abies homolepis Siebold & Zucc. var. ***umbellata*** (Mayr) E. H. Wilson, Conif. Tax. Japan: 58. 1916; *Abies umbellata* Mayr, Monogr. Abiet. Japan. Reich.: 34, t. 1, f. 2. 1890; *Abies brachyphylla* Maxim. var. *umbellata* (Mayr) Dallim. & A. B. Jacks., Handb. Conif.: 88. 1923. Type: not designated.

Description

Seed cones 10–14 cm long, 4–5 cm wide, greenish; apex more or less umbilicate.

Distribution

Japan: central Honshu (Saitama, Aichi, Gifu).
TDWG codes: 38 JAP-HN JAP-SH

Conservation

IUCN: DD

Abies kawakamii (Hayata) T. Itô, Encycl. Japon. 2: 167. 1909. *Abies mariesii* Mast. var. *kawakamii* Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25 (19): 223. 1908. Type: Taiwan: Nantou, Chia-i Pref., Yu-Shan, ["Mt. Morrison"], *T. Kawakami & U. Mori 2369* (lectotype TI). Fig. 9

Etymology

The species epithet commemorates the Japanese plant collector T. Kawakami.

Vernacular names

Taiwan fir; Taiwan lengshan (Chinese)

Description

Trees to 16–20 m tall, d.b.h. to 0.5–1 m; trunk monopodial, straight, terete, in some old trees bent, but otherwise erect; crown broad pyramidal, on mountain tops irregular and open. Bark of young trees smooth, soon flaking, light grey or yellowish grey, in old trees becoming rough and scaly, greyish brown. Branches of first order heavy and long, spreading horizontally or curved; branches of second order spreading or assurgent. Branchlets stout, firm, pale yellowish brown, with prominent ridges and grooves, light brown pubescence in grooves, on cone bearing shoots pubescence red brown; leaf scars circular. Vegetative buds conical-ovoid, 4–5 mm long, very resinous; bud scales triangular, keeled, purple-brown, persisting several years. Leaves spirally arranged, spreading radially, pectinate below shoot, shorter and assurgent above shoot, covering it entirely, on coning shoots assurgent, (0.8–)1–2.2(–2.5) cm long, 1.5–2 mm wide, slightly twisted or curved at base, linear-falcate, flattened, lustrous green above, whitish green below; apex emarginate or obtuse, acuminate on cone bearing shoots. Stomata in two narrow bands separated by a midrib below. Pollen cones lateral, crowded, 1 cm long, yellowish. Seed cones lateral, erect, short pedunculate, oblong-cylindrical, with obtuse or umbilicate apex, (3–)5–7(–9) cm long, 2.5–4 cm wide, dark purple when immature, dark purple-brown when ripe; cone rachis persistent, cylindric-conical or narrowly fusiform, dark purplish brown. Seed scales flabellate, length × width at mid-cone 1.5–1.7 × 2–2.3 cm; surface smooth, puberulent; upper margin erose; base pedicellate. Bracts obcordate-rectangular, with very small cusps, 1–1.3 cm long, included. Seeds cuneate-oblong, 6–8 mm long, blackish brown; seed wings cuneate (oblique), 6–10 mm long, light brown with a black tinge.

Distribution

Taiwan (central mountains).
TDWG codes: 38 TAI

Ecology

A high mountain species, occurring between 2400 m and 3800 m a.s.l. in the central high mountains of Taiwan, on grey brown podzolized soils and also on mountain yellow earth, both acid and usually rocky. The climate is temperate, super humid: above humid subtropical foothills the annual precipitation exceeds 4000 mm, with maxima up to 10,000 mm, making the Taiwanese central high mountains one of the wettest mountain ranges in the world. There are some pure forests on N and NE slopes at these high elevations (3200 m to 3600 m a.s.l.), or the species occurs mixed with scattered *Pinus armandii* var. *mastersiana, Tsuga chinensis* var. *chinensis, Picea morrisonicola*, and with *Juniperus squamata* var. *morrisonicola* at the upper limit of *Abies*. At lower elevations the forest becomes progressively more mixed with broad-leaved trees, e.g. *Acer insulare, Trochodendron aralioides, Quercus semecarpifolia* subsp. *glabra, Ilex bioritsensis*, and *Eurya* spp. Other conifers in this belt are *Tsuga chinensis* var. *chinensis*, which becomes more abundant than *Abies kawakamii* between 2400 m and 3000 m a.s.l., *Pseudotsuga sinensis*, and *Chamaecyparis obtusa* var. *formosana*, which is more abundant below 2400 m (Liu, 1971).

Conservation

Logging of this species, which occurred mainly during the period of Japanese occupation (1895–1945), has ceased almost completely and substantial populations now occur within national parks and other reserves. Its limited distribution and occurrence in a mosaic with subalpine bamboo grassland makes it vulnerable to fires that could be caused by much increased tourism.
IUCN: NT

Uses

The timber of this species was formerly exported to Japan, where it was used for general carpentry. It is little used for this purpose today in Taiwan. This species was introduced to England in 1930 and is occasionally found in arboreta in Europe and North America, but remains uncommon in cultivation.

Abies koreana E. H. Wilson, J. Arnold Arbor. 1: 188. 1920. Type: South Korea: Cheju-do, Halla-san, ["Hallai-san Quelpart Island"], *E. H. Wilson 9486* (holotype A). Fig. 10

Abies koreana E. H. Wilson f. *nigrocarpa* Hatus., Bull. Kyushu Univ. Forest. 5: 40. 1934.

Etymology

The species name denotes its origin, Korea where Ernest Wilson discovered it.

Vernacular names

Korean fir

Description

Trees to 15–18 m tall, d.b.h. to 0.5–0.8 m; trunk monopodial, straight, columnar, terete; crown broad pyramidal. Bark of young trees smooth, thin, with resin blisters, light grey with a purplish tinge, in old trees becoming thick and rough, breaking into irregular plates near base, greyish black. Branches of first order densely set to low above the ground, spreading horizontally, the lower curved downward; branches of second order spreading, ascending near the top. Branchlets slender, firm, yellowish grey or grey-green, shallowly grooved between the leaves, sparsely pubescent in the grooves, soon glabrous; leaf scars circular. Vegetative buds subglobose, 4–5 × 3–4 mm, very resinous; bud scales obtuse, membranous, brown, persisting several years. Leaves spirally arranged, radially spreading, the upper leaves shorter and curved upward or recurved, especially so on coning shoots, (0.8–)1–2(–2.2) cm long, 2–2.5 mm wide, slightly twisted or curved at base, linear-spathulate (often widest near the apex), flattened, with slightly revolute margins, lustrous dark green above, two white bands and green midrib and margins below; apex emarginate, obtuse or sometimes acute. Stomata none or a few near the apex above, in two broad bands separated by a midrib below. Pollen cones lateral, clustered around shoot, 1 cm long, yellowish with scarlet microsporophylls. Seed cones lateral, erect, often crowded together, numerous, even on the lower branches; peduncles 0.4–0.6 cm; shape cylindrical, with obtuse, umbilicate or papilliform apex, 4–7 cm long, 2.5–3 cm wide, purple or violet blue with greenish bracts when immature, maturing to purplish brown, with light brown bracts, ripening to dull brown or purplish brown; cone rachis persistent, narrowly conical, dark brown. Seed scales reniform, or wing-shaped (Liu, 1971, p. 45), length × width at mid-cone 1–1.2 × 1.2–1.6 cm; surface smooth, pubescent; upper margin erose, incurved; base pedicellate. Bracts broadly spathulate-obcordate, 1.2–1.5 cm long, exserted, (strongly) reflexed. Seeds cuneate, 4–6 mm long, light or dark brown, with a purple tinge; seed scales cuneate-dolabriform, 4–6 mm long, light brown, tinged with purple.

Distribution

North Korea (Mt. Daeseong); South Korea (Chiri-san, Halla-san [Cheju Island], Kaya-san, Kongo-san, Mudung-san, Tokyu-san).
TDWG codes: 38 KOR-NK KOR-SK

Ecology

On the medium high mountains of South Korea it occurs only at the higher elevations and summits, on shallow mountain soils poor in humus content. Its elevational range is between 1000 m and 1900 m a.s.l. The climate is cool temperate, with a summer monsoon bringing the annual precipitation above

1600 mm. *Abies koreana* grows in pure stands or mixed with *Betula ermanii* on Cheju Island; on the mainland it is also mixed with *Picea jezoensis, Pinus koraiensis, Taxus cuspidata, Quercus mongolica* var. *mandshurica, Cornus controversa, Acer* spp., and several genera of low shrubs, e.g. *Juniperus, Deutzia, Ribes* and *Rhododendron*. The forest is usually open and essentially dominated by conifers, of which *A. koreana* is often a minor component.

Conservation

IUCN: EN [B2ab (ii, iii, v)]

Uses

Korean fir is a small to medium sized tree that grows slowly and together with its rarity these qualities make it unsuitable as a timber tree. It is, however, perhaps the most widely used species in the genus for gardens. Its small stature, compact growth and the appearance of decorative seed cones even in very small trees have made it a target of growers for the selection of several cultivars. Wilson's original introduction came from Cheju Island (Quelpart Island) where trees remain small; later introductions from mainland Korea have produced better growing trees and, after nearly a century some have reached good size. The colours of bracts and seed scales of cones vary much and are one of the attractions of this conifer.

Abies lasiocarpa (Hook.) Nutt., N. Amer. Sylva 3: 138. 1849.

Etymology

The species epithet describes the strongly pubescent (hairy) 'fruits' (i.e. seed cones).

Vernacular names

Subalpine fir, Alpine fir

Description

Trees to 30–35 m tall, d.b.h. to 1–1.2 m; trunk monopodial, straight, columnar, terete; crown narrowly conical, forming a graceful spire. Bark of young trees smooth, thin, with horizontal resin blisters, white or grey, in old trees becoming thicker, creamy white or grey, fissured and brown or grey towards base. Branches of first order very dense, down to near the ground, short, spreading horizontally, pendant below, the ends curved upward; branches of second order spreading. Branchlets slender, pliable, very strong, pale brown, soon grey, with prominent ridges and grooves, pubescent with short brown hairs; leaf scars circular. Vegetative buds globose or subglobose, 3.5–6 × 3–5 mm, very resinous; bud scales obtuse, keeled, brown, persisting several years. Leaves spirally arranged, the lower longest and pectinate, the other leaves radially spreading, the upper leaves curved forward and assurgent, especially so on coning shoots, 2.5–4.5 cm long, 1.5–2 mm wide, slightly twisted at base, narrowly linear, curved or bent near base, flattened, longitudinal groove on the upper surface shallow, glaucous green, with 2 whitish bands below; apex obtuse to acute or weakly emarginate. Stomata in several rows in the adaxial groove, in two bands separated by a strong midrib below. Pollen cones lateral, usually crowded, pendulous, 1.5–2 cm long, yellow, with purplish blue microsporophylls. Seed cones lateral, erect, shortly pedunculate or sessile, oblong-cylindrical, with obtuse apex, 7–10 cm long, 2.5–3.5 cm wide, purple, or purplish green with greyish pubescence when immature, becoming purplish brown or brown with yellowish pubescence when ripe; cone rachis persistent, narrowly conical, dark brown. Seed scales cuneate-trapeziform, length × width at mid-cone 1.5–2.5 × 1.3–2.3 cm; surface smooth, strongly pubescent with yellowish brown hairs; upper margin entire, curved inward; base pedicellate. Bracts oblong, with small cusp, 0.6–1 cm long, included. Seeds cuneate-oblong, 5–6 mm long, brown; seed wings cuneate-oblong, with oblique end, 10–18 mm long, light brown tinged with purple.

Distribution

W North America: from Yukon to New Mexico, Arizona and N California.

TDWG codes: 70 ASK NWT-MK YUK 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 76 ARI CAL NEV UTA 77 NWM

Ecology

This is a species of the subalpine zone in the high mountains of W North America, occurring from

5 m to 1500 m a.s.l. in the north of its range and between 600 m and 3500 m in the Cascade Range and Rocky Mountains. It grows on a variety of high mountain lithosols, wet or dry. The climate is everywhere cold, but humid in the NW and dry in the S of its range, precipitation varies between 500 mm and 3000 mm annually. It forms usually very open stands with solitary or clustered trees, often mixed with *Tsuga mertensiana* in the NW and with *Picea engelmannii* in most of the Rocky Mountains. Other conifers are mainly *Pinus* spp., and also *Abies* spp. in the Pacific Northwest. Alpine meadows typically occur between the clumps of conifers.

Uses

Subalpine fir has little or no importance as a timber tree even though its wood properties are generally similar to other species of fir. To a large extent this is of course due to the rich heritage of conifers western North America enjoys above many other parts of the world; there is no need to use them as timber trees. Subalpine fir also tends to grow slowly, remains relatively small and grows in inaccessible places. It may be used locally for construction timber, doors, window frames, boxes and other such products, but the wood tends to be knotty due to the retention of branches. Although it naturally grows into the perfect Christmas tree shape, it is rarely used as such, because it grows slowly and cutting it from its habitat is environmentally destructive. It is also little used in horticulture (except perhaps cultivars derived from var. *arizonica*) for taking it into the lowlands of temperate regions usually exposes it to damage from 'late' frosts.

2 varieties are recognized:

Abies lasiocarpa (Hook.) Nutt. var. ***lasiocarpa***.
Pinus lasiocarpa Hook., Fl. Bor. Amer. 2 (10): 163. 1838; *Abies balsamea* (L.) Mill. subsp. *lasiocarpa* (Hook.) Boivin, Naturaliste Canad. 86 (10): 223. 1959. Type: USA: Washington, Columbia River, *D. Douglas s.n.* (holotype K).

Abies subalpina Engelm. var. *fallax* Engelm., Trans. St. Louis Acad. Sci. 3: 597. 1878; *Abies lasiocarpa* (Hook.) Nutt. var. *fallax* (Engelm.) Franco, Abetos: 15. 1950.

Description

Bark on large trunks relatively thin, grey-brown, fissured towards base.

Distribution

W North America: from Yukon to New Mexico and N California.
TDWG codes: 70 ASK NWT-MK YUK 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 76 CAL NEV UTA 77 NWM

Conservation

IUCN: LC

Abies lasiocarpa (Hook.) Nutt. var. ***arizonica*** (Merriam) Lemmon, Bull. Sierra Club 2: 167. 1898. *Abies arizonica* Merriam, Proc. Biol. Soc. Washington 10: 116. 1896; *Abies balsamea* (L.) Mill. subsp. *lasiocarpa* (Hook.) Boivin var. *arizonica* (Merriam) Boivin, Naturaliste Canad. 86 (10): 223. 1959; *Abies lasiocarpa* (Hook.) Nutt. subsp. *arizonica* (Merriam) E. Murray, Kalmia 12: 18. 1982; *Abies bifolia* A. Murray bis var. *arizonica* (Merriam) O'Kane & K. D. Heil, Harvard Pap. Bot. 7 (2): 324. 2003. Type: not designated.

Description

Bark on large trunks thick, creamy white, increasingly fissured towards base.

Distribution

USA: Arizona, Colorado, New Mexico.
TDWG codes: 73 COL 76 ARI 77 NWM

Ecology

Var. *arizonica* is most commonly mixed in forests with *Picea engelmannii, Pinus aristata* and *P. flexilis*, or it occurs in pure stands, at elevations between 2400 m and 3650 m a.s.l.

Conservation

IUCN: LC

Abies magnifica A. Murray bis, Proc. Roy. Hort. Soc. London 1863 (3): 318. 1863. Fig. 11

Etymology

The species epithet means 'magnificent' or 'outstanding' or any equivalent adjective.

Vernacular names

Red fir, California red fir

Description

Trees to 60–70 m tall, d.b.h. to 2–3 m; trunk monopodial, massive, straight, columnar, terete; crown narrowly conical, in old trees open. Bark of young trees smooth, with resin blisters, grey or light purplish grey, in old trees thick, rough, deeply fissured below, brown. Branches of first order relatively short, spreading, the lower bent downward or pendant; branches of second order spreading horizontally, pendant at last. Branchlets slender, strong but pliable, light brown or greenish, with ridges and grooves between leaves, for about two years densely pubescent with reddish brown hairs; leaf scars circular. Vegetative buds ovoid globose or more conical, small, hidden by terminal short leaves, not resinous; bud scales triangular, keeled, brown puberulent, persisting 2–3 years. Leaves spirally arranged, spreading laterally, but curved inward above shoot, on coning shoots assurgent and strongly curved, concealing shoot, 2–3.5 cm long, 1.3–1.6 mm wide, (abruptly) curved at base, narrowly linear, curved, only slightly flattened, no groove above, glaucous grey green on both sides; apex obtuse or acute. Stomata in two separate rows of lines above, in two bands separated by a midrib below. Pollen cones lateral, crowded, pendulous, 1.5–2 cm long, with scarlet microsporophylls. Seed cones lateral, erect, short pedunculate or sessile, broad conical or barrel shaped, with truncate or umbilicate apex, (10–)13–20 cm long, (5–)7–10 cm wide, purplish green when immature, maturing to yellowish brown or greenish brown, ripening to light brown; cone rachis persistent, narrowly conical, dark brown. Seed scales cuneate-flabellate, length × width at mid-cone (2.5–)3–4 × (2.5–)3–4 cm; surface smooth, densely pubescent with yellowish brown hairs; upper margin entire and incurved; base long pedicellate. Bracts oblong-spathulate, with a short cusp, 2–3.5 cm long, included or exserted and reflexed. Seeds cuneate-oblong, 13–15 × 5–6 mm, dark brown; seed wings cuneate, 15–20 mm long, lustrous roseate brown.

Distribution

USA: California, W Nevada, SW Oregon.
TDWG codes: 73 ORE 76 CAL NEV

Ecology

Abies magnifica occurs in the Canadian Life Zone of high mountains, between 1400 m and 2700 m a.s.l. (to 3000 m in the south of its range); commonly on soils of granitic (Sierra Nevada) or basaltic (Cascade Range) origin, which have been altered by glaciation and are usually slightly acid. The climate is characterized by short, warm and dry summers and long, cold winters with much snow. Annual precipitation varies between 750 mm and 1500 mm (80 % as snow). This species forms pure stands in some places, but more often it is a constituent of the mixed coniferous forest type with e.g. *Pinus* spp., *Abies concolor, A. procera, Pseudotsuga menziesii, Calocedrus decurrens, Juniperus occidentalis*, and at higher elevations *Abies lasiocarpa* and *Tsuga mertensiana* subsp. *grandicona*. Common shrubs are e.g. *Ceanothus cordulatus, Chrysolepis sempervirens* and *Arctostaphylos nevadensis*.

Uses

California red fir grows to large dimensions with extremely straight boles and has a high wood production per ha even in natural, unmanaged stands. It is therefore increasingly valuable as a timber tree used for general construction and plywood. This species is also valued as a Christmas tree, both grown in natural stands and in plantations. It is relatively rare in amenity plantings with few cultivars known; most existing planted trees date from the heydays of landscape conifer plantings in the 19th century.

2 varieties are recognized:

Abies magnifica A. Murray bis var. ***magnifica***. Type: USA: California, Sierra Nevada, *W. Lobb 441* (holotype K).

Description

Seed cones 14–20 cm long, 7–10 cm wide; bracts included.

Distribution

USA: California, W Nevada, SW Oregon.
TDWG codes: 73 ORE 76 CAL NEV

Conservation

IUCN: LC

Abies magnifica A. Murray bis var. ***shastensis*** Lemmon, [Cone-bearers Calif.] Calif. State Board Forest. Bienn. Rep. 3: 145. 1890. *Abies shastensis* (Lemmon) Lemmon, Gard. & Forest 10: 184. 1897. Type: not designated.

Description

Seed cones 10–13 cm long, 5–8 cm wide; bracts exserted and reflexed.

Taxonomic notes

Opinions vary among authors: Liu (1971) and Silba (1986) have treated this variety as a natural hybrid between *Abies magnifica* and *A. procera*, Rushforth (1987) kept it as a variety of *A. magnifica* and Little (1979) treated it as a synonym of *A. magnifica*. It seems to occur within the northern range of *A. magnifica* and the extreme southern range of *A. procera* and 'transitional' cone types are found in a broad zone with its southern limit around Lassen Peak in N California (R. J. Laacke in Burns & Honkala, 1990). Exserted bracts are a character state of *A. procera* and *A. magnifica* var. *magnifica* has only slightly smaller cones than that species, unlike the substantially smaller cones of var. *shastensis*. These character states are probably not constant within *A. magnifica* as there is a population of the latter in the southern Sierra Nevada, well beyond the transition zone, that shows exserted bracts. Artificial crossing experiments indicate the possiblity of introgression via pollen from *A. procera* into *A. magnifica*.

Distribution

USA: from Lassen Peak in California to Crater Lake in Oregon.
TDWG codes: 73 ORE 76 CAL

Conservation

IUCN: LC

Abies mariesii Mast., Gard. Chron., ser. 2, 12: 788. 1879. Type: Japan: Honshu, Awomori Pref., Nikko-san, *C. Maries 73* (holotype K). Pl. 2

Etymology

This species was named after C. Maries, who collected it on Mt. Nikko (Mt. Hakkoda) in 1878.

Vernacular names

Maries' fir; o-shirabiso (Japanese)

Description

Trees to 25–30 m tall, d.b.h. to 0.8–1 m; trunk monopodial, straight, columnar, terete; crown broad pyramidal, flat topped in old trees. Bark of young trees smooth, pale grey, nearly white, scaly and rough near base and dark grey in old trees. Branches of first order long, spreading wide, soon curved down to pendant; branches of second order spreading horizontally, dense. Branchlets firm, slender, light brown, ridged and grooved between the leaves, densely pubescent with brown hairs, but soon glabrous and light grey; leaf scars circular. Vegetative buds globose, covered by apical leaves, 2–3 mm long, resinous; bud scales brown, ciliate, persistent for 2–3 years. Leaves spirally arranged, the lower leaves pectinate, the upper ones curved inward and forward, shorter, covering shoots, on cone bearing branches almost erect, (0.6–)1–2(–2.5) cm long, 1.6–2.5 mm wide, widest near apex, strongly twisted and narrowed at base, linear, the upper leaves more ligulate

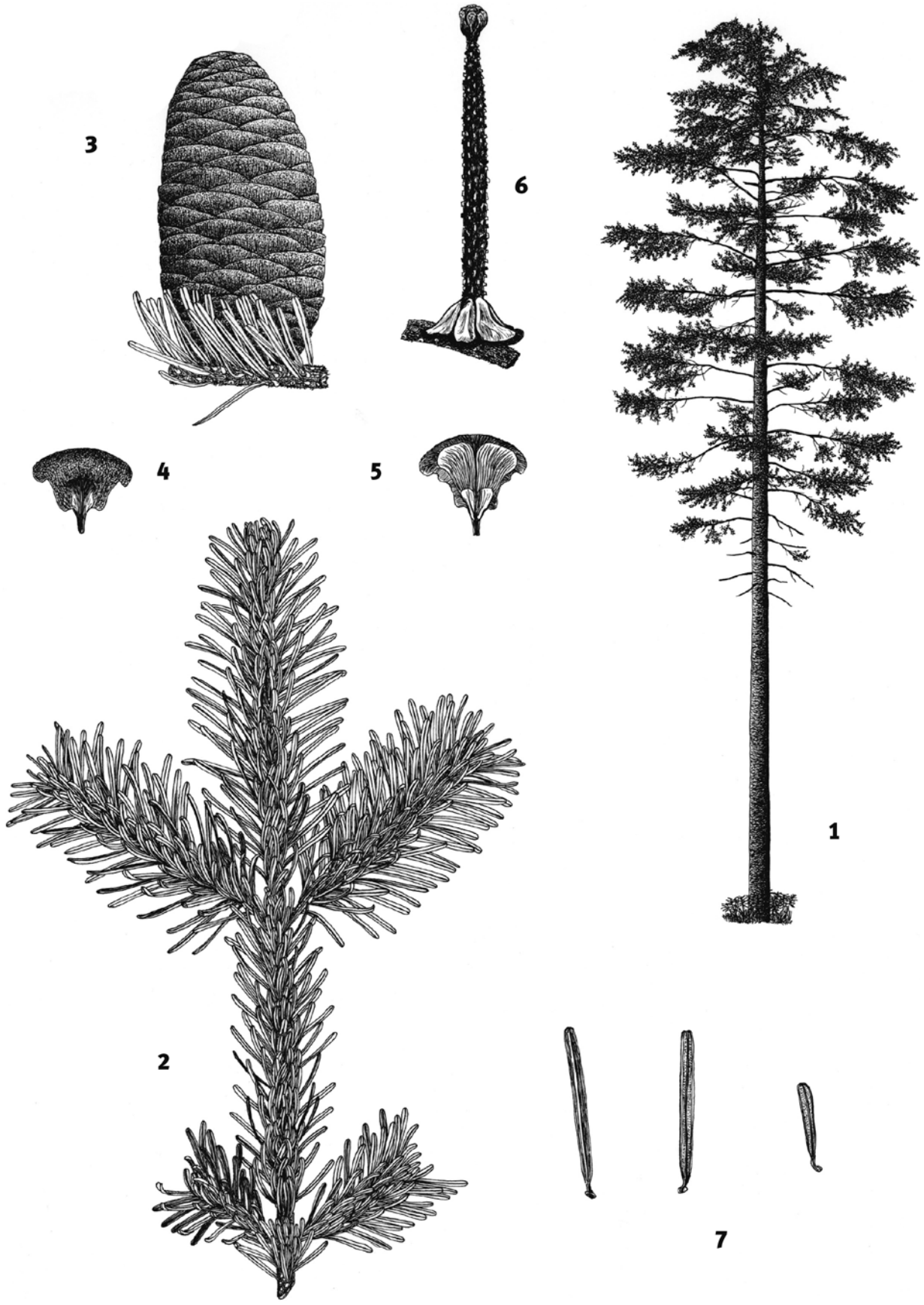


PLATE 2. *Abies mariesii.* **1.** Habit of tree. **2.** Foliage branch. **3.** Seed cone. **4, 5.** Seed scales with bract (4), with seeds (5). **6.** Rachis of seed cone. **7.** Leaves.

and curved, flattened, grooved above, with slightly revolute margins and emarginate apex (obtuse on coning shoots), lustrous dark green above, 2 white bands below separated by green midrib. Stomata in two bands separated by a midrib on lower surface only. Pollen cones lateral, axillary, pendulous, 1.5–2 cm long, yellowish. Seed cones lateral, short pedunculate or sessile, ovoid-oblong, with obtuse apex, 4–9 cm long, 2–4.5 cm long, violet-blue, ripening to dark blackish purple (brown inside); cone rachis persistent, narrowly conical, blackish brown. Seed scales cyathiform-flabellate, length × width at mid-cone 1.5–2.2 × 2–2.5 cm; surface smooth, puberulent on exposed parts; upper margin entire, incurved; base pedicellate. Bracts obovate or obcordate, 1–1.5 cm long, included. Seeds conical-ovoid, (4–)5–7 mm long, light brown; seed wings cuneate, 10–12 × 8 mm, light brown, with a purplish tinge.

Distribution

Japan: Honshu.
TDWG codes: 38 JAP-HN

Ecology

A species of the high mountain sides and ridges in the upper montane and subalpine zones, occurring commonly between 1000 m and 2800 m a.s.l. (as low as 750 m in N Honshu). The soils are mostly derived from volcanic rock, usually podzolic and slightly acid or neutral, well drained, and moderately moist (mesic). The climate is cold, with abundant winter snow and cool, moist summers, the annual precipitation exceeds 2000 mm in the mountains nearest to the Sea of Japan. Frequent typhoons are a destructive force reducing the maximum age of trees. *Abies mariesii* forms sometimes pure forests near the tree line, but is more common in mixed (coniferous) forests with e.g. *Abies veitchii, Tsuga diversifolia, Picea jezoensis* var. *hondoensis* and/or undergrowth of *Pinus pumila* and *Juniperus communis* var. *nipponica*, the latter two especially abundant on ridgetops. Common broad-leaved trees are *Betula ermanii, Sorbus commixta*, and *Acer* spp. In many previously disturbed areas with deep, fine textured soil, e.g. volcanic ash, there is a dense cover of small bamboo (*Sasa paniculata* and *S. nipponica*), which excludes most other plants (Franklin *et al.*, 1979).

Conservation

IUCN: LC

Uses

This species of fir has little value as a timber tree because it grows at high altitude and mostly in inaccessible localities. In horticulture it is rather uncommon despite its attractive dark green foliage leaves and contrasting white stomatal bands underneath. It is not at all tolerant of droughts and performs best in cool, wet conditions but on light, well-drained soils. It is mostly restricted to collections in botanic gardens and arboreta.

Abies nebrodensis (Lojac.) Mattei, Boll. Reale Orto Bot. Palermo 7: 64. 1908. *Abies pectinata* Gilib. var. *nebrodensis* Lojac., Fl. Sicula 2 (2): 401. 1904–1907; *Abies alba* Mill. var. *nebrodensis* (Lojac.) Svoboda, Trudy Bot. Inst. Akad. Nauk S.S.S.R., ser. 1, Fl. Sist. Vyss. Rast. 13: 60. 1964; *Abies alba* Mill. subsp. *nebrodensis* (Lojac.) Nitz., Lustgården 1968: 178. 1969. Type: not designated. Fig. 12

Abies pectinata Guss., Fl. Sicula Syn. 2: 614. 1844, *non* Gilib. (1792).

Etymology

The species epithet refers to the Monti Nebrodi, an alternative name for the Madonie Mountains where this species was discovered.

Vernacular names

Sicilian fir

Description

Trees to 10–15 m tall in Sicily at present, but may grow taller, d.b.h. to 0.4–0.6 m; trunk monopodial, straight, columnar, terete; crown (broad) conical (the only living old tree in the wild had its top broken off). Bark of young trees smooth, light grey, becoming rough and scaly with age, fissured at base. Branches of first order spreading horizontally; branches of second order idem. Branchlets

stout, firm, yellowish green, shiny, turning grey, with prominent ridges between the leaves, glabrous, or minutely pubescent in the first year; leaf scars circular, with a light central part. Vegetative buds conical, 8–9 × 4–6 mm, slightly resinous; bud scales triangular-ovate, laciniate, protruding, light brown, persisting several years. Leaves spirally arranged, spreading laterally in two sets, or the upper leaves covering shoot and directed forward, the lower leaves pectinate on shaded shoots, leaves on coning shoots assurgent, (1–)1.5–2(–2.2) cm long, 2–3.5 mm wide, twisted or curved at base, linear-ligulate, flattened, longitudinally grooved above, bright, lustrous green on the adaxial (upper) surface, two greenish white bands on the lower surface; apex variable: acute or mucronate, on shaded shoots obtuse but not emarginate. Stomata none or a few near the apex above, in two bands separated by a midrib below. Pollen cones lateral, crowded, 1.5–2 cm long, greenish yellow with purple microsporophylls. Seed cones lateral, erect, short pedunculate, cylindrical, with a conical apex, (7–)8–10(–12) cm long, 3–4 cm wide, yellowish green when immature, ripening to greenish brown (light reddish brown inside); cone rachis persistent, narrowly conical, brown. Seed scales cuneate-cyathiform, length × width at mid-cone 2–2.5 × 2.8–3.3 cm; surface smooth or slightly wrinkled, puberulent on exposed parts; upper margin entire or undulate; base pedicellate. Bracts linear-spathulate, 2.5–3 cm long, exserted and recurved. Seeds conical-oblong, 6–8 mm long, reddish brown; seed wings cuneate, oblique, 10–15 mm long, light brown.

Distribution

Italy: Sicily (Madonie Mountains: Monte Scalone, Polizzi Generosa).
TDWG codes: 13 SIC-SI

Ecology

A very local remnant population occurs in high mountains at around 1500 m a.s.l., on calcareous, rocky soil. Summers are warm and dry, winters mild and moist, the annual precipitation is 700 to 800 mm. No real forest stand is left of this once abundant species. It is today restricted to a few scattered trees associated with secondary maquis, in which *Quercus petraea* and, at its highest (potential) limit, *Fagus sylvatica* are the most common low trees. *Juniperus communis* forms dense ground covering carpets and could provide protection for seedlings of *A. nebrodensis* against dehydration and/or grazing and browsing animals.

Conservation

Abies nebrodensis is one of the rarest conifers in the world, with only 29 individual plants remaining in the wild in 2006. Most of these are small trees growing on heavily overgrazed scree slopes with clumps of *Fagus sylvatica* and *Quercus petraea* scatterd among them. Extensive logging since the beginning of the 18th century had brought this species to the brink of extinction when it was 'discovered' nearly a century ago in a nearby village, and more recently the remaining trees in the valley of Madonna degli Angeli on Mt. Scalone. An extensive *ex situ* conservation programme both locally and abroad is in operation but attempts at re-introduction have to date not been very successful due to harsh summer conditions and a totally depleted soil. New attempts funded by the EU and providing initial planting compost and watering in summer may be more successful; protection from direct sunlight, erosion and grazing are also essential. Ultimately the forest ecosystem has to be restored for the survival of this relict conifer.
IUCN: CR (D)

Uses

The cultivation of this species in several countries of Europe north of the Alps has been very successful and many trees are now growing well in arboreta and other collections. The next phase may well see it develop into a popular amenity tree. While this development is a positive one, at least safeguarding a threatened species from total oblivion, it is not to be seen as a substitute for conservation of the natural population. *Ex situ* conservation, i.e. safeguarding species outside their habitat, is an effort to breed individuals with the aim of re-introducing them or their propagules in the wild once the causes of decline have been eliminated. Most trees planted outside their natural habitat will remain where they are, and their seed, if viable, is without proper precautions taken usually not guaranteed free from

the genes of other species. As the synonymy given above indicates, this taxon has (not without reason) been interpreted as merely a variety or a subspecies of the European fir *Abies alba* and there is no doubt that it will hybridize with that species if the two are brought (once more?) together.

Abies nephrolepis (Trautv. *ex* Maxim.) Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 10: 486. 1866. *Abies sibirica* Ledeb. var. *nephrolepis* Trautv. *ex* Maxim., Mém. Acad. Imp. Sci. Saint-Pétersbourg (Sav. Etr.) 9: 206. 1859. Type not designated. Pl. 3

Abies ×*sibiriconephrolepis* Taken. & J. J. Chien, Acta Phytotax. Sin. 6 (1): 153. 1957.

Etymology

The species epithet is a Greek word composition: *nephrolepis* = with kidney-shaped scales.

Vernacular names

Hinggan fir, Khinghan fir; chou lengshan (Chinese); Pikhta amurskaya, Pikhta belokoraya (Russian)

Description

Trees to 30–35 m tall, d.b.h. to 1–1.2 m; trunk monopodial, straight, columnar, terete; crown conical or oval, old trees with densely branched flat tops ("stork's nests"). Bark of young trees smooth, light grey to greyish brown, in old trees shallowly fissured, dark greyish brown. Branches of first order spreading horizontally, those near the top ascending, the lowest drooping; branches of second order spreading horizontally, dense. Branchlets slender, firm, yellowish grey brown, turning to grey; surface ridged and grooved, with minute pubescence in the grooves; leaf scars circular. Vegetative buds ovoid or conical, broad, 5 × 4 mm, resinous, especially near apex; bud scales triangular, blunt, brown or purplish red, appressed, persisting several years. Leaves spirally arranged, radially around shoot, directed forward and assurgent, covering the upper part of shoot, 1–2.5(–3) cm long, 2 mm wide, strongly twisted at base, linear, flattened, with slightly revolute margins, dull, light (grey-)green, with whitish green bands below; apex variable: emarginate, obtuse, acute or acuminate. Stomata none or a few near apex above, in two bands divided by a midrib below. Pollen cones lateral, axillary, crowded at the underside of foliage, yellowish green with purple microsporophylls. Seed cones lateral, erect, often several crowded together, short pedunculate, cylindrical, with obtuse apex, 4.5–7.5 cm long, 2–3.5 cm wide, usually reddish purple and rarely green when immature, maturing to purplish brown, becoming dull brown when ripe; cone rachis persistent, narrowly conical, dark brown with blackish purple tinge. Seed scales reniform, length × width at mid-cone 1–1.2 × 1.5–1.8 cm; surface smooth, often covered with thick clots of yellowish white resin, puberulent on exposed parts; upper margin entire or slightly erose, incurved; base pedicellate. Bracts spathulate, with prominent, straight cusps, 1.4–2 cm long, only the cusps exserted. Seeds obovate-cuneate, 5 × 3 mm, blackish brown or shining black; seed wings short, dolabriform, with rounded edges, 6 × 5 mm, blackish brown or black.

Taxonomic notes

A natural hybrid between *A. sibirica* and *A. nephrolepis* has been reported from Heilongjiang Province, China: *Abies* ×*sibirico-nephrolepis* Taken. & Chien. Its leaves are described as being shorter than those of *A. nephrolepis* and its young shoots are greyish brown pubescent, while the seed cones are larger. Other character states are intermediate between the two parent species. It is reported to be common in river valleys in the Lesser Hinggan Range. The occurrence of *A. sibirica* in this region is not confirmed by other accounts (e.g. Flora of China 4, 1999) and the hybrid status of the firs in this area is doubtful.

Distribution

Russian Far East: from the Zeya River to the Sikhote Alin Range; NE China: Manchuria, Shaanxi, south to Shanxi (Wutai Shan); North Korea and South Korea. **TDWG codes:** 31 AMU KHA PRM 36 CHM CHN-HB CHN-SA 38 KOR-NK KOR-SK

Ecology

This is a species of low to medium high mountains, occurring at elevations between 500 m and 700 m a.s.l. in E Siberia at the northern limit of its range,

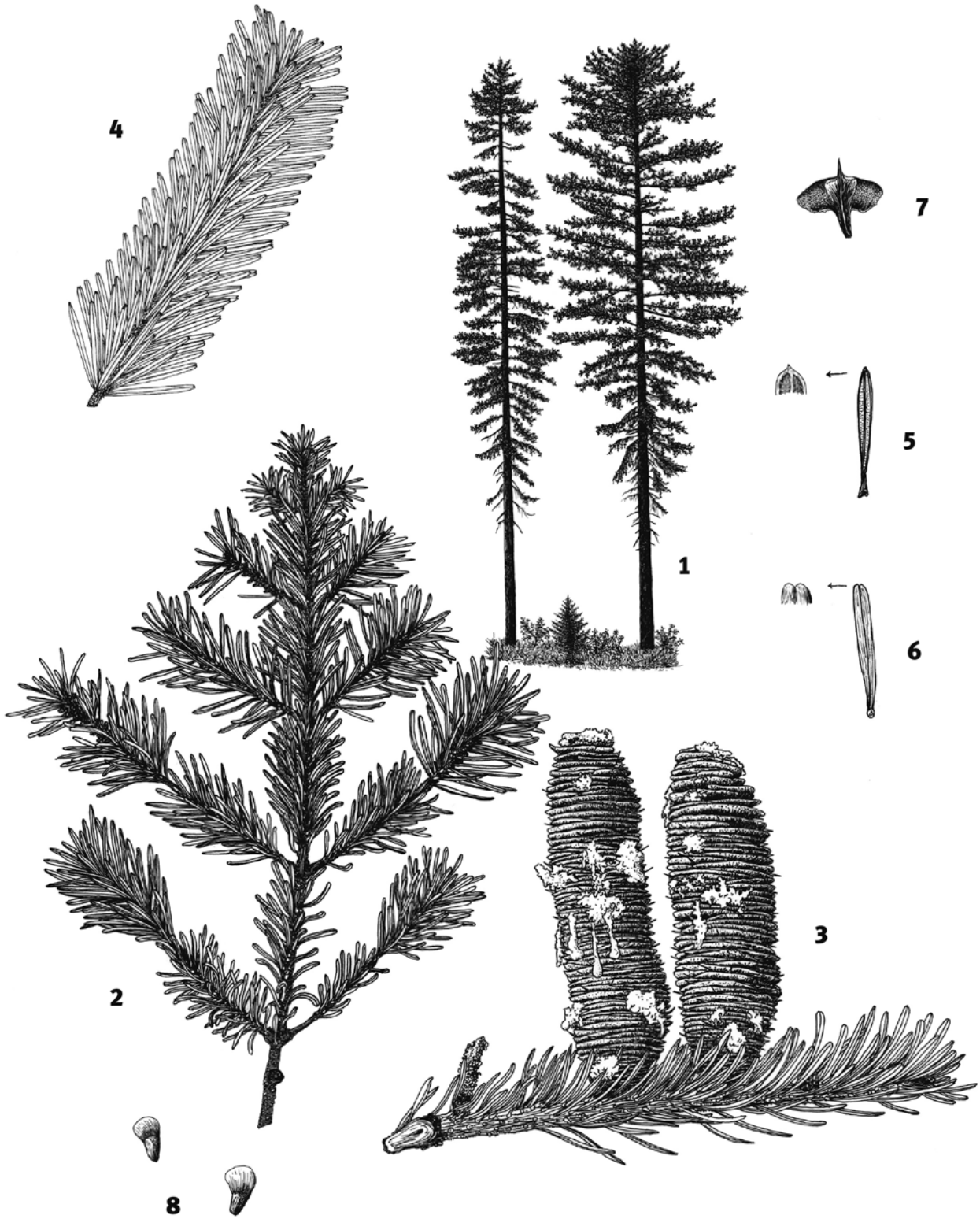


PLATE 3. *Abies nephrolepis.* **1.** Habit of trees. **2.** Foliage branch. **3.** Branch with seed cones. **4.** Detail of foliage. **5, 6.** Leaves. **7.** Seed scale with bract. **8.** Seeds.

between 750 m and 2000 m a.s.l. in NE China. This species grows on a variety of well drained mountain soils. The climate is cold, with short, cool and moist summers and long, cold winters. Most of the annual precipitation is snow. It is usually associated with other conifers, e.g. *Pinus koraiensis* and *Picea jezoensis*; also with *Pinus pumila* and *Juniperus sabina* var. *davurica* at higher elevations (maritime provinces of the Russian Far East); in the interior with *Picea obovata, Larix gmelinii, Pinus sibirica* or *Abies sibirica*. *Betula* spp. and *Sorbus amurensis* are common associated broad-leaved trees.

Conservation

IUCN: LC

Uses

Hinggan fir is an important timber tree in NE China and Korea. Its wood is used in carpentry and for plywood and veneer. The relatively small size of this tree on marginal sites makes exploitation commercially unlikely; the better, larger trees come from mixed conifer forests at middle elevations in the mountains. In horticulture, it was introduced to Great Britain in 1908 from the botanic garden in St. Petersburg, Russia. It remains a rarely planted species, which is susceptible to damage by late spring frosts in countries with an Atlantic maritime climate.

Abies nordmanniana (Steven) Spach, Hist. Nat. Vég. Phan. 11: 418. 1841. Pl. 4

Etymology

This species was named after the botanist A. von Nordmann, who introduced it to horticulture in 1838.

Vernacular names

Caucasian fir, Nordmann fir; Pikhta kavkazkaya (Russian)

Description

Trees to 50 m tall, d.b.h. to 1.5–2 m; trunk monopodial, straight, columnar, terete; crown broad conical or pyramidal, old trees often flat topped. Bark of young trees smooth, grey, in old trees rough, shallowly fissured, blackish grey-brown. Branches of first order spreading, ascending in upper part of crown; branches of second order spreading horizontally, assurgent near the top. Branchlets slender, firm, light olive brown or brown, ridged and grooved, with brown pubescence in grooves or glabrous; leaf scars circular, light. Vegetative buds ovoid, with pointed apex, 6 × 5 mm, not resinous or resinous; bud scales ovate, acute, keeled and with laciniate edges, red-brown, persisting several years. Leaves spirally arranged, pectinate below, the upper leaves pressed forward above shoot, on coning shoots assurgent, (1.5–)2–3(–3.5) cm long, 1.5–2.5 mm wide, strongly twisted at base, linear, flattened, sometimes with slightly revolute margins, grooved above, lustrous dark green above, two whitish green bands below; apex emarginate, obtuse on coning shoots. Stomata in two bands separated by a midrib below. Pollen cones lateral, crowded, pendulous, 1–2 cm long, yellowish. Seed cones lateral, erect, often crowded, short pedunculate, ovoid-cylindrical, with pointed and often papilliform apex, (10–)12–16(–20) cm long, 4–5.5(–6) cm wide, greenish when immature, ripening to light brown (reddish brown inside); cone rachis persistent, narrowly conical, dark brown. Seed scales flabellate or cyathiform, length × width at mid-cone 1.8–2.5 × 2.7–4 cm; surface smooth, slightly striated, pubescent on exposed parts; upper margin entire, often repand, slightly incurved; base pedicellate. Bracts spathulate-obcordate, with laciniate edges and a short or long cusp with midrib, 2.7–3.5 cm long, exserted and reflexed. Seeds cuneate, 10–12 × 7–8 mm, fawn brown, shiny; seed wings cuneate, with rounded edge, 15–18 × 15 mm, light purplish brown or rose, turning fawn brown.

Taxonomic notes

It is now generally accepted that the firs of NW Turkey are conspecific with *Abies nordmanniana*, which has its main distribution in the Caucasus Mountains. The disjunct populations of NW Turkey have been known as and are sometimes still accepted as two distinct species: *A. bornmuelleriana* (Ulu-Dagh) and *A. equi-trojani* (Kaz-Dagh), but the morphological differences between the two are minor and the character states are overlapping, not discrete. It seems better to recognize just one subspecies for the

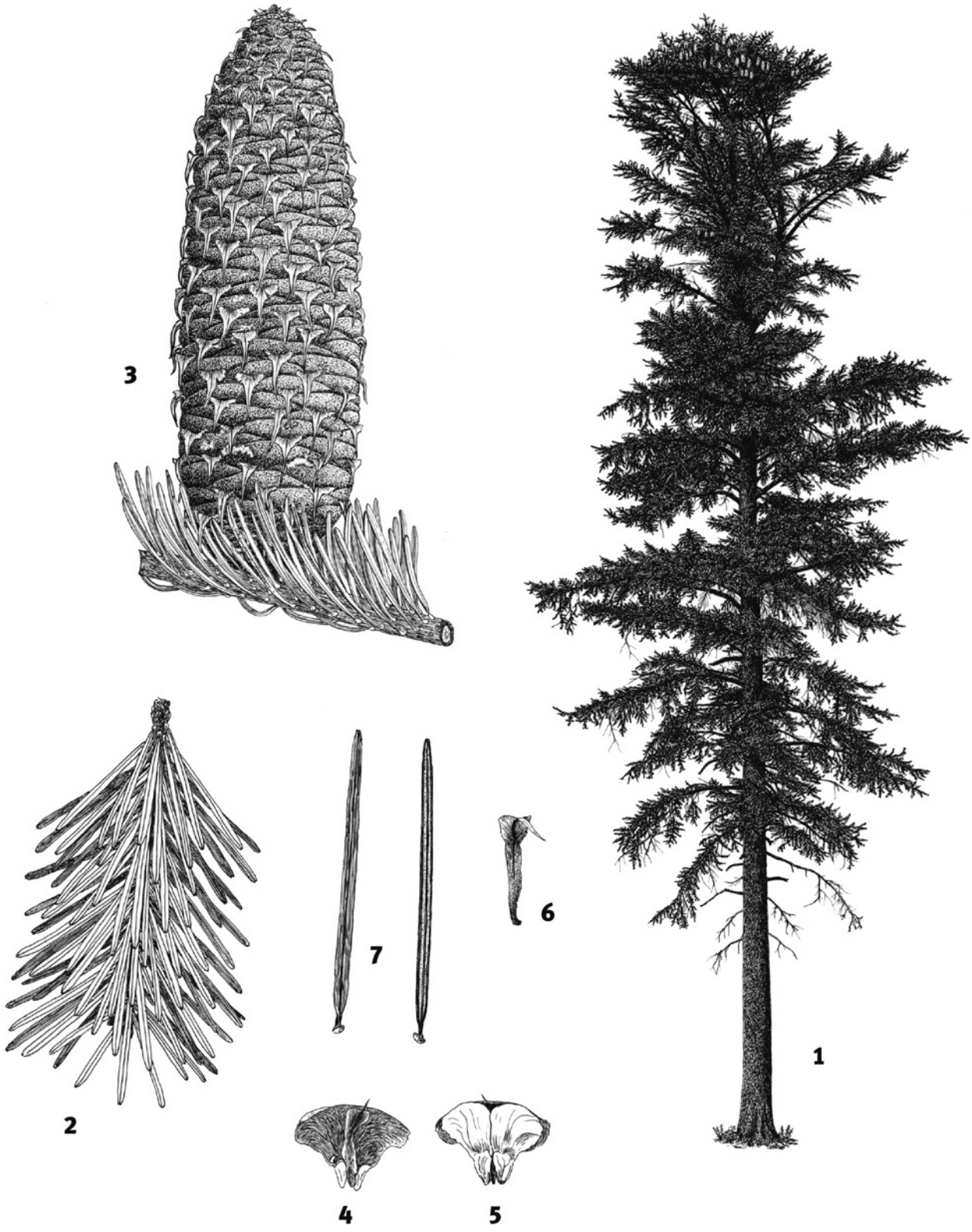


PLATE 4. *Abies nordmanniana.* **1.** Habit of tree. **2.** Foliage. **3.** Seed cone. **4, 5.** Seed scales with bract (4), with seeds (5). **6.** Bract. **7.** Leaves.

populations of NW Turkey. If recognized as a distinct subspecies of *A. nordmanniana*, the earliest combination made at that rank, *A. nordmanniana* subsp. *equi-trojani*, is the valid name.

Distribution

Caucasus Mts.; N & W Turkey.
TDWG codes: 33 NCS TCS 34 TUR

Ecology

Abies nordmannia is a fir of the high montane zone of the mountains around the eastern Black Sea, at elevations between 900 m and 2100 m a.s.l., on soils derived from igneous and granitic rocks. The climate is characterized by warm summers and cold winters, with a high annual precipitation, ranging in the Caucasus Mountains between 1000 mm and 3000 mm. On the mountains Kaz Dagh and Ulu Dagh in NW Turkey the subsp. *equi-trojani* extends to the tree line. This species occurs either in pure stands or mixed with *Picea orientalis*, at lower elevations also with *Pinus sylvestris*, gradually merging into deciduous broad-leaved forest with *Fagus orientalis, Acer trautvetteri, Carpinus caucasica, Ulmus elliptica, Acer pseudoplatanus, Tilia caucasica, Taxus baccata*, and *Rhododendron ponticum*.

Uses

Caucasian fir is an important timber tree in the W Caucasus and NW Turkey, where it provides large sizes of valuable, straight grained and easily workable wood for building materials, especially veneer. It grows fast and to large size even in plantations and parks provided the climate is moist enough. It is better appreciated in horticulture than other large European firs bacause of regular shape and dense foliage. Its popularity as a Christmas tree is largely due to its retention of needles well beyond the time the young trees are normally kept indoors. A large number of cultivars has been selected, both with variant foliage colours and different branching habits, including dwarf forms and spreading forms without an upright leader shoot.

Two subspecies are recognized:

Abies nordmanniana (Steven) Spach subsp. ***nordmanniana***. *Pinus nordmanniana* Steven, Bull. Soc. Imp. Naturalistes Moscou 11: 45, t. 2. 1838. Type: Georgia: Caucasus Mts. (South), ["source of the Kur River"], *A. von Nordmann s.n.* in herb. Steven (holotype H).

Description

Vegetative buds not resinous; young foliage shoots (branchlets) with brown pubescence in grooves. Cusps on bracts long, with a distinct midrib.

Distribution

Caucasus Mts, N Turkey (Paphlagonia).
TDWG codes: 33 TCS-AB TCS-AD TCS-GR 34 TUR

Conservation

IUCN: LC

Abies nordmanniana (Steven) Spach subsp. ***equi-trojani*** (Asch. & Sint. *ex* Boiss.) Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 26: 167. 1965. *Abies pectinata* Gilib. var. *equi-trojani* Asch. & Sint. *ex* Boiss., Fl. Orient. 5: 701. 1884; *Abies alba* Mill. subsp. *equi-trojani* (Asch. & Sint. *ex* Boiss.) Asch. & Graebn., Syn. Mitteleurop. Fl. 1: 192. 1897; *Abies nordmanniana* (Steven) Spach var. *equi-trojani* (Asch. & Sint. *ex* Boiss.) Guin. & Maire, Bull. Soc. Bot. France 55: 186. 1908; *Abies equi-trojani* (Asch. & Sint. *ex* Boiss.) Mattf., Mitt. Deutsch. Dendrol. Ges. 1925 (35): 29. 1925. Type: Turkey: ["M. Fola, in declivib. mont. Gargari"], *P. E. E. Sintenis 523* (holotype not located, isotype K).

Abies bornmuelleriana Mattf., Notizbl. Bot. Gart. Berlin-Dahlem 9: 239. 1925; *Abies nordmanniana* (Steven) Spach subsp. *bornmuelleriana* (Mattf.) Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 26: 167. 1965; *Abies nordmanniana* (Steven) Spach var. *bornmuelleriana* (Mattf.) Silba, Phytologia 68: 21. 1990.

Description

Vegetative buds (slightly) resinous; young foliage shoots (branchlets) glabrous. Cusps on bracts short, without a distinct midrib.

Distribution

NW Turkey: Kaz-Dagh (Ida Mts.), Ulu-Dagh (Mt. Olympus of Bithynia).
TDWG codes: 34 TUR

Conservation

The disjunct populations in NW Turkey here recognized as *A. nordmanniana* subsp. *equi-trojani* have a limited area of occupancy (AOO) compared to the species as a whole. The population on Ulu Dagh, although reasonably safe at present, could suffer if tourist development (ski resort, roads and lifts) would expand below the tree line in future. Infestation with Dwarf mistletoes (*Arceuthobium oxycedri, Loranthaceae*) has been observed in the fir forest on this mountain during a visit in 2004.
IUCN: NT

Abies numidica de Lannoy *ex* Carrière, Rev. Hort. 37: 106. 1866. *Abies pinsapo* Boiss. var. *numidica* (de Lannoy *ex* Carrière) Salomon, Deutsche Bäume Sträuch.: 26. 1884; *Abies pinsapo* Boiss. subsp. *numidica* (de Lannoy *ex* Carrière) E. Murray, Kalmia 12: 27. 1982. Type not designated. Fig. 13

Etymology

The species epithet refers to Numidia, a Roman name for what is now NE Algeria.

Vernacular names

Algerian fir; Sapin d'Algérie, Sapin des Babors (French)

Description

Trees to 20 m tall, d.b.h. to 0.5–0.8 m; trunk monopodial, straight, columnar, terete, but on exposed sites often twisted and forked; crown broad pyramidal, usually dense but irregular. Bark smooth and grey in young trees, fissured and scaly, dark grey brown in old trees. Branches of first order continuous to base of trunk, spreading, the lower ones curved down; branches of second order dense, spreading horizontally, ascending near the top of the tree. Branchlets stout, firm, greyish brown or yellowish, or shining orange-brown, prominently ridged between the leaves, glabrous; leaf scars circular. Vegetative buds ovoid or broad conical, 5 × 4 mm, not resinous, or only slightly resinous at base; bud scales ovate, obtuse or acute, appressed, brown, persisting several years. Leaves spirally arranged, radially spreading, especially on shoots in the periphery of the crown, those on lower shaded branches sometimes more or less pectinate, on cone bearing shoots likewise radial, the upper leaves almost recurved, (1–)1.5–2(–2.5) cm long, 2–3 mm wide, twisted or curved at base, linear or ligulate-linear, flattened, keeled by a prominent midrib below, (dark) green, glaucous near the apex, two whitish green bands below; apex obtuse or faintly emarginate, rarely acutish on coning shoots. Stomata especially near the apex or in a median groove above, in two bands divided by a midrib below. Pollen cones lateral, crowded, 1–2.5 cm long, yellowish. Seed cones lateral, erect; with short, scaly peduncles; cylindric, with acutish, often papilliform apex, 12–18 cm long, 4–6 cm wide, light green tinged with purple when immature, maturing to green with purple hue, becoming light purplish brown when ripe; cone rachis persistent, narrowly conical, brown. Seed scales cuneate flabellate, length × width at mid-cone 2–3 × 2.5–3.5 cm; surface smooth, slightly striated, puberulent on exposed parts; upper margin entire, repand; base pedicellate. Bracts spathulate, with small cusps, 0.8–1 cm long, included, rarely the cusps exserted in lowest part of cone. Seeds cuneate, 6–8 mm long, light brown; seed wings cuneate-oblong, 12–15 mm long, light brown, tinged with purple.

Distribution

N Algeria (Kabylie Range, Mts. Babor and Tababor).
TDWG codes: 20 ALG

Ecology

Abies numidica occurs in very isolated relict populations on north and east facing slopes of high mountains in the Algerian Atlas. Its altitudinal range is between 1800 m and 2000 m a.s.l. (Nitzelius, 1969), but Liu (1971) relates that occasional trees may be

found as low as 1220 m and as high as 2010 m. The soils are calcareous and rocky. The climate has warm, dry summers and cool, wet winters; the annual precipitation ranges between 1500 mm and 2000 mm, much of this falls as winter snow. The species may form pure stands, but more commonly it is mixed with *Cedrus atlantica*, which is either codominant or dominant. Other associated conifers are *Taxus baccata* and *Juniperus communis*. At lower elevations broad-leaved trees, e.g. *Acer obtusatum, A. campestre, A. monspessulanum, Quercus* spp. and *Ilex aquifolium* become more numerous; the only broad-leaved species accompanying *Abies* and *Cedrus* to the tree limit is *Populus tremula*. A common associated shrub is *Genista numidica*.

Conservation

Abies numidica has a very limited distribution in the Kabylie Range with an estimated area of occupancy (AOO) below 20 km² in only two major populations. The trees are legally protected against cutting but forest fires and other destructive events could well drive the species into extinction in the wild.
IUCN: CR [B1ab(i, ii, iii)+2ab(i, ii, iii)]

Uses

Algerian fir is not exploited for timber. It is a suitable tree for cultivation, but it is sensitive to low temperatures in winter and to air pollution in urban environments. It is mostly cultivated in countries around the Mediterranean Sea, where it is sometimes planted in hedges as it takes trimming well. Few cultivars are known and the species is mostly grown from seed collected *in situ*; due to political circumstances in Algeria it has been difficult to obtain seeds in recent decades. North of the Alps this species is still present in botanic gardens and arboreta (e.g. Chèvre-loup near Versailles, France), but it is becoming rare since dead trees are scarcely replaced with good stock from wild collected seed. Seeds used from planted trees are useless due to the ease with which this species hybridizes with its European congeners.

Abies pindrow (Royle *ex* D. Don) Royle, Ill. Bot. Himal. Mts. 1: t. 86. 1836.

Etymology

The species epithet takes up one of the vernacular names of this fir, as coined by Royle from its usage in the Simla Hills.

Vernacular names

Pindrow fir, West Himalayan fir; pindrau (Himachal); badar (Kashmir); ragha (Kumaon)

Description

Trees to 60 m tall, d.b.h. to 2.5–3 m; trunk monopodial, straight, columnar, terete; crown narrowly conical or pyramidal, often rather open and irregular. Bark of young trees smooth, light grey, turning greyish brown, in old trees becoming longitudinally fissured, rough and scaly, dark grey brown. Branches of first order relatively short, spreading horizontally; branches of second order similar. Branchlets stout, firm, light greyish pink, or light brown, soon becoming grey, faintly ridged and grooved, glabrous; leaf scars circular. Vegetative buds ovoid globose, 6–8 mm long, often very resinous, but most resin has disappeared after one growing season; bud scales broad triangular, with laciniate or erose margins, purplish brown or dull brown, persisting several years. Leaves spirally arranged, pectinate in two opposite level rows or standing out more radially, the uppermost leaves shorter and directed obliquely forward, on coning shoots assurgent, (2.5–)3–6(–7) cm long, 1.3–2 mm wide, twisted at base, narrowly linear, flattened, grooved above, lustrous (dark) green above, two greenish white bands below; apex sharply bifid or emarginate, or obtuse (acute on coning shoots. Stomata in two narrow bands, separated by a midrib below, none or a few near apex above. Pollen cones lateral, crowded on the underside of shoots, 1–1.5 cm long, yellowish brown. Seed cones lateral, erect, short pedunculate, cylindrical or ovoid-cylindrical, with obtuse apex, 10–14 cm long, 5–6(–7) cm wide, violet blue when immature, maturing to purplish brown and becoming dark reddish brown when ripe; cone rachis persistent, narrowly

conical, dark brown. Seed scales flabellate, length × width at mid-cone 2.5–3.5 × 3–4 cm; surface smooth, slightly striated, puberulent on exposed parts; upper margin entire, slightly incurved; base pedicellate. Bracts obovate or semi-orbicular, with small cusps, 1 cm long, entirely included. Seeds cuneate, angular, 10–12 mm long, shining dark brown or blackish; seed wings cuneate, 15–20 mm long, brown.

Distribution

Mountains from Afghanistan east to Nepal, Karakoram Range in Pakistan.
TDWG codes: 34 AFG 40 NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

Abies pindrow is a species of high mountains, occurring between 2000 m and 3300 m a.s.l. (occasionally as high as 3700 m; Liu, 1971), on alpine lithosols. The climate is cool, moist monsoon, with abundant precipitation, but less than in the eastern Himalayas, much of it falling as snow. It occurs in pure stands or in association with *Picea smithiana, Pinus wallichiana, Tsuga dumosa* and *Cedrus deodara*; at lower elevations broad-leaved trees, e.g. *Quercus semecarpifolia, Q. dilatata, Juglans regia, Aesculus indica, Acer* spp., *Prunus* spp., and *Ulmus* spp. become more important, replacing the conifers below 1600 m.

Uses

Pindrow fir is an important timber tree in the Himalayas, where its timber is used in construction (house building), in particular for interior work such as floor boards, ceilings, and stairs. In some parts shingles are used for roofing. Another application of its wood is for fruit cases and tea boxes. This species remains uncommon in cultivation in Europe and is regularly misidentified, with trees named *A. pindrow* var. *intermedia* turning out to belong to *A. spectabilis* (Rushforth, 1987). It requires a mildly cool and wet climate, such as prevails in the western parts of the British Isles.

2 varieties are recognized:

Abies pindrow (Royle *ex* D. Don) Royle var. ***pindrow***. *Pinus pindrow* Royle *ex* D. Don, London Edinburgh Philos. Mag. & J. Sci. 8: 255. 1836; *Abies webbiana* (Wall. *ex* D. Don) Lindl. var. *pindrow* (Royle *ex* D. Don) Brandis, Forest Fl. N.W. India: 528. 1874. Type: Illustration in Royle, Ill. Bot. Himal. Mts. 1: t. 86. May 1836 (lectotype, *vide* D. Don in Lambert, 1837).

Description

Leaves 3–6(–7) cm long, on vegetative shoots pectinately arranged; apex sharply bifid or emarginate; stomata only in two bands on the underside.

Distribution

Mountains from Afghanistan east to Nepal, Karakoram Range in Pakistan.
TDWG codes: 34 AFG 40 NEP PAK WHM-HP WHM-JK WHM-UT

Conservation

IUCN: LC

Abies pindrow (Royle *ex* D. Don) Royle var. ***brevifolia*** Dallim. & A. B. Jacks., Handb. Conif.: 126. 1923. Type not designated.

Abies gamblei Hickel, Bull. Soc. Dendrol. France 70: 38. 1929; *Abies pindrow* (Royle *ex* D. Don) Royle subsp. *gamblei* (Hickel) Rushforth, Int. Dendrol. Yearb. 1998: 63. 1999.

Description

Leaves 2.5–3.8 cm long, more or less radially arranged (not pectinate); apex obtuse on vegetative shoots; sometimes also a few stomata on the upperside.

Distribution

India: Garhwal and Kashmir Himalayas (Chamba District).
TDWG codes: 40 WHM-HP WHM-JK

Conservation

IUCN: LC

Abies pinsapo Boiss., Not. Abies Pinsapo: 8. 1838 [& Biblioth. Universelle Genève 13: 406. 1838].
Fig. 14, 15

Etymology

The species epithet 'pinsapo' is the Andalucian name for this fir.

Vernacular names

Spanish fir (including Moroccan fir); pinsapo (Spanish)

Description

Trees to 30 m tall, but most trees in nature smaller, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar and terete in sheltered trees, but often twisted and forked; crown in young trees narrowly conical, old trees irregular, open or dense. Bark of young trees smooth, dark grey, in old trees rough and scaly. Branches of first order long, curved downward, the ones near the top ascending; branches of second order dense, spreading horizontally and ascending. Branchlets stout, very firm, reddish brown or greenish brown, turning grey, faintly ridged between the leaves, glabrous; leaf scars circular or angular, large, purplish grey. Vegetative buds ovoid-globose, 5–6 × 4–4.5 mm, not resinous to very resinous; bud scales triangular, keeled and free at the apices, light reddish brown or purplish brown. Leaves spirally arranged, spreading radially and perpendicularly from shoots, or more or less pectinate, the upper leaves often recurved, in shaded shoots the lower leaves somewhat pectinate, 0.6–2 cm long, 2–3 mm wide, not or only slightly twisted at base, linear-ligulate, carinate or slightly flattened, rigid, grey-green or glaucous green; apex obtuse, acute or acuminate. Stomata above in several rows, below in two bands separated by a midrib and bordered by broad margins. Pollen cones lateral, crowded, 0.5–0.7 cm long, yellowish with red or violet microsporophylls. Seed cones lateral, erect, short pedunculate, cylindrical, with obtuse, often papilliform apex, 9–14(–18) cm long, 3–4(–5) cm wide, greenish purple when immature, becoming dark or light brown when ripe; cone rachis persistent, narrowly conical, purplish brown. Seed scales cyathiform or cuneate-flabellate, length × width at mid-cone 2.5–2.8 × 2.2–2.5 cm; surface smooth, slightly striated, yellowish pubescent on exposed parts; upper margin entire, somewhat undulate, incurved; base long pedicellate. Bracts oblong; apex obcordate, with a tiny cusp, 1–1.3 cm long, entirely included. Seeds cuneate-oblong, 8–10 mm long, light brown; seed wings cuneate-oblong, 13–20 mm long, light brown.

Distribution

N Morocco, S Spain.
TDWG codes: 12 SPA-SP 20 MOR-MO

Ecology

Abies pinsapo is a species of the north slopes of high mountains, where it occurs between 900 m and 1800 m a.s.l. (var. *pinsapo* in S Spain) and 1400 m and 2100 m a.s.l. (the Moroccan variety). It grows on rocky soils derived from dolomitic limestone or serpentine, with deep drainage. The climate is montane, with a mediterranean influence: dry, warm summers alternate with cool, moist winters, with annual precipitation around 1000 mm. Both varieties occur in pure, scattered stands (very rare in Spain) or mixed with *Cedrus atlantica* (Morocco) or *Pinus pinaster* (Spain). Commonly, broad-leaved trees, e.g, *Quercus ilex, Q. lusitanica*, and *Q. canariensis* (Morocco), and (often sclerophyllous) shrubs, e.g. *Ulex balticus, Cistus* spp., *Pistacia lentiscus, Daphne laureola* and *Berberis hispanica* are mixed with scattered *A. pinsapo* at lower elevations.

Uses

Spanish fir (including its Moroccan variety) is no longer exploited for its timber. This species is one of the most attractive firs in horticulture with its rigid needles spreading all around the shoots and especially some more glaucous-leaved trees have been selected as cultivars and are widely planted. While most remaining trees at high altitude in southern Spain are short and slow growing, Spanish fir can

grow tall in less exposed sites with ample moisture. For garden purposes slower growing 'dwarf' forms are more popular and a few cultivars, some derived from witches brooms found in natural populations, meet these requirements. Apparently this species can be easily hybridized with a number of other species, e.g. *A. alba, A. cephalonica, A. numidica* (its closest relative), *A. nordmanniana* and *A. pindrow*; some of these crosses have been the parental stock of further cultivars. Many hybrids resulting from (controlled or spontaneous) crossings in cultivation have been given nothospecific names e.g. *Abies* ×*vilmorinii* Matf. for the cross between *A. pinsapo* and *A. cephalonica*. Since seed produced from these F1 crossings in cultivation is likely to have been fertilized by unknown fir pollen, perpetuation of the hybrid is only guaranteed by vegetative propagation or by renewed controlled crossing of the parent species. Such plants should receive cultivar names, not taxon names.

2 varieties are recognized:

Abies pinsapo Boiss. var. ***pinsapo***. Type: Spain: Malaga, Sierra Bermeja, N of Estepona ["Sierra de la Nieve"], *E. Boissier s.n.* (holotype not located, isotype K).

Description

Leaves spreading radially and perpendicularly from shoots; apex obtuse or acute; resin ducts medial. Seed cones 9–14 cm long, 3–4 cm wide.

Distribution

S Spain: Prov. Málaga, Cádiz.
TDWG codes: 12 SPA-SP

Conservation

Abies pinsapo var. *pinsapo* is restricted to a small number of disjunct populations, the largest one situated within the Sierra de las Nieves National Park. Fires, some started by tourists, are a hazard threatening especially some of the smaller, isolated stands with destruction. Within and without the National Park grazing by goats, a pan-Mediterranean menace, hampers natural regeneration. Erosion of the already thin and depleted soil adds to the low ability to establish new trees naturally. A planting scheme to restore depleted populations is being implemented.
IUCN: EN [B1ab(i, ii, iii)+2ab(i, ii, iii)]

Abies pinsapo Boiss. var. ***marocana*** (Trab.) Ceballos & Bolaño, Bol. Inst. Nac. Invest. Agron. 1 (2): 18. 1928. *Abies marocana* Trab., Bull. Soc. Bot. France 53: 154. 1906. Type not designated.

Abies tazaotana S. Côzar *ex* Villar, Types Sols Afrique N. 1: 80. 1947; *Abies pinsapo* Boiss. var. *tazaotana* (S. Côzar *ex* Villar) Pourtet, Ann. Ecole Natl. Eaux 9 (1): 100. 1954; *Abies pinsapo* Boiss. subsp. *tazaotana* (S. Côzar *ex* Villar) R. Govaerts, World Checklist Seed Pl. 1 (1): 6. 1995.

Description

Leaves more ore less pectinately arranged, especially on lower branches, acute to acuminate; resin canals marginal. Seed cones 10–18 cm long, 3.5–5 cm wide.

Distribution

N Morocco (Rif Mts.).
TDWG codes: 20 MOR-MO

Conservation

IUCN: EN [B1ab(i, ii, iii)+2ab(i, ii, iii)]

Abies procera Rehd., Rhodora 42: 522. 1940. Type: USA: Washington, Columbia River, *D. Douglas s.n.* (holotype not located, isotype K). Fig. 16

Etymology

The species epithet means 'slender' or 'tall' and refers to the shape of the trees in dense forest stands.

Vernacular names

Noble fir

Description

Trees to 80–90 m tall, d.b.h. to 2.5–3.5 m; trunk monopodial, straight, columnar, terete, often bare of branches to a considerable height and very regular; crown narrowly pyramidal or more conical, in forest stands often only ⅓ or less of total tree height. Bark of young trees smooth, thin, with resin blisters, light grey with a purplish tinge, in old trees rather smooth, except on lower half of trunk where it breaks into irregular plates, greyish brown. Branches of first order spreading horizontally, the lower pendulous, but often contorted in old trees; branches of second order spreading horizontally and ascending near the ends of main branches. Branchlets slender, firm, reddish brown in the first year, soon purplish brown, faintly ridged and grooved, pubescent, but almost hidden by leaves; leaf scars oval or obovate. Vegetative buds ovoid-globose, hidden by leaves, 3 × 2 mm, slightly resinous; bud scales ovate, dark purplish red, persisting several years. Leaves spirally arranged, strongly assurgent on all shoots, the lower leaves spreading and S-curved, 1–2.5(–3.5) cm long, those midway of a year's shoot longest, 1.5–2 mm wide, curved at base, basi-falcate or falcate-linear, flattened or carinate, glaucous green above, glaucous white bands below; apex obtuse (rarely notched), acute on coning shoots. Stomata in several to many rows above, in two narrow bands separated by a midrib below. Pollen cones lateral, pedunculate, solitary or a few together in leaf axils, 1.5–2.5 cm long, yellow with red microsporophylls. Seed cones lateral, erect, short pedunculate, cylindric-conical, with obtuse or truncate apex, 15–20 cm long (–30 cm on cultivated trees), 5–8 cm wide, green and often tinged with red when immature, maturing to greenish grey, with yellowish bracts, ripening to light grey brown with light, orange brown bracts; cone rachis persistent, narrowly conical, purplish brown. Seed scales cuneate-flabellate or cyathiform, length × width at mid-cone 2.5–3 × 2.5–3.5 cm; surface smooth, pubescent to hirsute, with yellowish grey hairs; upper margin entire, strongly incurved; base long pedicellate. Bracts spathulate-obcordate, with laciniate upper margins and a long, curved cusp, 3–4 cm long, exserted, reflexed, covering much of the exposed parts of the seed scales. Seeds cuneate-oblong, 12–15 mm long, pale reddish brown; seed wings obovate or cuneate-oblong, ca. 20 × 15 mm, straw coloured.

Distribution

USA: NW California, Oregon, Washington (Cascade Range, parts of Coast Range).
TDWG codes: 73 ORE WAS 76 CAL

Ecology

A magnificent tree, occurring from the foothills of mountains in W Washington to high mountain sides in Oregon, between 60 m and 2700 m a.s.l. It is most abundant in the mountains of the Cascade Range, on a variety of mountain soils with ample moisture available to the vegetation. The climate is cool temperate, with short summers and snowy winters, the annual precipitation ranging from 1750 mm to 2600 mm, much of it as snow. It mainly grows in the Canadian Life Zone, but also in the lower Transition Zone, where it can be associated with several other conifers, e.g. *Tsuga heterophylla, Picea sitchensis* and *Thuja plicata* near the coast, *Pseudotsuga menziesii, Abies grandis, Pinus* spp. in much of its range, and *Abies lasiocarpa, A. amabilis, Tsuga mertensiana, Picea engelmannii, Larix occidentalis* at higher elevations. Common shrubs are *Rhododendron* spp., *Vaccinium* spp. and *Ribes* spp. *Abies procera* can be dominant, but occurs rarely in pure stands (Fowells, 1965).

Conservation

IUCN: LC

Uses

Noble fir attains large dimensions and grows an extremely straight bole under favourable site conditions. Almost pure natural stands can yield large volumes of timber per ha. Its wood is of higher quality than that of other firs in North America due to greater strength and indeed its size. Besides general construction and carpentry applications, special uses have been propellors of airplanes and ladders, now mostly replaced by various metals. The odourless, white wood is excellent for making boxes. Young trees make attractive Christmas trees with their dense, upturned glaucous leaves. In amenity planting and horticulture this fir is one of the more popular and commonly used species and several cultivars are known. It was introduced to England by David

Douglas in 1830. It has the largest seed cones of all species, with attractive, exserted yellowish bracts. It is unsuitable in climates with summer droughts or less than a good supply of rain spread evenly in the year as its bark tends to split open during dry spells.

Abies recurvata Mast., J. Linn. Soc., Bot. 37: 423. 1906.

Etymology

The species epithet refers to the often recurved or reflexed leaves (needles) on the shoots.

Vernacular names

Min fir; min kiang lien sha, zi guo leng shan (Chinese)

Description

Trees to 40–60 m tall, d.b.h. to 1.5–2.5 m; trunk monopodial, straight, columnar, terete; crown conical or pyramidal, flat topped in old trees. Bark of young trees smooth, soon with papery flakes, grey or pink brown, in old trees rough, flaky, breaking into small scales, dark grey brown. Branches of first order relatively short, horizontally spreading; branches of second order similar. Branchlets slender, firm, yellowish brown, light brown or pink-brown, later grey, smooth or slightly pubescent, shining and glabrous, ridged between the leaves; leaf scars circular, light grey. Vegetative buds ovoid or broad conical, 5–8 × 4–6 mm, resinous, but resin soon disappearing; bud scales triangular, keeled, light brown, persistent for several years. Leaves spirally arranged, spreading radially, more or less pectinate below, strongly assurgent to recurved above, especially on cone bearing shoots and on leading shoots higher in the crown, (1.2–)1.5–3.5 cm long, 1.9–2.5 mm wide, twisted or recurved at base, linear, but the shortest leaves oblanceolate, flattened, longitudinally grooved above, glossy green above, 2 greenish white bands below; apex emarginate, obtuse or acute. Stomata in two bands separated by a midrib below, occasionally a few near apex above. Pollen cones lateral, pendant, 1–1.5 cm long, yellow, with reddish microsporophylls. Seed cones lateral, erect, often clustered, short pedunculate, ovoid or ovoid-oblong, with obtuse or papilliform, sometimes umbilicate apex, 5–8(–9) cm long, 2.5–3.5 cm wide, bluish purple when immature, maturing to blue-grey, ripening to grey-brown; cone rachis persistent, thick, cylindro-conical to fusiform, purplish brown or light brown. Seed scales broadly flabellate to cyathiform, length × width at mid-cone 1.5–2 × 2–2.5 cm; surface smooth, puberulous; upper margin thin, entire, erose or irregularly fissured; base pedicellate. Bracts spathulate, with a short cusp, 1–1.5 cm long, entirely included, or occasionally the cusps exserted. Seeds cuneate, 5–8 × 3–4 mm, light brown; seed wings broadly cuneate, 6–10 × 5–6 mm, violet-blue, turning brown.

Distribution

China: SW Gansu, Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHT

Ecology

Min fir (both varieties) is a high mountain species of SW China, occurring between 2300 m and 3600 m a.s.l. or even higher. It grows usually on grey-brown mountain podzols. The climate is cold, moist, with annual precipitation between 700 mm and 1000 mm. Both varieties are usually constituents of a mixed coniferous forest type, with among other species *A. squamata, Picea likiangensis* var. *rubescens, P. asperata*, and *Larix potaninii; Picea purpurea* and *Abies fargesii* var. *faxoniana* are mainly found with the 'typical' variety, and *A. fabri* with var. *ernestii*. *Betula albosinensis* is the only common broad-leaved tree at higher elevations, but lower down the slopes other genera, e.g. *Acer, Populus*, but also different conifer species, e.g. *Tsuga chinensis, Picea brachytyla* var. *complanata* and *Pinus armandii* become more abundant.

Uses

A timber tree in western China, heavily exploited until recently when the Chinese government finally decided to preserve its remaining old growth forests in the western provinces. Its timber was used mainly for construction and carpentry work. The type collection (of var. *recurvata*) was collected by Ernest

H. Wilson on his first expedition to western China in 1903; the species was introduced to horticulture in the USA and UK from seed collected by him on subsequent journeys to the Min River drainage. As with most Chinese species in *Abies*, it remains a dendrological collector's item and has not entered the common gardening trade. A main reason for this is undoubtedly the unavailability of seed from its country of origin for a long period after the efforts of the early 20th century's plant collectors came to an end. Renewed collecting, made possible in the last few decades in partnership with Chinese botanists, has been undertaken under more restricting conditions and the results have largely remained within the confines of major botanic gardens. Even if trees in cultivation produce viable seed, unless they are grown in complete isolation from other species of *Abies*, that seed is likely to produce plants with a mixture of genes from almost any of those other species.

2 varieties are recognized:

Abies recurvata Mast. var. ***recurvata***. Type: China: Sichuan, Min River, Songpan, ["south of Sung Pan, Min Valley"], *E. H. Wilson 3021* (holotype K).

Description

Buds ca. 5 × 4 mm; shoots usually light brown or pink-brown, glabrous. Leaves (1.2–)1,5–3 cm long, often recurved at base; apex obtuse or acute; resin ducts medial. Seed cones with obtuse or papilliform apex; rachis usually cylindro-conical.

Distribution

China: SW Gansu, N Sichuan.
TDWG codes: 36 CHC-SC CHN-GS

Conservation

This variety is limited to an area along the Min River, south of Songpan in N Sichuan, where it may not occupy more than 20 km².
IUCN: VU (A2cd)

Abies recurvata Mast. var. ***ernestii*** (Rehd.) C. T. Kuan, Notes Roy. Bot. Gard. Edinburgh 41: 536. 1984. *Abies ernestii* Rehd., J. Arnold Arbor. 20: 85. 1939; *Abies chensiensis* Tiegh. var. *ernestii* (Rehd.) T. S. Liu, Monogr. Gen. Abies: 135. 1971. Type: China: Sichuan, Daxue Shan, Kangding, ["NE of Tachien-lu, Tapao-shan"], *E. H. Wilson 2090* (holotype A). Fig. 17

Description

Buds ca. 8 × 6 mm; shoots yellowish brown, faintly pubescent. Leaves 2–3.5 cm long, more or less straight; apex emarginate on vegetative shoots; resin ducts marginal. Seed cones often with an umbilicate apex and fusiform rachis.

Taxonomic notes

In Flora of China 4: 51 (1999) this variety is treated as a distinct species, while within *A. recurvata* no infraspecific taxa are recognized.

Distribution

China: SW Gansu, W Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHT

Conservation

IUCN: VU (A2cd)

Abies religiosa (Kunth) Schltdl. & Cham., Linnaea 5: 77. 1830. *Pinus religiosa* Kunth, in Humboldt *et al.*, Nov. Gen. Sp. Pl. 2 (5): 5. 1817. Type: Mexico: Guerrero, *F. W. H. A. von Humboldt & A. J. A. Bonpland s.n.* (holotype P).

Abies colimensis Rushforth & Narave, Notes Roy. Bot. Gard. Edinburgh 46: 105. 1989.

Etymology

The species epithet refers to the traditional religious significance of this tree to the peoples of Guatemala and Mexico.

Vernacular names

Sacred fir

Description

Trees to 50–60 m tall, but usually not exceeding 40 m, d.b.h. to 1.5–2 m; trunk monopodial, straight, columnar, terete; crown pyramidal or conical. Bark of young trees smooth, greyish white, of old trees rough, deeply fissured, breaking into small plates, grey brown. Branches of first order long, slender, ascending, later becoming horizontal, the lowest pendant; branches of second order spreading horizontally or slightly ascending. Branchlets slender, especially the lower vegetative shoots, firm, reddish brown to purple red, ridged and grooved between the leaves, slightly pubescent in the grooves or glabrous; leaf scars circular, light grey. Vegetative buds ovoid globular, small, covered with resin; bud scales broadly ovate, keeled, reddish brown, persisting several years. Leaves spirally arranged, pectinate on vegetative shoots, directed slightly forward, on coning shoots more or less radial and slightly assurgent, (1–)1.5–3(–3.5) cm long, 1.2–1.6 mm wide, twisted at base, narrowly linear, grooved above, flattened, shining dark green, or occasionally more glaucous, with two whitish bands below; apex acute or obtuse-truncate. Stomata absent or only a few above, in two narrow bands separated by a midrib below. Pollen cones lateral, more or less pendulous, 1–1.5 cm long, yellow, with red microsporophylls. Seed cones lateral, sometimes subterminal, usually erect, with short, often curved peduncles, ovoid oblong, cylindrical or curved, with obtuse apex, (8–)10–16 cm long, 4–6 cm wide, violet blue with yellowish bracts when immature, becoming dark (purplish) brown with brown bracts when ripe; cone rachis persistent, narrowly conical, dark brown. Seed scales cuneate-flabellate, length × width at mid-cone 2–3 × 3–3.5 cm; surface smooth, puberulent; upper margin rounded, entire; base pedicellate. Bracts linear-spathulate, with a tapering cusp, 3–3.5 cm long, exserted, reflexed, covering part of the seed scales. Seeds cuneate-oblong, 10 × 5 mm, shining brown; seed wings cuneate-dolabriform, 10–15 mm long, brown.

Distribution

Central and S Mexico (highlands).

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXG-VC MXN-SI MXS-GR MXS-MI MXS-JA MXS-OA

Ecology

Abies religiosa is a high mountain species, occurring between 1200 m and 4100 m a.s.l., but more commonly between 2100 m and 3100 m, usually on well drained mountain soils of volcanic origin. The climate is cool, moist oceanic on ranges near the coast, colder with more snow in the interior, with abundant precipitation. There are pure stands of this fir at the higher elevations, but it is often mixed with *Pinus montezumae, P. hartwegii*, in the north of its range also with *Pseudotsuga menziesii* var. *glauca*; at lower elevations *Quercus* spp., *Alnus acuminata, Prunus serotina*, and *Arbutus* spp. become more abundant. Shrubs are e.g. *Vaccinium* spp., *Andromeda* spp., *Ribes* spp., and *Fuchsia* spp.

Conservation

IUCN: LC

Uses

In Mexico the timber of this species is used for light indoor construction and general carpentry. Wholesale logging is unlikely to occur because this tree has traditional religious significance to Native Americans. With the conversion to (Roman Catholic) Christianity and hispanisation of the populations of this part of Latin America these traditions were incorporated into the new modes of worship and at times of religious festivals churches are being decorated with the foliage of this fir. This species also has a very special ecological significance since it serves as the hibernation tree (in a very limited part of its range in south-central Mexico) for many millions of Monarch butterflies (*Danaus plexippus*) yearly making one of the most spectacular displays in all of nature. No one, despite decades of research into the phenomenon, yet knows why these butterflies choose those trees in that particular locality

to congregate in such numbers, arriving from as far away as E Canada.

Abies sachalinensis (F. Schmidt) Mast., Gard. Chron., ser. 2, 12: 588. 1879.

Etymology

The species epithet refers to the island of Sakhalin from where its was first described.

Vernacular names

Sakhalin fir; akatodo, todo-matsu (Japanese); Pikhta sakhalinskaya (Russian)

Description

Trees to 25–30 m tall, d.b.h. to 0.8–1 m; trunk monopodial, straight, columnar, terete; crown broad pyramidal, often flat topped in old trees; dead branches remain on the bole. Bark of young trees smooth, with resin blisters, grey with a brown tinge, of old trees in lower part of the bole breaking into irregular plates, grey brown. Branches of first order long, slender, mostly ascending, the lower ones spreading horizontally; branches of second order similar. Branchlets slender, firm, red-brown or brown, sometimes grey-brown, with faint ridges and shallow grooves, minutely pubescent in grooves with red-brown hairs; leaf scars circular, small. Vegetative buds ovoid, small, very resinous; bud scales reddish brown, persisting several years. Leaves spirally arranged, spreading more or less radially, the upper leaves directed forward, covering shoot, on coning shoots slightly assurgent, 1.2–3.5 cm long, 1–1.2 mm wide, (strongly) twisted or curved at base, linear, grooved above, flattened, glossy dark green above, two greenish white bands below; apex emarginate or obtuse. Stomata none or a few near apex above, in two narrow bands separated by a midrib below. Pollen cones lateral, densely clustered on the underside of shoots, 1 cm long, yellowish, with red microsporophylls. Seed cones lateral, erect, often crowded, almost sessile, ellipsoid-cylindrical, with obtuse or acutish apex, 5–8 cm long, 2–3 cm wide, light or dark purple with greenish or reddish bracts when immature, becoming dark brown with brown bracts when ripe; cone rachis persistent, narrowly conical, blackish purple. Seed scales reniform, length × width at mid-cone 1 × 1.6 cm; surface smooth, pubescent on the exposed part; upper margin entire, incurved; base pedicellate. Bracts obcordate-quadrangular, 1–1.3 cm long, included or exserted, recurved, the upper bracts often included in ripe cones. Seeds cuneate, 6 mm long, lustrous brown with black spots; seed wings broad cuneate, 5 × 5 mm, purplish black.

Distribution

Japan: Hokkaido; Russian Far East: southern Kuril Islands, Sakhalin.
TDWG codes: 31 KAM KUR SAK 38 JAP-HK

Ecology

Sakhalin fir and its varieties occur from near sea level on the coast to an elevation of 1650 m a.s.l. in the mountains. The soils are well drained but moist throughout the year, due to abundant precipitation in a cool to cold, maritime climate. In the north of its range the species is more common at elevations between 800 m and 1100 m, where it is mixed with *Picea jezoensis, P. glehnii, Larix gmelinii* var. *japonica* or *Pinus pumila* at the highest limit of trees. At lower elevations pure stands occur, below 800 m broad-leaved-trees, e.g. *Betula ermanii, Acer* spp., *Quercus mongolica* var. *grossesserata, Castanea crenata, Kalopanax septemlobus*, and *Magnolia hypoleuca* become more abundant.

Uses

This species is mainly logged for the manufacture of wood pulp used in the paper industry; its timber is of low quality for construction and carpentry. As an amenity tree it is little used outside the cool to cold maritime climate of northern Japan and the Russian Far East. It is in cultivation in botanic gardens and arboreta in Russia, northern Europe and New England, USA, but rarely survives to maturity in countries with mild winters, where it will not go into prolonged winter dormancy and is susceptible to spring frosts.

4 varieties are recognized, one tentatively:

Abies sachalinensis (F. Schmidt) Mast. var. ***sachalinensis***. *Abies veitchii* Lindl. var. *sachalinensis* F. Schmidt, Mém. Acad. Imp. Sci. Saint-Pétersbourg, sér. 7, 12 (2): 175. 1868; *Abies nephrolepis* (Trautv. *ex* Maxim.) Maxim. subsp. *sachalinensis* (F. Schmidt) V. N. Voroshilov, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 96 (1): 133. 1991. Type: Russia: Russian Far East, Sakhalin, 1862, *F. Schmidt s.n.* (holotype not located, isotype K).

Abies sachalinensis (F. Schmidt) Mast. var. *corticosa* Tatew., Trans. Sapporo Nat. Hist. Soc. 45: 70. 1935; *Abies sachalinensis* (F. Schmidt) Mast. f. *corticosa* (Tatew.) Hayashi, Taxon. Phytogr. Japon. Conif.: 26. 1960.

Description

Bark grey or brownish grey. Leaves with medial resin ducts. Seed cones dark purple when immature; bracts exserted, reddish turning brown.

Distribution

Japan: Hokkaido; Russian Far East: Kuril Is., Sakhalin.
TDWG codes: 31 KUR SAK 38 JAP-HK

Conservation

IUCN: LC

Abies sachalinensis (F. Schmidt) Mast. var. ***gracilis*** (Kom.) Farjon, Pinaceae (Regnum Veg. 121): 83. 1990. *Abies gracilis* Kom., Trudy Imp. S.-Peterburgsk. Bot. Sada 20: 203. 1901; *Abies sibirica* Ledeb. var. *gracilis* (Kom.) Patschke, Bot. Jahrb. Syst. 48: 684. 1913. Type not designated.

Description

Bark grey. Leaves with marginal resin ducts. Seed cones purple when immature; bracts exserted, turning brown at maturity.

Taxonomic notes

Morphologically, this taxon is most similar to *Abies sachalinensis* and on these grounds alone does not seem to merit recognition as a distinct species. Its status as a species is accepted by some Russian botanists but disputed by others; to solve this problem analysis of its DNA in comparison with several related eastern Asian firs is much needed, but samples from the wild are not easy to obtain.

Distribution

Russian Far East: Kamchatka (Kronotzky Bay) [possibly introduced].
TDWG codes: 31 KAM

Ecology

The occurrence of a small, isolated 'grove' of ca. 30,000(?) trees occupying an area of no more than 20 ha in coastal lowland in the SE part of the peninsula of Kamchatka is something of an enigma. There is some expression of doubt to its indigenous status in the Russian literature but there seems to be no thorough scientific research published underpinning its status either as an introduction (by native people?) or as a 'Tertiary relict' as some others believe. A scientific assessment addressing its indigenity is urgently needed, because its locality seems totally at odds with what is known of the biogeography of its nearest relatives (Sect. *Balsamea*) in the genus *Abies*.

Conservation

IUCN: DD

Abies sachalinensis (F. Schmidt) Mast. var. ***mayriana*** Miyabe & Kudô, Trans. Sapporo Nat. Hist. Soc. 7: 131. 1919. *Abies mayriana* (Miyabe & Kudô) Miyabe & Kudô, Icon. Ess. Forest Trees Hokkaido 1: 9, t. 3, 4. 1920. Type not designated.

Description

Bark smooth, whitish grey. Leaves with medial resin ducts. Seed cones light purplish, with greenish, exserted bracts turning light brown at maturity.

Distribution

Japan: Hokkaido; Russian Far East: Sakhalin.
TDWG codes: 31 SAK 38 JAP-HK

Conservation

IUCN: LC

Abies sachalinensis (F. Schmidt) Mast. var. ***nemorensis*** Mayr, Monogr. Abiet. Japan. Reich.: 42, t. 3, f. 6. 1890. *Abies nemorensis* (Mayr) Miyabe & Kudô, in Miyabe & Miyake, Fl. Saghalin: 745. 1915. Type not designated.

Description

Bark grey. Leaves with medial resin ducts. Bracts of seed cones included or only the small cusps exserted.

Distribution

Japan: Hokkaido; Russian Far East: Sakhalin.
TDWG codes: 31 SAK 38 JAP-HK

Conservation

IUCN: DD

Abies sibirica Ledeb., Fl. Altaica 4: 202. 1833.

Etymology

The species epithet refers to its occurrence in Siberia.

Vernacular names

Siberian fir; Pikhta sibirskaya (Russian); Xinjiang lengshan, xian bei leng shan (Chinese)

Description

Trees to 35–40 m tall, d.b.h. to 1 m; trunk monopodial, straight, columnar, terete; crown narrowly pyramidal or conical. Bark of young trees smooth, with numerous resin blisters, grey or grey brown, finally breaking into plates in old trees. Branches of first order short, slender, spreading horizontally, the lower pendant; branches of second order dense, spreading out laterally or assurgent. Branchlets slender, firm, pale yellowish grey to fawn brown or yellowish brown, soon grey, smooth or only faintly ridged or more prominently ridged and grooved, with short pubescence, soon glabrous; leaf scars small, circular. Vegetative buds globose, 2–3 mm long, more or less resinous; bud scales reddish or yellowish brown, persisting several years. Leaves spirally arranged, the upper leaves covering shoot or assurgent, the lower leaves pectinate in two lateral planes, on coning shoots all leaves assurgent, (1–)1.5–3 cm long, 1.3–1.6 mm wide, twisted or curved at base, linear, flattened, light green, with 2 greyish green bands below; apex emarginate, obtuse, or acute with a callous tip especially on coning shoots. Stomata occasionally a few near apex above, in two bands separated by a midrib below. Pollen cones lateral, crowded on the underside of shoots, 1.5 cm long, yellow, with red microsporophylls. Seed cones lateral, erect, nearly sessile, ovoid-cylindrical, with obtuse apex, 5–7.5 cm long, 2.5–3.5 cm wide, violet blue when immature, maturing to bluish brown, or yellowish brown, becoming (light) cinnamon or greenish brown when ripe; cone rachis persistent, narrowly conical, dark brownish purple. Seed scales broad flabellate, upper scales more cuneate, length × width at mid-cone 1.5–1.7 × 2–2.2 cm; surface smooth, puberulent; upper margin entire or serrulate-erose; base pedicellate. Bracts short, rounded, with a tiny cusp, 0.8 cm long, entirely included. Seeds cuneate-oblong, 5–6 mm long, brown; seed wings cuneate-oblong, 10–12 mm long, light brown.

Distribution

Across N Russia and Siberia, from Archangel'sk eastward to the Amur River, southward to the mountains along the Sino-Russian border and the Tien Shan Range.
TDWG codes: 14 RUE RUN 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KHA 32 KAZ KGZ 36 CHX

Ecology

The 'typical' subspecies of Siberian fir is widespread across the Siberian taiga, where it occurs from near sea level on the northern plains to 2000 m a.s.l. in

the mountains. It remains well south of the arctic tree limit in Siberia, in fact it is more common in W Siberia and the Altai Mountains, which have a less severe climate. The soils are usually of alluvial origin, podzolic, and in the mountains also calcareous, well drained and free of permafrost. The climate is cold continental, but not extreme in most parts of the range of the species. There are pure forests, but more often it is mixed with other conifers, e.g. *Picea obovata, Larix gmelinii*, in the mountains also *L. sibirica* and *Pinus sibirica*; common broad-leaved trees or shrubs are *Betula pendula, Populus tremula, Sorbus aucuparia* and *Viburnum opulus*. In the southwestern part of its range other broad-leaved trees are mixed in: *Tilia cordata, Ulmus scabra*, and *Acer platanoides*.

Uses

Siberian fir is an economically important timber tree. Its wood is used in light-frame construction and for pulpwood. Planted in regions with mild winters it can be damaged by 'late' frost; it is also intolerant of air pollution. In Central and E Europe it has been introduced as an amenity tree and several 'forms' and cultivars are known.

Two subspecies are recognized:

Abies sibirica Ledeb. subsp. ***sibirica***. Type: Russia: Altai Mts., *C. F. von Ledebour s.n.*, 1826 (holotype LE).

Description

Shoots smooth or only faintly ridged, yellowish grey to fawn brown; buds resinous or very resinous. Resin ducts in leaves large, medial. Seed cones violet-blue, maturing to bluish brown.

Distribution

Across N Russia, from Archangel'sk eastward to the Amur River, southward to the mountains along the Sino-Russian border.
TDWG codes: 14 RUE RUN 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KHA 36 CHX

Conservation

IUCN: LC

Abies sibirica Ledeb. subsp. ***semenovii*** (B. Fedtsch.) Farjon, Pinaceae (Regnum Veg. 121): 81. 1990. *Abies semenovii* B. Fedtsch., Bot. Centralbl. 73 (7): 210. 1898; *Abies sibirica* Ledeb. var. *semenovii* (B. Fedtsch.) T. S. Liu, Monogr. Gen. Abies: 188. 1971. Type: Kirgyzstan: Talasskij Ala Tau, ["Turkestania, Bisch Tasch"], *V. A. Kallaur s.n.*, Sep 1897 (holotype G).

Description

Shoots prominently ridged and grooved, yellowish brown; buds slightly resinous. Resin ducts in leaves small, marginal. Seed cones yellowish brown when full grown but not dry.

Distribution

Kirgyzstan (Talasskij Alatau).
TDWG codes: 32 KGZ

Ecology

On N-facing slopes or in steep ravines at altitudes between 1300 m and 2850 m a.s.l. where moisture from snowmelt remains available through summer.

Conservation

IUCN: LC

Abies spectabilis (D. Don) Mirb., Mém. Mus. Hist. Nat. 13: 70. 1825. *Pinus spectabilis* D. Don, Prodr. Fl. Nepal. 2: 55. 1825. Type: India: Uttar Pradesh, Kumaun Himal, *W. S. Webb ex herb. Wallich 6058* (lectotype K, designated here). Fig. 18

Abies webbiana (Wall. *ex* D. Don) Lindl. var. *brevifolia* A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 4: 751. 1909; *Abies spectabilis* (D. Don) Spach var. *brevifolia* (A. Henry) Rehd., J. Arnold Arbor. 1: 54. 1919.

Abies spectabilis (D. Don) Spach var. *langtangensis* Silba, Phytologia 68: 22. 1990.

Etymology

The species epithet means 'splendid or 'superb'.

Vernacular names

Webb fir, Himalayan fir; bang, chilrao (Hindi); badar, paludar (Kashmir); dhunsing (Bhutan, Sikkim)

Description

Trees to 40–50 m tall, d.b.h. to 1.5–2.5 m; trunk monopodial, straight, columnar, terete, stunted at tree line; crown broad pyramidal or columnar, flat topped in old trees. Bark of young trees smooth, light grey or pinkish grey, later rough, breaking into plates and furrowed in old trees. Branches of first order thick, long, ascending near the top, curved down below; branches of second order spreading, assurgent. Leading shoots thick, side shoots (branchlets) slender, firm, light yellowish brown, turning grey-brown; surface prominently ridged and grooved, pubescent in grooves with brown hairs, but leading shoots sometimes glabrous; leaf scars circular ovate. Vegetative buds ovoid or subglobose, large, on leading shoots 10 × 8 mm, densely covered with resin; bud scales triangular, keeled, with erose margins, brown or red-brown, persisting several years. Leaves spirally arranged, pectinate in two lateral sets, the shorter upper leaves directed forward but leaving shoot bare, on coning shoots assurgent, 2.5–6 cm long, 2.2–3.5 mm wide, twisted at base, linear, flattened, with slightly recurved margins, continuously grooved above, dark glossy green above, white bands below, midrib and margins glaucous green; apex emarginate or bifid, on coning shoots obtuse. Stomata in two broad bands separated by a midrib below. Pollen cones lateral, crowded, pendulous, 3–4 cm long, yellowish, with purplish blue microsporophylls. Seed cones lateral, erect, nearly sessile, broad cylindrical, with truncate apex, (8–)10–17 cm long, 4–7 cm wide, violet-blue when immature, maturing to dark grey-blue, ripening to dark purplish brown; cone rachis persistent, narrowly conical, dark bluish brown. Seed scales flabellate-cuneate, thin, length × width at mid-cone 1.5–2.5 × 3–3.5 cm; surface smooth, slightly striated, puberulent on exposed parts; upper margin entire, undulate or incurved; base pedicellate, laterally auriculate. Bracts spathulate, with rounded, serrulate margin and small cusp, 1.5–2 cm long, usually included, or slightly exserted near base of cone. Seeds cuneate, 10 × 5 mm, brown; seed wings cuneate-oblong, 12 × 5 mm, brown-violet.

Distribution

Afghanistan: Hindu Kush; Pakistan: Karakoram Range; China: W Xizang [Tibet]; India: Kashmir Himalaya; Nepal.
TDWG codes: 34 AFG 36 CHT 40 NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

Abies spectabilis grows in the high mountains of the Himalayas, between 1600 m and 4000 m a.s.l., but commonly in a 'cloud belt' between 2600 m and 3800 m on N or NE slopes. The soils are various alpine lithosols with good drainage. The climate is cool, moist monsoon, with abundant precipitation, much of it as snow, in some parts of the western range rather drier. It forms pure stands at the higher elevations up to the tree line, but usually it is mixed with conifers, e.g. *Picea smithiana, Pinus wallichiana, Juniperus wallichiana*, and in Nepal also with *Tsuga dumosa*. It is usually well separated in elevation from the lower occurring fir *A. pindrow*. *Juniperus squamata* (a shrub), *Rhododendron campanulatum* and *Betula utilis* exceed *A. spectabilis* in elevation at tree line; at lower elevations some broad-leaved trees appear, e.g. *Juglans regia, Quercus* spp., *Acer* spp., *Prunus* spp., *Ulmus* spp., and *Aesculus indica*, and in Nepal especially large species of *Rhododendron*.

Conservation

IUCN: NT

Uses

Webb fir is an important timber tree in the Himalayas, where it is used in construction (house building), in particular for interior work such as floor boards,

ceilings and stairs. In some parts shingles are used for roofing; another use is the manufacture of boxes to pack tea. Its uses are similar to those of Pindrow fir, but as it occurs at higher elevations and often up to the tree line it is commercially of less importance. A local use of the purple cone scales has been to make a dye. Webb fir was introduced in England in 1822 and remains in cultivation. The variety *brevifolia*, as occasionally encountered in gardens and parks, is merely a high altitude form, as is the type specimen of the species. In nature, the length of the leaves varies, not only with the altitude, but also on the trees themselves. Describing and naming taxa from an odd tree in cultivation often leads to superfluous names.

Abies squamata Mast., Gard. Chron., ser. 3, 39: 299, f. 121. 1906. Type: China: Sichuan, Daxue Shan, Kangding, ["W of Tachien-lu"], *E. H. Wilson 3019* (holotype K). Fig. 19, 20

Etymology

The species epithet refers to the scaly bark.

Vernacular names

Flaky fir; linpi leng shan (Chinese)

Description

Trees to 40 m tall, d.b.h. to 2 m; trunk monopodial, straight, columnar, terete; crown broad or narrow, conical. Bark of young trees smooth, purplish or pink brown, exfoliating like *Betula*, the bark in older trees remaining shaggy from flakes of papery bark, breaking into rough and hard plates, orange-brown (when freshly exposed), blackish grey at base of trunk. Branches of first order long, spreading horizontally, the lower pendant; branches of second order spreading horizontally, assurgent near the top of the tree. Branchlets stout, firm, dark reddish or purplish brown, shining, ridged and grooved, usually glabrous or a few hairs in the grooves; leaf scars circular. Vegetative buds ovoid-globular, thickly covered with white, soon eroding resin; bud scales triangular-ovate, keeled, reddish brown, persisting several years. Leaves spirally arranged, dense, rigid, spreading in two lateral, pectinate sets, assurgent above, especially on cone bearing shoots, (1–)1.5–2.5(–2.8) cm long, 1.5–2 mm wide, curved or twisted at base, linear, more or less falcate, flattened, grooved above, green or glaucous green above, two glaucous white or greenish white bands below; apex obtuse or acute. Stomata few to many near apex above, in two bands separated by a midrib below. Pollen cones lateral, on the underside of shoots, pendant, 2–3 cm long, yellowish, with purple microsporophylls. Seed cones lateral, erect, short pedunculate, ovoid-cylindric, with obtuse apex, 5–7 cm long, 3–4 cm wide, violet-blue when immature, ripening to violet-brown; cone rachis persistent, fusiform, dark violet-brown. Seed scales cuneate-flabellate, length × width at mid-cone 1.3 × 1.5 cm; apically thickened; surface smooth, puberulent; upper margin entire, incurved; base auriculate-pedicellate. Bracts oblong-spathulate, 1.5–1.8 cm long, slightly exserted, cusps recurved or straight. Seeds oblong-cuneate, 5 × 2.5 mm, blackish brown; seed wings cuneate-obovate, 7–8 × 6 mm, violet-brown.

Distribution

China: S Gansu, S Qinghai (Banma Xian), W Sichuan, E Xizang [Tibet] (Markam Xian).
TDWG codes: 36 CHC-SC CHN-GS CHQ CHT

Ecology

A subalpine species of the high mountains of western China, where it occurs between 3500 m and 4500 m a.s.l. [3000–4700 m according to Liu (1971)] making it one of the highest reaching mountain trees in the world. The soils are commonly grey-brown mountain podzols or lithosols. The climate is cold, relatively dry (arid in E Xizang), but usually perpetual snow at higher elevations provides sufficient moisture throughout the year. It is a constituent of mixed coniferous high altitude forests, with among other species *Abies recurvata, A. fargesii* var. *faxoniana, Picea likiangensis* var. *rubescens, P. asperata, P. linzhiensis* (in E Xizang), *Larix potaninii* and possibly also *Tsuga forrestii*. There are very few broad-leaved trees at these high elevations, *Betula albosinensis* and *B. utilis* var. *prattii* being the most common.

Conservation

At these high altitudes forests form isolated patches on favourable sites, surrounded by treeless subalpine vegetation. Direct exploitation of the timber in these forest remnants is easily unsustainable due to very slow growth and past exploitation has led to a decline of this and other conifer tree species in these forests.
IUCN: VU (A2d)

Uses

Flaky fir is a potential timber tree but its occurrence at extremely high altitudes in inaccessible places prevents it from being exploited commercially. Ernest Wilson collected this fir with its peculiar bark in June 1904 in the Daxue Shan of western Sichuan, China, when on a plant hunting expedition for Veitch & Sons in England. Although it was successfully introduced in Europe and North America, it has remained rare in cultivation, restricted to a few collections in botanic gardens and arboreta, where it tends to be a slow grower. Its unusual bark has an attraction to dendrologists, but unless renewed seed collecting from wild sources can be resumed, this species may gradually disappear from horticulture.

Abies veitchii Lindl., Gard. Chron. 1861: 23. 1861.

Etymology

This species has been named after John Gould Veitch, founder of Veitch Nurseries, who 'discovered' it in 1861 on Mt. Fuji.

Vernacular names

Veitch's fir; shira-biso (Japanese)

Description

Trees to 25–30 m tall, d.b.h. to 0.8–1 m; trunk monopodial, straight, columnar, terete; crown (narrowly) pyramidal. Bark of young trees smooth, with prominent resin blisters, (light) greenish grey, lower part of trunk becoming scaly and dark grey. Branches of first order slender, relatively short, spreading horizontally, ascending near the top; branches of second order similar. Branchlets slender, firm, young shoots green or light brown, yellowish grey in second year; surface smooth, in later years with shallow grooves, densely yellowish pubescent, soon glabrous; leaf scars circular, yellowish brown. Vegetative buds ovoid globular, 3 × 3 mm, resinous; bud scales triangular, with erose margins, reddish or purplish brown. Leaves spirally arranged, radially spreading, the lower leaves more or less pectinate, the upper leaves directed forward, covering shoot, on coning shoots slightly assurgent, (0.5–)1.5–3(–3.8) cm long, 1.5–2.2 mm wide, widest near the emarginate or truncate apex, linear-ligulate or falcate, grooved above, flattened, dark green above, two whitish bands below. Stomata in two bands separated by a midrib below. Pollen cones lateral, axillary, pendant, 1–1.5 cm long, yellowish, with red microsporophylls. Seed cones lateral, erect, often crowded, short pedunculate or almost sessile, cylindrical to ellipsoid (often irregular), with obtuse or papilliform apex, (3–)4.5–7.5(–8) cm long, (1.5–)2–2.5(–3) cm wide, dark bluish purple (rarely green or olive-green) when immature, ripening to blackish brown or brown; cone rachis persistent, narrowly conical, purplish brown. Seed scales narrowly reniform or almost crescent shaped, length × width at mid-cone 0.8–1 × 1.4–1.6 cm; surface smooth, (silvery) puberulent on exposed parts; upper margin entire, incurved; base pedicellate. Bracts obcordate, 1–1.2 cm long, slightly exserted or only the cusps exserted, straight or recurved. Seeds cuneate, 5–6 × 3 mm, greyish black tinged with green; seed wings broadly cuneate, 3 × 5 mm, colour as seeds or blackish purple.

Distribution

Japan: Honshu, Shikoku.
TDWG codes: 38 JAP-HN JAP-SH

Ecology

The 'typical' variety of this species grows on high mountains at elevations between 1200 m and 2800 m a.s.l. [reported from as low as 1050 m (Wilson, 1916)]. The soils are usually of volcanic origin, podzolic and well drained. The climate is cool and

wet, with annual precipitation between 1000 mm and 2500 mm, and with cold, snowy winters; frequent typhoons cause destruction of the forest in most places before it reaches an age of 250 to 300 years (Franklin *et al.*, 1979). This variety is usually mixed with other conifers, e.g. *Abies mariesii, Picea jezoensis* subsp. *hondoensis, Larix kaempferi, Thuja standishii, Pinus parviflora*, at the highest elevations *Pinus pumila*, and the ubiquitous *Tsuga diversifolia*. The most common broad-leaved trees are *Betula ermanii, Sorbus commixta, Prunus nipponica*, and *Acer* spp. at lower elevations, and *Betula corylifolia* near the tree limit.

Uses

Veitch's fir is a relatively small tree which yields timber of low grade, mainly used for the manufacture of paper pulp. It is fairly common in cultivation, as an amenity tree in parks and gardens and in collections (arboreta). Its popularity in the British Isles, where it was introduced in 1879 from seeds sent by C. Maries to Veitch & Son in Chelsea, England, was due to the suitable and similar climate. As happens in such cases, this popularity has waned as other trees became available.

2 varieties are recognized:

Abies veitchii Lindl. var. ***veitchii***. Type not designated.

Abies veitchii Lindl. var. *olivacea* Shiras., Bot. Mag. (Tokyo) 27: 132. 1913; *Abies veitchii* Lindl. f. *olivacea* (Shiras.) Cinovskis, Introd. Rast. Bot. Sad. Pribaltiki: 33. 1974.
Abies veitchii Lindl. var. *komagatakensis* Hayashi, Bull. Govt. Forest. Exp. Stat. 57: 151. 1952.

Description

Leaves 1.5–3(–3.8) cm long, 1.5–2.2 mm wide. Seed cones cylindrical, (4–)4.5–7.5(–8) cm long, 2–2.5 cm wide; bracts slightly exserted beyond the cusps.

Distribution

Japan: Honshu.
TDWG codes: 38 JAP-HN

Conservation

IUCN: LC

Abies veitchii Lindl. var. ***sikokiana*** (Nakai) Kusaka, Conif. Japon. Ill., ed. 2: 212. 1954. *Abies sikokiana* Nakai, Bot. Mag. (Tokyo) 42: 452. 1928. Type not designated.

Description

Leaves (0.5–)0.8–2 cm long, 2 mm wide. Seed cones ellipsoid-cylindrical, 3–4 cm long, 1.5–2 mm wide; only the bract cusps are exserted.

Distribution

Japan: Shikoku (Ishizugi-san, Tsurugi-yama, Mt. Sasagamine).
TDWG codes: 38 JAP-SH

Conservation

IUCN: NT

Abies vejarii Martínez, Anales Inst. Biol. Univ. Nac. México 13 (2): 629. 1942.

Etymology

Named after Octavio Véjar Vázquez, at the time Mexican Minister for Public Education.

Vernacular names

Vejar's fir; hayarin (Mexico)

Description

Trees to 35–40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, columnar, terete; crown broad conical or pyramidal, old trees rather open. Bark of young trees smooth, thin, grey, of old trees rough, scaly and fissured on lower part of trunk, grey-brown. Branches of first order long, slender, spreading horizontally, ascending near the top; branches of second order similar. Branchlets slender, firm, purplish red in the first year, becoming lighter reddish brown or

orange-brown; surface almost smooth, shallowly grooved, glabrous; leaf scars circular. Vegetative buds globose, 3 × 2.5 mm, very resinous; bud scales triangular ovate, keeled, light brown, persisting several years. Leaves spirally arranged, the lower ones pectinate, the other leaves directed forward, covering shoot, on coning shoots spreading radially, 1–2(–2.5) cm long, 1.3–2 mm wide, slightly twisted or curved at base, narrowly lanceolate-linear, shallowly grooved above, flattened, grey-green or dark green above, whitish with a green midrib and margins below; apex acute or acutish. Stomata in a few or up to 10 lines above, in two bands separated by a midrib below. Pollen cones lateral, crowded, nearly globular, 0.5 cm, with reddish microsporophylls. Seed cones lateral, erect, short pedunculate, barrel-shaped or ovoid-oblong, with obtuse or truncate apex, 6–12(–15) cm long, 4–6(–7?) cm wide, dark purple when immature, maturing to purplish or bluish tinged with brown, becoming dark brown when ripe; cone rachis persistent, cylindric-conical, brown. Seed scales cuneate-flabellate, length × width at mid-cone 1.5–2 × 2–2.5 cm; surface smooth, puberulent on exposed parts; upper margin entire, incurved; base pedicellate. Bracts oblanceolate-spathulate, with a broad, triangular cusp with denticulate margins, 1.7–2.5 cm long, included or exserted, if exserted at first erect, but recurved in ripe cones. Seeds cuneate-oblong, 8–10 mm long, brown; seed wings cuneate-triangular, 15 × 12 mm, brown with a violet tinge.

Taxonomic notes

In a recent paper Strandby *et al.* (2009) carried out a morphometric study of Mexican and Central American firs, in which they concluded that *Abies vejarii* cannot be retained as a separate taxon from *A. religiosa* and should therefore be merged. They proposed the new combination *A. religiosa* subsp. *mexicana* to accommodate populations formerly named *A. vejarii, A. vejarii* subsp. *mexicana, A. guatemalensis, A. tacanensis, A. zapotekensis* and varieties of *A. guatemalensis*. They admit that "a consensus on the taxonomy of *Abies* ocurring in southern Mexico and Guatemala is undoubtedly still remote" and therefore this new taxonomy, reducing several species to synonymy or infraspecific status, is merely noted here.

Distribution

NE Mexico: Sierra Madre Oriental in Coahuila, Nuevo León, Tamaulipas.
TDWG codes: 79 MXE-CO MXE-NL MXE-TA

Ecology

Abies vejarii is a high mountain species, occurring between (1900–)2800 m and 3300 m a.s.l. on steep mountain slopes near the summits or in cool ravines. The soils are usually poor in humus content, but moist; the climate is cool, with relatively dry summers and wet winters. The species is commonly associated with various species of *Pinus* and with *Pseudotsuga menziesii* var. *glauca*, also with *Quercus* spp.; *Cupressus arizonica* and *Picea engelmannii* subsp. *mexicana* (another endemic relict taxon) have been reported with *Abies vejarii* var. *mexicana*.

Uses

This species and its infraspecific taxa are relatively rare trees with limited distribution, consequently their importance as timber trees is negligible. The species (including its infraspecific taxa) has been introduced to cultivation in the USA and Europe, but it remains restricted to arboreta and other plant collections despite its attractiveness and suitability especially in regions with warm summers and mild, wet winters. Cultivation from wild origin seed of var. *mexicana* would under appropriate circumstances contribute to *ex situ* conservation of this threatened taxon.

3 varieties are recognized:

Abies vejarii Martínez var. ***vejarii***. Type: Mexico: Tamaulipas, 20 km N of Miquihuana, *M. Martínez 3531* (holotype MEXU).

Description

Seed cones 6–12 cm long, 4–6 cm wide; bracts exserted.

Distribution

NE Mexico: Sierra Madre Oriental in Coahuila, Nuevo León and Tamaulipas.
TDWG codes: 79 MXE-CO MXE-NL MXE-TA

Conservation

IUCN: VU (D2)

Abies vejarii Martínez var. ***macrocarpa*** Martínez, Anales Inst. Biol. Univ. Nac. México 19: 90. 1948. Type: Mexico: Coahuila, Saltillo, Mesa de las Tablas, *E. E. M. Loock 123* (holotype MEXU).

Description

Seed cones 10–15 cm long, 5(–7?) cm wide; bracts exserted.

Distribution

Mexico: Coahuila (Mesa de las Tablas), Nuevo León (Cerro Potosí).
TDWG codes: 79 MXE-CO MXE-NL

Conservation

IUCN: VU (D2)

Abies vejarii Martínez var. ***mexicana*** (Martínez) T. S. Liu, Monogr. Gen. Abies: 261. 1971. *Abies mexicana* Martínez, Anales Inst. Biol. Univ. Nac. México 13 (2): 626. 1942; *Abies vejarii* Martínez subsp. *mexicana* (Martínez) Farjon, Pinaceae (Regnum Veg. 121): 103. 1990. Type: Mexico: Nuevo León, Sierra de Santa Catarina, *M. Martínez s.n.*, 1939 (holotype MEXU).

Description

Seed cones to 10 cm long; bracts with a narrow, straight cusp, entirely included.

Taxonomic notes

Rushforth (1987) has rejected alliance of this variety with *A. vejarii* and placed this taxon close to *Abies durangensis*.

Distribution

Mexico: SE Coahuila, Nuevo León (Sierra de Santa Catarina), Tamaulipas.
TDWG codes: 79 MXE-CO MXE-NL MXE-TA

Ecology

This variety occurs usually on N-facing slopes and in steep ravines at altitudes between 2000 m and 3000 m a.s.l. *Cupressus arizonica* and *Picea engelmannii* subsp. *mexicana* (another narrow endemic relict taxon) have been reported to occur with *A. vejarii* var. *mexicana*.

Conservation

IUCN: VU (D2)

Abies yuanbaoshanensis Y. J. Lu & L. K. Fu, Acta Phytotax. Sin. 18 (2): 206. 1980. Type: China: Guangxi, Rongshui Xian, Yuanbao Shan, *Y. J. Lü 1001* (holotype PE).

Etymology

The epithet refers to the mountain where this species was discovered.

Vernacular names

Yuanbaoshan fir; Yuanbaoshan lengshan (Chinese)

Description

Trees to 25 m tall, d.b.h. to 0.6 m (or more); trunk monopodial, straight, columnar, terete; crown probably like *A. forrestii* (not described). Bark smooth at first, becoming ridged and grooved, divided into small plates in old trees. Branches of first order long, spreading horizontally; branches of second order spreading and ascending. Branchlets slender, firm,

yellowish brown or light brown, becoming light or dark brown, glabrous; leaf scars circular. Vegetative buds ovoid-conical, very resinous; bud scales reddish brown, persisting several years. Leaves spirally arranged, densely set, subradially spreading above shoot, the lower leaves spreading laterally, the upper leaves shortest, on coning shoots assurgent or erect, 1–2.7 cm long (leaves of young trees longer: 3–3.8 cm, usually more pectinately arranged in two rows of equal length), longest in the middle portion of shoot, 1.8–2.5 mm wide, twisted or curved at base, linear or ligulate-linear, flattened; margins (*in sicco*) revolute, with a median groove above, dark green above, two very white bands below; apex obtuse to slightly emarginate. Stomata absent above, in two broad bands separated by a midrib below. Pollen cones solitary, axillary, on short branches, oblong cylindrical, 1–1.5 cm long, yellow. Seed cones lateral, erect, short pedunculate to almost sessile, broad ovoid-cylindric, short, with slightly narrowed, obtuse apex, 8–9 cm long, 4.5–5 cm wide, green or yellowish green when immature, maturing to light yellowish brown, becoming pale (yellowish) brown when ripe; cone rachis persistent, fusiform or conical, brown. Seed scales cuneate-flabellate, length × width at mid cone 2 × 2.2 cm; surface smooth, with thickened central portion of apical part, exposed part densely greyish white puberulent; upper margin entire, rounded to almost truncate, slightly incurved; lower margins auriculate; base short pedicellate. Bracts large, broad oblong, widest in the middle (9 mm), with rounded, erose-denticulate upper margins and a small cusp, 2.5–2.8 cm long, of the same colour as the seed scales, apical part 6–7 mm wide, reflexed, distinctly exserted. Seeds cuneate-oblong or obovate-oblong, 10 × 4 mm, resinous, dark red brown; seed wings cuneate-dolabriform, with a truncate apex, slightly longer than the seeds (9–11 × 8–10 mm), shining light brown.

Taxonomic notes

This species is closely related to *A. forrestii* and is therefore best placed in the section *Pseudopicea*, subsection *Delavayianae*.

Distribution

China: N Guangxi (Rongshui Xian, Yuanbao Shan).
TDWG codes: 36 CHS-GX

Ecology

The highest mountains in Guangxi, like Yuanbao Shan, have a very cool, wet climate, with annual precipitation exceeding 2000 mm. The summers are cool and cloudy, the winters last 4–5 months and bring abundant snow from December through March. This species occurs in mixed deciduous-coniferous forest with other conifers (e.g. *Tsuga chinensis*) and broad-leaved trees dominated by members of the *Fagaceae*; the *Abies* trees are very scattered.

Conservation

This species has an extremely limited distribution, distant from other species, and is only known from one small area in Guangxi Province.
IUCN: CR [B1ab (v) + B2ab (v)]

Uses

No uses have been recorded of this species.

Abies ziyuanensis L. K. Fu & S. L. Mo, Acta Phytotax. Sin. 18 (2): 208. 1980. *Abies fabri* (Mast.) Craib var. *ziyuanensis* (L. K. Fu & S. L. Mo) Silba, Phytologia 68: 14. 1990; *Abies beshanzuensis* M. H. Wu var. *ziyuanensis* (L. K. Fu & S. L. Mo) L. K. Fu & Nan Li, Novon 7 (3): 261. 1997. Type: China: Guangxi, Ziyuan Xian, Yinzhulao Shan, *Y. J. Lü 78001* (holotype PE).

Abies dayuanensis Q. X. Liu, Bull. Bot. Res. North-East. Forest. Inst. 8 (3): 85. 1988.

Etymology

The epithet refers to the name of the municipality (Ziyuan Xian) in which the type specimen was collected.

Vernacular names

Ziyuan fir; Ziyuan lengshan (Chinese)

Description

Trees to 30 m tall, d.b.h. to 0.6–0.9 m; trunk monopodial, straight, columnar, terete; crown broad, conical

or flat topped in old trees. Bark of young trees smooth, grey, in old trees shallowly ridged and grooved, broken into small plates on lower part of trunk. Branches of first order long, spreading horizontally, ascending towards the top of the tree; branches of second order spreading or ascending. Branchlets thick, stout, at first light yellowish brown, in the third year greyish brown; surface ridged and grooved between the leaves, glabrous or with short hairs in the grooves; leaf scars circular. Vegetative buds cylindric or ovoid-oblong, with acutish apex, covered with a thin layer of white resin; bud scales triangular, dorsally keeled, light yellowish brown. Leaves spirally arranged, spreading laterally in two overlapping sets, of unequal length, the longest near base of shoot, on coning shoots upper leaves assurgent, all leaves on vegetative shoots of young trees pectinate, widely spaced, 2–4.8 cm long, 3–3.5 mm wide, twisted or curved at base, linear, straight or curved, flattened, with margins (*in sicco*) slightly recurved, dark green above, two greenish white bands below; apex obtuse or slightly emarginate. Stomata absent on the adaxial (upper) surface, in two bands divided by a midrib below. Pollen cones lateral, in leaf axils, ca. 2 cm long, yellowish, with red microsporophylls. Seed cones lateral, with 0.5–1 cm long peduncles, oblong-cylindric or elliptical, with obtuse apex, 10–11 cm long, 4.2–4.5 cm wide, greenish or yellowish green when immature, maturing to dark greenish brown, becoming dark brown when ripe; cone rachis persistent, narrowly conical. Seed scales broad cuneate-flabellate, length × width at mid cone 2.3–2.5 × 3–3.3 cm; surface smooth, dark brown when ripe, sparingly puberulent; upper margin entire, rounded, not incurved, light brownish green; lateral margins finely toothed, auriculate near the pedicellate base. Bracts oblong-spathulate, near apex 9–10 mm wide, near base 3 mm, 2.1–2.3 cm long including the small cusp, included, or slightly exserted near base of cone and recurved; apical margin with fine teeth. Seeds cuneate-oblong, ca. 10 × 4 mm, purplish grey with dark resin; seed wings cuneate-dolabriform, with rounded or slightly truncate apex, 13–15 × 12–14 mm, light purplish grey, with dark spots, lustrous.

Taxonomic notes

According to Fu, Lu & Mo (1980), this species is closely related to *A. beshanzuensis* M. H. Wu, another novelty described around that time. Farjon & Rushforth (1989) classified *A. ziyuanensis* in section *Momi*, subsection *Holophyllae*, as its close affinity to *A. chensiensis* seemed more likely on morphological grounds. In Flora of China 4: 50 (1999) *A. ziyuanensis* has been reduced to a variety of *A. beshanzuensis*. If this taxonomy is accepted, *A. beshanzuensis* would no longer be considered an extremely rare species, but merely a variety of a still rare, but more widespread species. A recent phylogenetic study (Xiang *et al.*, 2009) based on nuclear DNA sequence data (ITS regions) sampled *A. ziyuanensis* amongst 48 species. This species appeared to be closely related to *A. homolepis* and also to *A. chensiensis*.

Distribution

China: NE Guangxi (Rongshui Xian, Yuanbao Shan), SW Hunan (Ziyuan Xian, Xingni, Chenbu), SW Jiangxi (Jinggang Shan).
TDWG codes: 36 CHS-GX CHS-HN CHS-JX

Ecology

Abies ziyuanensis is a rare fir occurring on the highest mountains in Jiangxi, Guangxi and on the border with Hunan, in a narrow belt between 1650 m and 1750 m a.s.l. These mountains have a cool, very wet climate, with a mean annual temperature between 9.2°–12° C, and a winter period of 4–5 months (November-March) in which the mean temperature is between -3° to -5° C (min. -10°). The weather is usually cloudy, with much fog, the annual precipitation is 2100–2400 mm and snow lasts from December through March. *Abies ziyuanensis* occurs, together with other conifers, scattered in a mixed forest dominated by deciduous broad-leaved trees. Above 1700 m on Yuanbao Shan it is replaced by *A. yuanbaoshanensis*.

Conservation

This species is only known from less than five localities, some in close proximity. As it occurs lower on the mountains, it has been logged for local use of timber. Present threats are landslides and overgrazing by sheep and cattle.
IUCN: CR [B1ab (iii) + C2a (i)]

Uses

No current uses have been recorded of this fir.

Acmopyle Pilg., in Engler, Pflanzenreich 4 (5, 18): 117. 1903. Type: *Acmopyle pancheri* (Brongn. & Gris) Pilg. (*Podocarpaceae*).

Greek: *akme* = highest point, tip; *pyle* = opening (gate); referring to the erect position of the mature seed.

Description

Dioecious (or sometimes monoecious?), small evergreen trees. Branching sparse in remote pseudowhorls (Massart's model). Terminal buds absent. Leaves spirally arranged, of two kinds: small and scale-like on leading and fertile shoots, larger and foliate on lateral, vegetative shoots; the larger leaves bilaterally flattened, falcate-linear, spreading obliquely or in pinnate ranks on shaded shoots, single-veined. Pollen cones lateral or terminal, axillary, solitary or a few together, catkin-like; microsporophylls helically attached to a slender rachis on very short stalks, triangular, with two basal pollen sacs containing bisaccate pollen. Seed cones solitary or occasionally grouped, on scale-leaved pedunculate branchlets axillary or sub-terminal on leafy shoots, when mature forming an irregular, fleshy and verrucose receptacle from several unfertilized bracts which remain partly visible. Seeds single, from a subterminal, inverted ovule, becoming (nearly) erect at maturity, entirely enclosed by a fleshy epimatium, its base partly enclosed by the receptacle, bluish pruinose when mature.

2 species

Distribution

New Caledonia; Fiji (Viti Levu).

Key to the species of *Acmopyle*

– Leaves falcate to weakly S-curved, in middle of branchlets 10–30 mm long, 1.5–3 mm wide. Pollen cones elongating to 20–25 mm long, ca. 3 mm wide. Fully developed receptacles 15–20 × 8–10 mm. New Caledonia ***A. pancheri***
– Leaves straight or falcate to weakly S-curved, in middle of branchlets 10–25 mm long, (0.6–)2–4(–4.8) mm wide. Pollen cones elongating to 5–8 mm long, ca. 1.5 mm wide. Fully developed receptacles 7–9 × 7–8 mm. Fiji ***A. sahniana***

Acmopyle pancheri (Brongn. & Gris) Pilg., in Engler, Pflanzenr. IV.5 [18]: 117. 1903. *Dacrydium pancheri* Brongn. & Gris, Bull. Soc. Bot. France 16: 330. 1869; *Nageia pancheri* (Brongn. & Gris) Kuntze, Revis. Gen. Pl. 2: 800. 1891. Type: New Caledonia: Grande Terre, Province Sud, *J. A. I. Pancher s.n.* (holotype P). Fig. 21

Podocarpus pectinatus Pancher *ex* Brongn. & Gris, Bull. Soc. Bot. France 16: 330. 1869.
Acmopyle alba J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 281. 1949.

Etymology

This species was named after J. A. I. Pancher, who collected the type specimen in 1869.

Vernacular names

No common names are recorded for this species.

Description

Small to medium size trees to 25 m tall, usually smaller; trunk monopodial, to 50 cm d.b.h. Bark on trunk becoming hard and scaly, breaking into small plates, brown weathering grey; inner bark more or less fibrous. Branches spreading horizontally in young trees, irregular and assurgent in older trees, with foliage towards the ends. Foliage branches terete, with small spreading leaf apices terminating spirally arranged, decurrent scale leaves; ultimate foliage branchlets 3–15 cm long, alternating, mostly plagiotropic, becoming deciduous after a few years, with short scale leaves at the base which gradually enlarge to pectinately arranged foliage leaves. Foliage leaves on seedlings alternate, pectinate, linear, straight, in the middle of the branchlet ca. 15 mm long, 1.5 mm wide, acute or pungent. Foliage leaves on young trees and mature trees similar, alternate, pectinate at 60°–90°, straight or more often falcate towards apex, or on vigorous branchlets weakly S-curved, in the middle of branchlets 10–30 mm long, 1.5–3 mm wide, gradually shorter especially towards the proximal and less so towards the distal end of branchlets,

twisted and decurrent at base; margins revolute; apex obtuse or acute, curved forward; midrib narrow above, often faint, prominent below; leaf colour lustrous dark green above, with two whitish bands separated by a green midrib and with green margins below. Stomata on both surfaces, in numerous intermittent lines, some on the midrib on the lower (abaxial) side and a few stomata near the base and/or apex on the upperside. Pollen cones subterminal or terminal on lateral foliage shoots, solitary or 2–3 together, on short, scale-leaved peduncles, initially globose, elongating to 20–25 mm long, ca. 3 mm wide at anthesis; microsporophylls imbricate, carinate, acute at first then acuminate, speading but apically incurved, with two basal, small pollen sacs. Seed cones subterminal or terminal on lateral foliage shoots, sometimes axillary to scale leaves or foliage leaves, solitary or sometimes 2–3 together, on up to 12 mm long, curved, scale-leaved peduncles; composed of several sterile and 1–2 fertile, amalgamated bracts, forming a fleshy, swollen, irregularly shaped, verrucose and pruinose receptacle 15–20 mm long and 8–10 mm wide. Seeds 1–2 at the distal end of the receptacle, subglobose, 7–10 mm diam. including the covering epimatium, crested and pruinose when full-grown.

Distribution

New Caledonia (Grande Terre).
TDWG codes: 60 NWC

Ecology

Acmopyle pancheri occurs scattered in rainforest as an understorey tree and in low forest and vegetation bordering on 'maquis minier' as a small canopy tree. Its altitudinal range is from near sea level to at least 1200 m a.s.l. and it is found on ultramafic soil derived from serpentine or similar rock as well as on acidic soil from metamorphic schist. It is associated with other conifers such as *Araucaria* spp., *Dacrydium araucarioides* and *Agathis ovata*, as well as with numerous angiosperms.

Conservation

IUCN: NT

Uses

No uses have been recorded of this species and it is in cultivation only in a few botanic gardens.

Acmopyle sahniana J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 28: 142. 1947. Type: Fiji: Western Division, Viti Levu, Vakarogasiu Mountain, ["Namosi Province"], *J. W. Gillespie 3273* (holotype A).

Etymology

This species was named after Prof. Birbal Sahni from Lucknow, India, who studied the morphology of the genus *Acmopyle*.

Vernacular names

No common names have been recorded for this species.

Description

Small (monoecious?) trees to 12 m tall; trunk normally monopodial, to 20 cm d.b.h. Bark mostly smooth, sometimes pustulate, brown weathering grey; inner bark red and more or less fibrous. Branches sparse, spreading to form a crown half as wide as the tree height, with foliage towards the ends. Foliage branches terete, with very small spreading leaf apices terminating spirally arranged, decurrent scale leaves; ultimate foliage branchlets 2–6(–12) cm long, alternating, mostly plagiotropic, becoming deciduous after a few years, with short scale leaves at base which often abruptly change to pectinately arranged foliage leaves. Foliage leaves on young trees and mature trees similar, alternate, pectinate at 60°–90°, straight or more often falcate towards apex, or on vigorous branchlets weakly S-curved, in the middle of branchlets 10–25 mm long, (0.6–)2–4(–4.8) mm wide, smallest towards proximal and distal end of branchlets, twisted and decurrent at base; margins revolute; apex acute, curved forward; midrib narrow above, often faint, prominent below; leaf colour lustrous dark green above, with two whitish bands separated by a green midrib and with green

margins below. Stomata on both surfaces, in numerous intermittent lines, some on the midrib on the lower (abaxial) side and a few stomata near the base and/or apex on the upperside. Pollen cones subterminal or terminal on lateral foliage shoots, solitary or in pairs, sessile or on very short peduncles, initially globose, elongating to 5–8 mm long, ca. 1.5 mm wide at anthesis; microsporophylls imbricate, carinate, acute, speading, with two basal, small pollen sacs. Seed cones subterminal or terminal on lateral foliage shoots, sometimes axillary to scale leaves or foliage leaves, solitary, on up to 6 mm long, curved, scale-leaved peduncles; composed of 2–3 sterile and 1(–2) fertile amalgamated bracts, forming a fleshy, swollen, irregularly shaped, verrucose and green or purple receptacle 7–9 mm long and 7–8 mm wide. Seeds solitary at the distal end of the receptacle, ovoid, 7–9 mm long, 5–6 mm wide including the covering epimatium, striated and greyish violet with whitish bloom when full-grown.

Distribution

Fiji Islands (Viti Levu).
TDWG codes: 60 FIJ

Ecology

Acmopyle sahniana is a small tree occurring sparsely in low rainforest on mountain ridges and summits in three localities on the island of Viti Levu. The altitudinal range is from 600 m to 1050 m a.s.l.

Conservation

The very limited area of occupancy (AOO) of this species and an estimated population not exceeding 50 mature trees put this species in the Critically Endangered category. Proposed mining activities in the area, which is not protected, further threaten this species (Doyle in Farjon & Page, 1999).
IUCN: CR [C2a (i)]

Uses

No uses have been recorded of this species.

Actinostrobus Miq., in Lehmann, Pl. Preiss. 1: 644. 1845. Type: *Actinostrobus pyramidalis* Miq. (*Cupressaceae*).

Greek: *actino-* = rayed, star-like; *strobus* = cone; referring to the six scales coming together at the apex of the seed cone.

Description

Evergreen, monoecious (decumbent) shrubs or trees with smooth, thin, flaking bark. Resin cavities in leaves. Branches short, stiff, spreading or ascending, forming a conical, pyramidal or bushy crown. Fastigiate forms common in nature. Leaves in whorls of 3, decurrent; juvenile acicular leaves on young plants only or also on mature plants; adult leaves mostly shorter than 5 mm, linear-lanceolate, abaxially keeled, denticulate on margins and keel or only on margins, acuminate-pungent, green or glaucous green, amphistomatic, stomata in 2 lines on each face. Pollen cones small, cylindrical; microsporophylls 10–18, in whorls of 3, with 2–4 abaxial pollen sacs. Seed cones solitary, with 2–3 together or aggregated along branches and stems, when closed broadly globose with dome-shaped apex, broadly globose-conical, or broadly utriculate. Bract-scale complexes in two whorls of 3, of nearly equal size at maturity, subtended by 4–6 alternating whorls of 3 broad, imbricate scale leaves. Bract tips entirely included in cone scales. Cone scales oblong, opening valvately, with light coloured seed scars towards base. Columella a strong, acute spike. Ovules in 2 whorls of 4–6 axillary to bracts, erect. Seeds 8–12 per cone, with 3 wings. Seedlings with 2 cotyledons.

3 species

Distribution

SW Western Australia, in a narrow coastal strip from S of Shark Bay to near Albany.

Key to the species of *Actinostrobus*

1a. Both juvenile, long acicular and adult, scale leaves present on mature plants. Seed cones not in clusters on stems ***A. acuminatus***

1b. Leaves on mature plants short, scale-like. Seed cones in clusters on stems **2**

2a. Seed cone scales with straight, acute apex ***A. arenarius***

2b. Seed cone scales with incurved, obtuse apex ***A. pyramidalis***

Actinostrobus acuminatus Parl., Index Sem. Hort. Florent. 1862: 25. 1862. Type: Australia: Western Australia, ["between Moore & Murchison Rivers"; "Swan River"], *J. Drummond 225* (holotype FI).

Etymology

The species epithet refers to the shape of the cone apex (Latin: *acuminatus* = tapering from inwardly curved sides to a narrow point).

Vernacular names

Dwarf Cypress

Description

Shrubs, erect or decumbent to ascending, dense, 1–4.5 m tall; trunk short or multistemmed. Bark smooth, soon flaking, thin, brown-grey. Branches numerous, spreading or prostrate, persistent, forming a broadly conical or more irregular crown (often partly buried in blown sand). Foliage branches numerous, contorted, spreading irregularly or ascending, rigid, slender, short, rather sturdy, angular with decurrent leaf bases, persistent, grey-brown to grey when leaves weather away. Leaves in alternating whorls of 3, decurrent; juvenile leaves on young and mature plants, acicular, 10–20 × 0.8–1.5 mm, with spreading free part (patent), abaxially keeled, acute-pungent, light green or yellowish green, adult leaves linear-lanceolate, 2–4 × 1 mm, with recurved or incurved free apex, abaxially keeled, denticulate on margins, acuminate, green; stomata in 2 narrow lines on each face. Pollen cones terminal on ultimate branchlets, yellowish green turning light brown, 7–10 × 2–3 mm; microsporophylls 10–16, in whorls of 3, ovate with acute apex, slightly keeled abaxially, with 3–4 abaxial pollen sacs. Seed cones terminal on short (ca. 1 cm), slightly thickened, lateral, short-leaved branchlets,

mostly solitary or with 2–3 together, when closed broadly utriculate, with a distinct 'neck' below apex of scales, 15–25 × 10–20 mm, glaucous green maturing to brown. Bract-scale complexes whorled, 6, of nearly equal size at maturity, subtended by 4–6 alternating whorls of 3 broad, imbricate scale leaves with denticulate margins; apex free, acuminate; smaller lower whorls partly overlapping larger upper whorls. Bract tips entirely included in cone scales. Cone scales oblong, 15–20 × 5–10 mm, more or less concave and finely wrinkled, dark brown abaxially, with recurved, acute apex, with smooth adaxial face, blackish or purplish black, with light coloured seed scars towards base. Columella a strong, acute central spike. Seeds 8–12 per cone, only a small number fertile, about half of these smaller and situated between bases of cone scales, irregularly triangular/angular, 5–6 mm long (including wings 9–12 mm), yellowish brown; wings narrow, 2–3 mm wide.

Distribution

SW Australia: from Three Springs south to Perth Region, in proximity of the coast.
TDWG codes: 50 WAU-WA

Ecology

Mostly in low dwarf scrub ('kwongan'), with *Myrtaceae, Proteaceae* etc.; also in low woodland dominated by *Eucalyptus* spp. ('mallee'), with *Banksia attenuata, Allocasuarina fraseriana, Hakea conchifolia*, and *Calothamnus quadrifidus*; on plains in dry or moist leached white or grey sand or clay usually over laterite (hardpan). The climate is characterized by warm, dry summers and winter rainfall.

Conservation

Although its habitat has been altered in some areas by agricultural development, much remains and this species is only at low risk of extinction at present. An increase of the incidence of fires could be hazardous if it occurred in key populations.
IUCN: NT

Uses

No uses are recorded.

Actinostrobus arenarius C. A. Gardner, J. Roy. Soc. W. Austral. 47: 54. 1964. *Actinostrobus pyramidalis* Miq. var. *arenarius* (C. A. Gardner) Silba, Phytologia Mem. 7: 11. 1984; *Actinostrobus pyramidalis* Miq. subsp. *arenarius* (C. A. Gardner) Silba, J. Int. Conifer Preserv. Soc. 13 (1): 1. 2006.
Type: Australia: Western Australia, Tammin, *C. A. Gardner 610* (holotype PERTH). Fig. 22, 23

Etymology

The species epithet refers to its habitat (Latin: *arena* = sand).

Vernacular names

Bruce cypress

Description

Erect shrubs or small trees, dense, 2–5 m tall; trunk short or multistemmed. Bark smooth, soon flaking, thin, brown-grey. Branches numerous, spreading or ascending, persistent, forming a narrowly or broadly conical or more irregular crown. Foliage branches numerous, contorted, spreading irregularly or ascending, rigid, slender, short, rather sturdy, angular with decurrent leaf bases, persistent, grey-brown to grey when leaves weather away. Leaves in alternating whorls of 3, decurrent (juvenile leaves on young plants only), linear-lanceolate, 3–5(–9) × 1–1.5(–2) mm, with spreading or recurved free distal part, abaxially keeled, denticulate on margins and keel, acuminate-pungent, green or glaucous green; stomata in 2 lines on each face. Pollen cones terminal on ultimate branchlets, yellowish green turning light brown, 5–7 × 2–2.5 mm; microsporophylls 12–18, in whorls of 3, ovate with cuspidate apex, slightly keeled abaxially, with 2–4 abaxial pollen sacs. Seed cones terminal on short (0.5–1 cm), slightly thickened, lateral, short-leaved branchlets, mostly aggregated along branches and stems, when closed broadly globose-conical, 12–18 × 10–18 mm, glaucous green or pruinose, maturing to purplish brown or grey-brown. Bract-scale complexes whorled, 6, of nearly equal size at maturity, subtended by 4–6 alternating whorls of 3 broad, imbricate scale leaves with denticulate margins; apex appressed, rounded, mucronate; smaller lower whorls partly overlapping larger upper whorls.

Bract tips entirely included in cone scales. Cone scales oblong, 10–15 × 5–8 mm, more or less flat, smooth, grey-brown abaxially, with straight, acute apex, with smooth adaxial face, purplish brown, with light coloured seed scars towards base. Columella ca. 6 × 4 mm, triangular, brown. Seeds 8–12 per cone, only a small number fertile, about half of these situated between bases of cone scales, irregularly triangular/angular, 4–5 mm long (including wings ca. 10 mm), yellowish brown; wings 2–3 mm wide.

Taxonomic notes

This species is a segregate from *A. pyramidalis*, of which the proposing author emphasised differences in glaucousness of leaves and cones as well as the shape of female cone scales. The leaves of *A. arenarius* can be green as well as glaucous green, resulting in more or less glaucous foliage or sometimes green foliage that is indistinguishable from that of *A. pyramidalis*. As in other conifers, glaucousness of foliage is highly variable and unreliable as a taxonomic character. In *A. arenarius* the free apical parts of leaves are nearly always spreading, while in *A. pyramidalis* they are either spreading or incurved, which gives the former species on the whole a rougher appearance in its foliage. This is certainly not a fully distinctive character. The shape of the mature cone scales does distinguish this species from *A. pyramidals*, and they are indeed larger when fully grown. These characters place the cone as intermediate in shape and size between *A. acuminatus* and *A. arenarius*. The two species *A. arenarius* and *A. pyramidalis* appear to be largely allopatric but occupy very similar habitats; *A. acuminatus* is mostly sympatric with *A. arenarius* (which has a larger range) but the two species are usually found at different localities and usually occupy somewhat different microhabitats.

Distribution

SW Australia: from Lake Grace to the Murchison River.
TDWG codes: 50 WAU-WA

Ecology

Usually in low, open dwarf scrub ('kwongan')with *Myrtaceae* (e.g. *Melaleuca*), *Proteaceae* (e.g. *Banksia, Conospermum, Grevillea, Hakea*), *Acacia* spp., *Callitris preissii*, and *C. roei*; often on road verges through arable fields ('wheat belt') in disturbed vegetation; on plains in leached white or yellow (gravelly) sand, sandstone, loam or on laterite (hardpan); to a maximum altitude of 200 m a.s.l. The climate is characterized by warm, dry summers and winter rainfall.

Conservation

This species is still widespread in most of its natural range despite the fact that large areas have been converted to agriculture. It is in fact colonising road verges and abandoned fields, often forming groves of some extent much as some species of *Juniperus* are known to do in the northern hemisphere. It is therefore considered not threatened.
IUCN: LC

Uses

No uses are recorded; it may be planted locally as an ornamental. See for comments about its potentials under *A. pyramidalis*.

Actinostrobus pyramidalis Miq., in Lehmann, Pl. Preiss. 1: 644. 1845. Type: Australia: Western Australia, Gordon River, ["et in depressis districtum Perth et Wellington"; the specimen in P has "Riv. des Cygnes" = Swan River], *L. Preiss 1311* (holotype U).

Etymology

The species epithet refers to the habit of this shrub.

Vernacular names

Swan River cypress, Swamp cypress

Description

Erect shrubs or small trees, dense, 2–6 m tall; trunk short or multistemmed. Bark smooth, soon flaking, thin, brown-grey. Branches numerous, ascending or nearly erect, persistent, forming a narrowly conical or pyramidal, less often rounded crown. Foliage branches numerous, contorted, spreading irregularly

or ascending, rigid, slender, short, rather sturdy, angular with decurrent leaf bases, persistent, grey-brown to grey when leaves weather away. Leaves in alternating whorls of 3, decurrent (juvenile leaves on young plants only), linear-lanceolate, 2–5(–8) × 1–1.5(–2) mm, with spreading or incurved free distal part, abaxially keeled, denticulate on margins and keel, acuminate-pungent, green; stomata in 2 lines on each face. Pollen cones subterminal on ultimate branchlets, reddish yellow turning reddish brown, 3–6 × 1.5–2 mm; microsporophylls 12–18, in whorls of 3, orbicular-ovate with cuspidate apex, slightly keeled abaxially, with 2–4 abaxial pollen sacs. Seed cones terminal on short (0.5–1 cm), slightly thickened, lateral, short-leaved branchlets, mostly aggregated along branches and stems, when closed broadly globose with dome-shaped apex, 12–15 × 12–16 mm, green or purplish green, maturing to purplish brown or grey-brown. Bract-scale complexes whorled, 6, of nearly equal size at maturity, subtended by 4–6 alternating whorls of 3 broad, imbricate scale leaves with denticulate margins; apex appressed, rounded, minutely mucronate; smaller lower whorls partly overlapping larger upper whorls. Bract tips entirely included in cone scales. Cone scales oblong, 10–14 × 5–6 mm, more or less flat, smooth, grey-brown abaxially, with incurved, obtuse apex, with smooth adaxial face, purplish brown or nearly black, with lighter coloured seed scars towards base. Columella a 5–7 mm long, dark brown to blackish spike. Seeds 8–12 per cone, only a small number fertile, about half of these situated between bases of cone scales, irregularly triangular/angular, 3–5 mm long (including wings 6–9 mm), yellowish brown; wings ca. 2 mm wide.

Distribution

SW Australia: From Lynton District (Hutt River) S to Albany District.
TDWG codes: 50 WAU-WA

Ecology

In low, open dwarf scrub ('kwongan'), or in low woodland dominated by *Eucalyptus* spp. ('mallee'); often in road verges through farmland in disturbed vegetation, associated with other *Myrtaceae* (e.g. *Melaleuca*), *Proteaceae* (e.g. *Banksia, Conospermum, Grevillea, Hakea*), *Acacia* spp., *Xanthorrhoea* sp., *Callitris preissii*, and *C. roei*; on plains in dry soil, or in or near (salt) marshes and lakes, on leached white or yellow sand, reddish lateritic soil (hardpan) and gravel. The climate is characterized by warm, dry summers and winter rainfall.

Conservation

While still common, because it occupies the smallest range of the three species of *Actinostrobus*, which in part coincides with a major metropolitan area, *A. pyramidalis* is more at risk. Threats are urbanisation, conversion of wildland to agriculture (limited) and especially increased incidence of fire. This species could therefore be at low risk as it is likely that some decline of populations or their size may have occurred. On the other hand it is also capable of colonising new sites, but a comprehensive assessment of the dynamics of these populations is not available.
IUCN: LC

Uses

No uses are recorded; it may be planted locally as an ornamental. The lack of interest in the horticultural use of this species and of similar-looking *A. arenarius* in their native country is remarkable; their habit as an often naturally columnar to pyramidal shrub and the attractive green or glaucous green foliage and seed cones seem to give them much merit. I suspect that this is an omission with cultural backgrounds. European (largely British) immigrants have created English gardens with English design and plantings, including manicured lawns that in the climate of much of Australia require constant and expensive watering. The native flora is considered 'bush' and while several of its more showy species, e.g. of the *Banksiaceae* and *Myrtaceae*, have found their way to gardens in Europe and beyond, Australian gardens have to look like those at home, which at least subconciously is still England. *Actinostrobus pyramidalis* should be able to do in Australian gardens what introduced 'cypresses' are doing there now, but with far less input of pumped up water. It would also do well in regions with a Mediterranean type climate in California, Chile, southern Europe and South Africa, taking care that it does not become invasive in natural vegetation. To establish this, more detailed research into its ecology is desirable.

Afrocarpus (J. T. Buchholz & N. E. Gray) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45 (2): 383. 1989. *Podocarpus* sect. *Afrocarpus* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 57. 1948. Type: *Afrocarpus falcatus* (Thunb.) C. N. Page [*Taxus falcata* Thunb.] (*Podocarpaceae*).

Latin: *afro-* = African; *carpus* = fruit; name given to distinguish the genus from the related genus *Podocarpus*.

Description

Evergreen, dioecious, large trees. Resin canals (1) in leaves only. Bark thin, becoming scaly with small plates. Terminal buds small or absent. Leaves spirally inserted or (on young plants) opposite, twisted in opposite directions so as to orientate the blades [on opposite sides of the same shoot] with the adaxial side uppermost and the adaxial side downwards, pectinately arranged or ascending, flattened, coriaceous, narrowly lanceolate-elliptic to linear-lanceolate, with a single midrib. Stomata on both surfaces (leaves amphistomatic). Pollen cones axillary, solitary or in groups of 2–3 on short naked peduncles, becoming narrowly cylindrical and catkin-like; microsporophylls spirally inserted, with two pollen sacs containing bisaccate pollen. Seed cones axillary or just below foliage leaves on a short peduncle with or without small scale leaves, consisting of a few sterile bracts and one larger fertile bract with an axillary, inverted ovule. Seeds single per reduced cone, subtended by small, withering scales (not by a receptacle), entirely enclosed by a fleshy, subglobose to obovoid or ellipsoid epimatium, maturing from greenish to yellow or reddish brown; seed proper with a hard, strongly sclerified seed coat.

5 species

Distribution

E Africa: Ethiopia, Kenya, Uganda, Rwanda, Burundi, Congo Republic (Kivu), Tanzania, Malawi; S Africa: South Africa, Mozambique (Lourenço Marques), Swaziland; W Africa: São Thomé.

Taxonomic notes

The genus *Afrocarpus*, raised to that rank by Page (1989) from a section under *Podocarpus*, has not met with universal recognition, in particular among South African botanists. Some morphological distinctions stressed by Page, such as the lack of a succulent and colourful receptacle, present in *Podocarpus sensu stricto*, are in reality less rigidly distinct, with the situation found in *P. henkelii* in particular representing an intermediate stage. The function of the receptacle, serving seed dispersal by means of offering birds an attractive 'imitation fruit', is apparently taken over by the fleshy epimatium surrounding the seed in *Afrocarpus*. There are botanists who would be inclined to emphasize such adaptational traits as significant, but others who would argue that they do not necessarily indicate phylogeny (adaptation can lead to convergent evolution) and if not, should be disregarded. Other morphological differences, such as the amphistomatic leaves of the species in *Afrocarpus*, appear to be more consistent and have supported a phylogeny separating *Afrocarpus* (Kelch, 1997). Recently, research into this taxonomic question has involved molecular (DNA) analysis (Barker *et al.*, 2004 and papers cited therein) and these data also gave support to the recognition of *Afrocarpus* as distinct from *Podocarpus*. Cladistic analyses of morphological as well as molecular data therefore appear to confirm the taxonomy proposed by Page, as is here adopted.

Key to the species of *Afrocarpus*

The species of *Afrocarpus* are difficult to key out on vegetative characters only; it is therefore necessary to examine especially the seeds with and without their soft covering (epimatium) and in their fully mature state in most cases.

1a. Adult leaves 3–7(–8) mm wide, up to 11 cm long (usually to 8 cm long). Microsporophylls of pollen cones broadly triangular ***A. mannii***

1b. Adult leaves (1.5–)2–4(–5) mm wide, up to 8 cm long (usually to 5 cm long). Microsporophylls of pollen cones triangular-trullate **2**

2a. Buds very small, 0.6–1 mm diam. Midrib prominent on both sides of leaves. Seed coat (3–)4–6(–8) mm thick (remove epimatium) ***A. usambarensis***

2b. Buds larger, ca. 2 mm diam. Midrib prominent on the adaxial (upper) sides of leaves only. Seed coat 1–4 mm tick (remove epimatium) **3**

3a. Seeds including the epimatium 20–30 mm long; seed proper (remove epimatium) rugose, with a 2–4 mm thick seed coat ***A. dawei***

3b. Seeds including the epimatium 12–20(–23) mm long; seed proper smooth or verrucose, with a 1–1.5 mm thick seed coat **4**

4a. Adult leaves (1–)2–4(–4.5) cm long. Seed proper spherical/compressed, 10–14 mm diam., with a verrucose seed coat ***A. falcatus***

4b. Adult leaves (1.5–)3–6(–8) cm long. Seed proper ovoid/compressed, 12–18 mm long, with a smooth seed coat ***A. gracilior***

Afrocarpus dawei (Stapf) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 384. 1989. *Podocarpus dawei* Stapf, in Prain, Fl. Trop. Afrika 6 (2): 342. 1917. Type: Uganda: Nile Land, South Buddu, Kaigera River, *M. T. Dawe 961* (holotype K) [holotype K, not found; isotype B, destroyed].

Etymology

The species epithet commemorates the botanist Morley Thomas Dawe (1880–1943), who collected the type specimen.

Vernacular names

No vernacular names have been recorded for this species.

Description

Trees to 33 m tall, d.b.h. to 1 m., with a long, clear bole. Bark smooth in young trees, flaking in rectangular or rounded small plates in large trees, dark brown, weathering grey. Branches ascending and spreading, forming a small flat-topped crown. Foliage dense, on numerous branches; new lateral branchlets ridged or more or less quadrangular; terminal buds small, ca. 2 mm diam., or absent; bud scales triangular or rounded with or without a rostrate apex. Leaves on seedlings and young plants mostly opposite, narrowly linear-lanceolate, up to 17 cm long and 4–8 mm wide, straight or falcate, tapering to a fine point. Adult leaves shorter, (2–)3–5(–6) cm long, (1.5–)2–4(–5) mm wide, spirally arranged, twisted at the attenuate base, spreading to ascending, straight or rarely slightly falcate, linear-elliptic or with parallel sides, gradually or abruptly tapered above 3/4 of their length, with a raised midrib most prominently on the adaxial (lower) side, grey-green; apex acute. Stomata on both surfaces, arranged in numerous intermittent lines not well separated by the midrib. Pollen cones solitary or with 2–3 on very short stalks or subsessile, axillary to foliage leaves or not, subtended by a whorl of papery bracts, initially subglobose, elongating to cylindrical, 10–20(–25) mm long, 2.5–3.5 mm diam.; microsporophylls spirally arranged, imbricate before anthesis, triangular-trullate, ca. 1 mm wide, with denticulate-lacerate margins and acute or apiculate apex, bearing two subglobose pollen sacs. Seed cones solitary on small, scaly or leafy branchlets situated axillary to or below foliage leaves, with several sterile and one terminal, larger fertile bract. Mature seed cones with a single seed subtended by a single, short bract; with seed enclosed by a fleshy, firm epimatium that ripens from green or glaucous green to yellow, globose or subglobose, 25–30 mm long. Seed proper ovoid but slightly compressed laterally, 16–21 mm long, 12–15 mm wide, with a rugose surface and hard, 2–4 mm thick seed coat.

Distribution

N Tanzania (Kagera and Mara Prov.); Uganda; E Congo Republic (Kivu).

TDWG codes: 23 ZAI 25 TAN UGA

Ecology

Afrocarpus dawei occurs as a co-dominant or emergent tree in seasonal swamp forest on or near floodplains of slow running rivers E and S of Lake Victoria. It is most commonly associated with *Baikiaea minor* (*Leguminosae*) and *Mimusops* sp. (*Sapotaceae*). These flatland (elevation 1100–1200 m a.s.l.) river forests stand on recent river alluvial soils and are inundated in the rainy season, when they become virtually inaccessible.

Conservation

This species does not fulfil the criteria for V, E, CR based on GIS information; its extent of occurrence (EOO) is 175,410 km² (possible NT) and area of occupancy (AOO) is 3,200 km² (NT). Human Footprint AVG in the area is low (7). It is considered NT on the basis of observational reports on exploitation cited on herbarium specimens, which indicates there is reason to suspect decline under criterion A2, but it cannot be quantified. A notable population occurs in the Minziro Forest Reserve in Tanzania, where 16 of 32 (=50%) herbarium collections used in the assessment were made.
IUCN: NT

Uses

The timber of this species, which can grow a tall, straight bole without branches, is valued for construction and carpentry or joinery work, and trees are singled out despite the seasonally difficult access to be logged. It is not exported and used locally or regionally. The species is not known to be in cultivation.

Afrocarpus falcatus (Thunb.) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 383. 1989. *Taxus falcata* Thunb., Prodr. Pl. Cap.: 117. 1800; *Podocarpus falcatus* (Thunb.) Endl., Syn. Conif.: 219. 1847; *Nageia falcata* (Thunb.) Kuntze, Revis. Gen. Pl. 2: 800. 1891 (*nom. illeg.* Art. 53.1); *Decussocarpus falcatus* (Thunb.) de Laub., J. Arnold Arbor. 50: 359. 1969. Type: South Africa: Cape Province, ["e Cap. b. Sp. Ribeek(capel?), Vleermuysdrift"], *C. P. Thunberg UPS 23779* (holotype UPS). Fig. 24

Podocarpus gracilimus Stapf, in Prain, Fl. Trop. Africa 6 (2): 343. 1917.

Afrocarpus gaussenii (Woltz) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 384. 1989; *Podocarpus gaussenii* Woltz, Trav. Lab. Forest. Toulouse T. 1 (8, 2): 6. 1969.

Etymology

The species epithet refers to the (occasionally) sickle-shaped leaves.

Vernacular names

Bastard yellowwood, Outeniqua yellowwood; Outeniekwageelhout; inkoba (South Africa); umgeya (Xhosa, Zulu)

Description

Trees generally to 25 m tall but attaining 60 m, with a massive trunk, d.b.h. to 2 m. Bark smooth in young trees, flaking in rectangular or rounded small plates in large trees, purplish brown or dark brown, weathering grey. Branches ascending and spreading forming a broad, domed crown. Foliage dense, on numerous branches; new lateral branchlets ridged or more or less quadrangular; terminal buds small, ca. 2 × 1 mm, or absent; bud scales narrowly triangular, acute. Leaves spirally arranged, on seedlings and young plants narrowly linear-lanceolate, up to 12 cm long and 3–6 mm wide, straight or falcate, tapering to a fine point. Adult leaves much shorter, (1–)2–4(–4.5) cm long, (1.2–)2–4(–5) mm wide, twisted at the narrowed base, spreading to ascending, straight or slightly falcate, linear-lanceolate to linear-elliptic, with a conspicuously raised midrib adaxially (lower side), obscurely present abaxially, grey-green; apex acute to obtuse. Stomata on both surfaces, arranged in numerous intermittent lines not well separated by the midrib. Pollen cones solitary or with 2–4 on very short stalks or subsessile, axillary to foliage leaves or not, subtended by a whorl of papery bracts, initially subglobose, elongating to cylindrical, 5–13(–15) mm long, 2–3 mm diam.; microsporophylls spirally arranged, imbricate before anthesis, broadly triangular-trullate, ca. 0.6 × 1 mm, with lacerate margins and acute or apiculate apex, bearing two slightly elongate pollen sacs. Seed cones solitary on small, scaly branchlets situated axillary to or below foliage leaves, with several sterile and one terminal, larger fertile bract. Mature seed cones with a single seed subtended by a single, short bract; with seed enclosed by a fleshy, firm epimatium that ripens from glaucous green to yellow or light reddish brown, globose to obovoid, 12–18 mm long, resinous. Seed proper nearly spherical but slightly compressed laterally, 10–14 mm diam. with a verrucose surface and a 1 mm thick, hard seed coat.

Taxonomic notes

In southern Africa, this species is still classified under *Podocarpus* (see e.g. Keith Coates Palgrave's popular handbook Trees of Southern Africa in its several editions, 1977–1988) despite obvious differences in the lack of development of a receptacle in the seed cone and in the anatomy and morphology of the leaves, e.g. amphistomatic versus hypostomatic leaves. Other differences are the placement of pollen cones and seed cones below foliage leaves on scaly dwarf shoots and the thickening and colouring of the epimatium to resemble a yellow plum-like fruit. None of these characters are shared with *Podocarpus sensu stricto* anywhere in the world. A form with small, very narrow leaves (1.5–2.5 cm × 1.5–2 mm) from Transvaal, South Africa was described as a new species *Podocarpus gracillimus* by Stapf, but there is much variation in leaf sizes, which may in part be influenced by growing conditions. The taxon originally described as *P. gaussenii* from Madagascar has turned out to be a case of introduction of *A. falcatus* to that island; it has not been found growing in the wild in recent surveys of the forest flora.

Distribution

SE & S Africa: from Malawi and Mozambique to Kwazulu Natal and Eastern and Western Cape Provinces, South Africa.
TDWG codes: 26 MLW MOZ 27 CPP-EC CPP-WC NAT OFS SWZ TVL-GA TVL-MP TVL-NP

Ecology

Afrocarpus falcatus occurs in the high, moist forests lining rivers in the southern Cape, where it attains its greatest size in the Knysna forest just above sea level. Several of the very large trees here may be 1000–1500 years old and the species is thus another of the large, emergent, long-lived conifers. Eastwards and northwards it ascends to higher elevations (alt. range 500–1700 m a.s.l.) and is restricted to patches of moist forest in ravines and wooded slopes exposed to oceanic winds that bring rain. Here it attains only 25 m or less. In the coastal forests it is associated with *Podocarpus latifolius, Ocotea bullata, Celtis africana, Ilex mitis, Nuxia* spp. and *Olea* spp. and the large podocarp trees are usually solitary, isolated individuals or occasionally form a small group. Presumably their regeneration is dependent on episodal canopy disturbance similar to e.g. *Podocarpus totara* in New Zealand and many other big, long-lived conifers.

Conservation

IUCN: LC

Uses

The wood of *Afrocarpus falcatus*, incorrectly known as yellowwood (= *Podocarpus latifolius*), is valuable especially in the large sizes it attains in the southern Cape. It was used in the past for ship masts and is still in high demand for boat building. The sawn timber is also used in construction for beams and rafters, house floors and wall panelling, carpentry and joinery, and furniture making. In horticulture it is increasingly popular as an amenity tree, mainly in countries with a mild climate like South Africa, e.g. western USA, Australia and New Zealand. It can also be seen in several botanic gardens and arboreta outside South Africa.

Afrocarpus gracilior (Pilg.) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 383. 1989. *Podocarpus gracilior* Pilg., in Engler, Pflanzenr. IV.5 [18]: 71. 1903; *Decussocarpus gracilior* (Pilg.) de Laub., J. Arnold Arbor. 50: 359. 1969. Type: Ethiopia: ["Gerra Abuna Tekla Zlaimanot (Haimanot), auf Bergen 2500 m ü. M."], *G. H. W. Schimper 1160* (syntype K). Fig. 25, 26

Etymology

The species epithet refers to the thin, slender leaves.

Vernacular names

East African yellowwood; sigba or zigba (Amharic, Ethiopia); mponda, poda (Kirangi, Tanzania)

Description

Trees to 40 m tall, d.b.h. to 2.5 m. Bark smooth in young trees, flaking in rectangular or rounded small plates in large trees, light or dark (red-)brown,

weathering grey. Branches ascending and spreading forming a broad, domed crown. Foliage dense, on numerous branches; new lateral branchlets ridged or more or less quadrangular; terminal buds small, ca. 2 mm diam., or absent; bud scales triangular with a rostrate apex. Leaves spirally arranged, on seedlings and young plants sometimes opposite and narrowly linear-lanceolate, up to 18 cm long and 4–8 mm wide, straight or falcate, tapering to a fine point. Adult leaves shorter, (1.5–)3–6(–8) cm long, (1.5–)2–4(–5) mm wide, spirally arranged, twisted at the narrowed base, spreading to ascending, straight or rarely slightly falcate, linear to linear-lanceolate, with a raised midrib adaxially (lower side), present at the proximal end or entirely absent abaxially, grey-green; apex acute. Stomata on both surfaces, arranged in numerous intermittent lines not well separated by midrib. Pollen cones solitary or with 2–3 on very short stalks or subsessile, axillary to foliage leaves or not, subtended by a whorl of papery bracts, initially subglobose, elongating to cylindrical, (5–)10–18(–23) mm long, 2.5–3.5 mm diam.; microsporophylls spirally arranged, imbricate before anthesis, triangular-trullate, ca. 1.5 mm wide, with denticulate-lacerate margins and acute or apiculate apex, bearing two subglobose pollen sacs. Seed cones solitary on small, scaly branchlets situated axillary to or below foliage leaves, with several sterile and one terminal, larger fertile bract. Mature seed cones with a single seed subtended by a single, short bract; with seed enclosed by a fleshy, firm epimatium that ripens from glaucous green to yellow or light orange, broad ellipsoid to pyriform or sometimes globose, 15–20(–23) mm long. Seed proper broadly ovoid but slightly compressed laterally, 12–18 mm long, with a smooth surface and hard, 1–1.5 mm thick seed coat.

Taxonomic notes

This species has been considered by some botanists to be conspecific with *Afrocarpus falcatus* in South Africa, but these species are not only geographically separated but also distinct in several, albeit minor, morphological characters. Such distinctions can of course seem relative; if one considers *Afrocarpus* and *Podocarpus* to be one genus (as many botanists in South Africa still do) then the difference between *A. falcatus* and *A. gracilior* may appear to be less significant. The distinction between species, however, is not a matter of degree, but of discontinuity of character states, indicating a history of genetically separated populations, regardless whether the two populations are now geographically adjacent or disjunct.

Distribution

Ethiopia, Kenya, Sudan (Equatoria), Tanzania, Uganda, E Congo Republic (Kiva), Rwanda, Burundi.
TDWG codes: 23 BUR RWA ZAI 24 ETH SUD 25 KEN TAN UGA

Ecology

Afrocarpus gracilior occurs in montane evergreen rainforest at altitudes from 1500 m to 2600 m a.s.l. In a wet type of forest in Ethiopia and Kenya *Olea welwitschii* and *Afrocarpus gracilior* are dominant, with an understorey in which *Coffea arabica* is frequent. Other dominants in similar forests elsewhere are *Syzygium* spp., *Schefflera* spp., *Celtis* spp., *Ilex mitis, Ocotea kenyensis*, and *Nuxia congesta*; bamboo thickets sometimes form a monotonous understorey. In small forest patches interspersed with subalpine grasslands (with *Arundinaria alpina*) *Afrocarpus gracilior* may occur with e.g. *Albizzia* sp., *Cussonia holstii* and *Erythrina abyssinica*. Many of these forests and forest patches have been degraded, but *A. gracilior* may still occur in the ensuing secondary woodland vegetation, even though it is a long-lived 'climax' tree. *Afrocarpus gracilior* also occurs among or can be co-dominant with *Juniperus procera*, forming characteristic juniper-podocarp forests on the high plateaus and ridges. These forests occur in regions with less high rainfall than in those where angiosperms dominate.

Conservation

IUCN: LC

Uses

Afrocarpus gracilior is an important timber tree in eastern Africa and the timber is exported as well as used locally. The sawn timber is used in construction and particularly inside work such as floors, doors and wall panelling, carpentry and joinery and furniture making. This species has been introduced

from Ethiopia as a forestry plantation tree into other countries, e.g. India, where trial plantations at Dehra Dun were begun in the early years of the 20th century. In northern Ethiopia it is also often planted in church compounds to provide shade and shelter for the congregation (Prof. Ib Friis, pers. comm.). It is not known to be introduced in horticulture and may only be present in a few botanic gardens.

Afrocarpus mannii (Hook. f.) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 384. 1989. *Podocarpus mannii* Hook. f., J. Proc. Linn. Soc., Bot. 7: 218. 1864; *Nageia mannii* (Hook. f.) Kuntze, Revis. Gen. Pl. 2: 800. 1891; *Decussocarpus mannii* (Hook.) de Laub., J. Arnold Arbor. 50: 359. 1969. Type: São Thomé Principe: São Thomé, Pico, on the summit, *G. Mann 1065* (holotype K).

Etymology

This species was named after Georg Mann, who collected the type specimen.

Vernacular names

pinheiro de São Thomé, pinheiro da terra (Portuguese)

Description

Trees generally to 15 m tall but on the summit area as krummholz. Bark undescribed. Branches ascending and spreading forming a broad crown. Foliage relatively sparse; new lateral branchlets ridged or more or less quadrangular; terminal buds small, ca. 2 × 1 mm, or absent; bud scales triangular, acuminate. Leaves spirally arranged, on seedlings and young plants linear-lanceolate to subfalcate, up to 16 cm long and 4–8 mm wide, straight or falcate, tapering to a fine point. Adult leaves slightly shorter, (2–)3–8(–11) cm long, 3–7(–8) mm wide, twisted at the petiolate base, spreading, straight or slightly falcate, lanceolate to linear-lanceolate, with a conspicuously raised midrib adaxially (lower side) and obscurely present abaxially, grey-green; apex acute to obtuse. Stomata on both surfaces, arranged in numerous intermittent lines not well separated by the midrib. Pollen cones solitary or with 2, sessile, axillary to foliage leaves or not, subtended by a few scaly bracts, initially subglobose, elongating to cylindrical, 10–20 mm long, 2–3 mm diam.; microsporophylls spirally arranged, imbricate before anthesis, broadly triangular, ca. 1 × 1 mm, with lacerate margins and acute apex, bearing two pollen sacs. Seed cones solitary on small, scaly branchlets situated axillary to foliage leaves, with several sterile bracts and one terminal, larger fertile bract. Mature seed cones with a single seed subtended by a single, short bract; with seed enclosed by a fleshy, firm epimatium that ripens from glaucous green to reddish brown, obliquely pyriform, 20–30(–35) mm long, resinous. Seed proper nearly obovoid but slightly compressed laterally, 16–25 mm long, with an uneven surface and a 4–5 mm thick, hard seed coat.

Distribution

West Central Africa (Gulf of Guinea Islands): São Tomé.
TDWG codes: 23 GGI-ST

Ecology

Afrocarpus mannii is endemic on the volcano Pico de São Tomé from ca. 1450 m to the summit area at 2142 m a.s.l. It is nowhere a tall tree and at the summit it is reduced to dwarfed krummholz. It is common in the high montane cloud forest where this has remained undisturbed.

Conservation

Deforestation at lower to middle altitudes on the mountain is the main threat to this species, which is endemic to the island.
IUCN: VU (D2)

Uses

The timber of *Podocarpus mannii* is valuable in trees of good size and shape, which have become scarce. It is used for light construction. This species has been planted in rural areas in Cameroon and Ivory Coast and probably elsewhere in W Africa as a canopy tree or windbreak for coffee plantations and as an amenity tree in villages.

Afrocarpus usambarensis (Pilg.) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 384. 1989. *Podocarpus usambarensis* Pilg., in Engler, Pflanzenr. IV.5 [18]: 70. 1903. Type: Tanzania: Tanga Prov., Usambara Mts., Mtai Hill, near Mpare village, *C. Holst 2467* (syntype K).

Etymology

The species epithet refers to the Usambara Mountains from where it was first described.

Vernacular names

mse, muze (Usambara Mts., Tanzania)

Description

Trees to 30 m tall, d.b.h. to 2 m. Bark smooth in young trees, flaking in rectangular or rounded small plates in large trees, dark brown, weathering grey. Branches ascending and spreading forming a broad, domed crown. Foliage dense, on numerous branches; new lateral branchlets ridged or more or less quadrangular; terminal buds very small, 0.6–1 mm diam., or absent; bud scales rounded with or without an apiculate apex. Leaves on seedlings and young plants mostly opposite, narrowly linear-lanceolate, up to 13 cm long and 4–7 mm wide, straight or falcate, tapering to a fine point. Adult leaves shorter, (1.5–)3–5(–6) cm long, (1.5–)2–4(–5) mm wide, spirally arranged, twisted at the narrowed base, spreading to ascending, straight or rarely slightly falcate, linear-elliptic or with parallel sides, gradually tapered above 2/3 or 3/4 of their length, with a raised midrib usually present on both sides, grey-green; apex acute. Stomata on both surfaces, arranged in numerous intermittent lines not well separated by the midrib. Pollen cones solitary or with 2–3 on very short stalks or subsessile, axillary to foliage leaves or not, subtended by a whorl of papery bracts, initially subglobose, elongating to cylindrical, (5–)10–20(–26) mm long, 2.5–3.5 mm diam.; microsporophylls spirally arranged, imbricate before anthesis, triangular-trullate, ca. 0.8 mm wide, with denticulate-lacerate margins and acute or apiculate apex, bearing two subglobose pollen sacs. Seed cones solitary on small, scaly or leafy branchlets situated axillary to or below foliage leaves, with several sterile and one terminal, larger fertile bract. Mature seed cones with a single seed subtended by a single, short bract; seed enclosed by a fleshy, firm epimatium that ripens from green or glaucous green to yellow, globose or sometimes broad ellipsoid, (17–)23–30(–35) mm long. Seed proper globose or broadly ellipsoid but slightly compressed laterally, (15–)20–25(–30) mm long, with a rugose-pusticulate surface and a (3–)4–6(–8) mm thick, hard seed coat.

Distribution

Tanzania, Kenya (Kyulu Hills, Taita Taveta District).
TDWG codes: 25 KEN TAN

Ecology

Afrocarpus usambarensis occurs in montane evergreen rainforest and dry evergreen forest, mixed with co-dominant angiosperms. Elevation ranges from ca. 1500 m to ca. 3000 m a.s.l. Trees are often solitary but not emergent, only reaching into the general canopy of the forest. In rainforest it occurs often with Podocarpus *milanjianus*; the co-dominant angiosperm tree in this wetter forest type is often *Ocotea usambarensis*, but many other species may occur with it. In dryer evergreen forest *Olea* and *Ficus* are common associates of *A. usambarensis*, other taxa are e.g. *Calodendrum capense, Syzygium cordatum* and *Bridelia micrantha*. These drier forests are often degraded or converted to coarse grassland in which *A. usambarensis* can survive as isolated trees, at least for a time.

Conservation

This species is considered threatened based on direct observation of intense local exploitation (aerial photography of many saw pits both within and without reserves). This species is under severe threat from illegal logging in the Chome Forest Reserve in Tanzania (evidence from aerial photography); the same type of saw pit exploitation is known from other locations. General deforestation and fires are also reducing the rainforest, which is usually

limited in extend even naturally. This species is the most valuable and specifically targeted tree for (illegal) logging in this type of forest. It is present in the following reserves in Tanzania: Chome, Hanang, Mafwomero, Mkusu, Nou, Shagayu and Wotta. The evidence is that this does not prevent illegal logging on a large scale using sawpits to remove and process individual trees.

IUCN: EN [A2, A4 + B 2ab (ii, iii, iv, v)]

Uses

This species, yielding 'yellowwood' or podocarp wood is highly valued for its timber and exploited mainly for sawn timber used in construction of houses. The wood is yellowish in colour, straight-grained, and clean of knots and can be used for general carpentry and furniture as well. This species is not known to be in cultivation.

Agathis Salisb., Trans. Linn. Soc. London 8: 311. 1807 (*nom. cons.*). *Dammara* (Rumph.) Lam., Enum. Pl. Hort. Berol. 2: 411. 1822. Type: *Agathis dammara* (Lamb.) Rich. & A. Rich. [*Dammara loranthifolia* Link (*Pinus dammara* Lamb.)] (*Araucariaceae*).

Salisburyodendron A. V. Bobrov & Melikyan, Komarovia 4: 62. 2006. Type: *Salisburyodendron australis* (D. Don) A. V. Bobrov & Melikyan [*Agathis australis* (D. Don) Lindl.].

Greek *Agathis* = a clew or ball of thread; it refers to the seed cone.

Description

Evergreen monoecious trees, often of great size, monopodial with straight boles. Resin canals in bark, leaves and seed cones. Branching in sub-verticillate pseudo-whorls (Massart's or Rauh's model), truncated in very large trees. Apical buds globose with imbricate scales. Leaves subopposite to opposite, short petiolate, broad and multi-veined, coriaceous, more or less hypostomatic, extremely variable in shape and size within a single tree; those on young trees usually larger than on mature trees. Pollen cones appearing after seed cones, axillary, solitary, sessile to pedunculate, subtended by more or less decussate bracts, the lower pair of which may be leaf-like or not, elongating to a cylindrical or catkin-like shape after anthesis. Microsporophylls helically attached to a rachis in imbricate or tesselate arrangement, consisting of a short stalk and a more or less peltate head of varied shape according to species; bearing from 2–12 elongated pollen sacs directed inward towards cone rachis. Seed cones axillary or sometimes terminal, solitary on stout stalks, globose to obovoid, usually smooth but sometimes rough with bossed scale margins, green or slightly glaucous, disintegrating when mature and drying. Cone scales composed of a fused bract and seed scale, the visible and largest part made up of the bractaceous element, helically attached to a stout rachis shorter than the cone, imbricate, thin except the outer, mostly exposed margin. Seeds 1 per cone scale, inverted, more or less ovoid but strongly flattened, with two thin, membranous wings, one obliquely placed relative to the seed axis, the other opposite and rudimentary to sometimes virtually absent. Seedlings with 2 cotyledons.

17 species

Distribution

Malesia: Malay Peninsula, Sumatera, Borneo, Sulawesi, Philippines, Maluku [Moluccas], New Guinea, New Britain; Australia: coastal Queensland; SW Pacific: New Caledonia, Vanuatu, Fiji, Solomon Islands (Santa Cruz Group), New Zealand (North Island).

Taxonomic notes

Few attempts have been made to investigate the possible relationships among the various species in this genus. Most studies of this kind have concerned themselves with relationships at the level of genus. Phylogenetic relationships of taxa within the *Araucariaceae* were investigated by Gilmore & Hill (1997), Setoguchi *et al.* (1998) and Kershaw & Wagstaff (2001) (the first two papers used *rbc*L DNA markers) and none of these studies sampled all species. We therefore still lack a hypothesis of the phylogeny of the species of *Agathis* upon which a classification of the genus could be based and, indeed, no infrageneric classification has been proposed. In order to conveniently and more reliably key out the species, they have here been divided into two geographically determined groups; each of these covers roughly half of the entire range of the genus. No taxonomy is implied with this division and it only serves the keys. The South-West Pacific here includes New Zealand and Malesia is the region, as defined in Flora Malesiana, from Peninsular Malaysia to New Guinea and the Solomon Islands. Few species are known in cultivation outside their 'own' region as here defined (the exceptions almost all involve *A. australis* from New Zealand) and a key to cultivated species is for this reason not considered necessary.

Key to the species of *Agathis* in Australia and the SW Pacific

Pollen cones provide most of the diagnostic characters of species in this genus; under mature trees (all are monoecious) these are often found in the leaf litter under their canopy. Only fully expanded cones should be taken into account. Leaves are highly variable but differ between 'juvenile' (phase 1) leaves and 'adult' (phase 2) leaves as treated in the species descriptions; only maximum length for the first category appears to be informative in this context. A single twig with foliage can never be determined with the macroscopic leaf characters (measurements and shapes) alone.

1a. Pollen cones short cylindrical, 0.9–1.6 cm long, 4–8 mm wide **2**

1b. Pollen cones cylindrical or oval-fusiform, 2–6(–7) cm long, (6–)7–18 mm wide **3**

2a. Microsporophylls of pollen cones imbricate, more or less convex. Seed cones 3.5–5 cm diam.; cone scales with a bossed upper margin ***A. atropurpurea***

2b. Microsporophylls of pollen cones tessellate, prismatic. Seed cones 6.5–10 cm diam.; cone scales with a smooth, slightly rounded upper margin ***A. microstachya***

3a. Juvenile leaves to 6 cm long. Pollen cones on (4–)5–20 mm long, stout peduncles; basal bract scales short, rounded or triangular. **5**

3b. Juvenile leaves to 20 cm long; pollen cones sessile or on short peduncles to 7 mm long; basal bract scales 1–7 mm wide, linear to triangular **4**

4a. Bark exfoliating with small flakes (smaller than 10 cm). Pollen cones 8–13 mm wide, with 8–10 decussate, imbricate basal bract scales ***A. robusta***

4b. Bark exfoliating with large flakes (to 15 cm). Pollen cones 15–18 mm wide, with 4–6 decussate, free basal bract scales ***A. silbae***

5a. Bark on trunk smooth, with small or large flakes. Trees becoming very large **6**

5b. Bark on trunk fissured, rough and scaly. Trees often stunted, up to 10 m tall (rarely taller to 25 m in forest) ***A. ovata***

6a. Pollen cones with 6 decussate, imbricate, short rounded bracts scales. Juvenile leaves to 6 cm long; adult leaves 2.3–4(–7) cm long ***A. australis***

6b. Pollen cones with 6–16 decussate, imbricate or free, linear to triangular bract scales. Juvenile leaves 11–20 cm long; adult leaves (2.5–)4–9 cm long **7**

7a. Pollen cones short cylindrical to nearly oval, 2–2.5 cm long, 8–10 mm wide; intact cones with 2 leaf-like bracts subtending 6–8 free bract scales ***A. lanceolata***

7b. Pollen cones cylindrical, (2–)2.5–5(–7) cm long, 6–15 mm wide; lacking 2 leaf-like bracts, with 8–16 imbricate bract scales **8**

8a. Bark on trunk with numerous small, granular lenticels. Bract scales at base of pollen cone 1–2 mm wide; microsporophyll heads umbonate. Seed cones up to 7 cm diam ***A. montana***

8b. Bark on trunk without or with few lenticels. Bract scales at base of pollen cone 4–7 mm wide; microsporophyll heads nearly flat or convex. Seed cones 9–13 cm diam **9**

9a. Pollen cones with 8–16 decussate bract scales at base, 6–9 mm wide; microsporophyll heads nearly flat with angular upper margin ***A. moorei***

9b. Pollen cones with up to 8 decussate bracts scales at base, 8–15 mm wide; microsporophyll heads convex, often notched at apex ***A. macrophylla***

Key to the species of *Agathis* in Malesia

1a. Juvenile (phase 1) leaves to 8 cm long, adult (phase 2) leaves to 5 cm (occasionally to 6–7 cm) long, the shortest leaves often obovate or oval-orbiculate (length less than 2 × width) **2**

1b. Juvenile (phase1) leaves to 14 cm long, adult (phase 2) leaves to 12(–14) cm long, the shortest leaves variable in shape but not obovate or oval-orbiculate **4**

2a. Pollen cones when fully expanded 1.2–1.5 cm long, 5–6 mm wide, lacking 2 leaf-like bracts subtending the cluster of smaller bract scales ***A. orbicula***

2b. Pollen cones when fully expanded 2.5–4 cm long, 8–10 mm wide; intact cones usually with 2 leaf-like bracts up to 3 cm long, subtending a cluster of smaller bract scales **3**

3a. Two subtending bracts of pollen cones to 30 × 10 mm. Seed cone scales with a boss on the upper margin. Endemic of Peninsular Malaysia ***A. flavescens***

3b. Two subtending bracts of pollen cones to 20 × 4 mm. Seed cone scales lacking a boss on the upper margin. Endemic of Borneo ***A. kinabaluensis***

4a. Pollen cones when fully expanded 8–9 cm long, 25–35 mm wide; short basal bracts in 2 decussate pairs; microsporophyll heads 5–6 × 4–8 mm (length × width) ***A. borneensis***

4b. Pollen cones when fully expanded (2.2–)3–6 (–7) cm long, 8–13 mm wide; short basal bracts in 2–5 decussate pairs; microsporophyll heads 0.7–2 × 1–2.5 mm (length × width) **5**

5a. Microsporophylls in tessellate arrangement, their heads prismatic; short basal bracts of pollen cones in 4–5 decussate pairs **6**

5b. Microsporophylls in imbricate arrangement, their heads more or less convex; short basal bracts of pollen cones in 2–4 decussate pairs **7**

6a. Pollen cones when fully expanded barrel-shaped, 2.2–3 cm long, 10–12 mm wide. Bark on large trunks with large (to 10 cm) flakes ***A. labillardierei***

6b. Pollen cones when fully expanded cylindrical, 4–6(–7) cm long, 8–13 mm wide. Bark on large trunks with small (to 5 cm) flakes ***A. robusta***

7a. Short basal bracts of pollen cones in 2–4 decussate pairs, free spreading; peduncle absent or to 5 mm long. Seed cone scales with smooth, slightly rounded margins ***A. dammara***

7b. Short basal bracts of pollen cones in 2–3 decussate pairs, imbricate; peduncle 2–10 mm long. Seed cone scales with bossed upper margin ***A. lenticula***

Agathis atropurpurea B. Hyland, Brunonia 1 (1): 109. 1978. Type: Australia: Queensland, Cook District, Bellenden Ker, ["N.P.R. 226"], *B. P. M. Hyland 5776* (holotype BRI).

Etymology

The species epithet describes the colour of the bark as dark or blackish purple (Latin *atratus* = dark, blackish; *purpureus* = purple).

Vernacular names

Blue kauri pine, Black kauri pine

Description

Trees to 50 m tall and 2.5 m or more d.b.h. with clear cylindrical bole to 30 m and a rounded or open crown with spreading to ascending branches. Bark smooth or sometimes scaly, exfoliating in irregular thin scales of up to 15 cm across; outer bark dark brown or red-brown, with purple patches under newly fallen scales; inner bark reddish, exuding white resin. Leaves subopposite, thin or thick, multinerved, coriaceous, glabrous, light green, sometimes glaucous on the underside especially leaves on new shoots. Leaves on saplings and young trees and/or in shade linear-lanceolate to elliptic, 5–8 cm long, 1.5–3 cm wide; leaves in crowns of mature trees lanceolate to elliptic, 3–7 cm long, (0.5–)1–2 cm wide, short petiolate and with an obtuse apex. Pollen cones axillary, solitary on a 2–3 mm long, stout peduncle, short cylindrical, when full grown 0.9–1.6 cm long, 4–7.5 mm diam., with 8–10 decussate (in 4–5 pairs), imbricate, 1–2.5 mm wide bract scales at their base. Microsporophylls in imbricate arrangement; head with rounded or minutely mucronate upper margin, 0.6–0.8 mm wide, 0.5–0.7 mm high in mature cones, bearing 2–5 pollen sacs. Seed cones solitary on thick peduncles, globose, 3.5–5.5 cm long, 3.5–5 cm wide, more or less rough, green and resinous, ripening brown. Cone scales with thick, slightly bossed, incurved upper margins, 1.6–2.3 cm long, 2.3–3 cm wide, broad triangular to reniform with rounded corners and more or less flanged on either side. Seeds 7–9 × 4–5 mm, ovoid, flattened, with two unequal wings; largest wing 12–15 × 8 mm; smallest wing a small acute triangular point 2 mm long opposite largest wing.

Distribution

Australia: NE Queensland (Cook District).
TDWG codes: 50 QLD-QU

Ecology

Agathis atropurpurea is a rare species occurring in lower montane rainforest at altitudes between 900 m and 1500 m a.s.l. on granite mountains and outcrops which rise above the Atherton Tableland.

Conservation

Wherever logging is/was allowed exploitation has been heavy and subpopulations have declined as a result. The extent of the decline is not accurately recorded; if this were better quantified this species could meet criterion A1c,d under Vulnerable (IUCN Red List Categories and Criteria version 3.1, 2001). A large percentage of the remaining forest is now protected. Part of the population of *A. atropurpurea* is protected in Wurunuru National Park.
IUCN: NT

Uses

Blue kauri pine used to be a valuable timber tree in the days of logging the old growth forests of Queensland. The large dimensions of these trees, combined with the excellent properties for carpentry and veneer work such as light weight, even and fine grain and texture with hardly visible growth rings and light colour, made them desirable. Today, few trees are logged from natural stands, as most are now protected. This species is uncommonly planted as an ornamental tree and no commercial timber plantations of it exist.

Agathis australis (D. Don) Lindl., in Loudon, Encycl. Pl.: 802. 1829. *Dammara australis* D. Don, in Lambert, Descr. Pinus 2: 14, t. 6. 1824; *Salisburyodendron australis* (D. Don) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006. Type not designated. Fig. 27, 28, 29

Etymology

The species epithet means 'from the south' and probably refers to the fact that this is the southernmost species in the genus.

Vernacular names

Kauri pine; kauri (Maori)

Description

Trees to 55 m tall, to 5 m d.b.h. or more in veteran trees, self-pruning and with a long, clear, almost cylindrical bole. Bark smooth, peeling frequently in irregular small patches, often creating a mix of colours on a single tree from salmon-pink through to grey. Branches in young trees semi-whorled, spreading, in large trees ascending from the top of the bole, forming a broad, domed crown. Leaves subopposite, thick, multinerved, coriaceous, glabrous, frequently glaucous to farinose when young, especially on the abaxial (lower) surface. Leaves on saplings and young or shaded trees variable in size and shape, usually lanceolate, 3.5–6 cm long, 6–10 mm wide, with acute apex, but occasionally much larger (9 cm long, 3.5 cm wide) and with rounded apices. Leaves in crowns of mature trees much smaller, 2.3–4 (rarely 7) cm long, 9–15 mm wide, broadly ovate in shape, often with a truncate apex. Pollen cones axillary, solitary on a stout, 5–15 mm long peduncle, cylindrical, when fully mature 3–5 cm long, 7–10 mm diam., ripening from yellowish green to brown; basal bract cluster loose, usually wider than pollen cone, typically consisting of three opposite pairs of imbricate, short, rounded bracts and frequently with up to two long-bracts 15–20 × 3–5 mm immediately subtending the basal bract cluster. Microsporophylls imbricate; pedicels 2.2–2.6 mm long, slender; heads 1.8- 2.5 mm wide, 2.1–2.7 mm high in cone, in adaxial view thick with narrow marginal flange; margins entire or rarely minutely erose; apex often notched. Seed cones solitary on thick peduncles, sometimes 2–4 cones together on a branch, globose, 5–7.5 cm diam., glaucous white-green, green or blue-green, (very) resinous, ripening brown. Cone scales imbricate, spreading distally at pollination time, later closing and becoming rhombic-rostellate, giving mature seed cones a rough, scaly surface, ca 2 cm long, 3 cm wide. Seeds 8–10 × 5 mm, ovoid-cuneate, with two unequal wings; largest wing ca. 12 × 8 mm, more or less square; smallest wing rudimentiary or virtually absent.

Distribution

New Zealand: North Island (Northland).
TDWG codes: 51 NZN

Ecology

Agathis australis is the dominant tree in mixed conifer-angiosperm subtropical lowland primary forest

that once covered the northern peninsulas of North Island from near sea level to 375 (–600?) m a.s.l., but of which only small remnants remain today. It is not clear why it did not occur naturally further south on the island, as planted trees grow well there now. Perhaps the dynamics of the Kauri forest in its natural state played a part in this limitation. The species is dependent for successful regeneration on episodal disturbance of the forest by fire or storm removing sizable swathes of forest cover. Even-aged stands of large trees in groves and a few scattered giant trees are a common pattern in the Waipoua Forest, the largest of the remaining primeaval Kauri forest remnants. The giants are more than 1000 years old and have survived one or more disturbances, acting as seed trees. In such a mature stand of Kauri there is little regeneration. Forest succession without disturbance eventually leads to dominance of angiosperms. Early phases in disturbed areas are dominated by *Leptospermum scoparium* and *Kunzea ericoides* (*Myrtaceae*) into which *A. australis* invades abundantly. The conifer *Phyllocladus trichomanoides* arrives next. Via stages with increased tree species diversity and the establishment of more shade tolerant trees, above which the 'rickers', i.e. Kauri trees with conical habit, rise, the forest restores itself. A drastic thinning of Kauri trees then results in fewer trees with ever wider spreading crowns, rising above the canopy as emergents. Eventually there is another disturbance, but these cycles may have a duration of 500 years or longer. Common conifers in mature Kauri stands are *Dacrydium cupressinum, Prumnopitys ferruginea, P. taxifolia, Podocarpus totara* and *Dacrycarpus dacrydioides*; common co-dominant angiosperms are e.g. *Beilschmiedia* spp., *Weinmannia racemosa* and *Metrosideros umbellata*.

Conservation

Since the arrival of Europeans in New Zealand, the estimated 1,215,000 ha once covered by primeaval kauri forests have been reduced to ca. 7,500 ha. These remnants are now strictly protected; the largest reserve is the Waipoua Forest covering 9,105 ha (not all of it is dominated by *A. australis*) created in 1952. However, natural regeneration, where land use as mixed (semi-)natural forest has not changed, is abundant in many places because the species of course does not distinguish between natural and man-made disturbance events. This regeneration is possible, in ecologically suitable locations, within some 80,000 ha of existing forest reserves. The Department of Conservation in New Zealand has plans to establish a Kauri National Park in order to give full protection to these forests. If IUCN Red List criteria were strictly applied to this history of reduction of population size (A criterion), *A. australis* would fulfil the criteria for a listing as (at least) Endangered (EN), even though the causes of decline have now ceased, because the reduction amounts to more than 70% over the last three generations (of mature trees). Conservationists in New Zealand object to such a rating because to them it would appear to be a denial of their successful efforts to curb the destruction and save this iconic tree from extinction. On the other hand one could observe that most of the historical reduction will be permanent under human occupation and land use and that while the reduction has ceased (and is even being reversed) no one can guarantee what the priorities of future generations are going to be.
IUCN: NT

Uses

The kauri of New Zealand was once the most important timber tree of these southern islands, but in the short space of roughly 50 years this natural resource had nearly been exhausted through one of the most wanton campaigns of exploitation and short-term thinking in the history of European colonisation of foreign lands. For several decades, the protection of remaining forests and regeneration projects have now ensured its continuing existence, but the great expanse of kauri forest has nevertheless been greatly reduced. The timber of old growth stands is/was of large dimensions and the properties of the wood are excellent for joiner's work, boat building and carpentry. 'Black kauri', dark brown in colour and very hard and durable, came from logs buried in peat deposits. Wood from burls is beautifully figured and was used in furniture and for panelling. The vast abundance of timber in the heyday of exploitation meant that it was also put to less refined use, such as mine-props and railway sleepers. Another valuable product is resin (copal) of which this tree produces great quantities. During and after the timber exploitation, a veritable 'copal rush' took place, with

thousands of resin diggers coming from all over to dig up the semi-fossil resin in the cut-over forests. Much of this was used in the manufacture of linoleum, paint and varnish. This species has been taken into cultivation both in (modest scale) forestry plantations and as an ornamental tree in several countries with a mild climate.

Agathis borneensis Warb., Monsunia 1: 184. 1900. Type: Malaysia: Sarawak, [locality not stated], *O. Beccari 596* (syntype K). Pl. 5, Fig. 30

Agathis endertii Meijer Drees, Bull. Jard. Bot. Buitenzorg, ser. 3, 16: 470. 1940.

Etymology

The species epithet refers to Borneo, where it is native.

Vernacular names

Numerous local common names are applied to this species. Some of these are general names for *Agathis* (like kauri, the Maori word adopted in English) and I cite only a few: bindang (Brunei, Sarawak); bembueng (Kalimantan) damar minyak (Malay Peninsula); damar pilau (Dayak, Kalimantan); tambunan (Sabah); hedje (Sumatera).

Description

Trees to 50(–55) m tall and 3.5 m or more d.b.h. with clear cylindrical bole up to 20–30 m and a broad crown radiating above. Bark variable; smooth or dippled and lenticellate or very rough and scaly, colour grey, dark brown or blackish outside, reddish brown or yellowish brown under outer, exfoliating layers. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade lanceolate to (narrowly) elliptic, up to 14 cm long, 1.5–4 cm wide, often acute; leaves in crowns of mature trees distinctly petiolate; shape variable, ovate to ovate-elliptic or sometimes (narrowly) lanceolate, 2.5–10 cm long, (1–)2–5 cm wide, mostly with an obtuse apex. Pollen cones axillary, solitary on a 1–5(–8) mm long, stout peduncle, when immature from globose becoming nearly cylindrical, 2–4 cm long, 10–25 mm diam., elongating past anthesis to 8–9 cm long and up to 35 mm wide, with 4 decussate (in 2 pairs) 5–8 mm wide, free spreading bract scales at their base. Microsporophylls in imbricate arrangement; head slightly convex towards the upper, rounded, paler coloured, minutely erose-denticulate margin, 4–8 mm wide and 5–6 mm high in mature cones, bearing 4–10 oblong pollen sacs. Seed cones solitary on thick peduncles, broadly ellipsoid to globose, to 10–13 cm diam., smooth, green, resinous, ripening brown. Cone scales with slightly rounded, incurved or slightly projecting upper margins, ca. 3.5 cm long, 3.5–4.5 cm wide in larger cones, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12–15 × 7–8 mm, ovoid-oblong, with two unequal wings; largest wing ca. 20 × 13 mm; smallest wing a small blunt triangle 3–5 mm wide opposite largest wing.

Taxonomic notes

Agathis borneensis has been confused with *A. dammara* in the past, which is perhaps understandable since the diagnostic characters that distinguish the two species are often not present even in quite large trees. These are mainly found in the pollen cones, which can often been found underneath trees on the forest floor but can decay quickly in the tropical climate. The cones of *A. borneensis* are more robust and more or less globose to oblong until elongation at anthesis makes them cylindrical; they are more cylindrical from the start in *A. dammara*. The microsporophylls of *A. borneensis* are much larger than those of *A. dammara* and have a distinct, lighter and thin upper margin. When using these characters the two species are found to be geographically separated. *Agathis endertii* Meijer Drees is listed as an accepted species in the World Checklist and Bibliography of Conifers (Farjon, 1998, [2001]). De Laubenfels (1988) placed it in a section separate from *A. borneensis* based on the shape of scales in seed cones (projected apex), but it is not really distinct in any diagnostic character and, in agreement with Whitmore (1980) is here treated as a synonym of *A. borneensis*.

Distribution

Borneo, Malay Peninsula, Sumatera.

TDWG codes: 42 BOR-BR BOR-KA BOR-SB BOR-SR MLY-PM SUM

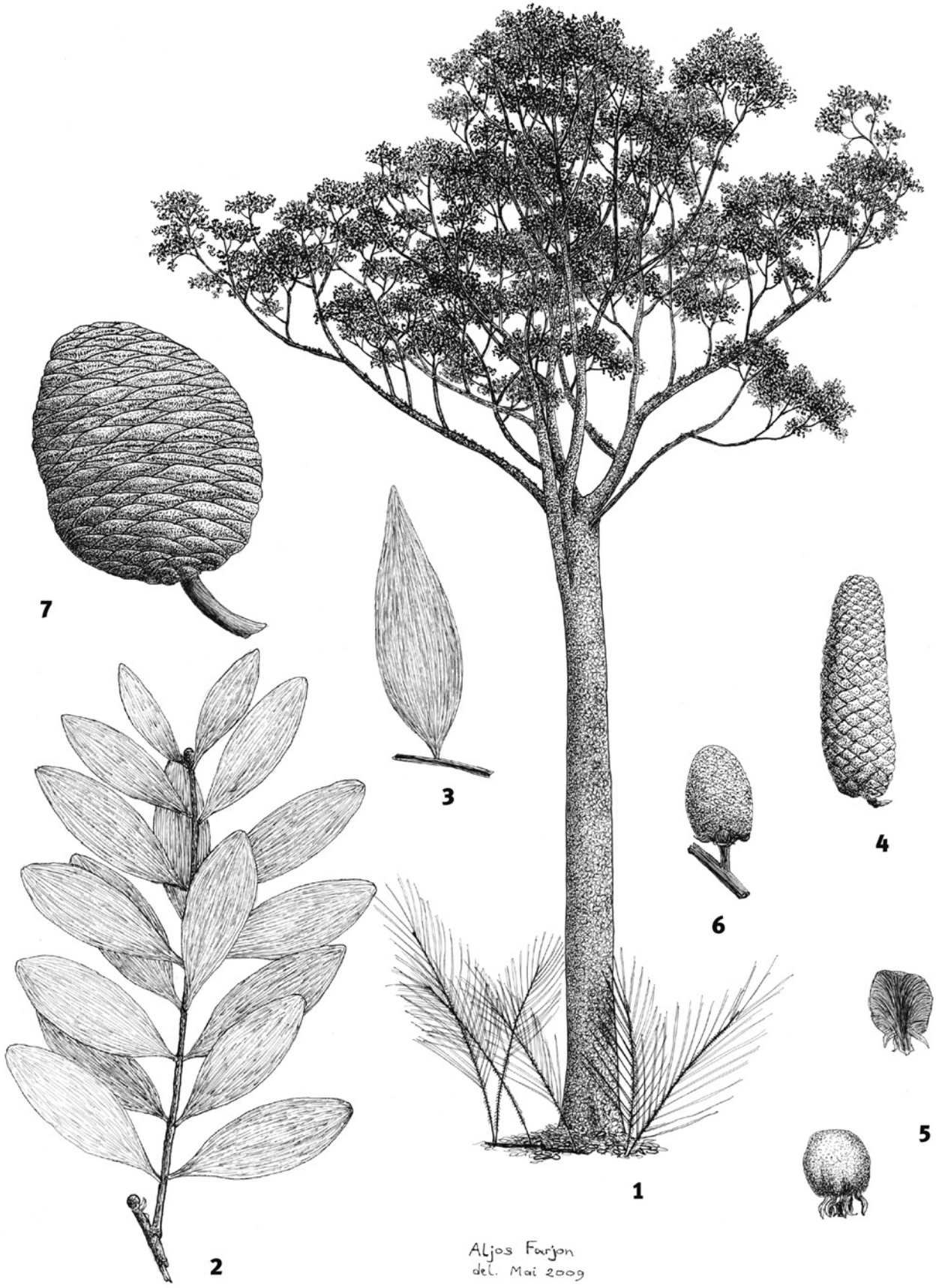


PLATE 5. *Agathis borneensis*. **1.** Habit of tree. **2.** Foliage branch. **3.** Leaf. **4.** Pollen cone. **5.** Microsporophylls. **6.** Immature pollen cone. **7.** Seed cone.

Ecology

Agathis borneensis occurs in lowland to upland tropical rainforest as scattered emergent trees and in low lying kerangas forest on sandy or sometimes peaty soils, where it can form extensive pure stands, or occurs mixed with the following conifers: *Dacrydium pectinatum, Falcatifolium falciforme, Nageia wallichiana, Podocarpus* spp., and *Sundacarpus amarus*. The most common angiosperm tree on peaty soils growing with *A. borneensis* is probably *Gonystylus bancanus* (*Thymaelaeaceae*). In lowland to lower montane rainforest it can be associated with *Dipterocarpaceae* and/or *Fagaceae*; however, *Agathis* often retreats to ridges with thin, rocky soils or to water-logged areas where these dominant angiosperms are less vigorous. It is also reported from "heath forest" which occurs on higher mountain ridges and summits and is usually dominated by species in the *Myrtaceae*. The altitudinal range of *A. borneensis* is substantial, from near sea level to ca. 2400 m a.s.l., but with greater abuncance below ca. 1200 m a.s.l.

Conservation

This species has been very heavily over-exploited in many areas and as a result its total area of occupancy (AOO) is estimated to have at least been reduced by half and this is still ongoing. Stands covering an estimated total of 30,000 ha discovered in Kalimantan in the 1930s had effectively been logged out by the mid 1960s. Most stands outside the few well protected nature reserves (mostly situated in the Malay Peninsula and in Sabah) have been seriously depleted and it is doubted that regeneration will be sufficient to restore the losses. Habitat degradation has caused further reductions in recruitment of young trees to replace felled ones.
IUCN: EN (A4cd)

Uses

This species is one of the most valuable and sought after timber trees in Southeast Asia. It produces lightweight, almost white to pale yellowish wood with no visible growth rings and a very fine and even texture and without resin. It is not durable, so it will mostly find indoor uses, but these are many, from light construction and carpentry, joinery, masts for boats, and panelling to veneer and tool or furniture making. Drawing boards are made of its wood as it is extremely easy to plain to a smooth surface. Its odourless quality was noted in the manufacture of food containers, until plastics took over from it. The inner bark exudes a translucent to white resin known as 'copal' and is still used for varnishes in photographic colour prints and as a component for the paint used to make lines etc. on tarmack road surfaces. There is still a large export trade in its timber, but with a deminishing quantity per annum and a trend to shift from round wood to sawn timber, which fetches much higher prizes. This species (and *A. dammara*) are planted on a fairly large scale in forestry plantations in Jawa, but only locally on a small scale within its native range. This will have to change dramatically if the resource is to be made anywhere near sustainable for the future. *Agathis borneensis* is present in some tropical botanic gardens.

Agathis dammara (Lamb.) Rich. & A. Rich., in A. Richard (ed.) Comm. Bot. Conif. Cycad.: 83. 1826. *Pinus dammara* Lamb., Descr. Pinus 1: 61, t. 38. 1803. Type: Illustration in Rumphius, Herb. Amboinense 2: 174, t. 57. 1741 (lectotype).

Agathis celebica (Koord.) Warb., Monsunia 1: 185. 1900; *Dammara celebica* Koord., Meded. Lands Plantentuin 19: 263. 1898.
Agathis philippinensis Warb., Monsunia 1: 185. 1900.

Etymology

'Dammar' is the local (Moluccan) name for the resin, both subfossil ('copal') and recent, of this tree.

Vernacular names

Amboina pitch tree; dammar raja (Indonesia); dammar malolo, dammar lulu (Sulawesi); almaciga, saleng (Philippines); kaláne, kèssi, oeneëla (Maluku [Moluccas]) and many other local names (see e.g. in Flora Malesiana, ser. 1, 10 (3): 438, 1988).

Description

Trees to 55(–65) m tall and 3.5–4 m or more d.b.h. with clear cylindrical bole up to 20–25 m and a

broad crown radiating above. Bark variable; smooth or dippled and lenticellate or rough and scaly, colour grey, dark brown or blackish outside, reddish brown or yellowish brown under outer, exfoliating layers. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade lanceolate to (narrowly) elliptic, up to 14 cm long, 1.5–4 cm wide, often acute, sometimes acuminate; leaves in crowns of mature trees distinctly petiolate; shape variable, ovate to ovate-elliptic or sometimes (narrowly) lanceolate, 2.5–8(–9) cm long, (1–)2–4 cm wide, with an obtuse or acute apex. Pollen cones axillary, solitary on a 0–5 mm long, stout peduncle, when immature a small cylinder, 1–2 cm long, 6–8 mm diam., elongating past anthesis to 3–4 cm long and up to 12 mm wide, with 4–8 decussate (in 2–4 pairs) 2–4 mm wide, free spreading bract scales at their base. Microsporophylls in imbricate arrangement; head slightly convex towards the upper, rounded or retuse, minutely erose-denticulate margin, 2–2.5 mm wide and 1–1.5 mm high in mature cones, bearing 3–6 oblong pollen sacs. Seed cones solitary on thick peduncles, broadly ellipsoid to globose, to 10–13 cm diam., smooth, green, resinous, ripening brown. Cone scales with slightly rounded, incurved upper margins, ca. 3.5 cm long, 3.5–4.5 cm wide in larger cones, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12–15 × 7–8 mm, ovoid-oblong, with two unequal wings; largest wing ca. 20 × 13 mm; smallest wing a small blunt triangle 3–5 mm wide opposite largest wing.

Taxonomic notes

The nomenclature of this species is complicated, reflecting in part conflicting views on its taxonomy for nearly 200 years. In more recent time, Whitmore (1980) included not only all trees belonging to the genus occurring in Sulawesi, the Moluccas and the Philippines, but also several montane populations in Borneo and the Malay Peninsula in *A. dammara*. De Laubenfels (1988) considered *A. philippinensis* a distinct species, occurring in the Philippines but also in Sulawesi and on the Moluccas. He furthermore recognized *A. celebica* in Sulawesi and the Moluccas, with a few outliers in the Philippines. In addition, some of the montane populations cited above (Whitmore, 1980) were by De Laubenfels separated as distinct species. De Laubenfels (1988) complicated the nomenclatural knot by asserting that, under the rules of ICBN and in case a proposal to reject the name *Pinus dammara* Lamb. in favour of *A. borneensis* Warb. was not accepted at the next International Botanical Congress, *A. borneensis* would have to be called *A. dammara*. His taxonomic views were followed in the World Checklist & Bibliography of Conifers (Farjon, 1998, [2001]). This proposal was indeed rejected, but only if one sinks *A. borneensis* (the western species) taxonomically into *A. dammara* (the eastern species) would the resulting taxon have to bear that name. The type of *A. dammara* is from Amboina, not from Borneo, and the pollen cones of the two are very different. These are separate species. This is not so with the trio *A. celebica, A. philippinensis* and *A. dammara*; the distinctions mentioned in Flora Malesiana (De Laubenfels, 1988) e.g. acuminate juvenile leaves (meaning: leaves on juvenile trees) are found occasionally in specimens from all (major) Malesian islands and are clearly just one of the possible shapes of these highly variable leaves. The diagnostic pollen cones are a much better organ than the leaves on young trees to look for consistent characters, and they unite *A. celebica, A. dammara* and *A. philippinensis*, a species which therefore bears the earliest name. Other characters, some involving leaves of mature trees, do separate some of the montane populations in Borneo, and are here not sunk into *A. dammara*.

Distribution

Malesia: Maluku [Moluccas], Philippines, Sulawesi.
TDWG codes: 42 MOL PHI SUL

Ecology

Agathis dammara occurs in lowland to upland tropical rainforest as scattered emergent trees. In lowland to lower montane rainforest it can be associated with *Dipterocarpaceae* and/or *Fagaceae*; however, *Agathis* often retreats to ridges with thin, rocky soils or to water-logged areas where these dominant angiosperms are less vigorous. The species occurs on a wide variety of substrates, from white sand to peaty soils, volcanic soils, metamorphic rock such as ser-

pentine or schist, or limestone. The altitudinal range of *A. dammara* is from near sea level to ca. 2200 m a.s.l., but with greater abuncance below ca. 1200 m a.s.l.

Conservation

This species has been over-exploited in many areas and as a result its total area of occupancy (AOO) is estimated to have at least been reduced by 30% or more and this is still ongoing. The tapping of resin when exploited too intensively has killed large numbers of trees in the forests, especially in the Philippines. Habitat degradation has caused further reductions in recruitment of young trees to replace felled ones. There is now a total ban on cutting *Agathis* trees in the remaining forests in the Philippines, but there is still illegal logging going on in some areas.
IUCN: VU (A4cd)

Uses

Large trees of this species are highly valuable timber trees, yielding large sizes of straight, knot-free, strong and light coloured sawn timber. It is used for construction as beams, joists and frames, in carpentry for joiner's work, for boat building including oars due to its elasticity, idem for light aircraft as a substitute for Sitka spruce, and for floor boards, panelling and furniture as well as picture frames, pencils, rulers and T-squares. Lower grade wood is used as pulpwood in the paper industry. In parts of Sulawesi where this tree no longer occurs subfossil resin ('copal') is found and mined, most likely produced by trees that lived there many centuries ago. This hardened resin is the source for products like paints and varnishes and is searched for and dug up by 'copal diggers' as itinerant labourers setting up camps in the forest, often following logging operations. This resin was formerly a much more important product of this tree to the local inhabitants than its wood. *Agathis dammara* is used in forestry plantations, mainly in Jawa, where the genus does not occur naturally. It is very rare in tropical botanic gardens, where trees labeled *A. dammara* may be *A. borneensis* instead.

Agathis flavescens Ridl., Kew Bull. 1914: 332. 1914. *Agathis dammara* (Lamb.) Rich. & A. Rich. subsp. *flavescens* (Ridl.) Whitmore, Pl. Syst. Evol. 135 (1–2): 59. 1980; *Agathis celebica* (Koord.) Warb. subsp. *flavescens* (Ridl.) Veldkamp & Whitmore, Taxon 33 (2): 346. 1984. Type: Malaysia: Peninsular Malaysia, Pahang, Gunung Tahan, *H. N. Ridley 16023* (holotype K).

Etymology

The species epithet (Latin *flavescens* = yellowish or pale yellow) refers to leaf colour.

Vernacular names

Tahan agathis.

Description

Trees to 18(–21) m tall and 1.5 m or more d.b.h. with short cylindrical bole and a spreading, rounded or more or less flat-topped crown. Bark smooth or dippled and lenticellate, colour grey, reddish brown under outer, exfoliating layers. Leaves subopposite, thick, multinerved, coriaceous, glabrous, (yellowish?) green. Leaves on saplings and young trees and/or in shade ovate-lanceolate, up to 8 cm long and 3 cm wide, acute or slightly acuminate; leaves in crowns of mature trees distinctly petiolate, ovate to ovate-lanceolate, (2–)3–5(–7) cm long, (1–)2–3 cm wide, with an obtuse or rounded apex. Pollen cones axillary, solitary on a (2–)5–10(–15) mm long, stout peduncle, when immature a small cylinder, 1–2 cm long, 6–8 mm diam., elongating past anthesis to 3–4 cm long and up to 10 mm wide, with 4 decussate (in 2 pairs) 2–4 mm wide, free spreading bract scales at their base, subtended by two much longer (up to 30 × 10 mm) leaf-like bracts. Microsporophylls in imbricate arrangement; head convex towards the upper, rounded or retuse, minutely erose-denticulate margin, 2 mm wide and 1.5 mm high in mature cones, bearing 3–6 oblong pollen sacs. Seed cones solitary on thick peduncles, broadly ellipsoid to globose, to 7–8 cm diam., with bossed scales (surface not smooth), green, resinous, ripening brown. Cone scales with rounded to angular or bossed,

thick upper margins, ca. 3 cm long, 4 cm wide in middle part of full-grown cones, rounded triangular to broadly reniform and more or less flanged on either side. Seeds 11–13 × 7–8 mm, ovoid and flattened, with two unequal wings; largest wing ca. 15 × 10 mm; smallest wing a small blunt triangle 3 mm wide opposite largest wing.

Taxonomic notes

Whitmore (1980) recognized this taxon as a subspecies of *Agathis dammara*, citing as the only morphological differences the two leaf-like bracts and a slightly larger maximum size of pollen cones in subspecies *flavescens*. However, the seed cone scales in *A. flavescens* often have an upper angular or bossed margin, giving the cone a more or less rough, not smooth surface, as in *A. dammara*. The leaves are, though of course variable, smaller than in *A. dammara*; but whether this is a trait, like the smaller size of trees, dependent on a more exposed environment at high altitudes, can only be solved experimentally by growing them under equal conditions. This has not been done because *A. flavescens*, unlike *A. dammara*, is not of economic importance and is therefore not being grown in plantations. The often yellowish colour of the leaves has been attributed to environmental conditions, e.g. nutrient deficiency in the soil. If so, that would not be a taxonomic character, as it would change to green given access to more nutrients. Its isolated occurrence within the broader range of *A. borneensis*, not within that of *A. dammara*, indicates that it will be found to be genetically isolated from both and is a distinct species.

Distribution

Malaysia: Peninsular Malaysia (Gunung Rabong and Gunung Tahan).
TDWG codes: 42 MLY-PM

Ecology

Agathis flavescens occurs in the summit areas of two isolated mountains, at altitudes between 1100 m and 1900 m a.s.l. They are usually emergents above low mossy forest or occur as scattered small trees in mountain scrub. On Gunung Tahan, the highest mountain at 2189 m, they do not reach the summit, which is mostly covered in heath-like dwarf shrubs. *Agathis borneensis* occupies a lower zone on this mountain covered with taller forest; the two appear to be separated by a belt of vegetation devoid of *Agathis* (Chung-Lu Lim, FRIM unpublished data).

Conservation

This species is restricted to isolated populations on two (possibly three) mountains. There may be fewer than 10,000 mature trees existing in total. There is no exploitation of this species for timber because the trees are small with mostly very short boles and they are on road-less mountains.
IUCN: VU (D1)

Uses

No uses have been recorded of this species. It is not known to be in cultivation.

Agathis kinabaluensis de Laub., Blumea 25 (2): 535. 1979. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N.P., Summit Trail, *D. J. de Laubenfels P 625* (holotype L). Fig. 31, 32

Etymology

The species epithet refers to Mt. Kinabalu, from where it was first described.

Vernacular names

tumu (Sabah)

Description

Shrubs or trees to 20(–36) m tall and 1.5 m d.b.h. with slender or short cylindrical bole and a spreading, rounded or more or less flat-topped crown. Bark smooth or dippled and lenticellate, colour grey, reddish brown under outer, exfoliating layers. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade ovate, up to 9 cm long and 4.5 cm wide, (strongly) acuminate; leaves in crowns of mature trees distinctly petiolate, ovate to obovate, occasionally ovate-lanceolate, (2–)3–5(–7) cm long,

(1–)2–3.2 cm wide, with an obtuse or rounded, occasionally slightly acuminate apex. Pollen cones axillary, solitary on a 2–5 mm long, stout peduncle, when immature a small cylinder, 1–1.5 cm long, 6–8 mm diam., elongating past anthesis to 2.5–3 cm long and up to 10 mm wide, with 4–6 decussate (in 2–3 pairs) 2–4 mm wide, free spreading bract scales at their base, subtended by two narrow, leaf-like bracts to 20 × 4 mm. Microsporophylls in imbricate arrangement; head slightly convex towards the upper, slightly angled, minutely erose-denticulate margin, 1.6–1.8 mm wide and 1.2–1.6 mm high in mature cones, bearing 3–6 oblong pollen sacs. Seed cones solitary on thick peduncles, broadly ellipsoid to subglobose, to 11 cm long and 7–8.5 cm diam., smooth, green, resinous, ripening brown. Cone scales with rounded, thick upper margins, ca. 3 cm long, 4–4.5 cm wide in middle part of full-grown cones, rounded triangular and more or less flanged on either side. Seeds 11–13 × 7–8 mm, ovoid and flattened, with two unequal wings; largest wing 15–20 × 10–12 mm; smallest wing a small blunt triangle 3 mm wide opposite largest wing.

Taxonomic notes

Herbarium collections of this species from Mt. Kinabalu go back at least to 1915; those from Gunung Murud to 1970. De Laubenfels (1979, 1988) appears to have overlooked the latter collections in his accounts of the genus in Borneo, while Whitmore (1980) seems to have included all of them in *Agathis dammara*. The latter author did recognize *A. dammara* subsp. *flavescens* as distinct from *A. dammara* subsp. *dammara* based on the elongated pair of bracts subtending the pollen cones, but this character is also present in *A. kinabaluensis* (they often have been broken off in dried herbarium specimens). *Agathis flavescens* and *A.* kinabaluensis are hardly different morphologically: the distinctions are minor and variable; perhaps with the exception of acuminate leaves, which are not found in *A. flavescens*, and of more or less bossed seed cone scales, not seen in *A. kinabaluensis*.

Distribution

Borneo: Sabah (Mt. Kinabalu), Sarawak (Gunung Murud, Kelabit Highlands).
TDWG codes: 42 BOR-SB BOR-SR

Ecology

Agathis kinabaluensis is found in upper montane forest, mossy low forest and subalpine scrub, at altitudes between (1050–)1500 m and 2400 m a.s.l. At the most exposed and highest sites it has a shrubby habit with hardly any length of a single trunk, but in taller forest at lower altitudes it can become a tall tree itself. It occurs on nutrient-poor substrates such as ultramafics, granite or sandstone, in *Fagaceae-Lauraceae* dominated forest or stunted forest to scrub with *Myrtaceae* and numerous epiphytes.

Conservation

This species is now recognized to occur on (at least) two major mountains in N Borneo, but the populations are relatively small and could be negatively impacted by stochastic events such as forest fires. Some subpopulations at lower altitude are under pressure from land-use conversion, in particular agriculture. The population in Mt. Kinabalu National Park is under legal protection, but the other population on Gunung Murud is not.
IUCN: EN [B1a, b(ii, iii, v) + B2a, b(ii, iii, v)]

Uses

No economic used have been reported of *A. kinabaluensis*, but where larger trees occur(ed) in the forest, they may have been logged by local people to use the timber for construction and carpentry work. This species is not known to be in cultivation outside perhaps a few specimens in regional botanic gardens.

Agathis labillardierei Warb., Monsunia 1: 183. 1900, ["*labillardieri*"]. Type: Papua New Guinea, *J. J. H. de la Labillardière B-W 17793* (holotype B-W).

Etymology

This species was named after Jacques Julien Houtton de Labillardière (1775–1834), French explorer of the Pacific.

Vernacular names

New Guinea kauri; kayu damar putih (Indonesia, general); kessi, fuko and many other local names,

several cited in Flora Malesiana, ser. 1, 10 (3): 442 (1988) (New Guinea).

Description

Trees to 60 m tall and 2 m or more d.b.h. with clear cylindrical bole the height of the canopy and a rounded or open crown emerging. Bark smooth, exfoliating in irregular scales of up to 10 cm across; outer bark brown, purplish under newly fallen scales; inner bark pinkish, exuding copious white resin. Leaves subopposite, thin or thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade broadly lanceolate, 9–14 cm long, 3–6 cm wide; leaves in crowns of mature trees ovate-lanceolate or elliptic, 5–12 cm long, 1.5–3 cm wide, distinctly petiolate and with an acute or obtuse apex; however some may be linear-lanceolate, 8–11 cm long and 1–1.5 cm wide. Pollen cones axillary, solitary on a 2–6(–10) mm long, stout peduncle, short cylindrical or barrel-shaped, when full grown 2.2–3 cm long, 10–12 mm diam. with a rounded apex, with 8 decussate (in 4 pairs), imbricate but spreading, 4–6 mm wide bract scales at their base. Microsporophylls in tesselate arrangement; head rectangular to hexagonal, prismatic, with a raised, flat central part 1–1.5 mm wide, 0.7–1 mm high in mature cones; margins hidden. Seed cones solitary on thick peduncles, subglobose or obovoid, 8–10 cm long, 7.5–9 cm wide, smooth, green and resinous, ripening brown. Cone scales with slightly rounded, strongly incurved upper margins, ca. 3 cm long, 3.5–4 cm wide, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12 × 7 mm, ovoid, flattened, with two unequal wings; largest wing ca. 20 × 15 mm; smallest wing a small acute triangle 3–4 mm wide opposite largest wing.

Distribution

New Guinea, including major islands around Bird's Head Peninsula and eastwards as far as the Sepik Valley.
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

Agathis labillardierei occurs in tropical evergreen lowland to lower montane rainforest, in which it is an emergent tree. Locally it can be abundant in early phases of regeneration, but eventually angiosperms increase once more and close the canopy, leaving a few solitary trees of *A. labillardierei* rising above it. The altitudinal range of this species is from near sea level to 1830(–2500?) m a.s.l., most trees occur between 200 m and 1350 m a.s.l. This species is found to grow on a variety of substrates, including ultrabasic rock which produces soils poor in nutrients essential to tree growth.

Conservation

This species has a wide distribution and is still common in many areas where the tropical rainforest of New Guinea remained intact to this day. It is to be expected, however, that as similar resources elsewhere in Malesia are being exploited towards general scarcity of large trees with long boles and with relatively easy access, the pressure on New Guinea kauri will increase. The ban on export of round logs from Papua New Guinea will work in favour of more sustainable use, but most of the megapopulation of this species occurs in Papua (the Indonesian half of New Guinea), where this ban has not (yet) been imposed. It is perhaps prudent to upgrade the conservation status of this species in anticipation of these developments.
IUCN: NT

Uses

New Guinea kauri is one of the most valuable timber trees of the island. While logging continues, export of round logs from Papua New Guinea has been banned in an attempt to provide work for local sawmills and increase the value of timber. The wood is used for indoor construction, carpentry, boat building, veneer and tool making. In remote villages, where modern sawing equipment is not available, planks are sometimes split to build house walls. The resin (copal) is tapped and is an important component of varnish; more local and traditional uses include burning it as torches and for incense and other forms of divination.

Agathis lanceolata Warb., Monsunia 1: 186. 1900. *Dammara lanceolata* Lindl. ex Sébert & Pancher, Notes Bois Nouv. Calédonie: 169. 1874, *non* Vieill. (1862); *Salisburyodendron lanceolata* (Warb.) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006. Type: New Caledonia: Grande Terre, Cougui (Mt. Koghis), *J. A. I. Pancher s.n.*, 1870. (holotype P).

Etymology

The species epithet comes from Latin *lanceolata* = lanceolate; in reference to the shape of the leaves, which (especially when young) are often in the shape of a lance point.

Vernacular names

Koghis kauri, kaori

Description

Trees to 40(–50) m tall and 1 m or more d.b.h. with clear cylindrical bole the height of the canopy and a broad crown radiating above. Bark extremely smooth, peeling in patches of up to 20 cm across from the trunk, falling often and accumulating in large piles around the base of the tree; colour variable – in forest deep red, but becoming greyer (while remaining smooth) with exposure to sun. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade lanceolate to falcate, 9–13 cm long, 3–5 cm wide; leaves in crowns of mature trees ovate-lanceolate, 6–8 cm long, 1.5–2 cm wide with an obtuse apex; however some may be long and linear, ca. 8–10 cm long and 1.5 cm wide. Pollen cones axillary, solitary on a 4–5 mm long, stout peduncle, cylindrical or nearly oval, when full grown 2–2.5 cm long, 8–10 mm diam., with 8 decussate (in 4 pairs), free, 4 mm wide bract scales at their base, the lowest pair often developed into small leaflets. Microsporophylls in tesselate arrangement; head prismatic, forming a bossed surface, less than 1.6 mm wide, 0.5–1.75 mm high in mature cones; margin entire. Seed cones solitary on thick peduncles, globose, 10–12 cm diam., smooth, green or glaucous green, (very) resinous, ripening brown. Cone scales with slightly rounded, incurved upper margins, ca. 2.5 cm long, 3–3.5 cm wide, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12–15 × 7 mm, ovoid-oblong, with two unequal wings; largest wing ca. 20 × 13 mm; smallest wing a small blunt triangle 3–5 mm wide opposite largest wing.

Distribution

New Caledonia: Grande Terre, mainly in Province Sud (southern massif).
TDWG codes: 60 NWC

Ecology

Agathis lanceolata occurs mostly in rain forest, often in valley bottoms and can occasionally form relatively pure stands there, or it grows together with *Araucaria subulata*; sometimes it is associated with *Nothofagus* spp. This species is also found, possibly in relict stands following 19th century logging, in isolated pockets of humid forest (often with *Arillastrum gummiferum, Montrouziera cauliflora*, and *Calophyllum* spp., or sometimes with *Podocarpus sylvestris*) in the hollows of valley heads of the southern massif around the Plaine des Lacs, an area otherwise dominated by maquis, and in areas where the boundary between forest and maquis is not sharp. It is a species of lower altitudes, between 50 m and 500 m a.s.l., rarely up to 900 m a.s.l. It usually grows on red ultramafic soils.

Conservation

Historically, this species has been seriously overexploited for both timber and resin. Some populations are now protected in several reserves, including major reserves, across the southern part of the country, but ongoing decline is projected to occur elsewhere.
IUCN: VU [B1ab(iii)+2ab(iii), C2a(i)]

Uses

Timber of this tree is extremely valuable: the species is widely used in reafforestation projects in southern New Caledonia. It was logged heavily in the past and used for carpentry and boat building; as large trees in the wild are no longer felled, the smaller sizes of planted trees have to be used instead. Resin was another major product from the old stands, largely going to the turpentine and varnish industries.

Agathis lenticula de Laub., Blumea 25 (2): 537. 1979. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N.P., near Park Headquarters, *D. J. de Laubenfels P 619* (holotype L). Fig. 33, 34

Etymology

The species epithet (Latin *lenticularis* = lens-shaped) refers to the leaves.

Vernacular names

tangilan (and variant spellings) (Sabah).

Description

Trees to 40(–45) m tall and 2.2 m or more d.b.h., with clear cylindrical bole up to 20–25 m and a broad crown radiating above. Bark variable; usually lenticellate and scaly with large but irregular flakes, colour grey to dark brown or greenish purple outside, reddish brown or yellowish brown under outer, exfoliating layers, exuding clear or white resin turning yellow. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green and often glaucous underneath. Leaves on saplings and young trees and/or in shade broadly lanceolate to elliptic, 6–11 cm long, 2–4.5 cm wide, acute or slightly acuminate; leaves in crowns of mature trees distinctly petiolate, lenticular or ovate-elliptic, 5–8 cm long, 1–2.5 cm wide, acute or obtuse. Pollen cones axillary, solitary on a 2–10 mm long, stout or slender peduncle, when immature from subglobose becoming nearly cylindrical, 1–1.5 cm long, 7–8 mm diam., elongating past anthesis to 3–4 cm long and 9–10 mm wide, with 4–6 decussate (in 2–3 pairs) 3–4 mm wide, imbricate bract scales at their base. Microsporophylls in imbricate arrangement; head slightly convex towards the upper, rounded to angular, minutely erose-denticulate margin, 2–2.5 mm wide and 1.5–2 mm high in mature cones, bearing 3–6 oblong pollen sacs. Seed cones solitary on thick peduncles, globose, to 8–10 cm diam., more or less rough with raised seed scale margins, especially in immature cones, green, resinous, ripening brown. Cone scales with more or less rounded, bossed, thick and incurved upper margins, 2.5–3 cm long, 3–3.5 cm wide in mature cones, roughly flabellate with rounded corners and more or less flanged on either side. Seeds ca. 10 × 6 mm, ovoid, flattened, with two unequal wings; largest wing ca. 15 × 8 mm; smallest wing a small, blunt triangle of 3 mm opposite large wing, or absent.

Taxonomic notes

Whitmore (1980) included herbarium collections of this species in a broader concept of *Agathis dammara*, which although having a distribution generally to the east of *A. borneensis*, in his opinion occupied several isolated montane stations within the range of *A. borneensis*. These isolated populations were all recognized as distinct species by De Laubenfels (1979, 1988) in a nearly simultaneous taxonomic study of the genus in Malesia.

Distribution

Malaysia: Sabah (mainly Crocker Range to Mt. Kinabalu, some outlying localities), Sarawak (Gunung Murud).
TDWG codes: 42 BOR-SB BOR-SR

Ecology

Agathis lenticula is an emergent tree in lower montane evergreen tropical rainforest. It occurs in dipterocarp rainforest and forest dominated by *Fagaceae* at altitudes between 1050 m and 1700 m a.s.l. on a variety of dark to light soils.

Conservation

This species has been assessed as Vulnerable primarily on the basis of a limited distribution (area of occupancy less than 100 km² under IUCN 1994 criteria) because it is very difficult to estimate its decline due to exploitation. Most herbarium collections at K from the Crocker Range and lower spurs and slopes of Mt. Kinabalu in Sabah have been identified as *A. lenticula*, but *A. borneensis* does occur in the region and foresters do not distinguish them. Exploitation of both, being tall trees with long, free boles, must be similar outside protected areas. If we would know more about specific rates of exploitation in particular areas where *A. lenticula* has been found, it could well be that *A. lenticula* turns out to be more seriously threatened than the more widespread species *A. borneensis*.
IUCN: VU [B1ab (ii, iii, v) + B2ab (ii, iii, v)]

Uses

This species is not distinguished from *A. borneensis* by foresters and will be logged as that species or 'dammar' or 'kauri' timber. Its uses are similar to those of *A. borneensis*.

Agathis macrophylla (Lindl.) Mast., J. Roy. Hort. Soc. London 14: 197. 1892. *Dammara macrophylla* Lindl., J. Hort. Soc. London 6: 271. 1851. Type: Solomon Islands: Santa Cruz Group, Vanikoro Island, Vanikolo, ["Hab. Island of Vanikolla"], *C. Moore s.n.* (holotype CGE).

Dammara obtusa Lindl., J. Hort. Soc. London 6: 270. 1851; *Agathis obtusa* (Lindl.) Mast., J. Roy. Hort. Soc. London 14: 197. 1892; *Agathis macrophylla* (Lindl.) Mast. var. *obtusa* (Lindl.) Silba, Phytologia 68: 23. 1990.
Dammara brownii hort. ex Lem., Ill. Hort. 2, Misc.: 60. 1855; *Agathis brownii* (Lem.) L. H. Bailey, Cult. Conif. N. Amer.: 18 *passim*, 151. 1933.
Dammara vitiensis Seem., Fl. Vitiensis: 265, t. 76. 1868; *Agathis vitiensis* (Seem.) Benth. & Hook. f., Gen. Pl. 3 (1): 436. 1880.

Etymology

The species epithet comes from Greek *macrophylla* = 'with large leaves'; compared with most other *Agathis* species, this species has especially large leaves.

Vernacular names

Fijian kauri pine; dakua, ndakua, ndakua makandre (Fiji); nendö, notopiti (Santa Cruz Group); kauri (Vanuatu).

Description

Trees to 35(–40) m tall and 1 m or more d.b.h. with clear but usually short bole and an ultimately broad crown formed by long, spreading and ascending branches. Bark very scaly, exfoliating in irregular patches of variable shape and size; colour grey. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green or glaucous to farinose esp. on the abaxial (lower) side. Leaves on saplings and young trees and/or in shade broadly lanceolate, sometimes slightly falcate, 8–17 cm long, 3–6 cm wide, with acute or obtuse apex; leaves in crowns of mature trees ovate-lanceolate to obovate or occasionally nearly round, (2.5–)4–8 cm long, (0.8–)1.5–3 cm wide with an obtuse or round apex. Pollen cones axillary, solitary on a (0–)3–7 mm long, stout peduncle, mostly becoming cylindrical, (2–)2.5–4.5 cm long, 8–15 mm diam., with 8 decussate (in 4 pairs), imbricate, 4–7 mm wide bract scales at their base, spreading to form a basal collar somewhat wider than the pollen cone base. Microsporophylls in imbricate arrangement; head convex, 1.4–2.2 mm wide, 1.8–2.2 mm high in mature cones; margin minutely erose-denticulate, often notched at apex. Seed cones solitary on thick peduncles, globose, 10–13 cm diam., smooth, green or glaucous green, (very) resinous, ripening brown. Cone scales with slightly rounded, incurved upper margins, ca. 3.5 cm long, 3.5–4.5 cm wide, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12–15 × 7–8 mm, ovoid-oblong, with two unequal wings; largest wing 20–25 × 10–15 mm; smallest wing a small blunt triangle 3–6 mm wide opposite largest wing.

Taxonomic notes

Foresters and others in the SW Pacific familiar with this tree tend to recognize two or more distinct entities (species), especially a distinction between the trees in Fiji and those in the other island groups. Taxonomists (e.g. Whitmore, 1980) are more impressed by the continuous variation observed in numerous herbarium specimens collected from all islands where *Agathis* occurs. There is perhaps no other species in this genus with more variable foliage leaves than *A. macrophylla*; especially expressed in canopy foliage. Specimens from Fiji are often glaucous to farinose on one side of the leaves, but non-glaucous specimens have been collected on these islands, too. Characters that really matter in this difficult genus, like those of the pollen cones, are quite uniform across the island groups. I therefore concur with Whitmore (1980) and here recognize one species, under its earliest name, *A. macrophylla*, for these entities. This excludes trees more recently discovered on Santo Peak, Espiritu Santo, in Vanuatu, which are a distinct species *A. silbae*. Such discoveries may hint at the possibility of one or more other

'hidden' distinct species on these islands, but such have not been observed among the material available to researchers at this time.

Distribution

Fiji: Kadavu Is., Viti Levu, Vanua Levu; Solomon Islands: Santa Cruz Group (Utupua Is., Vanikoro Is.); Vanuatu: Anatom Is., Erromango Is., Tanna Is.
TDWG codes: FIJ SCZ VAN

Ecology

Agathis macrophylla is an emergent tree in lowland to low montane tropical rainforest; usually growing in soils derived from volcanic rocks like basalt. Its altitudinal range is recorded from herbarium collections as being between 75 m and 900 m a.s.l. In Fiji on the main islands it is most common between 600 m and 900 m a.s.l. The species was the subject of a pioneering study on its role in the rain forests of the type locality, which demonstrated that unlike *Agathis australis* in New Zealand, and many other species which exhibit a regeneration strategy based on periodic landscape-scale disturbance (cf. Enright & Hill, 1995) *A. macrophylla* appears to behave as a normal component of rainforests dominated by angiosperms. This means that it is capable of small-gap regeneration like other large forest trees.

Conservation

Overall, this species was listed as Near Threatened (IUCN Redlist 1999). However, individual island populations may well be severely threatened, e.g. that on Utupua in the Santa Cruz Group. Doyle (in Farjon & Page, 1999) assessed the species separately for each of the island groups as follows: Fiji: VU – Vulnerable, IUCN 1994-criteria A2d (>20% reduction within next three generations based on current exploitation levels) and B2e (continuing decline in the number of mature individuals). Santa Cruz Islands: NE – not evaluated. Vanuatu: VU – Vulnerable, IUCN 1994-criteria A2d and B2e. *Agathis macrophylla* is now quite rare outside plantations in the Santa Cruz Group, though an unlogged population apparently survives on the upper Lawrence River on Vanikoro. A re-assessment using version 3.1 of the IUCN criteria (IUCN, 2000) in 2011 concluded that the entire known population is seriously threatened.
IUCN: EN [B2ab (i–v)]

Uses

The wood of this species is white or sometimes with a reddish hue and known in Fiji as Dakua wood and in the Santa Cruz Group as Vanikoro kauri. It is very valuable and used for construction, for flooring in houses, for masts, booms and spars in sailing boats, for carpentry and for furniture making. The resin exuded from the bark is fragrant and inflammable and is (was) burnt to provide light. Recent resin is transparent and nearly colourless but weathers white in contact with air and sunlight; subfossil resin has a yellowish or orange-brown hue approaching some types of amber, which is completely fossilized ('matured') resin from conifers. Resin is tapped from trees, but also dug from the ground (subfossil resin) and used in making varnishes, pottery glazing, and dying cloth black with the smoke from burning it. Fijian kauri pine has been planted as a forestry tree in the Solomon Islands (Santa Cruz Group) and elsewhere in the SW Pacific in an attempt to obtain timber more sustainably from a truly renewable resource. It is also in cultivation in some greenhouses of botanic gardens.

Agathis microstachya J. F. Bailey & C. T. White, Contr. Queensland Fl. Bot. Bull. 18: 13. 1916. Type: Australia: Queensland, Cook District, *H. W. Mocatta s.n.* (holotype BRI). Fig. 35

Etymology

The species epithet derives from the Greek *micros* = small and *stachys* = ear of corn (maize, not known in ancient Greece) or a flower spike, and alludes to the small male strobili.

Vernacular names

Bull kauri, Bull pine, Atherton kauri pine

Description

Trees to 50 m tall and 2.5 m or more d.b.h. with clear cylindrical bole to 35 m and a rounded or open

crown with spreading to ascending branches. Bark smooth or sometimes scaly, exfoliating in irregular coarse scales of up to 15 cm across; outer bark brown or grey-brown, with bluish purple patches under newly fallen scales; inner bark reddish, exuding white resin. Leaves subopposite, thin or thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade broadly lanceolate to elliptic, 5–9 cm long, 1.5–3.5 cm wide; leaves in crowns of mature trees lanceolate to elliptic, 3–8 cm long, (0.8–)1–2.2 cm wide, short petiolate and with an obtuse or rounded apex. Pollen cones axillary, solitary on a 0–1 mm long peduncle, subglobose becoming short cylindrical, when full grown 1–1.6 cm long, 5–8 mm diam., with 8–10 decussate (in 4–5 pairs), imbricate, 1–2.5 mm wide bract scales at their base. Microsporophylls in tesselate arrangement; heads prismatic, with raised central part irregularly pentagonal or hexagonal and becoming free at anthesis, 0.5 mm wide, 0.5–0.7 mm high in mature cones, bearing 2–5 pollen sacs. Seed cones solitary on thick peduncles, globose or ovoid, 7.5–11.5 cm long, 6.5–10 cm wide, smooth or nearly so, green or slightly glaucous, ripening brown. Cone scales with thick, rounded, incurved upper margins, 2.5–3.5 cm long, 3.3–4.5 cm wide, broad triangular with rounded corners and more or less flanged on either side. Seeds 10–12 × 6–8 mm, ovoid, flattened, with two unequal wings; largest wing 20–25 × 10–13 mm; smallest wing a more or less triangular point 2–5 mm long, opposite largest wing.

Taxonomic notes

Agathis atropurpurea and *A. microstachya* are more or less sympatric, but remain often separated from each other by altitudinal range (with *A. microstachya* usually occurring at a lower altitude), and slight habitat differences, e.g. soil conditions, which are generally poorer with *A. atropurpurea*. They do not seem to hybridize. The most consistent difference between them is the morphology of the microsporophylls in the pollen cones (these cones are small in both species). In *A. atropurpurea*, these are imbricately arranged (the most common situation in the genus), while the microsporophylls in *A. microstachya* are tesselate, i.e. laying together like paving stones, with no parts overlapping. The shapes of the microsporophyll heads are also markedly different. The seed cones of *A. microstachya* are, when mature, much larger than the smallish seed cones of *A. atropurpurea*. There is a general leaf shape difference in leaves on mature trees in that *A. microstachya* has obtuse or rounded leaf apices, while *A. atropurpurea* has only obtuse apices, but this character is less reliable.

Distribution

Australia: NE Queensland (Cook District).
TDWG codes: 50 QLD-QU

Ecology

Agathis microstachya occurs mainly scattered in lowland to low montane semi-evergreen tropical rainforest in mountains E of the Atherton Tablelands, but also less frequently on these plateaus. Its altitudinal range is between 400 m and 1100 m a.s.l. It is an emergent species in a species-rich canopy of angiosperm trees. Soils are loamy sands or light clays and derived from acidic to neutral silicate-rich rock, usually of volcanic origin. Annual rainfall varies, with maxima to over 3000 mm on ocean-facing mountain slopes.

Conservation

Before 1985 the population of *A. microstachya* had been nearly halved by logging but 70% of the forests are now protected. The remaining population is estimated to consist of fewer than 10,000 mature trees. Under IUCN Red List criteria (version 3.1, 2001) this species would therefore qualify for the status VU, but due to cessation of large-scale logging and effective protection in a National Park and other protected areas, its threat with extinction has been greatly reduced. Logging continues in unprotected areas, but the decline appears to have been halted.
IUCN: NT

Uses

Bull kauri is a valuable timber tree and was formerly intensively logged and taken to local sawmills. The timber is soft, light, easy to work and polishes well. It is used for house framing, flooring, and joinery, as well as veneer production. This species is planted on a limited scale mainly in arboreta and tree collections in parks in Queensland.

Agathis montana de Laub., Trav. Lab. Forest. Toulouse T. 1 (8, 5): 2. 1969. *Salisburyodendron montana* (de Laub.) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006. Type: New Caledonia: Grande Terre, Province Nord, Mt.Panié, *M. Schmid 1420* (holotype P).

Etymology

The species epithet means "from the mountain" and refers to its habitat.

Vernacular names

No common names are known for this species.

Description

Medium size trees to 15–20 m tall, either multi-stemmed from near base or with clean bole for 8–10 m; sometimes almost flat-topped in appearance but crown usually very sparse, with long, spreading, crooked branches. Young trees possibly conforming to Rauh's architectural model, with whorled tiers of assurgent branches forming a conical crown. Bark reddish brown or tan to grey with numerous small, granular lenticels, flaking, coming away from the tree in irregular small pieces, excuding copious white resin. Leaves subopposite, thick, multinerved, coriaceous, glabrous, glaucous on the abaxial surface. Leaves of saplings and young trees broadly ovate, 8–11 cm long, 2.4–3.8 cm wide; leaves in crown of mature trees becoming more lenticular, 5.5–9 cm long, 1.4–2.2 cm wide. Pollen cones axillary, solitary, short pedunculate or sessile, with a tight basal-bract cluster of 5–8 imbricate, 1–2 mm wide bract pairs and without a pair of leaf-like bracts, cylindrical, 4–5 cm long but expanding to 7 cm or more past anthesis, 8–10 mm wide. Microsporophylls imbricate; microsporophyll heads umbonate, apices weakly acuminate, 2.0–2.6 mm wide and 2.2–2.5 mm high. Seed cones axillary, solitary on stout peduncle, globose to obovoid, ca. 9 cm long, 7 cm wide, smooth, green to glaucous green ripening brown, very resinous. Cone scales with rounded, thick and slightly incurved upper margins and thin, fragile lateral margins, ca. 3 cm long and wide. Seeds ovoid, 6–8 × 5 mm, with one large ovate wing and a small, triangular wing on the opposite side (no intact wings seen).

Distribution

New Caledonia (Massif du Panié, Roches d' Ouaième).
TDWG codes: 60 NWC

Ecology

Agathis montana is abundant to dominant from 1100–1200 m upwards on the Panié massif, the highest and wettest mountains in New Caledonia. It occurs in fern-rich rain forest habitat with *Retrophyllum comptonii*, the only other large tree, on reddish soil overlying micaschists. On the summit of Mt. Panié *Agathis montana* occurs together with *Araucaria schmidii* on or near exposed outcrops of rock and steep summit slopes, where it becomes stunted. The altitudinal range of this species is from 950 m a.s.l. to 1600 m a.s.l. on the summit crest.

Conservation

IUCN: NT

Uses

No uses are recorded of this species. The first botanical collection is from as recently as 1939 and the altitude and relative inaccessibility of all the known stands may have prevented earlier utilization, e.g. the collecting of resin. The commonly crooked shape and shortness of the boles render it less suitable for timber than most other species in the genus. It is not known to be in cultivation.

Agathis moorei (Lindl.) Mast., J. Roy. Hort. Soc. London 14: 197. 1892. *Dammara moorei* Lindl., J. Hort. Soc. London 6: 271. 1851; *Salisburyodendron moorei* (Lindl.) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006. Type: New Caledonia: Grande Terre, ["on East Coast"], *C. Moore s.n.* (holotype CGE).

Agathis corbassonii de Laub., Trav. Lab. Forest. Toulouse T. 1 (8, 5): 2. 1969. *Salisburyodendron corbassonii* (de Laub.) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006.

Etymology

This species was named after Charles Moore (1820–1905), a Director of the Royal Botanic Gardens Sydney, who collected the type specimen.

Vernacular names

Moore's kauri; kaori blanc, kaori rouge (French in New Caledonia)

Description

Trees to 40(–50) m tall and 1 m or more d.b.h. with clear cylindrical bole to 25 m; crown conical or rounded in trees of medium size, becoming more open and irregular in old trees. Bark smooth or rough and scaly, peeling in small or large, irregular flakes; colour variable – in forest reddish brown to tan, but becoming greyer (and harder) with exposure to sun, often resinous. Branches spreading. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green, sometimes glaucous on the abaxial (lower) side. Leaves on saplings and young trees and/or in shade lanceolate to elliptic, 10–20 cm long, 2–4 cm wide; leaves in crowns of mature trees narrowly ovate-elliptic, 4.5–7 cm long, (6–)8–12 mm wide with an obtuse apex. Pollen cones axillary, solitary on a slender, (1–)8–12 mm long peduncle, cylindrical, when full grown 2.5–3(–5) cm long, 6–9 mm diam., with 8–16 decussate (in 4–8 pairs), imbricate, 4–5 mm wide bract scales at their base. Microsporophylls in imbricate arrangement; head more or less angular but nearly flat, 1–3 mm wide, 0.75–2 mm high in mature cones; margin minutely erose-denticulate. Seed cones solitary on thick peduncles, subglobose to globose, 10–15 cm long, 9–12 cm diam., smooth, green or glaucous green, (very) resinous, ripening brown. Cone scales with slightly rounded, incurved upper margins, 3–4 cm long, 3–4 cm wide, roughly triangular with rounded corners and more or less flanged on either side. Seeds 15–20 × 8–10 mm, ovoid-oblong, with two unequal wings; largest wing 20–30 × 15–20 mm; smallest wing reduced to a narrow appendix 3–5 mm long, opposite large wing.

Taxonomic notes

Agathis corbassonii was segregated from *A. moorei* on the basis of its very reddish brown bark and its narrow leaves which are often glaucous beneath. The possibility of separate species (kaori blanc, kaori rouge) was first suggested by Michel Corbasson, Director of the Tropical Forestry Institute in Noumea. However, the variation in leaf sizes and shapes in *A. moorei* is perhaps greater than in any other species in the SW Pacific (T. G. Waters, unpublished D.Phil thesis, Oxford 2008) and those specimens ascribed to *A. corbassonii* appear to fall mostly within the ranges observed in *A. moorei*. Glaucousness is not a sound character for taxonomic distinction as it so often varies within populations in conifers. Field observation strongly indicates that shaded boles within forests have reddish brown bark, while sun-exposed trees develop grey bark through a weathering process. This exposed bark also becomes harder than on trees in moist forests. [It is understandable that local foresters took note of these bark differences, which is often all one can see of a large tree in tropical rainforest.] The number of bract scales at the base of the pollen cones in *A. moorei* is not consistently 16 (8 pairs in decussate arrangement) as is stated in some published descriptions, but can be fewer; it is a maximum number distinguishing the pollen cones of *A. moorei* from other species in New Caledonia. *Agathis corbassonii* is here treated as a synonym of *A. moorei*. The lower number of bract scales recorded for *A. corbassonii* (based on few good specimens) is therefore included in the character states as found in *A. moorei*, and in agreement with the measurements compiled by Waters and his judgement on the matter.

Distribution

New Caledonia: Grande Terre.
TDWG codes: 60 NWC

Ecology

Agathis moorei occurs in dense rain forests on soil derived from schists, micaschists, gneiss, and serpentines. It is usually restriced to non-ultramafic

soils, either forming small groves of pure *Agathis moorei*, or scattered through mixed angiosperm forest. Its altitudinal range is from (30) 100 m to 700 (1000) m a.s.l.

Conservation

This species has been heavily exploited for its timber in the past and consequently it has disappeared or become very scarce in many parts of the forest, especially in more accessible localities. Even in pre-European times its wood was preferred for the making of outrigger canoes. Substantial decline has occurred also within recent years and may continue because illegal logging is a particular concern (Watt in Farjon & Page, 1999). However, the species still occurs over much of the island of Grande Terre and, given adequate protection, could recover in many areas to former abundance.
IUCN: VU [B1ab(iii)+2ab(iii). C1]

Uses

Moore's kauri is a valuable timber tree and its wood is (was) much used for carpentry, joinery, veneer, and for the construction of 'pirogues' (outrigger canoes). In the extreme southern part of Grande Terre some limited forestry plantations of this species have been established on ultramafic soils.

Agathis orbicula de Laub., Blumea 25 (2): 540. 1979. Type: Malaysia: Sarawak, 5th Division, Lawas, ["Bumbong Rumah, N of Lawas"], *D. J. Laubenfels de P 614* (holotype L).

Etymology

The species epithet (Latin *orbis* = globe) describes the shape of (some of) the leaves as being nearly round.

Vernacular names

tumuh (Murut); tubu (Kenyah); bulok (Iban)

Trees to 40 m tall and 2 m or more d.b.h., with clear cylindrical bole up to 20 m and a broad crown radiating above. Bark sparsely lenticellate, hard and smooth, exfoliating in small plates to 4 mm thick, colour dark brown or greenish purple outside, reddish brown under outer, exfoliating layers, exuding light yellow resin. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green and often glaucous underneath. Leaves on saplings and young trees and/or in shade broadly lanceolate, 4–7 cm long, 2–3.5 cm wide, acute or slightly acuminate; leaves in crowns of mature trees distinctly petiolate, oval or ovate to nearly orbiculate, (2–)2.5–4(–6) cm long, 1–2.5 cm wide, acutish or obtuse to rounded at apex. Pollen cones axillary, solitary on a 2–3 mm long peduncle, when immature from subglobose becoming nearly cylindrical, 6–8 mm long, 4–5 mm diam., only slightly elongating past anthesis to 12–15 mm long and 5–6 mm wide, with 4–6 decussate (in 2–3 pairs) 2–3 mm wide, free spreading bract scales at their base. Microsporophylls in imbricate arrangement; head slightly convex towards the upper, rounded to angular, minutely erose-denticulate margin, 1.2–1.5 mm wide and 1 mm high in mature cones, bearing 2–4 oblong pollen sacs. Seed cones solitary on thick peduncles, ovoid to subglobose, to 8 cm long and 6 cm diam., more or less rough with raised seed scale margins especially in immature cones, green, resinous, ripening brown. Cone scales with more or less rounded, bossed, thick and strongly incurved upper margins, ca. 2 cm long and 3 cm wide in mature cones, flabellate to nearly reniform with rounded corners and more or less flanged on either side. Seeds ca. 10 × 6 mm, ovoid, flattened, with two unequal wings; largest wing ca. 12 × 6 mm; smallest wing a small triangle of 2 mm opposite large wing, or absent.

Taxonomic notes

Agathis orbicula has similar shapes and sizes of leaves to *A. kinabaluensis*, but those of the latter are not glaucous on the abaxial (lower) side. The pollen cones of *A. orbicula* are among the smallest in the genus (after anthesis) and lack the two elongated basal bracts observed in *A. kinabaluensis*. *Agathis orbicula* occurs at lower altitudes in tall forest and consequently is a tall tree; *A. kinabaluensis* occurs at high montane altitudes and is mostly a short, stunted tree, but grows tall when in high forest.

Distribution

Borneo: Indonesia (Kalimantan Timur); Malaysia (Sabah, Sarawak).
TDWG codes: 42 BOR-KA BOR-SB BOR-SR

Ecology

Agathis orbicula occurs at lower altitudes than *A. lenticula* in evergreen tropical rainforest and high kerangas. It is, like that and other species at these lower altitudes (for this species between 450 m and 1050 m a.s.l.) a tall emergent tree.

Conservation

This species is known from seven localities. In addition to those mapped in Flora Malesiana, ser. 1, 10 (3): 437, f. 78 (De Laubenfels, 1988) there are two in Kalimantan Timur. Exploitation of all tall trees of *Agathis* in Borneo has been intensive and is still ongoing. As a consequence, we can infer a decline even though this species is not distinguished by foresters or loggers from the more widespread species *A. borneensis*, which occurs in the same general area. The true rate of decline could be impossible to estimate, as logged trees and their stumps are no longer identifiable to species and cut trees assumed to belong to the more common *A. borneensis* may have been *A. orbicula*. It may have been present in several more than the presently known localities.
IUCN: VU [B2ab (ii, iii, v)]

Uses

The wood of this species has the same properties as other lowland species of *Agathis* in Borneo and is used for the same purposes; see therefore under *A. borneensis*. The resin is said to have a yellow colour, but since the resin of *A. lenticula* and other species comes out clear or white and tends to turn yellowish on exposure to air, this may be a somewhat doubtful property and is not known to be relevant to its applications. This species is not known to be in cultivation, but since plantations for forestry have not made the taxonomic distinction between this species and *A. borneensis*, it may be present in some plantations.

Agathis ovata (C. Moore *ex* Vieill.) Warb., Monsunia 1: 186. 1900. *Dammara ovata* C. Moore *ex* Vieill., Ann. Sci. Nat. Bot., sér. 4, 16: 56. 1862; *Salisburyodendron ovata* (Vieill.) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006. Type: New Caledonia: Grande Terre, Province Sud, Col de Yaté, ["Monts d'Unia"], *E. Vieillard 1263* (holotype P). Fig. 36, 37

Dammara hypoleuca C. Moore *ex* Henkel & W. Hochst., Syn. Nadelhölz.: 217. 1865; *Agathis hypoleuca* (C. Moore *ex* Henkel & W. Hochst.) Warb., Monsunia 1: 186. 1900; *Salisburyodendron ovata* (Vieill.) A. V. Bobrov & Melikyan subsp. *hypoleuca* (C. Moore *ex* Henkel & W. Hochst.) A. V. Bobrov & Melikyan, Komarovia 4: 63. 2006.

Etymology

The species epithet refers to the often ovate leaves.

Vernacular names

Scrub kauri; kaori de montagne, kaori nain (French in New Caledonia)

Description

Small, often shrubby trees up to 10 m tall (occasionally to 25 m in forest), usually with a short trunk to 80 cm d.b.h. and branching from near the base, with orthotropic primary branches (Rauh's model) forming a flat-topped or irregular, spreading crown. Leaf-bearing branches and cones held in dense pseudo-verticillate, upright or ascending clusters at tips of main branches, often glaucous to farinose. Bark with deep fissures, hard, slowly flaking off and forming irregular polygonal patches and scales on main trunks and branches, tan or reddish soon becoming grey. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green or glaucous green on the abaxial (under) side. Leaves on saplings or young trees well spaced, spreading in a plane, obovate-truncate, 4–6 cm long, 10–15 mm wide. Leaves in crowns of mature trees crowded, often in 4 more or less erect rows, similar in shape, often somewhat wider and with the leaf apex truncate or notched, 4–8.5 cm long and 1.5–5 cm wide

but occasionally almost orbiculate in shape. Pollen cones axillary, solitary on a stout 4–20 mm long peduncle, more or less fusiform (widest in the middle) but with an obtuse apex, 3–5 cm long, 10–15 mm diam.; subtended by two small leaf-like bracts and 4–5 pairs of imbricate, short, rounded bract scales; basal-bract cluster usually narrower than widest point of pollen cone. Microsporophylls imbricate, microsporophyll head 2–4.5 mm wide, 1.75–4.5 mm high in mature cone, more or less convex with entire margin. Seed cones globose, ca. 6 cm long, 5 cm wide; seed scales bossed to shortly rostrate: mature cones not smoothly globose. Cone scales 16–20 mm long, 22–26 mm wide, with a rounded, thick, more or less shortly rostrate (bossed) upper margin and thin, rounded lateral margins ending in a cuneate base. Seeds ovoid, 9–11 mm long, 7–8 mm wide, with truncate base and apex; wings of unequal size; largest wing 15–20 mm long and 9–12 mm wide and extended at a right angle to the seed; smaller wing opposite with a rounded edge, ca. 3 mm long and 5 mm wide.

Distribution

New Caledonia: Grande Terre, mainly in Province Sud (Massif du Sud) but with two localities further north, one as far as Commune de Houaïlou in Province Nord.
TDWG codes: 60 NWC

Ecology

Agathis ovata is usually growing on ultramafic soils in both maquis and (more rarely) forest environments. Its altitudinal range is from 30 m to 1050 m a.s.l. In maquis environments it commonly occurs with *Araucaria* spp., *Babingtonia leratii, Xanthostemon* spp., *Grevillea* spp., various members of the *Cyperaceae, Pteridium esculentum, Dracophyllum* spp., various members of the *Cunoniaceae, Myodocarpus* spp., *Dacrydium araucarioides, Lomandra insularis, Gymnostoma* spp., *Styphelia* spp., *Asplenium* spp., *Hibbertia* spp., and lichens such as *Cladia retipora*. In forest environments it occurs in mixed tropical rain forest, usually on drier, exposed slopes or ridges, but including forests otherwise dominated by species of *Nothofoagus*. Here it may occasionally attain 20–25 m and, due to competition with other trees, grow as an upright tree.

Conservation

This species is widespread but scattered in ultramafic maquis in Province Sud, and protected in some major reserves. Fire remains a threat in many areas where its incidence has been increased by humans, and a continuing decline is projected to occur.
IUCN: EN [B1 ab(iii)+2ab(ii, iii)]

Uses

Due to its usually low stature and crooked habit, this species is not exploited for timber, although an occasional tall specimen may have been logged from forest habitat. It is not known to be in cultivation outside a few collections in botanic gardens in the (sub-)tropics.

Agathis robusta (C. Moore *ex* F. Muell.) F. M. Bailey, Syn. Queensland Fl.: 498. 1883.

Etymology

The species epithet 'robust' may refer to the leaves, which are often larger than those of the few species known in 1857 when C. Moore coined the name.

Vernacular names

Queensland kauri pine, Smooth-barked kauri; asong, muwaka, ogapa (Papua New Guinea, mostly for subsp. *nesophila*).

Description

Trees to 50 m tall and 2 m or more d.b.h. with clear cylindrical bole to 30 m and a rounded or open crown with spreading to ascending branches. Bark smooth, often lenticellate, exfoliating in roundish small scales of up to 5 cm across; outer bark brown, reddish under newly fallen scales; inner bark pinkish, exuding white resin. Leaves subopposite, thin or thick, multinerved, coriaceous, glabrous, light or mid lustrous green above, dull green below. Leaves on saplings and young trees and/or in shade broadly lanceolate, 8–12(–14) cm long, 3–5 cm wide, sometimes acuminate; leaves in crowns of mature trees narrower, lanceolate, oblanceolate or elliptic, 5–11(–14) cm

long, 1–3 cm wide, distinctly petiolate and with an obtuse or rounded apex. Pollen cones axillary, solitary on a 2–10(–18) mm long, stout peduncle, cylindrical, when full grown 4–6(–7) cm long, 8–13 mm diam., becoming flexible, with 8–10 decussate (in 4–5 pairs), imbricate but spreading, 3–6 mm wide bract scales at their base. Microsporophylls in tesselate (or very weakly imbricate) arrangement; head obtuse-triangular to rhombic in outline, with a raised, prismatic, nearly flat or keeled central part 1–2 mm wide, 0.7–1.5 mm high in mature cones; margins partly hidden, bearing 2–8 pollen sacs. Seed cones solitary on thick peduncles, subglobose or obovoid, 8–15 cm long, 8–10 cm wide, smooth, green and resinous, ripening brown. Cone scales with slightly rounded, incurved upper margins, ca. 3 cm long, 3.5–4.2 cm wide, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12–14 × 7–8 mm, ovoid, flattened, with two unequal wings; largest wing 20–25 × 12–15 mm; smallest wing a small acute triangular point 3–4 mm long, opposite largest wing.

Distribution

Papuasia: New Britain, Papua New Guinea; Australia: coastal Queensland.
TDWG codes: 43 BIS NWG-PN 50 QLD-QU

Ecology

Agathis robusta is an emergent tree in lowland subtropical and tropical evergreen or semi-evegreen rainforest. In Queensland this species (subsp. *robusta*) occurs at its southernmost locality in a seasonal climate with occasional winter frost, at altitudes from near sea level to 900 m a.s.l. Here the forest is semi-evergreen and dominated by *Eucalyptus pilularis* (on Fraser Island). In northern Queensland it occurs in the notophyll vine forest, a rainforest type rich in lianas and with much higher rainfall (2000–3000 mm annually) than in the south. In New Guinea *A. robusta* is mostly represented by subsp. *nesophila*, but some specimens have been identified as subsp. *robusta*, apparently from similar habitat. Here the species is a scattered rainforest emergent of lower montane distribution at altitudes between 600 m and 1900 m a.s.l.; in New Britain it has been found at around 400 m a.s.l. It grows on a variety of nutrient-poor soils derived from granite or other igneous rock, including ultrabasic types.

Uses

The Queensland kauri pine is a valuable timber tree and was exploited in the past in Queensland, but logging of natural stands has all but ceased there. In New Guinea the timber of this species is used locally for house construction and the resin is tapped for various uses, but since this tree occurs very scattered in the forest it is not of economic importance to the timber industry. Export of round logs of *Agathis* from Papua New Guinea is banned. This species is widely planted as an ornamental in the tropics and subtropics and is present in most (sub) tropical botanic gardens and many parks. Most of the provenance of these trees will be populations in Queensland, especially from the northern population in Cook and Kennedy Districts. It is also planted locally with more utilitarian aims, especially resin tapping in PNG.

2 subspecies are recognized:

Agathis robusta (C. Moore *ex* F. Muell.) F. M. Bailey subsp. ***robusta***. *Dammara robusta* C. Moore *ex* F. Muell., Quart. J. Trans. Pharm. Soc. Victoria 2: 173. 1860. Type: Australia: Queensland, Cairns, Wide Bay, *C. Moore s.n.* (holotype MEL?, isotype K).

Description

Pollen cones when full grown up to 9 mm wide; microsporophylls obtuse-triangular, with raised head, ca. 1 × 1 mm.

Distribution

Australia: coastal Queensland (disjunct); Papua New Guinea: Owen Stanley Range (E of Port Moresby).
TDWG codes: 43 NWG-PN 50 QLD-QU

Conservation

It is not known how much effect historical logging has had on the size of the two populations in

Queensland, if any. Presently, logging has all but ceased and the subspecies is effectively not threatened with extinction.
IUCN: LC

Agathis robusta (C. Moore *ex* F. Muell.) F. M. Bailey subsp. ***nesophila*** Whitmore, Pl. Syst. Evol. 135 (1–2): 64. 1980. Type: Papua New Guinea: Morobe, Wau, Middle Creek, *J. J. Havel s.n.* (holotype K).

Agathis spathulata de Laub., Fl. Malesiana, ser. 1, 10 (3): 435. 1988.

Description

Pollen cones when full-grown 9–13 mm wide; microsporophyll heads rhombic in outline, not raised, 1.5–2 mm wide, more or less flat or keeled.

Distribution

Papua New Guinea: Eastern Highlands, New Britain.
TDWG codes: 43 BIS NWG-PN

Conservation

The scattered nature of the distribution of this subspecies renders commercial logging less likely; the timber is only used locally. The main threat would be deforestation for agriculture, which may occur in some locations with this tree, especially at lower altitudes in valleys near villages.
IUCN: NT

Agathis silbae de Laub., Phytologia 61: 448. 1987. Type: Vanuatu: Santo/Malo, Espiritu Santo, Tasmaloum, *M. Askin 13156* (holotype NY).

Etymology

This species was named after John Silba, an American with a long record of naming conifers himself.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 35(–40) m tall and 1–4 m or more d.b.h. with a clear but usually short (<10 m) bole and an ultimately broad crown formed by long, spreading and ascending branches. Bark smooth or scaly, exfoliating in large patches; colour grey weathering to white; inner bark red to pink near the wood; resin white turning yellowish in time. Leaves subopposite, thick, multinerved, coriaceous, glabrous, light green. Leaves on saplings and young trees and/or in shade broadly lanceolate, rarely slightly falcate, 5–12 cm long, 2–5 cm wide, with acute or obtuse apex; leaves in crowns of mature trees lanceolate, ovate-lanceolate to ovate, 4–8 cm long, (1–)2–4 cm wide with an obtuse or acute apex. Pollen cones axillary, solitary on a 0–6 mm long peduncle, cylindrical, when fully mature ca. 3.5–6 cm in length and 15–18 mm diam.; microsporophyll arrangement markedly tessellate when immature and becoming imbricate towards anthesis. Basal bract cluster loose, usually narrower than pollen cone, usually consisting of two or three opposite pairs of large triangular bracts, long-bracts not present. Microsporophylls in tesselate arrangement, their pedicel 2.5–2.8 mm long, slender; microsporophyll head, prismatic, 1.8–2.5 mm wide, 2.1–2.5 mm long, in adaxial view head thick with marginal flange very narrow or absent; margins entire, slightly undulate; apex notched; head with prismatic process both at apex and (in microsporophylls near pollen cone apex) between base and apex. Seed cones solitary on thick peduncles, globose, ca. 10–12 cm diam., smooth, green, often resinous, ripening brown. Cone scales with rounded, incurved upper margins, ca. 3.5 cm long, 4–5 cm wide, roughly triangular with rounded corners and more or less flanged on either side. Seeds 12–15 × 7–8 mm, ovoid-oblong, with two unequal wings; largest wing 20–25 × 13–17 mm; smallest wing a small blunt triangle 4–6 mm wide, opposite largest wing.

Taxonomic notes

This species was assumed to be identical with *A. macrophylla* by Whitmore (1980), who had seen a specimen at K from the Cumberland Peninsula which has foliage, fragments of a seed cone and fragments of

pollen cones. Later, he identified it as *A. silbae* when this species had been published. The main distinction between the two species is in the morphology of the microsporophylls of the pollen cone, which in *A. silbae* are distinctive with a 'double prismatic' head not seen in other *Agathis* species. The leaves, while variable, are less so than in *A. macrophylla* and differ very little in shape between young trees and old trees and only slightly more in size, with much overlap. As far as is known, no other species is indigenous to Espiritu Santo, but it may be that *A. macrophylla* is present among the planted trees on the island. These planted trees are so far restricted to village grounds near the coast.

Distribution

Vanuatu: Espiritu Santo (Cumberland Peninsula and Mt. Tabwémasana = 'Santo Peak').
TDWG codes: 60 VAN

Ecology

Agathis silbae occurs as an emergent large tree in tropical lower montane rainforest on the wetter, western and northwestern slopes of the central mountain range, at altitudes between 450 m and 760 m a.s.l. No detailed record of its habitat is available, but it is assumed to occupy a similar niche in the forest as *A. macrophylla* in Fiji. Trees are variously reported to grow on ridges or in hollows on the middle to upper slopes of the mountains. Very large trees have been found, so it can be assumed to be long-lived.

Conservation

The occurrence of large trees of *Agathis* in the interior mountains of the island of Espiritu Santo in Vanuatu has long been known, both to native islanders and at least since 1963 to visitors. De Laubenfels & Silba (1987) reported sightings of big emergent trees in the forest by others, but collections could not be made and the new species was described from a cultivated tree on the coast. In April 1987 G. Bourdy collected numerous herbarium specimens from 'Santo Peak' = Mt. Tabwémasana, where the trees were observed to be abundant, with several very large individuals seen. This was thought to be the only station of the species, but an earlier collection (specimen at K) dating from February 1979 was made at the nothern end of the mountain range on the Cumberland Peninsula on the "top western slopes" (ca. 600 m a.s.l.) and so there are at least two (sub)populations of this species. There is little incentive to logging because the large trees all have very short boles and massive branching rendering them of limited use as timber.
IUCN: NT

Uses

The timber of this species is similar to that of *A. macrophylla* in its properties, but the shape of most trees in the wild does not make them valuable as timber trees. The inflammable white resin ('latex') was traditionally used instead of kerosene for lighting fires. Trees are grown by local people in oceanside villages of southwest Espiritu Santo, especially Tasmalum and Wailapa and some will have attained harvestable dimensions.

Amentotaxus Pilg., Bot. Jahrb. Syst. 54: 41. 1916. Type: *Amentotaxus argotaenia* (Hance) Pilg. [*Podocarpus argotaenia* Hance] (*Taxaceae*).

Latin: *amentum* = string; referring to the racemose arrangement of pollen cones; *Taxus* is the classical Latin name for yews.

Description

Dioecious, evergreen shrubs or small trees. Resin canals (1) in leaves only. Bark smooth, exfoliating in thin flakes. Foliage shoots with conical (sub-) terminal buds; branching in trees rhytmic and plagiotropic (Massart's model). Leaves usually opposite-decussate, pectinately arranged by twisted petiolate leaf bases, flattened, large, narrowly lanceolate to linear-lanceolate or slightly falcate, coriaceous, with two conspicuous, broad, white stomatal bands on the abaxial side (turned downwards by twisting of petioles of half of the number of leaves on a shoot; in the other half the abaxial side is the lower side without a twist). Pollen cones aggregated in umbellate clusters of (1–)3–6 racemes from large buds at or just below apex of vegetative shoots, forming rows of mostly opposite pairs on each raceme, subglobose; microsporophylls 6–10 per cone, peltate, bearing 2–8 small pollen sacs containing spherical pollen. Seed-bearing structures usually in groups near apex of vegetative shoots, long pedicellate, consisting of several pairs of decussate, imbricate bracts and a single, terminal, erect ovule partly enclosed by the upper bracts and subtended by a cupular aril. Aril surrounding ripe seed greatly enlarged, ellipsoid or ovoid, fleshy and succulent, red or purple. Seeds much smaller, with a mucronate apex.

6 species.

Distribution

China, Taiwan, NE India (Arunachal Pradesh), Viet Nam.

Key to the species of *Amentotaxus*

The size and shape of leaves, used as characters to distinguish species by Li (1952) turn out to be variable and not very reliable as diagnostic characters. The colour of the stomatal bands is more or less white in all species, but will turn brownish in some when leaves are older than one year.

1a. Stomatal bands as wide as the green leaf margins, or nearly so ***A. argotaenia***
1b. Stomatal bands 1.5–3(–4) times as wide as the green leaf margins **2**
2a. Stomatal bands 2–3(–4) times as wide as the green leaf margins, white at first, turning brown **3**
2b. Stomatal bands 1.5–2 times as wide as the green leaf margins, white or (creamy) grey, not turning brown **4**
3a. Leaves spreading at angles of 70–90° from the shoot. Pollen cones with 10–15 pairs on ca. 10 cm long racemes ***A. hatuyenensis***
3b. Leaves spreading at angles of 50–70° from the shoot. Pollen cones with 12–20 pairs on 10–15 cm long racemes ***A. yunnanensis***
4a. Leaf texture on the adaxial (upper) surface smooth. Microsporophylls 6–8 per pollen cone, with 2–4 pollen sacs ***A. assamica***
4b. Leaf texture on the adaxial (upper) surface rugose. Microsporophylls 8–11 per pollen cone, with (3–)4–8 pollen sacs **5**
5a. Leaf apices long acuminate; stomatal bands about twice as wide as the green leaf margins ***A. formosana***
5b. Leaf apices long acute or obtuse; stomatal bands about 1.5 times as wide as the green leaf margins ***A. poilanei***

Amentotaxus argotaenia (Hance) Pilg., Bot. Jahrb. Syst. 54: 41. 1916.

Etymology

The species epithet (Greek *argyr-* = silver,and *taenia-* = ribbon or band) describes the two stomatal bands of the leaves.

Vernacular names

Catkin yew; sui hua shan (Chinese)

Description

Shrubs or small trees to 7 m tall. Bark smooth, exfoliating in thin flakes. Branches few, spreading or ascending. Foliage branchlets opposite, spreading at 25–70° from the leading shoot axis, ascending or spreading, subterete, with alternatingly twisted grooves running from one leaf base to the next above, green in the first year, turning from greenish yellow to orange-brown in following years, terminating in a conical bud with ovate-triangular, acute scales. Leaves spreading distichously at 45–90°(–95°) from shoot axis, linear or linear-lanceolate, (2–)3–9(–11) cm long, falcate or nearly straight, 5–11 mm wide, subsessile to short petiolate and curved or asymmetric at base, tapering to an obtuse or acute-acuminate apex; margins flat or slightly revolute. Leaf texture coriaceous, with sclereids causing a mottled, rugose upper surface, dark green; on the lower surface two white bands bordered by wide green leaf margins and a midrib. Midrib prominently raised on the adaxial (upper) side, lying in a shallow groove, 0.8–1 mm wide, continuous to the apex; on the abaxial side nearly flat and 1.2–1.5 mm wide. Stomata on the abaxial surface in two bands about as wide or slightly narrower than the green leaf margins, numerous, randomly dispersed. Pollen cone racemes from large axillary or sub-terminal buds with 2–5(–10) together, 3.5–6.5 cm long, each with 10–12 cone pairs when full-grown; cones ovoid, 3–3.5 mm long; microsporophylls 6–8, peltate, each with 2–5 pollen sacs. Seed-bearing structures near ends of foliage shoots, axillary, solitary on a slender, downcurved, with 1.5–2 cm long peduncle, with 6–8(–10) decussate, keeled bracts enclosing a single, terminal ovule. Aril surrounding the seed ellipsoid or narrowly obovoid, 20–26 × 10–13 mm, smooth, lustrous bright red when ripe, with a mucronate apex. Seed proper much smaller, ca. 15 × 7 mm, oblong or ellipsoid, with a small mucronate apex.

Distribution

China: Chongqing, Fujian, S Gansu, Guangdong, Guangxi, Guizhou, Hong Kong, W Hubei, Hunan, Jiangsu, NW Jiangxi, Central and SE Sichuan, SE Xizang [Tibet], S Zheijiang; Taiwan; Indochina: Lao PDR, N Viet Nam.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHN-GS CHS-FJ CHS-GD CHS-GX CHS-HK CHS-HN CHS-JS CHS-JX CHT 38 TAI 41 LAO VIE

Ecology

Amentotaxus argotaenia is widespread and occurs on limestone as well as sandstone, shale or granite, and in ravines, on steep slopes or cliffs, on summits and ridges and in mountain forests along shady stream banks. The altitudinal range is between 600 m and 1100 m a.s.l. Associated trees and shrubs vary with the types of rock, mainly between limestone and other rocks. On limestone, it may grow with *Pinus kwangtungensis, Nageia* spp., *Podocarpus neriifolius, P. pilgeri, P. macrophyllus* and *Taxus chinensis*. On acidic rock types it is associated with *Amentotaxus yunnanensis, Cephalotaxus* spp. and broad-leaved trees and shrubs (angiosperms) like *Magnolia, Quercus*, and *Rhododendron* in montane evergreen or semi-deciduous forests.

Uses

The wood is used for tool making, furniture and wood turning (handicrafts). This species is in cultivation in China and was introduced to Europe from Hong Kong; it makes an attractive foliage shrub but only grows outside in warmer regions. This (and other) species is rare in gardens due to poor availability in the horticultural trade. In China it is used as a bonsai plant. The seeds have high oil content and are surrounded by a very striking red aril. Recent investigations have been undertaken to analyse its potential for anti-cancer drugs similar to those found in *Taxus*.

2 varieties are recognized:

Amentotaxus argotaenia (Hance) Pilg. var. ***argotaenia***. *Podocarpus argotaenia* Hance, J. Bot. 21: 357. 1883; *Nageia argotaenia* (Hance) Kuntze, Revis. Gen. Pl. 2: 800. 1891; *Cephalotaxus argotaenia* (Hance) Pilg., in Engler, Pflanzenr. IV.5 [18]: 104. 1903. Type: China: Fujian, ["in jugo Lo-fau shan, prov. Cantonensis"], *E. Faber s.n. [Acc. No. 22121]*, Sep 1882, (holotype BM).

Amentotaxus cathayensis H. L. Li, J. Arnold Arbor. 33: 195. 1952; *Amentotaxus argotaenia* (Hance) Pilg. var. *cathayensis* (H. L. Li) P. C. Keng, [Chin. title; see Fl. Reipupl. Pop. Sin. 7: 452. 1978]: 2. 1957.

Description

Leaves 3–11 cm long, 6–11 mm wide. Pollen cone racemes grouped with 2–4(–5) together, rarely solitary. Seeds including the aril 20–26 mm long and 10–13 mm wide.

Distribution

China: Chongqing, Fujian, S Gansu, Guangdong, Guangxi, Guizhou, Hong Kong, W Hubei, Hunan, Jiangsu, NW Jiangxi, Central and SE Sichuan, SE Xizang [Tibet], S Zheijiang; Taiwan; Indochina: Lao PDR, N Viet Nam.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHN-GS CHS-FJ CHS-GD CHS-GX CHS-HK CHS-HN CHS-JS CHS-JX CHT 38 TAI 41 LAO VIE

Conservation

This species (variety) is widespread but its overall occurrence has presumably been reduced through deforestation. This reduction is difficult to quantify and may have ceased if the nationwide ban on logging of natural forest in China turns out to have positive effects on the remaining forest cover. The Near Threatened category indicates that this balance could shift towards further decline, moving the species into a threatened category.
IUCN: NT

Amentotaxus argotaenia (Hance) Pilg. var. ***brevifolia*** K. M. Lan & F. H. Zhang, Acta Phytotax. Sin. 22 (6): 492. 1984. Type: China: Guizhou, Libo, Dongjiang Shan, *K. M. Lan & F. H. Zhang 82–002* (holotype GACP).

Description

Leaves 2–3.7 cm long, 5–7 mm wide. Pollen cone racemes grouped with up to 10 together, 1.5–5.5 cm long. Seeds including the aril ca. 20 mm long and 10 mm wide.

Distribution

China: SE Guizhou (Libo Xian).
TDWG codes: 36 CHC-GZ

Ecology

This variety occurs on limestone karst mountains on steep rocky slopes and ridges at around 1000 m altitude.

Conservation

Amentotaxus argotaenia var. *brevifolia* is known from a very limited area and has been severely reduced in population size due to deforestation on the more accessible slopes.
IUCN: CR (A2cd)

Uses

This variety grows to a small tree; its uses are similar to those of the species but it is not known if it is in cultivation in or outside China.

Amentotaxus assamica D. K. Ferguson, Kew Bull. 40 (1): 115. 1985. Type: India: Arunachal Pradesh, Delei River, Camp Chibaon, *F. Kingdon Ward 8026* (holotype K).

Etymology

The species epithet refers to Assam, its native region (now Arunachal Pradesh).

Vernacular names

Assam catkin yew

Description

Trees to 20 m tall; trunk sometimes divided low above the ground. Bark smooth, exfoliating in thin flakes, whitish grey. Branches spreading or sweeping down. Foliage branchlets opposite, spreading at 25–70° from the leading shoot axis, ascending or spreading, subterete or angular, with alternatingly twisted grooves running from one leaf base to the next above, green in the first year, turning from greenish yellow to yellowish brown in following years, terminating in a conical bud with ovate-triangular, acute-mucronate scales. Leaves spreading distichously at 45–80° from shoot axis, linear or

linear-lanceolate, (2–)7–11(–15) cm long, falcate or more or less S-shaped, (4–)7–12 mm wide, short petiolate and curved or asymmetric at base, gradually tapering to an acute-acuminate apex, green with two white or silvery grey bands bordered by wide green leaf margins and a midrib on the lower surface; margins flat or slightly revolute. Leaf texture coriaceous, with a smooth or finely striated upper surface (lacking sclereids in the leaf anatomy). Midrib prominently raised on the adaxial (upper) side, lying in a shallow groove, 0.4–0.7 mm wide; continuous to the apex, slightly raised and 1–1.8 mm wide on the abaxial side. Stomata on the abaxial surface in two bands 1.5–2 times as wide as the green leaf margins, numerous, randomly dispersed. Pollen cone racemes from large axillary or sub-terminal buds with 2–4 together, 4–5.5 cm long, each with 8–10 cone pairs when full-grown; cones ovoid, 3–5 mm long; microsporophylls 6–8, peltate, each with 2–4 pollen sacs. Seed-bearing structures axillary, solitary on 1.5–2.5 cm long peduncles, with 8 decussate, ovate, keeled, 2.5–5 mm long and 2.5–5 mm wide bract scales (the upper scales largest). Aril obovoid-oblong to ellipsoid, 25–35 × 15–25 mm, lustrous green turning yellow to purple, with a mucronate apex. Seed proper much smaller, 15–20 × 7–10 mm, oblong or ellipsoid, with a small mucronate apex.

Taxonomic notes

Ferguson (1985) has distinguished this species from *A. yunnanensis* mainly on leaf anatomical characters. One of these, the lack of sclereids in the upper mesophyll of the leaves, present in all other species, gives the leaves a smooth texture quite different from its congeners. At the time, the seed bearing structures were unknown, these were later described from newly collected specimens and appear to be larger than in most other species, though variable.

Distribution

India: Arunachal Pradesh ["Assam"].
TDWG codes: 40 EHM-AP

Ecology

Amentotaxus assamica occurs in warm temperate montane rain forest on N-facing slopes at altitudes between 1600 m and 2000 m a.s.l. These are mossy forest dominated by *Quercus* spp., *Castanopsis* spp., *Acer* sp. and *Rhododendron* spp., with associated taxa such as *Magnolia* sp., *Michelia* sp., *Corylopsis himalayana, Betula alnoides, Carpinus viminea* and *Exbucklandia populnea. Amentotaxus assamica* is a rare species only known from two localities.

Conservation

This species is known from two disjunct localities in Arunachal Pradesh, NE India, in only one of which it has been collected recently (1980s). It is obviously rare because several searches during the 1970s for it remained unsuccessful until it was found again in 1984. However, the region remains poorly explored botanically and we cannot say whether it is restricted to the localities known or more widespread. So far it is not known from outside the state. Activities like road building are opening up this border region to settlement, leading to shifting agriculture and consequently forest disturbance and destruction. There is an urgent need to establish forest reserves as well as cultivation action to provide *ex situ* conservation for this species (Sahni, 1990).
IUCN: EN [B1ab (iii) + 2ab (iii)]

Uses

No specific uses have been recorded of this species.

Amentotaxus formosana H. L. Li, J. Arnold Arbor. 33: 196. 1952. *Amentotaxus yunnanensis* H. L. Li var. *formosana* (H. L. Li) Silba, Phytologia 68: 25. 1990. Type: Taiwan: Pingtung Co., ["Taririku"], *S. Sasaki s.n.* (holotype TAI). Fig. 38, 39

Etymology

The species epithet refers to Taiwan (formerly Formosa), where this species is indigenous; see also Latin: *formosus* = handsome or well formed.

Vernacular names

tai wan sui hua shan (Chinese)

Description

Small trees to 10 m tall. Bark smooth, brown, exfoliating in thin flakes. Branches few, spreading or ascending. Foliage branchlets opposite, spreading at 25–70° from the leading shoot axis, ascending or spreading, subterete, with alternatingly twisted grooves running from one leaf base to the next above, green in the first year, turning to yellowish brown with dark grooves in following years, terminating in a conical bud with ovate-triangular, acute scales. Leaves spreading distichously at 50–70° from shoot axis, lanceolate or linear-lanceolate, (3.5–)5–8.5(–9.5) cm long, slightly or more strongly falcate, 5–10 mm wide, subsessile to short petiolate and curved or asymmetric at base, gradually tapering to a long acuminate apex, dark green, with two white bands bordered by wide green leaf margins and a midrib on the lower surface; margins (slightly) revolute. Leaf texture coriaceous, with sclereids causing a mottled, rugose upper surface. Midrib prominently raised on the adaxial (upper) side, lying in a shallow groove, 0.8 mm wide, continuous to apex, raised at least near base and 1–1.5 mm wide on the abaxial side. Stomata on the abaxial surface in two bands about twice as wide as the green leaf margins, numerous, randomly dispersed, thickly covered with white wax. Pollen cone racemes from large axillary or sub-terminal buds with 2–5 together, rarely solitary, 1.5–3.5 cm long, each with 7–10 crowded cone pairs when full-grown, cones subglobose, ca. 2.5 mm long; microsporophylls 8–10, peltate, each with 5–8 tiny pollen sacs. Seed-bearing structures near ends of foliage shoots, axillary, solitary on a slender, down-curved, 1.5–2 cm long peduncle, with 8–10 decussate, keeled bracts enclosing a single, terminal ovule. Aril surrounding the seed ellipsoid or narrowly obovoid, 20–25 × 9–11 mm, smooth, lustrous reddish purple when ripe, with a mucronate apex. Seed proper much smaller, ca. 15 × 7 mm, oblong or ellipsoid, with a small mucronate apex.

Taxonomic notes

This species was formerly not recognized as being distinct from *A. argotaenia* and many earlier accounts of the flora of Taiwan refer to it under this name. In fact, *A. argotaenia* appears to occur in Taiwan as well, making things not easier. The main distinction between the two species is in the width of stomatal bands, which in *A. formosana* are about twice as wide as the green leaf margins. With leaves about equally wide, this amounts to narrower leaf margins in *A. formosana* compared with leaves of *A. argotaenia*. The pollen cone racemes of *A. formosana* are shorter than those of *A. argotaenia*, resulting in crowded pollen cones in *A. formosana* where they are spaced in *A. argotaenia*.

Distribution

Taiwan (southernmost mountains).
TDWG codes: 38 TAI

Ecology

Amentotaxus formosana is a rare tree in montane evergreen tropical rainforest and broad-leaved subtropical forest. It is usually found on steep slopes, in ravines, or on cliffs in the sub-canopy under taller trees. Its altitudinal range is between 500 m and 1300 m a.s.l. with most trees occurring above 900 m a.s.l. In these primary forests members of the *Fagaceae* (*Castanopsis, Lithocarpus, Quercus*) are often the dominant or emergent trees and there is an abundance of ferns, including tree ferns, and shrubs.

Conservation

This species was evaluated as Endangered (EN) by the Taiwanese botanist S. Y. Lu in Rare and Endangered Plants in Taiwan 1 (1996) and as Critically Endangered (CR) by the Conifer Specialist Group in the Status Survey and Conservation Action Plan: Conifers (Farjon & Page, 1999), both under the now superseded 1994 criteria. This species is certainly rare, but is also very difficult to find (as I experienced recently) and deciding on the number of mature individual plants under the (amended) C-criterion (250 for CR, 2500 for EN) is much more difficult than it sounds. Assuming that more than 250 trees still exist, Lu's estimate is probably more correct, also because it has recently been found in 'new' localities. The greatest threat to it appears to be conversion of native mixed evergreen forest to plantations with primarily *Cryptomeria japonica*, which has been pursued at least until recently, when the government vowed to discontinue this programme of 'afforestation' in favour of natural regeneration where possible. This species is present in the Tawu

Taiwan Nature Reserve, a small forest reserve of 86 ha.
IUCN: EN C2a (i)

Uses

The wood, though of small dimensions, is valued and used for the making of furniture, farm implements, tools and utensils, and wood turning for souvenirs. This species is in cultivation as an ornamental tree in China, Japan and Taiwan, but very rare and only seen in some botanic gardens elsewhere. Its broad, white bands of stomata are very striking, although normally hidden from view on the underside of leaves. Lack of commercially available cuttings or seed has prevented this species from being grown more widely; it is obviously not suitable for climates with winter frost.

Amentotaxus hatuyenensis Hiep, Fl. Cambodge, Laos et Vietnam 28: 126. 1996. Type:
Viet Nam: Ha Tuyên Prov., Pho Bang, Lung Cun, *Vu Xuan Phuong 329* (holotype P).

Etymology

The species epithet refers to Ha Tuyên Province, from where it was first described.

Vernacular names

Dẻ tùng sọc nâu rộng (Vietnamese)

Description

Shrubs to 4–5 m tall. Foliage branchlets slender, terete, with grooves alternately running from one leaf base to the next, green turning yellowish or pale brown, terminating in a conical bud with ovate-triangular, acute scales. Leaves spreading distichously at 70–90° from shoot axis, lanceolate, 4–7 cm long, usually straight or sometimes slightly falcate, 7–13 mm wide, subsessile to short petiolate and broadly cuneate or obtuse at base, tapering to an acuminate apex, light green or mid green, with two initially white or yellowish white, later reddish brown or brown bands bordered by wide green leaf margins and a midrib on the lower surface; margins revolute. Leaf texture coriaceous, with sclereids causing a mottled, rugose upper surface. Midrib prominently raised on the adaxial (upper) side, lying in a shallow groove, 0.8–1 mm wide and continuous to the apex, raised and 1–1.5 mm wide on the abaxial side. Stomata on the abaxial surface in two bands 2–3(–4) times as wide as the green leaf margins, numerous, randomly dispersed, white or cream in a brown matrix. Pollen cone racemes from large axillary or sub-terminal buds with 3–5 together, ca. 10 cm long, each with 10–15 cone pairs when full-grown, cones subglobose, ca. 3.5 mm long; microsporophylls 8–10, peltate, each with 5–8 tiny pollen sacs. Seed-bearing structures near ends of foliage shoots, axillary, solitary on a 1.5 cm long peduncle, with 10–12 decussate, keeled bracts enclosing a single, terminal ovule. Aril surrounding the seed only known in immature state.

Taxonomic notes

This species remains taxonomically poorly known; its main distinguishing character from *Amentotaxus yunnanensis* seems to be the colour of the stomatal bands on the abaxial leaf surface. These bands are described in the original description as "rousses ou brunâtres", but in *A. yunnanensis* they are also not entirely white but become yellowish white or pale brown. Initially, in new leaves at least, all stomatal bands seem to be white, they may turn to brown later or only in drying leaves. The leaf shape, at least in the type specimen of *A. hatuyenensis*, is more lanceolate than in *A. yunnanensis*, but there was no other material available when *A. hatuyenensis* was described and we still know little about variation in both characters. I have not seen the later specimens from Ha Giang Province ascribed to this species and cannot say how much they differ from *A. yunnanensis*. More recently, trees or shrubs found in some localities in Ha Giang Province reported to be *A. hatuyenensis* have turned out to be either *A. yunnanensis* or *A. argotaenia* (Philip Thomas, RBGE, pers. comm. May 2008). The characters mentioned may only indicate two varieties, not two species.

Distribution

Viet Nam (Ha Giang Prov., Ha Tuyên Prov.).
TDWG codes: 41 VIE

Ecology

This is a rare species occurring on steep ridges of limestone karst mountains at altitudes between

1000 m and 1500 m a.s.l. In its few known localities it may grow together with the conifers *Pinus fenzeliana, Tsuga chinensis, Amentotaxus yunnanensis, Cephalotaxus mannii, Xanthocyparis vietnamensis, Nageia fleuryi, Podocarpus neriifolius* and *P. pilgeri*, as well as with various angiosperm trees, e.g. *Acer, Carpinus, Lithocarpus, Quercus*, and *Ulmus* and a rich epiphytic flora of mosses, ferns, and orchids. Frequent fog and rain amount to annual precipitation above 1800 mm, usually under cool temperatures of ca. 15–18° C.

Conservation

When described in 1996, this species was known from a single locality in Ha Tuyen Province; subsequently botanical surveys have found it in a few other localities, all in Ha Giang Province, one is in the Bat Dai Son Nature Reserve, known to protect the new genus and species in the *Cupressaceae: Xanthocyparis vietnamensis*. *Amentotaxus hatuyensis* remains poorly known, and although currently thought to be a local endemic, it may turn up in other locations with continued surveys in future. Forest degradation as a result of fires, fuelwood and timber cutting are adversely influencing its habitat, but the shrubby habit of this species makes it unlikely to be targeted for cutting. Observed regeneration is poor, but this is also an imperfectly known factor at present.
IUCN: EN [A2c, C2a (i)]

Uses

No uses have been recorded of this species.

Amentotaxus poilanei (Ferré & Rouane) D. K. Ferguson, Adansonia, sér. 4, 11 (3): 316. 1989. *Amentotaxus yunnanensis* H. L. Li var. *poilanei* Ferré & Rouane, Trav. Lab. Forest. Toulouse T. 1 (9, 1): 3. 1978. Type: Viet Nam: Kon Tum Prov., Ngoc Pan Massif, Mt. Ngoc Linh, *E. Poilane 32686* (holotype P).

Etymology

This species is named after Eugène Poilane (1888–1964), who collected the type specimens.

Vernacular names

Poilane's catkin yew; Dẻ tùng Nam, Sam bông Nam (Vietnamese)

Description

Trees to 20 m tall; trunk to 1 m d.b.h. Bark smooth, becoming scaly on large trunks, brown, exfoliating in flakes. Branches spreading or ascending. Foliage branchlets opposite, spreading at 25–60° from the leading shoot axis, ascending or spreading, angular in cross-section, with alternatingly twisted grooves running from one leaf base to the next above, green in the first year, turning to yellowish brown in following years, terminating in an ovoid bud with ovate-triangular, keeled and acute scales. Leaves spreading distichously at 50–70° from shoot axis, elliptical, oblanceolate or linear, (3–)5–8(–9) cm long, straight to slightly or more strongly falcate, (4.3–)5–8.5 mm wide, short petiolate and more or less gradually narrowing at base, gradually tapering to a long acute or obtuse apex, dark green, with two white or creamy grey bands bordered by green leaf margins and a midrib on the lower surface; margins revolute. Leaf texture coriaceous, with sclereids causing a mottled, rugose upper surface. Midrib prominently raised on the adaxial (upper) side, lying in a shallow groove, 0.5 mm wide, continuous to apex, raised at least near base and 1–1.8 mm wide on the abaxial side. Stomata on the abaxial surface in two bands about 1.5 times as wide as the green leaf margins, numerous, randomly dispersed, thickly covered with white wax. Pollen cone racemes from large axillary or sub-terminal buds with 3–4 together, rarely solitary, 2.5–4.5 cm long, each with 8–12 cone pairs when full-grown, cones subglobose or ovoid, 3–4 mm long; microsporophylls 8–11, peltate, each with (3–)4–6(–8) pollen sacs. Seed-bearing structures near ends of foliage shoots, axillary, solitary on a slender, downcurved, 1–2 cm long peduncle, with ca. 8 decussate, keeled bracts enclosing a single, terminal ovule; only known in immature stage.

Taxonomic notes

This species was originally described as a variety of *A. yunnanensis*, based on observed variations of leaf length and width. As pointed out by Ferguson

(1989), who raised this taxon to species rank, leaf dimensions are of dubious value to distinguish between species as there is usually much overlap and the measurements vary considerably within species. Ferguson found that length/width ratios are probably more informative, showing *A. poilanei* to have narrower leaves. These values similarly overlap, but to a lesser extent. He then went on to describe features of leaf anatomy of both taxa and found several differences to justify not only to retain var. *poilanei* as distinct but to raise it to species level. There is a single resin duct in the leaf that is much narrower in *A. poilanei* than in *A. yunnanensis*, and 'flanges' are absent in the revolute leaf margins of *A. poilanei*. The morphology and anatomy of *A. poilanei* are, according to Ferguson, closer to *A. formosana* than to *A. yunnanensis*. Like the other localized Vietnamese species, *A. hatuyenensis, A. poilanei* remains a somewhat doubtfully distinct species. The as yet unknown mature female organs do not help solving this problem, so more good material needs to be collected from the single locality where it is known to occur.

Distribution

Viet Nam (Kon tum Prov., Mt. Ngoc Linh).
TDWG codes: 41 VIE

Ecology

This species is apparently a large tree occurring in high montane closed evergreen rainforest, at an altitude around 2300 m a.s.l. It is locally common but scattered, mixed with broad-leaved (angiosperm) trees and perhaps *Nageia wallichiana* as the only other conifer present. Rainfall is very high, at least over 3000 mm per annum and cool temperatures prevail due to almost continuous cloud cover.

Conservation

This species is still only known with certainty from a single mountain, where it was discovered in 1946. Reports from other localities need confirmation by taxonomists who know the genus *Amentotaxus* well. The primary forest in this locality is still present and the total population probably consists of fewer than 1000 mature trees. The status of *A. poilanei* was assessed under the IUCN Red List criteria of 1994 as Vulnerable, assuming a modest decline due to forest fragmentation at lower altitudes, approaching or encroaching on the population. More recent visits have indicated that there are no direct threats at present and that the species should be classified as Vulnerable on the basis of its small population size alone, using the revised 2001 criteria. There are protected forest areas on the mountain which include this species.
IUCN: VU (D2)

Uses

No uses have been recorded of this species. The size of the largest trees would certainly make it valuable as a timber tree used for the making of furniture, tools, etc. Inaccessibility is probably a factor limiting its use. It is not known to be in cultivation at present.

Amentotaxus yunnanensis H. L. Li, J. Arnold Arbor. 33: 197. 1952. *Amentotaxus argotaenia* (Hance) Pilg. var. *yunnanensis* (H. L. Li) P. C. Keng, [Chin. title; see Fl. Reipupl. Pop. Sin. 7: 452. 1978]: 2. 1957. Type: China: SE Yunnan, Maguan, ["Makwan"], *H. T. Tsai 51887* (holotype US). Fig. 40

Etymology

The species epithet refers to Yunnan, China, from where it was first described.

Vernacular names

Yunnan catkin yew; Yunnan sui hua shan (Chinese); Dẻ tùng Vân Nam (Vietnamese)

Description

Trees to 25(–30) m tall; trunk to 80 cm d.b.h. Bark smooth, brown, exfoliating in thin flakes. Branches spreading or ascending, forming a broad crown. Foliage branchlets opposite, spreading at 45–80° from the leading shoot axis, ascending or spreading, subterete, with alternatingly twisted grooves running from one leaf base to the next above, green in the first year, turning to light yellow or yellowish brown in following years, terminating in a conical bud with ovate-triangular, acute scales. Leaves spreading distichously at 50–70° from shoot axis, linear or linear-lanceolate, (3.5–)5–10(–15) cm long, usually straight

or sometimes slightly falcate, 8–12(–15) mm wide, subsessile to short petiolate and broadly cuneate or obtuse at base, tapering to an obtuse or more or less acuminate apex, light green or mid green, with two yellowish white to pale brown bands bordered by wide green leaf margins and a midrib on the lower surface; margins (slightly) revolute. Leaf texture coriaceous, with sclereids causing a mottled, rugose upper surface. Midrib prominently raised on the adaxial (upper) side, lying in a shallow groove, 0.8–1 mm wide, continuous to apex, raised at least near base and 1–1.5 mm wide on the abaxial side. Stomata on the abaxial surface in two bands 2–3 times as wide as the green leaf margins, numerous, randomly dispersed, white or cream in a pale brown matrix. Pollen cone racemes from large axillary or sub-terminal buds with 4–6 together, 10–15 cm long, each with 12–20 cone pairs when full-grown, cones subglobose, ca. 3.5 mm long; microsporophylls 8–10, peltate, each with 4–6(–8) tiny pollen sacs. Seed-bearing structures near ends of foliage shoots, axillary, solitary on a slender, downcurved, 1.5–2 cm long peduncle, with 8–10 decussate, keeled bracts enclosing a single, terminal ovule. Aril surrounding the seed ellipsoid or narrowly ovoid, 22–26(–30) × 12–15 mm, smooth, lustrous bright red to reddish purple when ripe, with a mucronate apex. Seed proper much smaller, ca. 18 × 10 mm, oblong or ellipsoid, with a small mucronate apex.

Distribution

China: SW Guizhou (Xingyi), SE Yunnan; N Viet Nam (Bac Can, Ha Giang, Ha Tuyen, Lao Cai, Nghe An and Thanh Hoa provinces); Lao PDR (Houaphan Prov.).
TDWG codes: 36 CHC-GZ CHC-YN 41 LAO VIE

Ecology

Amentotaxus yunnanensis is usually a small understorey tree occurring scattered in mixed evergreen and deciduous broad-leaved forests, but occasionally it can become much larger and reach into the canopy of primary closed evergreen tropical rainforest. The altitudinal range is between 800 m and 1600 m a.s.l. Annual precipitation is above 1500 mm and fog is frequent. It is most commonly found on limestone karst formations, where it mixes with other conifers, e.g. *Fokienia hodginsii, Xanthocyparis vietnamensis* (locally), *Pseudotsuga sinensis, Tsuga chinensis, Podocarpus neriifolius, Dacrydium elatum* and *Taxus chinensis*, as well as with angiosperms. On substates derived from silicious rocks (granite, gneiss) it is sometimes a large tree amongst angiosperms, with only a few associated conifers e.g. *Cephalotaxus mannii, Dacrycarpus imbricatus* and *Nageia wallichiana*. It is a relatively shade tolerant species, with seedlings and saplings successfully growing up under a forest canopy.

Conservation

Due to recent discoveries made of this species during intensive botanical surveys in Viet Nam, this species is now known to have a wider distribution than previously assumed. The majority of its (sub)populations appear to be in Viet Nam, not in China, and it is also in Viet Nam where the species attains large tree size. A re-assessment for Viet Nam (Nguyen Tien Hiep *et al.*, 2004) gave it the status of Vulnerable (VU) for that country; the implication of this is that its global status cannot be more threatened and should also become VU on re-assessment. In China it had been given the status of Endangered (EN). Its current status on the IUCN Red List is therefore Vulnerable. It is still threatened mainly by deforestation, leading to fragmented areas of forest with declining population size in most. Targeted logging removes seed-producing trees, which may lead to diminished recruitment of seedlings and saplings in the population. Few (sub)populations occur in protected areas and it has been observed that this is often insufficient to protect the species from deforestation or logging.
IUCN: VU (A2cd)

Uses

The timber of larger trees is valued for furniture making, while smaller sizes go to handicrafts and tool making. Much of this is done in China and it is likely that timber of Vietnamese origin is used. The seeds are rich in oils and these are extracted for medicinal purposes. Screening for anti-cancer drugs, as in other species like *A. agrotaenia*, may be conducted with this species as well, now that it is known to occur more widely. This species is in limited cultivation, e.g. as a bonsai plant.

FIGURE 2. *Abies amabilis* in Wenatchee N.F., Washington, USA

FIGURE 1. *Abies alba* in the Forêt de la Joux, Jura Mts., France

FIGURE 4. *Abies cephalonica* flushing leaves

FIGURE 3. *Abies bracteata* in the Santa Lucia Mts., California, USA

FIGURE 6. *Abies delavayi* var. delavayi seed cone

FIGURE 5. *Abies delavayi* var. delavayi seed cones

FIGURE 7. *Abies delavayi* var. nukiangensis seed cones

FIGURE 8. *Abies homolepis* pollen cones

FIGURE 10. *Abies koreana* young seed cones

FIGURE 9. *Abies kawakamii* stand in Taroko N.P., Taiwan

FIGURE 11. *Abies magnifica* in the Sierra Nevada, California, USA

FIGURE 13 *Abies numidica* tree with seed cones

FIGURE 12. *Abies nebrodensis* seed cone

FIGURE 15. *Abies pinsapo* seed cone

FIGURE 16. *Abies procera* seed cones (photo W. Milliken)

FIGURE 14. *Abies pinsapo* helically arranged leaves

FIGURE 17. *Abies recurvata* var. ernestii seed cones (photo X. C. Zhang)

FIGURE 18. *Abies spectabilis* mature seed cone

FIGURE 19. *Abies squamata* bark of young tree (photo P. de Spoelberch)

FIGURE 20. *Abies squamata* bark of old tree (photo P. de Spoelberch)

FIGURE 22. *Actinostrobus arenarius* along Hwy. 123, Western Australia

FIGURE 21. *Acmopyle pancheri* foliage and seed cones (© Bedgebury Pinetum)

FIGURE 23. *Actinostrobus arenarius* seed cones

FIGURE 26. *Afrocarpus gracilior* foliage and seeds (photo Forest & Kim Starr)

FIGURE 24. *Afrocarpus falcatus* foliage and seeds (photo D. Luscombe)

FIGURE 27. *Agathis australis* in Trounson Park, North Island, New Zealand

FIGURE 25. *Afrocarpus gracilior* tree in Ethiopia (photo J. Grimshaw)

FIGURE 28. *Agathis australis* The Tane Mahuta (Lord of the Forest)

FIGURE 29. *Agathis australis* seed cones

FIGURE 30. *Agathis borneensis* leaves

FIGURE 31. *Agathis kinabaluensis* on the Mesilau River, Mt. Kinabalu, Borneo

FIGURE 32. *Agathis kinabaluensis* sapling on the Mesilau River

FIGURE 37. *Agathis ovata* leaves and pollen cone

FIGURE 33. *Agathis lenticula* tree at Kinabalu Park H.Q., Borneo

FIGURE 35. *Agathis microstachya* trees at Lake Barrine, Queensland

FIGURE 34. *Agathis lenticula* trunk in Crocker Range, Borneo

FIGURE 36. *Agathis ovata* trees near Yaté, New Caledonia

FIGURE 38. *Amentotaxus formosana* tree in southern Taiwan (photo C. N. Page)

FIGURE 40. *Amentotaxus yunnanensis* in Ha Giang, Viet Nam (photo P. Cribb)

FIGURE 42. *Araucaria araucana* pollen cones

FIGURE 41. *Araucaria araucana* in Chile (photo M. Gardner)

FIGURE 43. *Araucaria araucana* seed cones

FIGURE 39. *Amentotaxus formosana* leaves underside

FIGURE 44. *Araucaria bernieri* in New Caledonia

FIGURE 45. *Araucaria bidwillii* emergent trees in the Bunya Mts. Queensland

FIGURE 47. *Araucaria columnaris* on the Isle of Pines, New Caledonia

FIGURE 46. *Araucaria bidwillii* tree in the Bunya Mts. Queensland

FIGURE 50. *Araucaria heterophylla* seed cones

FIGURE 48. *Araucaria columnaris* seedlings

FIGURE 51. *Araucaria laubenfelsii* foliage with pollen cones

FIGURE 49. *Araucaria cunninghamii* var. cunninghamii tree in the Bunya Mts. Queensland

FIGURE 52. *Araucaria muelleri* in New Caledonia

FIGURE 53. *Araucaria scopulorum* seed cones in New Caledonia

FIGURE 54. *Araucaria scopulorum* foliage

FIGURE 55. *Athrotaxis cupressoides* at Dove Lake, Tasmania, Australia

FIGURE 56. *Athrotaxis selaginoides* at Dove Lake, Tasmania, Australia

FIGURE 57. *Athrotaxis selaginoides* seed cones

FIGURE 58. *Austrocedrus chilensis* forest on lava, Chile (photo M. Gardner)

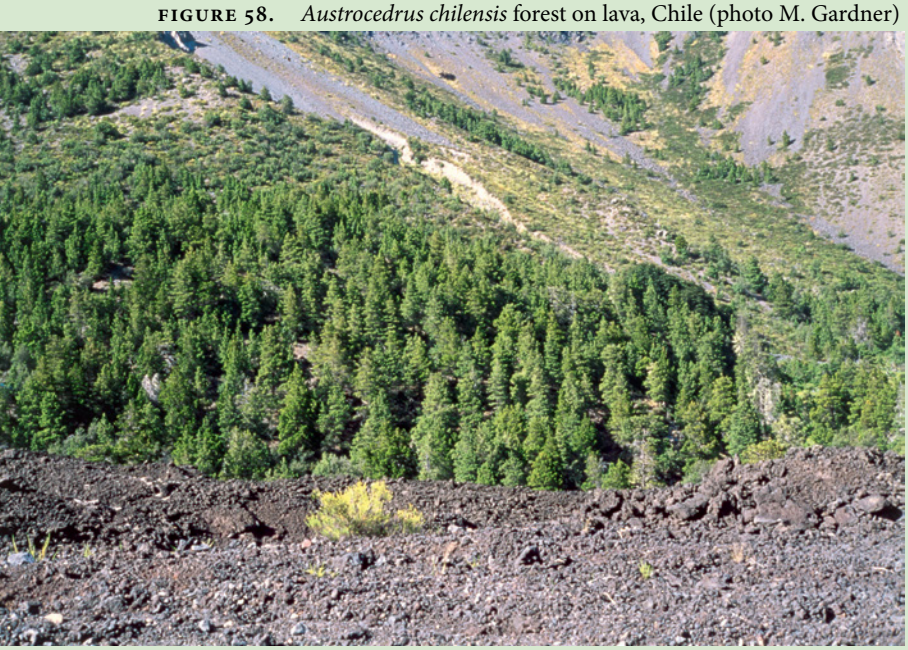


FIGURE 59. *Austrocedrus chilensis* seed cones

Araucaria Juss., Gen. Pl.: 413. 1789. *Dombeya* Lam., Encycl. 2: 301. 1786, *non* Cav. (1785); *Columbea* Salisb., Trans. Linn. Soc. London 8: 317. 1807; *Eutassa* Salisb., Trans. Linn. Soc. London 8: 316. 1807; *Eutacta* Link, Linnaea 15: 543. 1842. Type: *Araucaria araucana* (Molina) K. Koch [*Pinus araucana* Molina] (*Araucariaceae*).

Marywildea A. V. Bobrov & Melikyan, Komarovia 4: 57. 2006. Type: *Marywildea bidwillii* (Hook.) A. V. Bobrov & Melikyan [*Araucaria bidwillii* Hook.]. *Titanodendron* A. V. Bobrov & Melikyan, Komarovia 4: 60. 2006 Type: *Titanodendron hunsteinii* (K. Schum.) A. V. Bobrov & Melikyan [*Araucaria hunsteinii* K. Schum.].

Name derived from the Araucanos (more correctly known as Pehuenche) who live in the region of the type species.

Description

Small to very tall monoecious or more rarely dioecious trees with monopodial branching; branched to ground when young but with clear bole when old, resinous. Trunk terete, clothed with leaves when young. Crown columnar to candelabra- or umbrella-shaped. Bark exfoliating in plates and scales, or in horizontal strips. Branching conforming to either Massart's or Rauh's model depending on species (sometimes intermediate between the two), often reiterating. Apex of shoot a cluster of incompletely formed leaves; bud scales absent. Leaves persisting for many years (in some species including on trunk). All leaves similar or more often differentiated into more-or-less distinct juvenile and adult states. Leaves spirally arranged on all axes including the trunk, multi-veined, weakly to strongly keeled abaxially and sometimes adaxially; apex incurved or not; margin entire or papillate or denticulate. Stomata amphistomatic (often very unequally, with fewer stomata abaxially). Resin canals in leaves alternating with vascular bundles and in the same plane, or peripheral. Pollen cones solitary, terminal or axillary (lateral) on the ultimate foliage branchlets, on different branchlets to the seed cones and often lower down on the tree and/or on younger trees, subtended by a cluster of ± modified leaves, initially erect, frequently pendulous when shedding pollen, cylindrical to ovoid, varying considerably in size between species and sometimes massive (up to 25 cm long), deciduous after shedding pollen. Microsporophylls imbricate, spreading at 45–90° from a thin to stout rachis, apically free at anthesis, divided into a stalk and a lamina; stalk thin and weak, linear; lamina triangular, rhombic or peltate. Pollen sacs 6–20. Seed cones confined to the mid and upper crown, axillary or terminal, sessile or borne on a short, robust peduncle-like shoot, subtended by modified leaves and then a transition zone of sterile cone bracts, large, globose and ± heavy (to 5, occasionally 10 kg), with milky resinous exudate, usually ripening in second year. Bract-scale complexes numerous, spirally arranged on a ± thick rachis. Bracts broad, obtrullate, ovoid-oblong, cuneate or flabellate, often extended laterally into membranous (occasionally woody) wings, apical margin thickened and with a narrow apophysis at tip. Seed scale enclosed within and partly fused with bract, not or slightly wider than the seed, terminating in a free scale-like 'ligule' reaching more-or-less to base of the spur of the fertile bract. Ovules one (occasionally 2) per scale. Seeds cuneate; seed coat fused partly or wholly with scale, in one species (*A. bidwillii*) scale and seed becoming separated; wing absent. Germination epigeal or hypogeal; cotyledons in 2 free and 2 fused pairs, with 4 free, or 4 fused into 2 pairs at base.

19 species in 4 sections.

Distribution

South America: Argentina, Brazil, Chile, Paraguay; Australia: New South Wales, Norfolk Island, Queensland; New Caledonia; New Guinea.

Synopsis

Recent phylogenetic analysis (Hollingsworth *et al.*, unpubl. data RBG Edinburgh) using various DNA sequence data supports a taxonomic division of the genus into 4 sections. These sections can also be recognized by specific combinations of morphological characters; some of which are given below with the section names.

Sect. *Araucaria*. Dioecious or less commonly monoecious. Leaves undifferentiated into juvenile and adult states, large, flat, thick or thin. Pollen cones axillary, often 2-several close together at tips of foliage branches. Bract-scales nut-like, without wings, indehiscent; seed retained on scale when shed. Germination hypogeal. Cotyledons 2, long-stalked in germination, stalks not fused. Seedling fleshy. Species: *A. angustifolia, A. araucana*.

Sect. *Bunya* Wilde & Eames. Monoecious. Leaves undifferentiated into juvenile and adult states, large, flat, spreading or slightly imbricate. Pollen cones axillary, often with 2–6 together. Seed cones axillary, subsessile or shortly pedunculate. Seeds only partly fused with scale, becoming separated. Germination hypogeal. Cotyledons 2, remaining inside the seed coat. Seedling fleshy. Species: *A. bidwillii*.

Sect. *Eutacta* Endl. Monoecious. Leaves clearly differentiated into juvenile and adult states; juvenile leaves more-or-less narrow, falcate, spreading; adult leaves scale-like and imbricate, adpressed. Pollen cones terminal. Seed cones terminal, long-pedunculate. Bract-scales samara-like, thinly winged, indehiscent; seed retained on scale when shed. Germination epigeal. Cotyledons 4, completely free or fused into two pairs at base, freed from seed at germination. Seedling not fleshy. Species: *A. bernieri, A. biramulata, A. columnaris, A. cunninghamii, A. heterophylla, A. humboldtensis, A. laubenfelsii, A. luxurians, A. montana, A. muelleri, A. nemorosa, A. rulei, A. schmidii, A. scopulorum, A. subulata*.

Sect. *Intermedia* C. T. White. Monoecious. Leaves differentiated into juvenile and adult states, juvenile leaves small, needle-like, flat; adult leaves large, flat, spreading, sometimes slightly imbricate. Pollen cones axillary. Seed cones axillary. Bract-scales samara-like, with broad relatively thin wing, indehiscent; seed retained on scale when shed. Germination epigeal. Cotyledons 2, free, freed from seed at germination. Seedling not fleshy. Species: *A. hunsteinii*.

Key to the sections of *Araucaria*

The leaves of many species in the genus *Araucaria* are highly variable and part of this variation is associated with the age of the branch on which they appear. There are often juvenile and adult forms, as well as intermediate shapes. Seedlings have different leaves from saplings or young trees as well as mature trees. On mature trees adventitious branching often occurs and the leaves on these branches are quite similar, but not equal to those on young trees. The adult leaves described in the keys are those of the ultimate primary foliage branches of mature trees that can produce cones and exclude those of adventitious branches. Under cultivation, trees may retain (semi-)juvenile leaf shapes and sizes longer than in their natural habitat, especially when grown under glass. It is virtually impossible to key these out, as juvenile leaves of many species are highly similar. Pollen cones, as in the genus *Agathis*, have more informative characters than seed cones and are sometimes crucial for determination of species in addition (or in preference) to foliage. They can often been found under the tree (most species are monoecious) and are then full size, having shed their pollen, and can be used for comparison of character states if not too far disintegrated. Trees grow a trunk and branches in specific ways that may be distinct among taxa. The *architecture* of branching has been studied and *models* are named after their describers. Two of these models apply to the species of *Araucaria*, Massart's and Rauh's. In both, there is a single, dominant, erect leader making the stem (trunk in mature trees) and branching occurs in pseudo-whorls at regular intervals on it. The branches spread out more or less horizontally. In Massart's model they remain horizontal, as do the lateral branches, or they may be more or less drooping, and buds facing up and down on each subsequent pseudo-whorl remain dormant. In Rauh's model, the branches are curved upward towards their ends and all buds on a pseudo-whorl can grow to form new branches, repeating the pattern on the stem. Adventitious branching, often triggered by some damage, usually does not conform to the model and can disrupt the architecture, so only primary branching should be considered.

1a. Leaves differentiated into juvenile and adult stages. Bract scales of seed cones samara-like. Seedlings not fleshy **2**

1b. Leaves undifferentiated into juvenile and adult stages. Bract scales of seed cones nut-like or large and heavy. Seedlings fleshy **3**

2a. Adult leaves imbricate, often adpressed. Cotyledons of seedlings 4, free or sometimes fused into two pairs at base **Sect. *Eutacta***

2b. Adult leaves spreading. Cotyledons of seedlings 2, free
Sect. *Intermedia*; a single species, *A. hunsteinii*

3a. Bract scales of seed cones nut-like, without wings, indehiscent; seed retained on scale when shed **Sect. *Araucaria***

3b. Bract scales of seed cones large, heavy, with woody wings, dehiscent; seed shed from scale at maturity
Sect. *Bunya*; a single species, *A. bidwillii*

Key to the species of Section *Araucaria*

1a. Foliage branches with and including adult leaves up to 40 mm wide. Pollen cones 15–30 mm wide. Resin exuding from bark on trunk reddish ***A. angustifolia***

1b. Foliage branches with and including adult leaves 60–90 mm wide. Pollen cones 40–50 mm wide. Resin exuding from bark on trunk clear, drying white ***A. araucana***

Key to the species of Section *Eutacta*

1a. Foliage branches with and including adult leaves (12–)15–50 mm wide; branching architecture according to Rauh's model **2**

1b. Foliage branches with and including adult leaves (2.5–)3–13(–16) mm wide; branching architecture mostly according to Massart's model (in one species Rauh's model) **5**

2a. Foliage branches with and including adult leaves 30–50 mm wide; adult leaves 20–32 × 9.5–18.5 mm, triangular to linear-triangular
A. muelleri

2b. Foliage branches with and including adult leaves (12–)15–33 mm wide; adult leaves 8–20 (–25) × 4–14 mm, broadly lanceolate, ovate or nearly triangular **3**

3a. Trees with sparse but long branches; crown candelabra shaped, with tufts of thick foliage branches at ends; adult leaves broadly lanceolate, short retained on leading branches
A. rulei

3b. Trees with numerous branches; crown columnar, broadly conical or domed; foliage branches usually not limited to ends of main branches; adult leaves broadly ovate to nearly triangular, long retained on leading branches **4**

4a. Adult leaves nearly triangular. Crown columnar or broadly conical. Mature seed cones 10–13 × 7–9 cm; bract scales 22–25 × 15–20 mm
A. laubenfelsii

4b. Adult leaves broadly ovate. Crown domed, very open. Mature seed cones 8–11 × 7–9 cm; bract scales 25–35 × 18–25 mm ***A. montana***

5a. Branching architecture according to Rauh's model, without or with infrequent adventitious branching, developing an open crown in mature trees ***A. biramulata***

5b. Branching architecture according to Massart's model, often with frequent adventitious branching, developing a more or less dense crown in mature trees **6**

6a. Adult leaves ovate or broadly ovate with a rounded apex, 4–16 × 2.5–6.5(–8) mm. Pollen cones (10–)12–15(–17) cm long and 20–28 mm wide ***A. luxurians***

6b. Adult leaves from subulate-acicular to broadly ovate with an acute, acuminate or obtuse, never rounded apex, 2–10 × 1.2–5(–6) mm. Pollen cones 2–12 cm long and 3–22 mm wide **7**

7a. Adult leaves subulate or lanceolate **8**

7b. Adult leaves (ob)ovate or elliptic-ovate **11**

8a. Pollen cones very slender, 3–7 mm wide; microsporophylls connate. Outer bark on trunks exfoliating with thin, curling flakes
A. cunninghamii

8b. Pollen cones 7–20 mm wide; microsporophylls imbricate or divergent. Outer bark on trunks exfoliating in horizontal strips **9**

9a. Pollen cones 2–5 cm long, 7–11 mm wide. Seed cones when mature 7–9 × 5–6 cm. Foliage branches with and including adult leaves 6–10 mm wide. Endemic to the summit of Mt. Panié in New Caledonia ***A. schmidii***

9b. Pollen cones 5–12 cm long, 10–20 mm wide. Seed cones when mature 7.5–12 × 6–10 cm. Foliage branches with and including adult leaves 4.5–8(–12) mm wide. Occurring elsewhere in New Caledonia **10**

10a. Microsporophylls of pollen cones divergent, spreading at nearly 90° from the rachis, ovate, 5–8 × 4–5 mm. Adult leaves 4–10 mm long
A. nemorosa

10b. Microsporophylls of pollen cones imbricate, spreading at 45° from the rachis, triangular, 3–4 × 2–2.5 mm. Adult leaves (3–)4–6 mm long
A. subulata

11a. Crown of mature trees domed to flat-topped. Microsporophylls of pollen cones connate, 2.5 × 2 mm ***A. scopulorum***

11b. Crown of mature trees columnar or narrowly conical. Microsporophylls of pollen cones imbricate, 3–7(–10) × 2–4 mm **12**

12a. Foliage branches with and including adult leaves very slender, 3–7 mm wide; adult leaves broadly ovate, 2.5–4.7 × 1.5–2.5 mm ***A. bernieri***

12b. Foliage branches with and including adult leaves slender to more robust, (3–)5–12 mm wide; adult leaves elliptic-ovate or ovate, 4–8 × 1.8–5(–6) mm **13**

13a. Crown of mature trees columnar but open, in older trees with a flat or candelabra shaped top, in young trees pyramidal. Pollen cones small, 3–3.5 cm long and 9–10 mm wide ***A. humboldtensis***

13b. Crown of mature trees narrowly columnar or narrowly conical, with a narrowing top, in young trees (narrowly) conical. Pollen cones (2.5–)4–7(–10) cm long and 10–22 mm wide **14**

14a. Crown of mature trees narrowly columnar. Pollen cones 13–22 mm wide; microsporophylls oblong-triangular, 5–7(–10) × 2.5–3(–4) mm ***A. columnaris***

14b. Crown of mature trees narrowly conical. Pollen cones 10–15 mm wide; microsporophylls rhombic, 3–4 × 4 mm ***A. heterophylla***

Araucaria angustifolia (Bertol.) Kuntze, Rev. Gen. Pl. 3: 375. 1898. *Columbea angustifolia* Bertol., Opusc. Sci. 3: 411. 1819. Type: Brazil: Rio de Janeiro, Corcovado, ["In Brasilia legit G. Raddi"], *G. Raddi s.n.* (holotype BOLO). Pl. 6

Araucaria angustifolia (Bertol.) Kuntze var. *dependens* J. R. de Mattos, Loefgrenia 21: [2]. 1967.
Araucaria angustifolia (Bertol.) Kuntze var. *vinacea* J. R. de Mattos, Loefgrenia 111: 1. 1997.

Etymology

The species epithet alludes to the (often) narrower leaves than those of *A. araucana*, the only other species native to South America.

Vernacular names

Parana pine, Candelabra tree; pinheiro-do-Paraná, also recorded are: pinhao, pinheiro, pinho-nacional (Portuguese); pino Paraná (Spanish); curiy or kuriy (perhaps originally Amerindian) and many other variants denoting ecotypes or seed types.

Description

Dioecious or less commonly monoecious trees to 50 m tall, to 2 m d.b.h.; trunk straight. Bark to 15 cm thick, rough and deeply fissured, exfoliating in small chips and plates, sometimes exposing smooth patches of reddish inner bark; outer bark grey. Resin exudate reddish. Crown in mature trees domed and finally flat-topped, with branches only at the top of the tree; branching according to Rauh's model. Primary branches in pseudo-whorls of 4–8, up to 5 m long, spreading or assurgent, mostly with second to third order branches, caducous. Adventitious foliage branches uncommon, usually associated with damage. Foliage branchlets spreading or ascending (sometimes more or less pendent) on primary branches, forming large tufts of foliage, of unequal length up to 50 cm, up to 40 mm wide (including leaves), but of unequal width from base to apex depending on size and spread of leaves, more or less flexible. Adult leaves imbricate or variously spreading (40°–90°), decurrent, ovate to lanceolate, 1.5–5 cm × 3–20 mm, varying much in length and width often on a single branch, flat or slightly concave adaxially, sometimes weakly keeled abaxially, smooth or striate, tapering to a pungent apex; margins entire. Stomata in 40–50 indistinct rows on the abaxial surface and slightly fewer but more conspicuous rows on the adaxial surface. Pollen cones axillary at end of foliage branchlets, solitary or in small clusters, initially erect, cylindrical and green, becoming pendulous, elongated, curved and pinkish brown at anthesis, 8–15 cm × 15–30 mm. Microsporophylls connate, spreading at ca. 90° from a stout rachis, apically free at anthesis; stalk thin and weak, linear, 3–5 mm long; lamina cuneate, rhombic in outline, 4–5 × 3 mm, lateral margins entire; apex curved; abaxial surface smooth. Pollen sacs 8–12(–15), linear, 6–8 mm long. Seed cones axillary on stout foliage branches which widen below the cone, usually 3–5 together in whorls, erect. Immature cones

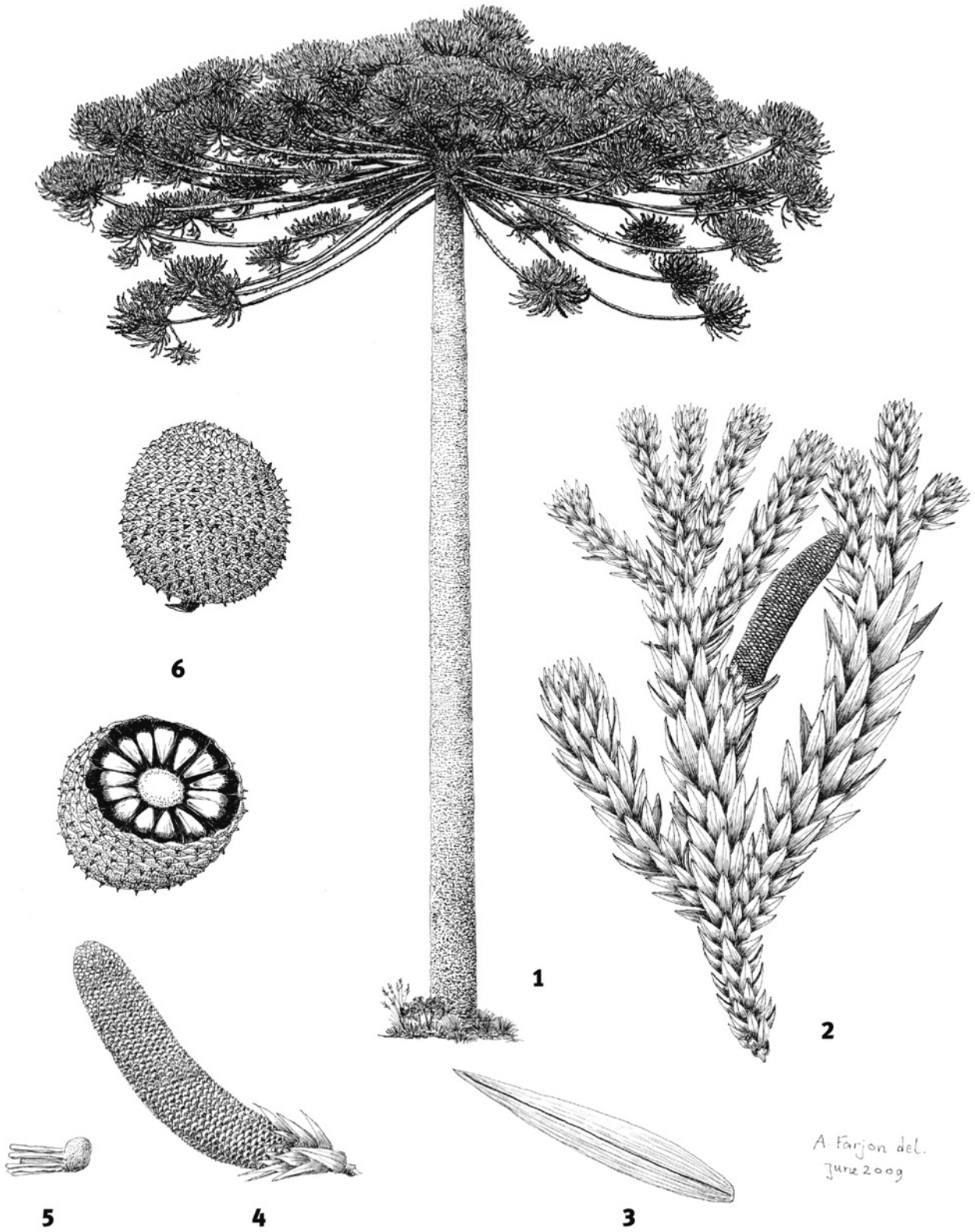


PLATE 6. *Araucaria angustifolia*. **1.** Habit of tree. **2.** Foliage branch with pollen cone. **3.** Leaf. **4.** Pollen cone. **5.** Microsporophyll with pollen sacs. **6.** Seed cones, one with top removed to show seeds.

ovoid, 4–6 cm long, densely covered with recurved bract tips, green, maturing in 20–22 months. Mature cones chestnut brown, ovoid-globose to globose, usually slightly longer than wide, (8–)12–20 × 8–18 cm (green weight 3–4 kg). Bracts ovoid-oblong to cuneate, more or less angular, ca. 5 × 2 cm including vestigial wings if present, distally thickened to a more or less rhombic, transversely keeled apophysis, ending in a caudate, slightly curved, 8–10 mm long tip. Seed scale not wider than the seed; ligule fragile, 1–1.5 mm long, sometimes absent. Seeds ovoid-oblong, ca. 4 × 1.5 cm, not flattened, striated longitudinally or smooth, ripening lustrous red-brown (sometimes striped darker red, or with white or pale apex, or occasionally whole seed very pale).

Distribution

Argentina, S Brazil, Paraguay. The range of this species before European settlement was extensive and predominantly located in southern Brazil, with extensions into eastern Paraguay and the Argentinian Misiones region between the Paraná and Uruguay Rivers. To the NE its range is broken up into more scattered occurrences.
TDWG codes: 84 BZL-MG BZL-SP BZS-PR BZS-RS BZS-SC 85 AGE-MI PAR

Ecology

This species is a dominant and/or emergent tree in temperate to subtropical forests or forest enclaves (capâo) amid extensive grassland (campo limpo), or sometimes in small isolated groups of trees. Altitudinal range: (300–)500–1800 m a.s.l. Its most extensive and more or less continuous occurrence (before large scale deforestation through logging) was on the Planaltos, a more or less level plain at medium altitudes between 500 m and 1000 m. Tree ferns (*Alsophila, Dicksonia*) and also many deciduous as well as evergreen smaller trees and shrubs form one or more understoreys. Most common among deciduous trees is *Cedrela fissilis*; other angiosperm trees are *Cryptocarya aschersoniana, Drimys brasiliensis* and the genera *Leandra, Miconia, Ocotea, Nectandra* and *Tibouchina*, as well as the tall palm *Arecastrum romanzoffianum*. *Podocarpus lambertii* and, locally, *P. sellowii* are two other conifers growing under or with *A. angustifolia*, but they are less common and indicate undisturbed forest. The climate varies with latitude and altitude; on the Planaltos at around 1000 m frost is a common occurrence in winter with minima to –10° C while snowfall, although rare, can occur in most of the range of the species. According to Golte (1993) the northern limit of natural occurrence of *A. angustifolia* coincides with the zone where tropical winter dry seasons begin to have influence upon the vegetation. Rains are mostly summer rains in much of its range, but with more winter rains in the south, to a total of 1400–2500 mm per annum. The prevalent soil type in the *Araucaria* forests is a well-drained, iron-rich red-yellow podzol with a low pH value.

Conservation

At the beginning of the 20th century according to estimates the area of occupancy (AOO) of *A. angustifolia* was around 20 million ha. Based on LANDSAT-II imagery, it was calculated that by 1982 only 565,419 ha remained and this was still being logged at a rate of almost 80,000 ha per year (Gantzel, 1982). Further statistics are given by Koch & Celeste Correa (2002). AOO was ca. 200,000 km² on arrival of European colonists in the 19th century; it is now down to 4000 km². The greatest losses occurred between 1915–1960, by the latter year the area was down to 20,000 km², but most of that has now also gone. Based on these figures, the species is Critically Endangered under criterion A1cd even though exploitation rates may have been drastically reduced as logging of natural stands is now prohibited by law. Even that is doubtful, as illegal logging is reported to continue, even in nature reserves, while many remaining stands are in private hands, where the owners consider the trees their disposable property. Plantation of the species has been substantial, but that does not make up for the loss of 'old growth' under IUCN criteria. Economic factors have caused the replacement of *Araucaria* by faster growing plantations of *Pinus* and *Eucalyptus* in many areas, while only few landowners are inclined to substantially replant with *A. angustifolia*, preferring exotics for that purpose.
IUCN: CR (A2cd)

Uses

This species remains one of the most valuable timber trees of Brazil, despite its very substantial reduction

in total volume of standing timber due to sustained over-exploitation. It is known as Paraná pine in the trade. It is essentially the only native conifer of large size to produce long, straight boles of excellent sawing quality. Its wood is soft and light and large, straight trees have little or no knots from branches. Paraná pine 'knot' wood, unsuitable for anything else, was burnt in (among other things) steam locomotives. The uses of its wood have been highly varied over the years of exploitation, from construction timber to matches and toothpicks and from pulp for paper making to plywood and musical instruments. The knot powder is used in Brazil in flexographic inks, plastic laminates, furniture varnishes, and as a partial substitute for phenolic resins. In rural areas, houses and farmsteads were built of it. Plantations are generally not favoured by the timber trade as growth of *Araucaria* is much slower than that of introduced eucalypts and pines. Despite this, there are now some plantations of this species in the region aimed at harvesting trees in due course. Its seeds are edible and are eaten by the Brazilian Amerindians in a similar manner to bunya nuts (*A. bidwillii*) in Australia and the seeds of *A. araucana* in Chile and Argentina. The tree is also sacred to several of the Amerindian tribes, such as the Kaingang people of the Paraná River in S Brazil who regard it as a masculine symbol. Although still uncommon, it is seen more often recently in arboreta and large gardens in milder parts of Europe and North America (Grimshaw & Bayton, 2009: 152).

Araucaria araucana (Molina) K. Koch, Dendrol. 2 (2): 206. 1873. *Pinus araucana* Molina, Sag. Stor. Nat. Chili: 182. 1782. Type not designated. Fig. 41, 42, 43

Etymology

The species epithet is derived from the Araucanos, a group of Amerindian tribes of the Araucana linguistic family.

Vernacular names

Monkey Puzzle, Chilean pine, Araucaria; chihuén, also recorded are pehuén, araucaria de Neuquén, pino de Neuquén, pino hachado, pino solo (Spanish, with some influence from Amerindian languages).

Description

Dioecious or more rarely monoecious trees to 50 m tall, to 2.5 m d.b.h.; trunk straight. Bark to 15 cm thick, rough and deeply fissured, exfoliating in small chips and plates; inner bark brown; outer bark grey or grey-brown. Crown in mature trees variously domed or more or less flat-topped, with branches only at the top of the tree; branching according to Rauh's model. Primary first order branches of mature trees in pseudo-whorls of 8–10 or sometimes more, up to 5 m long, spreading or assurgent, mostly with second to third order branches, caducous. Adventitious foliage branches common, but usually associated with damage, showing a tendency to produce secondary crowns. Foliage branchlets spreading or ascending on primary branches, of unequal length up to 1 m or more, 6–9 cm wide (including leaves), of regular width from base to apex, rigid, lower foliage branches sometimes sub-pendulous. Adult leaves variously spreading (45°–90°), with a decurrent, reflexed base merging with bark, ovate to lanceolate, 2.5–6 × 1.5–3 cm, varying little in length and width on a single branch, flat or slightly concave adaxially, ca. 1 mm thick, rigid and coriaceous; margins entire; surface smooth or striate, abaxially keeled and gradually or more abruptly tapering to a pungent apex. Stomata in irregular and intermittent lines from leaf base to apex, rows more numerous on the abaxial surface than on the adaxial. Pollen cones axillary, solitary or more often in small clusters, initially erect, stoutly cylindrical or slightly fusiform, becoming elongated and curved down at anthesis, 8–15 cm × 40–50 mm. Microsporophylls imbricate, spreading at ca. 60° from a 10 mm thick rachis; stalk thin and weak, ca. 10 mm long, straight or slightly curved; lamina 15–20 mm long, 4–5 mm wide at the thickened and curved base, lateral margins denticulate; apex acuminate, recurved; abaxial surface slightly rugose. Pollen sacs 10–15, linear, ca. 10 mm long, tightly packed. Seed cones axillary on very short foliage branches which widen below cone, usually solitary, erect. Immature cones ovoid, 6–8 cm long, densely covered with recurved bract tips, green, maturing in 22–24 months. Mature cones dull brown, subglobose to globose, 15–20 cm diam. (green weight 3–4 kg). Bracts ovoid-oblong to cuneate, more or less angular, 4–6 × 1.5–2 cm including vestigial wings if present, distally thickened to a more or less triangular, transversely keeled apophysis,

ending in a long-caudate, curved, 2–2.5 cm long tip. Seed scales not wider than the seed; ligule fragile, ca. 2 mm long, sometimes absent. Seeds oblong-conical, 3.5–5 × 1–1.5 cm, not flattened, smooth, matt tawny brown when ripe.

Taxonomic notes

Araucaria araucana shows surprisingly little morphological diversity among populations in Chile as well as between cultivated trees elsewhere. Due to its size and harsh nature the foliage has rarely been collected for herbaria and most botanists know it primarily from the numerous planted trees, especially common in NW Europe. Original material does not exist and a neotype would therefore be necessary to fix the accepted name. Its nearest relative species, also from South America, is *A. angustifolia*.

Distribution

S Argentina: Neuquén; S Chile: Biobio, La Araucania, Los Lagos. Mainly in S Chile, but part of the Andean distribution is across the border in Argentina.
TDWG codes: 85 AGS-NE CLC-BI CLC-LA CLS-LL

Ecology

To the north, *A. araucana* is limited by a summer-dry Mediterranean type climate, to the south by an increasingly cooler and wetter oceanic temperate climate; its natural distribution therefore marks a narrow transitional zone between two floristic realms: neotropic and antarctic (Golte, 1993). Especially in the Andes, its distribution is closely associated with volcanic activity, primarily with deposits of tephra and scoria; the coastal mountains are composed of granitic or metamorphic rocks. Altitudinal range: 600–1800 m a.s.l. Both coastal mountains and Andes receive high amounts (2000–3000 mm) of annual precipitation within the altitudinal zone of the araucarias, but also experience dry and hot spells in summer. *Araucaria araucana* builds typical stands either pure or at lower altitudes mixed with Valdivian rain forest angiosperm trees especially *Nothofagus dombeyi*; towards the tree line in the Andes only shrubs, especially *Nothofagus pumilio*, or small trees like *N. antarctica* and *Drimys winteri*, grow under the conifers. Easternmost populations in Argentina occur in areas with much less precipitation (1000–1500 mm) and here the conifer *Austrocedrus chilensis* can be found associated with *A. araucana*. Araucarias are capable of colonizing fresh falls of tephra or scoria after volcanic eruptions before other tree species and maintain dominance, slowly increasing stand density and so shading out competitors. Trees killed off above ground can regenerate from epicormic buds at the base or even from shallow roots. Resistance to low intensity fires also helps to maintain its dominance over *Nothofagus* at such sites. It is a typical example of a tree species well adapted to episodic, large scale disturbance events.

Conservation

In the Andes, the populations are scattered and fragmented and its area of occupancy (AOO) may not have exceeded 4000 km² in historical times (Golte, 1993). The limited AOO of this species in the wild, combined with the scattered nature of its remaining populations, put it in the category Vulnerable under IUCN criteria. Between the 1920s and 1970s, the area covered by the species was halved as a result of logging and fires. While (illegal) logging has played a part in its historical decline, most stands are now on protected lands. However, these are largely situated in proximity of active volcanos with their inherent periodic eruptions causing forest destruction. Fires have in recent years caused substantial damage to several subpopulations. The limited occurrence in the Coastal Cordillera is only partly protected and threatened by habitat loss and conversion to plantation forestry. Sufficient recruitment through natural seed dispersal and regeneration to replace such losses may be hampered by a number of factors which have increased their impact through human interference, e.g. the harvesting of seeds for food markets. The species is listed on Appendix I of CITES and as a Natural Monument in Chile, which gives it legal protection against logging. However, during the 2001/02 fire season, catastrophic fires caused by lightning destroyed much of the remaining available habitat including 60% of Tolhuaca National Park. Additional protection through active management of some of these factors would be necessary to ensure the existence of healthy and sufficiently large populations throughout the natural area of extent of *A. araucana*, and especially in the disjunct coastal

subpopulations, one of which is genetically distinct from all the others.
IUCN: EN [B1ab(i, ii, iii, v)]

Uses

Before logging was outlawed, *A. araucana* was one of the most desirable sources of sawn timber in Chile. The edible seeds are traditionally harvested by the Mapuche Indians, particularly a mountain tribe called the Pehuenche. They are eaten raw, boiled, or toasted in the ashes of a fire or in a pot or stove, or ground into flour that can be used to make bread or as a condiment in soups; they are also made into a fermented drink known as chavid. As well as being eaten during the collection season, they are preserved for year-round use, either by hydration in a pit of cold water or by dehydration in the sun or over the family fire. Piñones are now increasingly traded (on rather unfavourable terms) in local and regional markets for yerba maté, sugar and other foodstuffs as well as for cash. *Araucaria araucana* was introduced into Europe soon after its discovery in the late 18th century, it proved to be winter hardy in most countries and in the 19th century became a fashionable tree for large gardens, parks, and stately avenues to country houses. Trade for horticultural purposes is now entirely based on plants raised in cultivation due to an export ban under the CITES convention.

Araucaria bernieri J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 280. 1949. Type: New Caledonia: Grande Terre, Province Sud, Rivière des Pirogues, near Lucien's sawmill, *J. T. Buchholz 1562* (holotype ILL). Fig. 44

Etymology

Julien Bernier was the first Conservator of the New Caledonian Museum, Nouméa; his son (another J. Bernier) collected a fragment of *A. bernieri* near Pic Busse.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 50 m tall, to 1 m d.b.h.; trunk straight or curved. Bark exfoliating in horizontal strips; inner bark dark reddish brown; outer bark grey or brown. Crown columnar but open, branched along greater part of trunk, often widest in top; branching according to Massart's model. Primary branches followed by infrequent adventitious branching in the lower ¾ of the crown; first order branches in pseudo-whorls of 5–7(–10), 0.5–2.5 m long, spreading or assurgent, caducous. Foliage branchlets of more or less equal length ((8–)19–35 cm) on either side of the axis branch and shortening towards the end, 3–7 mm wide (including leaves), remaining of equal width almost throughout, flexible. On mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets broadly ovate, 2.5–4.7 × 1.5–2.5 mm, 3-edged and incurved with acute or obtuse apex, smooth, prominently keeled abaxially; leaves subtending seed cones 8–10 × 6–8 mm, with a rostrate apex, much larger than normal foliage leaves. Stomata on the abaxial side of adult leaves restricted to the proximal part of the leaf; on the adaxial side numerous in rows from just above base to apex. Semi-juvenile leaves divergent, oblong, curved, 4–6 × 1–2 mm, widest at base, three-faced, bilaterally flattened; apex obtuse. Pollen cones terminal, cylindrical, initially erect and straight but pendulous and curved at anthesis, light brown with glaucous bloom, (2.5–)3.5–4.5(–10) cm × 8.5–10 mm. Microsporophylls spreading at 45°–90° from a stout rachis; stalk thin and weak, linear, 2 mm long; lamina ovate, 3–4 × 2–2.5 mm, curved at base; apex acute or pungent. Pollen sacs 4–6, linear, 2–2.5 mm long. Seed cones terminal on short, stout foliage branches which widen below the cone, usually solitary, sometimes 2–3 together, erect, subglobose, often widest above the middle, 8–10 × 6.5–8 cm. Bracts flabellate, 2.5–3 × 2–2.5 cm including rounded, thin membranous wings, distally thickened but thin-edged, ending in a caudate, slightly curved, 6–8 mm long bract tip. Seed scales not wider than the seed; ligule broadly triangular, fragile, 1.5–2 mm long. Seeds obovoid, 15–20 × 6–8 mm, transversely flattened, striated longitudinally or smooth, light brown when ripe.

Distribution

New Caledonia: Grande Terre, restricted to the extreme south and on heights along the SE coast.
TDWG codes: 60 NWC

Ecology

This species is commonly found in angiosperm evergreen rainforest on slopes of lower mountains, with an altitudinal range of (1–)100–500(–800) m a.s.l. It does not form dense stands but rather scattered individual trees that emerge well above the closed canopy of the forest, sometimes in association with *A. subulata*. In some localities *A. bernieri* has been observed to follow stream beds in ravines. A few collections were made from localities near sea level in the extreme south of the island, usually near streams lined with closed forest patches. *Araucaria bernieri* seems nearly everywhere to be limited to soils derived from ultramafic rock (peridotite and serpentine) with a high content of heavy metals such as iron, manganese, and nickel. It is likely that the forest canopy and resulting leaf litter prevent dehydration of these permeable soils, which can quickly occur despite very high annual rainfall in this region (2000–3000 mm). Where the forest has been disturbed *A. bernieri* may survive in stream beds with permanent (underground) water.

Conservation

Mining is a potential threat to *A. bernieri* because it is virtually restricted to ultramafic rock types with high metallic content. Deforestation by cutting and burning has been extensive within its range and many populations are in isolated remnants of rain forest on slopes and in hollows and ravines of mountains. Some of these have been observed to have been recently affected by fires. The species is still fairly common in the south and occurs in a number of protected forest areas, e.g. Montagne des Sources, Pic du Grand Kaori and Rivière Bleue.
IUCN: VU (C1)

Uses

The wood is of high quality and has been locally exploited.

Araucaria bidwillii Hook., London J. Bot. 2: 503, t. 18, 19. 1843. *Marywildea bidwillii* (Hook.) A. V. Bobrov & Melikyan, Komarovia 4: 58. 2006. Type: Australia: Queensland, Wide Bay District, Mt. Brisbane Range, ["Wide Bay" near Gympie], *J. C. Bidwill s.n.* (lectotype K). Fig. 45, 46

Etymology

This species was named after the collector, John Carne Bidwill (1815–1853).

Vernacular names

Bunya pine (a corruption of the Aboriginal name bon-yi).

Description

Monoecious trees to 45 m tall, to 1.75 m d.b.h., with straight trunk. Bark 7.5–10(–30) cm thick, rough and scaly, exfoliating in thin plates and scales; inner bark orange to reddish; outer bark grey to black. Resin exudate clear, weathering white to grey. Crown in mature trees domed and open especially in the lower part, with primary branches restricted to upper part of tree; branching according to Rauh's model. Primary first order branches of mature trees in pseudo-whorls of 10–16, up to 7 m long, spreading, down-curved or assurgent, caducous. Adventitious foliage branches common. Foliage branchlets spreading in all directions or pendent on ends of primary branches, forming large tufts of foliage, of unequal length up to 60 cm, up to 4 cm wide (including leaves), of unequal width from base to apex, flexible or more rigid. Leaves present on first to third order branches, retained on (pen)ultimate branches which are caducous in mature trees. Adult leaves imbricate or variously spreading (radially to distichously), dimorphic: on orthotropic shoots narrowly triangular to acicular, on plagiotropic shoots triangular to lanceolate, 10–50 × 3–15 mm, varying much in length and width often on a single foliage branch, nearly flat in long leaves to navicular in short leaves, smooth or striate or faintly keeled, tapering to an acuminate apex, pungent or not. Stomata in 35–80 irregular and intermittent rows from base to apex on each surface. Pollen cones axillary, in small clusters of 2–6, narrowly cylindrical, initially erect,

becoming elongated, curved to pendulous at anthesis, 6–15 cm × 8–15 mm. Microsporophylls connate, spreading at ca. 90° from a thin, fragile rachis; stalk thin and weak, 3 mm long; lamina curved, the exposed part rhombic in outline, 3 × 2 mm. Pollen sacs 8–10, linear, ca. 3 mm long. Seed cones axillary (appearing sub-terminal) on a very short, stout and leafy peduncle, usually solitary, erect. Mature cones green, ovoid-globose to globose, usually slightly longer than wide, 20–30(–35) × 20–25 cm (green weight typically 4–5 kg but up to 10 kg), often falling when still intact. Bracts broadly obtrullate to cuneate, 10–12 × 10–15 cm, lateral sections thin, distal part thickened to a more or less rhombic, sharply keeled apophysis, ending in a slightly curved, 10–15 mm long, caducous tip. Seed scales not wider than the seed; ligule thick, c. 15 × 10 mm. Seeds deeply sunken in the seed scale, ovoid-cuneate, 4–5 × 2.5–3 cm, slightly flattened, smooth, ripening lustrous brown and breaking free from cone scale.

Distribution

Australia: Queensland. Two disjunct areas ca. 1000 km apart: in S Queensland in the Blackall Ranges, Bunya Mts., Brisbane River, Mary River Valley and Yarraman/Blackbutt area; in N Queensland at Cannabullen Falls and Mt. Lewis.
TDWG codes: 50 QLD-QU

Ecology

Araucaria bidwillii is a large, emergent tree in (sub) tropical rainforest ('notophyll vine forest') on basaltic or other igneous substrates; sometimes associated with *A. cunninghamii*, raising its domed crowns well above a canopy of evergreen angiosperm trees. Its altitudinal range is 150–1000 m a.s.l. *Araucaria bidwillii* does not form pure stands, but is always mixed to a greater or lesser extent with numerous species of angiosperm trees mostly belonging to tropical families. Dominant among these are *Argyrodendron actinophyllum, Drypetes australasica, Ficus macrophylla*, and *F. obliqua*; also common are the palm *Archontophoenix cunninghamiana* and tree ferns. The forest is divided into larger and smaller woods by 'balds', coarse grasslands or open savannas which form sharp boundaries with the forest patches. Annual precipitation is 1100–1400 mm in the southern area, with a dry season from April/May to September; the northern populations receive a more evenly distributed annual precipitation of 1500–2000 mm.

Conservation

Beginning in the early decades of European settlement and in the Bunya Mountains continuing until the end of the Second World War in 1945, logging must have reduced the original area of occupancy of this species, especially in the Blackall Range and headwaters of the Brisbane River. According to Golte (1993), no detailed map of the distribution, past or present, of *A. bidwillii* exists in the literature, a situation that frustrates attempts to evaluate the IUCN Red List status of this species. Herbarium specimens that could give clues of past occurrence are few, due to the difficulty of collecting them. Nearly all remaining stands are now on protected land and logging has virtually ceased.
IUCN: LC

Uses

Bunya pine produces excellent seeds for human consumption. The species is sacred to the Australian Aborigines; its importance to Aboriginal culture was celebrated in a series of articles published in a special issue of the Queensland Review in 2002. The Aborigines used to meet in years of good seed crops (cones mature in three years) in large numbers for harvest and festivities. Each clan or tribe had jurisdiction over certain trees and their crop of seeds. Their traditional harvesting rights have not been upheld; their last great gathering for the bon-yi harvest was held in 1902. Interest in aboriginal foods, 'bush tucker' as it is popularly called in Australia, is growing and the seeds of *A. bidwillii* are again on the menu, now also of white Australians. The wood is light and easily worked, and used for flooring, plywood and cabinet-making. In the past these trees were logged by European settlers, but the last sawmill closed in 1945 and most of the remaining trees are protected in the Bunya Mountains National Park. This species has been widely introduced as an ornamental in New Zealand, India, Portugal and other countries.

Araucaria biramulata J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 279. 1949. Type: New Caledonia: Grande Terre, Province Sud, Forêt du Mois de Mai (on ridge between rivers Bleue and Blanc), *J. T. Buchholz 1691* (holotype ILL).

Etymology

The species epithet "…refers to the characteristic twice-branched character vegetative twigs" (Buchholz, *op. cit.*, p. 280).

Vernacular names

None are recorded.

Description

Monoecious trees to 30 m tall, to 0.8 m d.b.h.; trunk straight. Bark to 2 cm thick, exfoliating in horizontal strips; inner bark deep wine red; outer bark grey with some brown. Resin exudate white or creamy, drying opaque and powdery. Crown in mature trees conical or columnar but open, branched along greater part of trunk; branching according to Rauh's model. Adventitious branching absent or infrequent. Primary first order branches of mature trees in pseudo-whorls of 4–5, 1–2.5 m long, ascending, sometimes with second order branches, caducous. Foliage branchlets strongly assurgent on primary branches and confined to distal parts, of unequal length (10–37 cm), shortening towards end of branchlet, (5–)8–13(–16) mm wide (including leaves), variable in width from base to apex with changing size and spreading of leaves, flexible, often branching again. In mature trees leaves of two kinds: adult and semi-juvenile. Adult leaves on (pen)ultimate branchlets ovate or broadly lanceolate, (4–)5–10 × 3–6 mm, ± naviculate with incurved, subacute non-pungent apex, coriaceous, smooth, lustrous green, rather weakly keeled abaxially; leaves subtending seed cones 10–16 × 2.5–4 mm, with a rostrate apex. Stomata on the abaxial surface of adult leaves mostly in the proximal half of leaf; on the adaxial surface 10–14 rows from base to apex on each side of the mid-vein. Semi-juvenile leaves on adventitious branches spreading more widely than adult leaves on primary branches, lanceolate, 4–8 × 2–4 mm, straight in lower 2/3 but distally incurved, keeled abaxially; apex subacute and shortly mucronate. Pollen cones terminal on the ultimate foliage branchlets, cylindrical, initially erect, pendulous and curved at anthesis, 6–7 cm × 15–20 mm. Microsporophylls imbricate, spreading at 45° from a stout rachis, apically free at anthesis; stalk thin and weak, 3–4 mm long; lamina triangular-apiculate, 4–5 × 3–4 mm; abaxial surface rugose. Pollen sacs 7–8, ca. 3.5 mm long. Seed cones terminal on short, stout foliage branches which widen below cone, usually solitary, sometimes 2–3 together, erect, subglobose, 9–11 × 8–10 cm, with a truncate apex. Bracts flabellate, 2.5–3 × 2–2.5 cm including rounded, thin membranous wings, distally thickened and prominently keeled, ending in a cuspidate, curved, 8 × 2.5 mm tip. Seed scales not wider than the seed; ligule fragile, 2–2.5 mm long. Seeds obovoid-oblong, 20–25 × 8–10 mm, transversely flattened, smooth, light brown when ripe.

Distribution

New Caledonia: Grande Terre.
TDWG codes: 60 NWC

Ecology

This is one of the New Caledonian species that is restricted to peridotite and serpentine. Altitudinal range: 190–1150 m a.s.l. It forms thickets and is often seen growing on steep rock faces and cliffs, leaning over instead of upright. It also occurs in humid valley bottom forest and in more open 'maquis minier', usually on slopes. It is sometimes associated with *Agathis lanceolata*.

Conservation

This species has probably been seriously reduced in its occurrence on some mountains that are intensively mined for nickel, especially in Province Nord. On Mt. Kaala and the Massif de Kopéto the species has not been found since 1980; from the first mountain it has almost certainly gone (pers. obs. November 2005). Since the number of mature trees is estimated to be fewer than 10,000 this species meets the criteria for Vulnerable.
IUCN: VU [B1ab(iii); C2a(i)]

Uses

No uses have been recorded of this species.

Araucaria columnaris (J. R. Forst.) Hook., Bot. Mag. 78: sub t. 4635. 1852. *Cupressus columnaris* J. R. Forst., Fl. Ins. Austr.: 67. 1786. Type: New Caledonia: Province Sud, Île des Pins, *W. Anderson s.n.* (holotype BM). Fig. 47, 48

Etymology

The species epithet refers to the columnar habit of this species.

Vernacular names

Cook's pine, New Caledonia pine; pin colonnaire (French).

Description

Monoecious trees to 50(–60) m tall, to 1–1.5 m d.b.h.; trunk straight or curved. Bark to 3 cm thick, exfoliating in horizontal strips, forming small, curled flakes; inner bark dark reddish brown; outer bark light grey. Resin exudate yellow to orange, drying white or brown. Crown in mature trees narrowly columnar, branched along greater part of trunk; branching according to Massart's model. Primary branches followed by frequent adventitious branching. Primary first order branches of mature trees in pseudo-whorls of 5–7(–10), 1–2(–3) m long, spreading or assurgent, caducous. Foliage branchlets in mature trees confined to distal parts of primary branches (and on adventitious branches), of variable length (2–40 cm), 5–10 mm wide (including leaves), more or less terete, flexible, caducous. In mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets elliptic-ovate to obovate-elliptic with the shortest leaves ovate-lanceolate, 4–8 × 1.8–5 mm, rhythmically varying in shape and size along a branch, more or less navicular with incurved, acute or obtuse apex, smooth, keeled abaxially; leaves subtending seed cones more or less triangular, 8–14 × 4–8 mm. Stomata on adult leaves of ultimate branchlets abaxially confined to the proximal part of the leaf, on adaxial surface in 30–33 rows. Semi-juvenile leaves divergent, erecto-patent, narrowly oblong-lanceolate, falcate, on branchlets 5.5–11 × 0.6–1.5 mm, ending in a short blunt tip. Pollen cones terminal, solitary, conical-cylindrical, initially erect, pendulous and curved at anthesis, (2.5–)4–7(–10) cm × 13–22 mm, lax. Microsporophylls spreading at 45° from a stout rachis; stalk thin and weak, 3–5 mm long; lamina oblong-triangular, 5–7(–10) × 2.5–3(–4) mm; apex acute and ± cuspidate. Pollen sacs 10–12 or more, linear, 4–6 mm long. Seed cones terminal on short, stout foliage branches, usually solitary, sometimes 2–3 together, erect, subglobose, 8–10 × 7–8.5 cm when mature. Bracts flabellate, 2.5–4 × 3–4.5 cm including rounded, thin membranous wings, distally thickened but thin-edged, ending in a caudate, upward curved, 8–10 mm long tip. Seed scales not wider than seed; ligule triangular, 2–3 mm long. Seeds obovoid, 18–30 × 6–12 mm, more or less transversely flattened, striated longitudinally or smooth, light brown when ripe.

Distribution

New Caledonia: Grande Terre (Province Sud), Île des Pins, Loyalty Islands.
TDWG codes: 60 NWC

Ecology

Araucaria columnaris occurs on coral reefs and coastal headlands in proximity of the sea in natural habitats, and is an emergent. It is widely planted elsewhere in New Caledonia, especially on coastal headlands and islands and in some valleys of the interior. It occurs in the wild mostly, but not exclusively, on calcareous substrate, often on coral. Occasionally, as at Port Boisé, it is found on basalt or serpentine substrates. In the southern part of Grande Terre it is restricted to off-shore reefs and islets and some coastal slopes on ultramafic rock or soil, from just above high tide to ca. 50 m a.s.l.; on the Loyalty Islands and the Île des Pins it grows on low lying calcareous rock derived from coral reefs. The tall trees are emergent high above a canopy of sclerophyll scrub ('maquis minier') or dry forest with e.g. *Pandanus bernardii* and grow as scattered individuals either more or less solitary or in more or less dense 'groves'. Where the forest is less dense dominant associates include *Argusia argentea, Cycas seemannii, Scaevola taccada, Pandanus tectorius, Premna integrifolia, Boerhavia repens* and *Pisonia grandis*. On beaches, *A. columnaris* grows in association with *Acacia simplicifolia, Calophyllum inophyllum*

and *Casuarina equisetifolia*. On the ultrabasic rocks at Port Boisé, *Araucaria columnaris* is associated with the local endemic *A. nemorosa*.

Conservation

Although it is not always possible to determine with certainty the distinction between natural stands and trees planted in the past within the assumed natural range of this species, it is obvious that extensive natural stands still occur. There is no longer any timber exploitation of these stands anywhere and due to their close proximity to the coast and predominantly calcareous substrate nickel mining is not an issue. Trees may be thrown in high storms (typhoons), but regeneration is abundant in many places. The trees also enjoy traditional protection from the Polynesian Kanaks and it is generally prohibited to fell them.
IUCN: LC

Uses

The wood is of high quality and has been locally exploited in the past. *Araucaria columnaris* is sacred to the Kanak Polynesian people of New Caledonia, who regard it as a male symbol and have planted it widely in their settlements. This species is also introduced as an ornamental tree in other islands in the SW Pacific and in India, where it is a popular landscape tree in the foothills of the Himalaya and in the Western Ghats.

Araucaria cunninghamii Aiton *ex* A. Cunn., in Lambert, Descr. Pinus, ed. 3, 2, *p. s.n. inter* 144–145. 1832.

Etymology

This species was named after the plant collector Allan Cunningham (1791–1839).

Vernacular names

Hoop pine; several Australian Aboriginal names and local New Guinea names have been recorded in the literature about this species.

Description

Monoecious trees to 66 m tall, to 2 m d.b.h.; trunk straight. Bark to 10 cm thick, exfoliating with thin, curling flakes; inner bark orange brown and white; outer bark grey-brown to dark brown or maroon. Resin exudate yellowish white, thick and opaque, drying to an amber colour. Crown in mature trees broadly conical and finally flat-topped, with branches only in the top of the tree; branching according to Massart's model. Primary first order branches of mature trees in pseudo-whorls of 6–10, up to 5 m long, spreading or assurgent, mostly with second to third order branches, caducous. Adventitious foliage branches common. Foliage branchlets assurgent or nearly erect in mature trees, forming tufts of foliage, of unequal length up to 40 cm, up to 15 mm wide (including leaves), of equal width but with a tapering apex, more or less flexible, caducous. In mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets imbricate or variously spreading but incurved, subulate, (2–)4–11 × (0.6–)1–3.5(–6) mm, widest below middle, slightly concave adaxially, 4-faced, keeled on both sides, distally tapering to an incurved, acute or subacute, blunt apex; margins minutely denticulate; leaves subtending seed cones larger than lower leaves, less curved, with a widened base. Stomata abaxially in 6–7 rows on each side of the keel; adaxially in numerous rows extending from base to apex. Semi-juvenile leaves divergent, loosely adpressed forwards, lanceolate-elliptic to ovate-lanceolate; apex subacute and rostrate, shortly pungent. Pollen cones terminal on ultimate foliage branchlets, solitary, cylindrical, initially erect, pendulous and curved at anthesis, 2–5.5(–10) cm × 3–7 mm. Microsporophylls connate, spreading at ca. 90° from a slender rachis; stalk thin and weak, 2.5 mm long; lamina peltate, rhombic or rounded in outline, 2 × 1.5–2 mm; apex acute. Pollen sacs 4–5, pendent, oblong, 2 × 0.6 mm. Seed cones terminal on stout foliage branches, usually solitary, erect, ovoid to broadly ovoid or ellipsoid, 5.8–12 × (3.7–)4.5–8 cm. Bracts flabellate, 2–3 × 2.5–3.5 cm including membranous wings, distally thickened to a transversely keeled apophysis, ending in an acuminate, curved, 5–8 mm long tip. Seed scales not wider

than seed, abruptly terminating in a 2–3 mm long ligule. Seeds oblong, more or less almond-shaped, 15–20 × 5–8 mm, flattened, brown when ripe.

Distribution

New Guinea; Australia: Queensland, from near Cape York south to New South Wales.
TDWG codes: 43 NWG-IJ NWG-PN 50 NSW QLD-QU

Ecology

In New Guinea, where this species is widespread, it occurs most commonly in montane and high montane forests above 1000 m altitude, and in cooler and wetter sites than *A. hunsteinii*. In Australia it is a component of 'dry vine forest' and thickets that occur on the eastern slopes of the Great Dividing Range at moderate elevations. In Australia, its range partially overlaps that of *A. bidwillii*, and in localities where both species occur, they are frequently co-dominant emergents. The two species have different periods of seed ripening and dispersal. *Araucaria cunninghamii* is wind dispersed and the seeds ripen in the period overlapping the two monsoons, whereas *A. bidwillii* is animal dispersed and produces ripe seed between December and April which is both the hottest and the wettest period in the Bunya Mountains. In New Guinea, *A. cunninghamii* and *A. hunsteinii* also occur together, but usually one species predominates. In New Guinea, common tree genera with *A. cunninghamii* are *Castanopsis, Lithocarpus, Cinnamomum, Calophyllum*, and *Schizomeria*. In Australia, *Argyrodendron* is the most common dominant; numerous other trees and lianas are found in these forests where the vegetation is left undisturbed. *Araucaria cunninghamii* is an emergent rising well above a closed canopy of angiosperm trees at around 30 m.

Conservation

In Australia, logging by European colonists from the 19th century onwards has greatly reduced the area of occupancy (AOO) of *A. cunninghamii*, especially in New South Wales, where by the beginning of the 20th century only small fragments remained (Baker & Smith, 1910). In Queensland the reduction was less severe, but here only anecdotal evidence exists concerning its extent before European settlement. Deforestation in the highlands of New Guinea has a much longer history, but, until recently, Papuans had no incentives to exploit the trees of this species on a large scale and in fact often protected individual stands while burning the surrounding (secondary) grassland. It is therefore difficult to quantify total reduction of the species within a time frame of 'three generations' (of trees) as required by IUCN Red List criteria. Due to its large ranges both in Australia and New Guinea, the species (and its two varieties) is considered not threatened at the present time.
IUCN: See under varieties for ratings.

Uses

The timber of Hoop pine is easily worked and is used for joinery, construction, plywood, balustrades, decking, doors, musical instruments, aircraft components, etc. There are extensive plantations in Australia (production capacity 400,000 m^3 per year) and also in other parts of the world, e.g. Vanuatu and India, in particular around Dehra Dun and in the foothills of the Himalaya. This species was introduced to cultivation in 1827 and is commonly grown in city parks, e.g. in New Zealand and South Africa, where some trees have attained large dimensions.

2 varieties are recognized:

Araucaria cunninghamii Aiton *ex* A. Cunn. var. ***cunninghamii***. Type: Australia: Queensland, ["East Coast New Holland 1818–1829"], *A. Cunningham s.n.* (lectotype K). Fig. 49

Description

Juvenile leaves (4–)6–20(–23) mm long, 0.8–2 mm wide. Microsporophylls usually rhombic, smooth; apex acute.

Distribution

Australia: coastal Queensland, New South Wales (Dorrigo Plateau).
TDWG codes: 50 NSW QLD-QU

Conservation

IUCN: LC

Araucaria cunninghamii Aiton *ex* A. Cunn. var. ***papuana*** Lauterb., Bot. Jahrb. Syst. 50: 51. 1914. Type: Papua New Guinea: Morobe, Waria River, ["Wasserscheide zwischen Küste und dem Waria-Inlandtal, Berggrat, 2000 m"], *H. Klink 3* (lectotype K).

Description

Juvenile leaves 6–20(–22.5) mm long, 1–2.3 mm wide. Microsporophylls usually with a rounded upper margin and rugose surface.

Distribution

New Guinea (including Ferguson & Japen Islands) from the Owen Stanley Range to the Vogelkop (Bird's Head) Peninsula, but especially abundant in the central highlands.
TDWG codes: 43 NWG-IJ NWG-PN

Conservation

IUCN: LC

Araucaria heterophylla (Salisb.) Franco, Anais Inst. Super. Agron. (Lisboa) 19: 11. 1952. *Eutassa heterophylla* Salisb., Trans. Linn. Soc. London 8: 316. 1807. Type: Australia: Norfolk Island, *P. G. King s.n.* (lectotype G). Fig. 50

Etymology

The species epithet refers to the very different juvenile and adult foliage, in contrast to the homophyllous leaves of *A. araucana*, which was the only other species of the genus known at the time.

Vernacular names

Norfolk Island pine, Star pine.

Description

Monoecious trees to 57 (in the past to 70) m tall, to 1.5(–3) m d.b.h.; trunk straight. Bark to 5 cm thick, exfoliating in horizontal strips, forming small, curled flakes; inner bark reddish brown; outer bark light grey. Resin exudate yellow to orange, resembling amber, drying white or brown. Crown in mature trees narrowly conical, branched along greater part of trunk; branching according to Massart's model. Primary first order branches of mature trees in pseudo-whorls of 5–7(–10), 2–3 m long, spreading horizontally and assurgent at ends or ascending, caducous. Adventitious foliage branches occurring in older trees mostly after damage. Foliage branchlets steeply ascending in mature trees and confined to distal parts of primary branches (and adventitious branches), 30–40 cm long, 7–12 mm wide (including leaves), straight or slightly curved, more or less terete, flexible. In mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets scale-like, ovate or triangular, 4–7 × 3–4(–6) mm, 3-faced, showing rhythmic variation in size along a branch; margins thick and entire; apex incurved, acute or obtuse, with an abaxial keel. Stomata on both surfaces, on abaxial surface proximal only and on either side of the abaxial keel. Semi-juvenile leaves closely adpressed, acicular, very gently falcately curved for most of their length, with incurved apex. Pollen cones terminal on ultimate branchlets, solitary, initially erect but pendulous when shedding pollen, obovoid then ovoid-ellipsoid and slightly curved at anthesis, 4–5 cm × 10–15 mm. Microsporophylls spreading at 45° from the rachis; stalk linear, thin and weak, 3–4 mm long; lamina rhombic, 3–4 × ca. 4 mm; apex acute or apiculate, upturned. Pollen sacs 10–12, linear, straight, later curved, 4–5 mm long. Seed cones terminal on 4–10 cm long, very thick foliage branches, usually solitary, erect, subglobose to globose, 7.5–10.5 × 8–11.5 cm (green weight to 1 kg). Bracts cuneate-flabellate, 3.5–4 × 2.5–3 cm including rounded, thin membranous wings, distally thickened, ending in a caudate, upward curved, 5–8 mm long tip. Seed scales not wider than the seed; ligule triangular, 2–3 mm long. Seeds oblong-cuneate, 2.5–3 × 1.2–1.5 cm, slightly flattened, striated longitudinally or smooth, light brown when ripe.

Taxonomic notes

Araucaria heterophylla is the 'type' species for Massart's model of architecture in trees.

Distribution

Australia: Norfolk Island, where now largely restricted to the Norfolk Island National Park (formerly Mt. Pitt Reserve). The island's area is only 34 km². The species also occurs on Philip Island, a 4 km² small island 6 km S of Norfolk Island.
TDWG codes: 50 NFK-NI

Ecology

Araucaria heterophylla occurs on basalt of the island remnant of a Pliocene volcano sitting on the highest point of the submerged Norfolk Island Rise, most abundantly at lower elevation up to ca. 120 m, more sparsely and remaining smaller up to the highest point of the island (Mt. Bates, 318 m). The climate is subtropical with an average rainfall of 1350 mm evenly distributed. The original vegetation cover has been largely disturbed except near the highest point, hence the present occurrence as solitary trees on coastal headlands or in 'groves' with a low undergrowth of mostly grasses or of open scrub, with many introduced species. The original vegetation was an evergreen subtropical forest with angiosperm trees and tree ferns 10–20 m high, over which the araucarias emerged. Common angiosperm trees are (were) *Nestegis apetala, Elaeodendron curtipendulum, Streblus pendulinus, Lagunaria patersonia, Acronychia simplicifolia, Zanthoxylum pinnatum, Meryta angustifolia, Baloghia lucida*, and *Dysoxylum patersonianum*.

Conservation

Norfolk Island, although it may have been visited by seafaring Polynesians, was uninhabited when James Cook found it on his second voyage in October 1774. At that time the island was covered with a mixed evergreen rainforest in which *A. heterophylla* was an emergent occurring everywhere in greater or lesser densities, probably with least density at the highest elevation points and greatest density on the lower plateaux nearest the coast. Of this, only scattered stands of araucarias remain, while the rainforest has mostly disappeared. Dieback has been observed recently in some Norfolk Island Pine subpopulations. The natural populations are threatened by introduced species such as *Lantana camara, Psidium cattleyanum* and *Solanum mauritianum*. The tiny population on Philip Island is critically endangered (CR) (Greene, 1979, cited in Golte, 1993).
IUCN: VU (D2)

Uses

Norfolk Island pine is probably the most widely cultivated species of *Araucaria*. As well as being introduced as a plantation or outdoor ornamental tree in suitable climates, e.g. in Australia, New Zealand, Hawaii, Fiji, Micronesia, Pitcairn Island, Philippines, South Africa, Côte d'Ivoire, Egypt, Turkey, Canary Islands, Puerto Rico, Cuba, Florida and southern California, it is frequently used worldwide as an indoor ornamental houseplant in offices and similar buildings. It is salt tolerant and is consequently used in landscaping in areas susceptible to sea spray. However, it is not as wind-resistant as some other species of *Araucaria*, especially in areas that are also susceptible to frosts, to which the species is not very resistant. This species has been introduced and is now self-sown on Lord Howe Island beside the lagoon, where it is becoming naturalised, to the detriment of native species because of its invasive nature and its capability to change the soil chemistry, making conditions unsuitable for the germination of many native species. For these reasons it is being targeted for eradication there.

Araucaria humboldtensis J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 279. 1949. Type: New Caledonia: Grande Terre, Province Sud, Mt. Humboldt, *J. T. Buchholz 1571* (holotype ILL).

Etymology

This species was named after the type locality, Mt. Humboldt.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees 6–20(–30) m tall, to 0.7 m d.b.h.; trunk straight. Bark to 3 cm thick, exfoliating in horizontal strips, forming small, curled quadrangu-

lar flakes; inner bark brown; outer bark light (yellowish) grey or light green. Resin exudate white, opaque. Crown in mature trees columnar, open, branched along greater part of trunk, usually flat-topped and candelabra shaped; branching according to Massart's model. Adventitious foliage branches rare or absent. Primary first order branches of mature trees in pseudo-whorls of 5–7, 1.5–2.5 m long, spreading horizontally or ascending, caducous on lower part of trunk. Foliage branchlets steeply ascending on primary branches and confined to distal parts, 5.5–23 (–30) cm long, 3–9(–11) mm wide (including leaves), more or less the same width throughout except for base, straight or slightly curved, more or less terete, flexible. Adult leaves on ultimate branchlets helically arranged obliquely to axis and overlapping slightly, scale-like, ovate, 4–6(–7) × 2–4.5 mm, 4-faced, similar in shape and size throughout the length of a branchlet, keeled abaxially; apex incurved, acute. Stomata on both sides, on the abaxial side restricted to the proximal part and the extreme apex, on the adaxial side in regular, closely spaced lines from middle to apex. Pollen cones terminal, subtended by lanceolate, incurved leaves, cylindrical, initially erect, pendulous and slightly curved at anthesis, 3–3.5 cm × 9–10 mm. Microsporophylls imbricate; stalk thin, 3–4 mm; lamina triangular, 3 × 3 mm; apex acuminate to acute. Pollen sacs ca. 6, thin, straight. Seed cones terminal on short, very thick foliage branches, usually solitary, erect, broadly ovoid to subglobose, 6.5–9 × 4.5–8 cm. Bracts cuneate-flabellate, 2–3 × 1.8–2.8 cm including rounded, thin membranous wings, distally thickened, ending in an upward curved, 4–5 mm long tip. Seed scales not wider than the seed; ligule triangular, 1–3 mm long. Seeds oblong, 17–22 × 9–10 mm, slightly flattened, striated longitudinally or smooth, light brown when ripe.

Distribution

New Caledonia: Grande Terre, Province Sud, concentrated in the large southern massifs (Massif du Humboldt, Montagne des Sources, Mt. Mou).
TDWG codes: 60 NWC

Ecology

This species occurs in montane dense humid forest and especially in montane tall maquis (2–8 m), on ultramafic soils derived from serpentine or peridotite. It reaches to the ridges and summits of the highest mountains of the 'Grand Massif du Sud' and is especially abundant on E and SE slopes and in gullies. Altitudinal range: 750–1600 m a.s.l. It is sometimes associated with *A. montana* or *A. laubenfelsii* and often with other conifers such as *Callitris neocaledonica, Falcatifolium taxoides, Prumnopitys ferruginoides*, and *Podocarpus* spp., and numerous angiosperm trees and shrubs, e.g. *Metrosideros* sp. (*Myrtaceae*), *Araliaceae, Dilleniaceae* and *Lauraceae*. Tree ferns (*Dicksonia deplanchei*) and small palms are also often present, while ferns and sedges form a herbaceous layer. Lichens and mosses are very abundant, especially at the higher altitudes above 1200 m.

Conservation

This species mainly occurs on remote mountain massifs that are (partly) in nature reserves and at present not threatened by mining activities although the geology is similar to the ultramafic rock types that are actively mined. The main threats are frequent fires, some of which are very destructive and difficult to fight.
IUCN: EN [B1ab(i–iii, v)+2ab(i–iii, v)]

Uses

The wood is not exploited and there are no other recorded uses.

Araucaria hunsteinii K. Schum., in Schumann & Hollrung, Fl. Kaiser Wilhelms Land: 11, t. 4, f. 8. 1889. *Titanodendron hunsteinii* (K. Schum.) A. V. Bobrov & Melikyan, Komarovia 4: 61. 2006. Type: Papua New Guinea: Morobe, Butaweng, ["oberhalb Bataueng"], *C. Hunstein s.n.* (holotype not located, isotype K).

Araucaria schumanniana Warb., Monsunia 1: 187, t. 10, f. A. 1900; *Titanodendron schumanniana* (Warb.) A. V. Bobrov & Melikyan, Komarovia 4: 61. 2006.
Araucaria klinkii Lauterb., Bot. Jahrb. Syst. 50: 48, f. 1. 1914; *Araucaria hunsteinii* K. Schum. var. *klinkii* (Lauterb.) Silba, Phytologia 68: 26. 1990; *Titanodendron klinkii* (Lauterb.) A. V. Bobrov & Melikyan, Komarovia 4: 61. 2006.

Etymology

Named after Carl Hunstein (ca. 1843–1888), German collector in New Guinea in 1878–1888, after whom the Hunstein Range in East Sepik in Papua New Guinea is also named.

Vernacular names

Klinki pine (also trade name for timber). There are many local names in New Guinea for this tree.

Description

Monoecious trees to 90 m tall, to 2 m d.b.h. or more; trunk straight, very gradually tapering. Bark thick, rough and scaly, exfoliating in large plates and scales; inner bark reddish; outer bark dark brown to black. Resin exudate clear, changing to golden-coloured on contact with air and weathering white to grey. Crown in mature trees very open, with several branches retained in lower part of tree, flat-topped; branching according to Rauh's model. Adventitious foliage branches common in older trees. Primary first order branches of mature trees in pseudo-whorls of 6–8, up to 6 m long, spreading horizontally, bearing foliage branches near distal end, slowly caducous. Foliage branchlets spreading in all directions or pendent on ends of primary branches in mature trees, forming large tufts of up to 50 cm long foliage branchlets of very unequal width (including leaves) from base to apex. In mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves of ultimate branchlets imbricate at base but spreading radially at a wide angle, often in 5 distinct rows, bifacially flattened, triangular to lanceolate, (2–)5–10(–15) cm × (8–)12–20(–25) mm, increasing in size from base to apex of branchlet; margins tapering to a sharply pungent apex. Stomata in numerous intermittent rows covering both leaf surfaces from base to apex. Leaves on adventitious branches variable in length but narrower than adult leaves. Pollen cones axillary, sessile or pedunculate, in clusters of 2–6, narrowly cylindrical, initially erect, elongated, pendulous and curved at anthesis, 10–22 cm × 11–25 mm. Microsporophylls spreading at ca. 70° from a thin, fragile rachis; stalk thin and weak, linear, 4–5 mm long; lamina curved, the exposed part ligulate, 5–8 × 2.5–3 mm; abaxial surface rugose, lateral margins erose-denticulate; apex acuminate. Pollen sacs 8–10, linear, straight, ca. 6 mm long. Seed cones axillary (appearing subterminal) on a short, stout, leafy peduncle, usually solitary, erect, broadly obovoid to cylindrical, 15–25 × 12–16 cm. Bracts obtrullate to cuneate, 5–6 × 7–9 cm including wings, lateral sections thin and membranous, distal part thickened to a rhombic, sharply keeled apophysis, ending in a 8–15 mm long, caducous tip. Seed scales not wider but longer than the seed; ligule small, 2–3 × 5 mm. Seeds narrowly almond-shaped, ca. 30 × 8 mm, distinctly flattened, smooth.

Taxonomic notes

The two species of *Araucaria* that are indigenous in New Guinea, *A. hunsteinii* and *A. cunninghamii*, are distinct and classified in two sections: *Intermedia* White and *Eutacta* Endl. When Schumann first described *A. hunsteinii*, he does not seem to have had a mature seed cone but only an immature cone and some separate bract-scale complexes. Warburg described *A. schumanniana* as a new species distinct from *A. hunsteinii*, but the differences he gave in the description and in the Figures A and B of Plate 10 do not hold when more specimens with mature, full-grown male and female cones are examined. Lauterbach described yet another species of *Araucaria* from New Guinea, *A. klinkii*, a name that apparently became popularized as the vernacular name for the species now known as *A. hunsteinii*. Lauterbach himself expressed some doubt about the distinctiveness of his new species from *A. hunsteinii* and considered it possible that the leaves of *A. klinkii* are merely the adult stage of *A. hunsteinii*. With the availability of more specimens we can be sure now that Lauterbach based his species on mature foliage of *A. hunsteinii* and that therefore *A. klinkii* is a taxonomic synonym of *A. hunsteinii*. Forms with glaucous blue-green leaves and male and female cones with white exudate or powder on their surface have been called *A. klinkii* Lauterb.; however, De Laubenfels (1988) has pointed out that the young leaves are glaucous, and in some forms the adult leaves and female cones are grey-blue due to a white exudate.

Distribution

Papua New Guinea. In the central mountain range from an isolated population on the Wamira River in the east through the Owen Stanley Range and the Bismarck Range, with other isolated stands near Sattelburg in the Huon Peninsula and on the Tagari River in the Central Highlands.
TDWG codes: 43 NWG-PN

Ecology

This species forms 'groves' or stands, or occurs scattered in tropical montane monsoon forests on moist sites usually in inter-montane valleys. Its altitudinal range is (550–)750–1700(–2100) m a.s.l. Mature trees are canopy emergents above angiosperm trees, effectively forming an upper canopy layer. This species occurs in two types of forest, a drier and a wetter one; in the drier type the canopy of angiosperms reaches only 15–25 m of average height, with *A. hunsteinii* attaining twice that height. Associated common evergreen tree species in this forest type are *Aleurites moluccana, Celtis* sp., *Heritiera* sp., *Macaranga* sp., and *Pouteria luzonensis*; deciduous species are *Garuga floribunda, Protium macgregorii, Sterculia* sp., and *Terminalia* sp. In high rainfall localities both angiosperms and *A. hunsteinii* become much taller, with the conifer towering to 60–90 m. Common associated canopy tree species are *Acmena* sp., *Elmerillia papuana, Flindersia amboinensis, F. pimenteliana, Pometia pinnata*, and *Xanthophyllum papuanum*. *Cerbera floribunda, Cryptocarya* sp., *Dysoxylum* sp., *Gnetum gnemon, Litsea* sp., and *Myristica* sp. are common in the subcanopy tree layer. Soils are neutral to acidic with a high clay content. Precipitation ranges from 800 mm to more than 4000 mm per year.

Conservation

This species was graded LR(nt) by Farjon & Page (1999), which was still the rating (NT) in the 2008 IUCN Red List of Threatened Species™ (www.iucnredlist.org) although the destruction of so many trees in recent forest fires may mean that the species needs to be reassessed. The recalcitrant seeds cannot be stored for long periods making propagation from seed difficult.
IUCN: NT

Uses

Araucaria hunsteinii has been grown as a plantation crop in New Guinea since 1948. The wood is used in the local sawmilling and plywood industries and for making aircraft frames. Fires destroyed much of the Bulolo plantation in 1997. Klinki pine plantations have also been established on tin tailings in Malaysia and more recently in Costa Rica. The latter plantations were set up as part of a controversial programme, KLINKIFIX, which aims to mitigate greenhouse gas emissions.

Araucaria laubenfelsii Corbasson, Adansonia, sér. 2, 8: 467. 1969. Type: New Caledonia: Grande Terre, Province Sud, on ridge between Mts. Dzumac and Mt. Ouin, *H. S. MacKee 16441* (holotype P). Fig. 51

Etymology

This species was named after David J. de Laubenfels, specialist on gymnosperms especially the Podocarpaceae and the Araucariaceae.

Vernacular names

ouaoué (name recorded on H. S. MacKee 30370, P).

Description

Monoecious trees to 30 m tall, to 1 m d.b.h.; trunk straight. Bark to 4 cm thick, exfoliating in horizontal strips; inner bark reddish to pink; outer bark brown or grey. Resin exudate clear or yellow, drying white or grey. Crown in mature trees columnar or broadly conical, open, branched along the greater part of the trunk; branching according to Rauh's model. Primary branches followed by adventitious branching lower on the trunk. Primary first order branches of mature trees in pseudo-whorls of 4–5, 1–2.5 m long, spreading nearly horizontally to assurgent, caducous. Foliage branchlets assurgent or nearly erect on primary branches in mature trees and confined to distal parts, of more or less equal length (35–45 cm) on either side of the axis branch and shortening towards the end, (12–)20–33 mm wide (including leaves). On mature trees leaves of two kinds: adult leaves and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate

branchlets nearly triangular, 8–20(–24) × 4–12 mm, at least twice as long as wide, similar in size along length of branchlet, strongly convex, usually with 5 longitudinal ridges alternating with grooves or sometimes smooth; margins incurved; apex acute or obtuse. Stomata abaxially in bands located in the grooves between the ridges; adaxially in numerous continuous rows from base to apex. Semi-juvenile leaves irregularly spreading at 40°–90°, acicular to lanceolate, 13–25 × 4–8 mm, tapering to an incurved, acute apex. Pollen cones terminal, solitary, initially erect but becoming pendulous and curved at anthesis, 8–11(–15) × 2–3 cm. Microsporophylls imbricate, spreading at 45° from a slender rachis; stalk thin and weak, 3–5 mm long; lamina nearly triangular, 4–6 × 3–5 mm, thick and firm; lateral margins entire; apex obtuse; abaxial surface smooth. Pollen sacs 10–12, thin, straight, 5–6 mm long. Seed cones terminal on short, stout foliage branches, usually solitary, sometimes 2–3 together, erect, broadly ovoid to subglobose, 10–13 × 7–9 cm. Bracts flabellate, 2.2–2.5 × 1.5–2 cm including rounded, thin membranous wings, distally thickened and transversely keeled, ending in a rostrate, upturned, 10–15 mm long, acute tip. Seed scales not wider than the seed; ligule fragile, 1.5–2 mm long. Seeds cuneate, 14–16 × 6–8 mm, smooth, yellowish brown when ripe.

Distribution

New Caledonia: Grande Terre. In Province Nord only known from Île Art and Mt. Kaala; more abundant in Province Sud.
TDWG codes: 60 NWC

Ecology

Araucaria laubenfelsii is an emergent from ombrophilous lower to middle-montane forest, and occurs also in 'maquis minier'; on ultramafic substrates derived from serpentine or peridotite, or on lateritic soil at lower elevations. Its altitudinal range is (26–) 250–1160 m a.s.l. On slopes and summit ridges it is often associated with *A. montana* and sometimes with *A. humboldtensis; Myrtaceae, Casuarinaceae*, small palms and the conifers *Falcatifolium taxoides* and *Prumnopitys ferruginoides* are common in a second tree layer or in the understorey. Regeneration is most successful in open and low vegetation and diminishes when the vegetation closes to become dense forest, in which the surviving araucarias become large and tall emergents. It appears therefore that this species is dependent on episodic fires for its perpetuation in the vegetation.

Conservation

The threats are those common to most of the New Caledonian species: fires, land management of non-agricultural areas, and clear-cutting. Most populations occur on serpentine and some, especially in the Province Nord, are subject to nickel mining. The species has probably now disappeared from one of such sites, Mt. Kaala (pers. observation, Nov 2005). A reassessment of its status seems necessary.
IUCN: NT

Uses

The wood of this species is not exploited and no other uses are recorded.

Araucaria luxurians (Brongn. & Gris) de Laub., Fl. Nouv. Calédonie Dépend. 4: 92. 1972. *Araucaria cookii* R. Br. *ex* Lindl. var. *luxurians* Brongn. & Gris, Ann. Sci. Nat. Bot., sér. 5, 13: 354. 1871; *Araucaria columnaris* (G. Forst.) Hook. f. *luxurians* (Brongn. & Gris) E. H. Wilson, J. Arnold Arbor. 7: 84. 1926. Type: New Caledonia: Grande Terre, Province Sud, Mt. Canala, *B. Balansa 2510* (lectotype P).

Etymology

The species epithet (Latin *luxurians* = 'luxuriant') refers to the branching habit.

Vernacular names

sapin de Noël (New Caledonia)

Description

Monoecious trees to 40 m tall, to 0.6 m d.b.h.; trunk straight or curved. Bark to 2 cm thick, exfoliating in horizontal strips; inner bark dark red; outer bark grey. Resin exudate from bark red, from foliage branchlets whitish translucent and semi-opaque. Crown in mature trees variable, often short, densely branched, with a conical or rounded top; branching

according to Massart's model. Primary branches followed by some adventitious branching. Primary first order branches of mature trees in pseudo-whorls of 5–7 at regular intervals, 2–3 m long, spreading or assurgent, mostly persistent. Foliage branchlets assurgent on primary branches in mature trees and confined to distal parts, giving a candelabra appearance, 7–30 cm long and at thickest parts 9–13(–16) mm wide (including leaves), narrowed at base and at intervals rhythmically along a branchlet, there only 6–8 mm wide (including leaves). Adult leaves on ultimate branchlets ovate-lanceolate, ovate or broadly ovate, 4–16 × 2.5–6.5(–8) mm, slightly convex, abruptly narrowed at base, straight or incurved, loosely imbricate and slightly divergent, strongly keeled abaxially; apex rounded or subacute, strongly incurved. Stomata abaxially in intermittent rows from base to apex or (in smaller leaves) only near base; adaxially in numerous rows. Semi-juvenile leaves on adventitious branches 6–10 × 0.7–2.5(–3.2) mm. Pollen cones terminal, solitary, initially erect but pendulous and curved at anthesis, (10–)12–15(–17) cm × 20–28 mm. Microsporophylls imbricate, spreading at 45° from a stout rachis; stalk thin and weak, 4–5 mm long; lamina ovate-oblong, 8–10 × 5–6 mm, lateral margins denticulate, scarious; apex acute when mature. Pollen sacs 12–15, linear, thin, straight, ca. 8 mm long, directed towards the rachis. Seed cones terminal on short, stout foliage branches, usually solitary, erect, subglobose, 10–12 × 8–10 cm. Bracts flabellate, 3–3.5 × 3–3.5 cm including rounded, thin membranous wings, distally thickened but thin-edged, ending in a caudate, straight or upward curved, 8–10 mm long tip. Seed scales not wider than the seed; ligule triangular, 2–3 mm long. Seeds obovoid, 18–25 × 6–10 mm, more or less flattened, smooth, light brown when ripe.

Taxonomic notes

Araucaria luxurians was first described by Brongniart & Gris (1871) as a new variety of *Araucaria cookii* (= *A. columnaris*) and it was said to occur along the coast mixed with that species. The authors described the variety as having larger, roundly ovate leaves 8–9 mm long and having larger, often curved pollen cones being 12 cm long with larger pollen sacs. According to De Laubenfels (1972), who first raised it to the rank of species, the two taxa are ecologically distinct, with *A. columnaris* growing on limestone (coral) and *A. luxurians* on serpentine. However, De Laubenfels's morphological justification is minimal. On the same branchlet, leaves mostly vary with each burst of growth. Adult leaves, being either smaller or larger than those of *A. columnaris*, can easily be found on a single tree of *A. luxurians*. The pollen cones of *A. luxurians* are indeed about twice, sometimes nearly three times as large as those of *A. columnaris*; its constituent organs are therefore also larger. The habit of the smaller species *A. luxurians* is less columnar than in *A. columnaris* and reiteration of its first order branches, which are persistent, is rare. *Araucaria luxurians* is here accepted as a distinct species.

Distribution

New Caledonia: Grande Terre and Îles Bélep.
TDWG codes: 60 NWC

Ecology

Araucaria luxurians is forming escarpment forest on serpentine cliffs next to the sea or in the interior, with an altitudinal range of 1–1000 m a.s.l. It grows in rocky ravines, or on coastal mountains and there usually in 'maquis minier'; on eroded, ultramafic substrates of serpentine or peridotite origin. De Laubenfels (1972) gives the substrate for this species as on serpentine; in some lowland coastal areas where it may be more or less sympatric with *A. columnaris*; the latter species is mostly restricted to limestone derived from coral reefs, whereon *A. luxurians* is not known to occur. The Bélep isles are of peridotite (Golte, 1993).

Conservation

According to the 2008 Red List of Threatened Taxa™ (www.iucnredlist.com), there are fewer than five populations still extant, none of which is protected. Some are seriously threatened by fire and erosion, while settlement and mining are other concerns. Some localities, like Mt. Kaala and Col de Mô, were revisited in November 2005 by me, and no trees of *A. luxurians* could be found there at that time. The most recent assessment estimated fewer than 2500 mature trees.
IUCN: EN [B1ab(i–v); B2ab(i–v)]

Uses

The wood is of high quality and has been locally exploited. It is a beautiful tree, especially in younger stages, and is used as an ornamental on ultrabasic soils in New Caledonia.

Araucaria montana Brongn. & Gris, Nouv. Arch. Mus. Hist. Nat. Paris 4: 215, t. 14. 1868. Type: New Caledonia: Grande Terre, ["Sommet Mi"], *B. Balansa 2512a* (lectotype P).

Etymology

The species epithet means "of the mountains".

Vernacular names

None are recorded.

Description

Monoecious trees to 40 m tall, to 1 m d.b.h.; trunk straight. Bark to 3 cm thick, exfoliating in horizontal strips; inner bark red or dark red; outer bark pale grey, sometimes almost white. Resin exudate white. Crown in mature trees broadly domed, very open, branched in the upper part of trunk, flat-topped in older trees; branching according to Rauh's model. Primary first order branches of mature trees in pseudo-whorls of 4–5, 1–3 m long, spreading nearly horizontally to assurgent, caducous. Adventitious foliage branches similar to primary branches but shorter. Foliage branchlets assurgent or nearly erect in mature trees and confined to distal parts of primary branches (and on adventitious branches), often curved, 15–45 cm long, (12–)15–25 mm wide (including leaves), more or less flexible. On mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets broadly ovate, 8–15 × 6–11 mm, similar in size throughout the length of the branchlet, strongly incurved near the obtuse apex, abaxially with longitudinal grooves or striate, more or less obscurely keeled. Stomata on the abaxial surface restricted to the lower half of the leaf, more numerous on the adaxial face. Semi-juvenile leaves 5–12 × 4–7 mm, arcuate, with an abaxial keel; apex incurved. Pollen cones terminal, solitary, erect and remaining straight, cylindrical, 5–16.5 cm × 15–30 mm. Microsporophylls spreading at 45° from a stout rachis; stalk thin and weak, 2–3 mm long; lamina ovate-triangular, with a thick, curved base, 5–7 × 4–5 mm; lateral margins minutely denticulate or papillate; apex acute; abaxial surface smooth. Pollen sacs 10–12, linear, straight, 5–6 mm long. Seed cones terminal on short, stout foliage branches, usually solitary, erect, broadly ovoid to subglobose, 8–11 × 7–9 cm. Bracts flabellate, 2.5–3.5 × 1.8–2.5 cm including rounded, thin membranous wings, distally thickened and transversely keeled, ending in a caudate, upturned, 10 mm long, acute tip. Seed scales not or slightly wider than the seed; ligule small, triangular, fragile, 1.5–2 mm long. Seeds cuneate, 20–25 × 7–8(–10) mm, smooth, yellowish brown when ripe.

Distribution

New Caledonia: Grande Terre.
TDWG codes: 60 NWC

Ecology

Araucaria montana occurs in dense and low humid forest and in tall 'maquis minier' ('maquis buissonnant') on mountain ridges, in ravines and on elevated plateaux, often on ultramafic peridotite, serpentine or brown laterite, more rarely on acidic micaschists. Altitudinal range: (200–) 500–1400 m a.s.l., but usually in the range 800–1200 m. It is sometimes a co-dominant in *Araucaria-Nothofagus* forest.

Conservation

This is a widely distributed species and one of the few that occurs not exclusively on ultramafic substrates. Populations are often quite extensive, yet it is affected by nickel mining in several of its locations and expansion of mining threatens a continuing reduction of numbers of mature trees and ultimately populations.
IUCN: VU [A3c; B1ab(i–v)]

Uses

The wood is not exploited. It has been planted in ecological restoration projects in New Caledonia. No other uses are recorded.

Araucaria muelleri (Carrière) Brongn. & Gris, Nouv. Arch. Mus. Hist. Nat. Paris 4: 219, t. 15 & 16. 1868. *Eutacta muelleri* Carrière, Rev. Hort. 37: 392. 1866. Type: Illustration in Rev. Hort. 37, pl. inserted betw. pp. 392–393, f. 3. 1866 (lectotype). Fig. 52

Etymology

Named after Ferdinand Jacob Heinrich von Mueller (1825–1896), a famous German botanist who studied the flora of Australia.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 15(–20) m tall, to 0.6 m d.b.h.; trunk straight. Bark to 3 cm thick, exfoliating in horizontal strips; inner bark dark red; outer bark light grey or reddish grey. Resin exudate translucent to opaque, drying white. Crown in mature trees very open, candelabra shaped, branches along greater part of trunk but few in number; branching according to Rauh's model. Primary first order branches of mature trees 1.5–3 m long, bearing foliage branches towards the ends, several branches lowest on the trunk caducous. Adventitious foliage branches rare or absent. Foliage branchlets steeply ascending to erect on primary branches in mature trees and confined to distal parts, to 50 cm long, 3–5 cm wide (including leaves), narrowest proximally and broadest distally, straight or slightly curved, more or less terete, rigid. Adult leaves on ultimate branchlets lanceolate to ovate, 20–32 × 9.5–18.5 mm, flat or weakly navicular, widest just above base, tapering to an obtuse apex; abaxial surface coriaceous, smooth, typically matt but rarely very lustrous (these forms also ± lacking abaxial stomata), with strong slightly excentric longitudinal abaxial keel from base to apex; margins inrolled. Stomata on both faces of leaves in numerous intermittent, closely spaced rows from base to apex, in some trees with lustrous abaxial leaf surfaces nearly absent on that face. Pollen cones terminal on the ultimate foliage branches, erect when shedding pollen, straight, 20–25 × 3–4 cm. Microsporophylls attached to a stout, 10–12 mm thick rachis, imbricate, the laminate part spreading but with an incurved apex; stalk linear, 4–5 mm long; lamina broadly ovate, 6–8 × 5–6 mm, thick near the base; margins entire or erose-denticulate; apex mucronate. Pollen sacs 15–20, linear, ca. 10 mm long, strongly contorted after dehiscence. Seed cones terminal on short, very thick branches, usually solitary, erect, broadly ovoid, 11–15 × 9–11 cm. Bracts flabellate, 2–2.5 × 1.8–2.2 cm including rounded, thin membranous wings, distally thickened, ending in a rostrate, upward curved, 10–15 mm long tip. Seed scales not wider than the seed; ligule triangular, 2–3 mm long. Seeds oblong, 17–22 × 9–10 mm, slightly flattened, light brown when ripe.

Distribution

New Caledonia: Grande Terre, Province Sud.
TDWG codes: 60 NWC

Ecology

Araucaria muelleri occurs both in maquis and open thickets above a shrub layer and in dense humid forest with *Nothofagus*, but most commonly in 'maquis buissonant' and 'maquis minier', on serpentine ridges, peridotite, gabbros and iron-rich rocks ('ironstone' or 'cuirasse de fer') or brown laterite. Its altitudinal range is 150–1000(–1250) m a.s.l. In lowlands this species is commonly associated with *Dacrydium araucarioides* (*Podocarpaceae*) and *Gymnostoma chamaecyparis* (*Casuarinaceae*), both of which have nearly the same candelabra shaped habit which is also assumed by *A. muelleri* on a larger scale. Populations are invariably small and consist of scattered individuals, often at considerable distance from each other.

Conservation

This species has been found in more localities since De Laubenfels (1972) published his map, but it cannot be concluded from this that the species has increased. Populations are almost always very small, often down to 1–10 trees in a particular location. Regeneration has been observed in the field, but seems to be slow and could not stand up against increased incidence of fires, which are particularly frequent in the far south. This is for this species the

main threat, due to its predominant habitat 'maquis minier'. Many populations are considered to be severely fragmented as a result of fires.
IUCN: EN [B1ab(i–v)+2ab(i–v)]

Uses

This species has been used in local reforesting and ecological restoration projects, e.g. at Chûtes de la Madeleine.

Araucaria nemorosa de Laub., Trav. Lab. Forest. Toulouse T. 1 (8, 5): 1. 1969. Type: New Caledonia: Grande Terre, Province Sud, Port Boisé, western shore, *H. S. MacKee 20218* (holotype P).

Etymology

The species epithet is from Latin *nemorosa*, pertaining to woods and groves.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 20 m tall, to 0.7 m d.b.h.; trunk straight. Bark to 2 cm thick, exfoliating in horizontal short strips and flakes; inner bark dark red; outer bark grey. Resin exudate translucent, drying white. Crown in mature trees variable, columnar or domed or umbrella-shaped, if columnar then flat-topped; branched mainly in the upper half of the trunk; branching according to Massart's model. Primary first order branches of mature trees in pseudowhorls of 5–7, 1–2.5 m long, spreading, assurgent, mostly persistent. Adventitious foliage branches on the lower part of the trunk, shorter than primary branches. Foliage branchlets assurgent to erect on primary branches and confined to distal parts, in two pectinate rows, 10–22 cm long, rhythmically narrowed at intervals along a branchlet, thicker parts 6–12 mm wide, thinner parts 2.5–6(–7) mm wide (including leaves). Adult leaves on ultimate branchlets variable, somewhat spreading, subulate-acicular to narrowly lanceolate, 4–10 × 1.3–3 mm, keeled abaxially; apex incurved, obtuse or acute; leaves subtending pollen cones distinct, spreading, more or less linear, 10–15 × 1.5–2.5 mm, widest at base. Stomata abaxially in 6–7 intermittent rows each side of keel; adaxial stomata numerous. Semi-juvenile leaves on adventitious branchlets 4-angled, acicular, 3.5–9 × 0.5–1.8 mm. Pollen cones terminal, solitary, initially erect but pendulous and curved near base at anthesis, narrowly cylindrical, 5–12 cm × 10–20 mm. Microsporophylls with laminar parts spreading at nearly 90° from a stout rachis at anthesis; stalk thin and weak, 5–7 mm long; lamina ovate, 5–8 × 4–5 mm; lateral margins denticulate; apex acute or acuminate. Pollen sacs linear, ca. 12, directed towards the rachis, ca. 8 mm long. Seed cones terminal on short, stout foliage branches, usually solitary, erect, ovoid to subglobose, 8–12 × 6–10 cm. Bracts flabellate, 2.6–3 × 2.3–2.6 cm including rounded, thin membranous wings, distally thickened but thin-edged, ending in a rostrate, upward curved, 11–15(–20) mm long tip. Seed scales not wider than the seed; ligule triangular, 2–3 mm long. Seeds obovoid, 20–22 × 7–9 mm, smooth, brown when ripe.

Distribution

New Caledonia: Grande Terre, Province Sud, near Port Boisé and nearby at Cap Reine Charlotte.
TDWG codes: 60 NWC

Ecology

The main population of this species occurs on a level plateau just inland from Port Boisé at around 20–40 m a.s.l. which consists of impoverished indurated ferritic soils overlying peridotites. The altitudinal range of *A. nemorosa* is (1–)20–50(–100) m. The trees stand in small groups or wide apart among low (to 10 m) and open to dense evergreen forest or scrub interspersed with nearly black, stony areas (cuirasse) almost devoid of vegetation. Common angiosperm species here are *Baeckea ericoides* and *Melaleuca quinquenervia* and abundant *Gymnostoma chamaecyparis*. Where the plateau falls off to the bay *A. nemorosa* is replaced by *A. columnaris*, which forms dense stands lining the steep coastal strip and narrow beaches as well as the headlands. Annual precipitation at Port Boisé is approximately 2500–3000 mm.

Conservation

This species is among the most seriously threatened of the 19 species of *Araucaria*. Two distinct localities are known to exist with certainty, in the main locality (Port Boisé) several subpopulations exist, while at Cap Reine Charlotte there is only one very small population. The potential for fire is very high in the area due to the type of vegetation and increased activities such as road building and mining. None of the (sub)populations of this species are in a protected area and they occur just outside the narrow belt of *A. columnaris* which benefits from traditional protection by the Kanaks. The land is mostly privately owned by a few Kanak residents of Port Boisé. Expansion of human settlement and possibly tourism are other threats to the population.
IUCN: CR [B1ab(i–v)+2ab(i–v)]

Uses

None are recorded.

Araucaria rulei F. Muell., Rep. Burdekin Exped.: 18–19. 1860. Type: New Caledonia: Grande Terre, [locality not given], *W. H. Duncan s.n.* (lectotype K).

Etymology

Named after John Rule, who was a nurseryman in Melbourne, Victoria, in the mid-19th century.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 20(–25) m tall, to 0.6 m d.b.h.; trunk straight, sometimes curved. Bark to 2 cm thick, exfoliating in horizontal strips; inner bark dull brown or dark red-brown; outer bark light grey. Resin exudate copious, white. Crown in mature trees very open; branches along greater part of trunk but few in number, branching according to Rauh's model. Primary first order branches of mature trees 1.5–3 m long, middle and upper ones assurgent but lower ones strongly declinate and turned upwards only at the end; most branches finally caducous. Adventitious foliage branches rare, usually on other branches. Adult leaves on ultimate branchlets broadly lanceolate, (8–)13–25 × 5–14 mm, flat, widest and curved just above base, tapering to a curved, acute apex, weakly keeled abaxially, smooth or sometimes striate, lustrous green. Abaxial stomata only in the most proximal part of the leaf, ± obscured by overlapping leaves; adaxial stomata in ca. 35 rows from base to apex. Pollen cones terminal, erect when shedding pollen but horizontal when old, straight or curved, 8–25 cm × 20–35 mm. Microsporophylls attached to a stout, 10 mm thick rachis, imbricate, the laminate part spreading at 45° with a free apex; stalk linear, 3–7 mm long; lamina broadly lanceolate to caudate, 6–9 × 3–5 mm; margins entire or weakly denticulate; abaxial surface smooth; apex acute or pungent. Pollen sacs 10–16, linear, 5–8 mm long. Seed cones terminal on short, very thick branches, usually solitary, erect, broadly ovoid, 8–12 × 5.5–8 cm. Bracts flabellate-cyathiform, 2–2.3 × 1.8–2 cm including rounded, thin membranous wings, distally thickened, ending in a caudate, upward curved, 15–20 mm long tip. Seed scales not wider than the seed; ligule triangular, 1–2 mm long. Seeds oblong, slightly narrowing towards base of scale, 16–20 × 9 mm, slightly flattened, striated longitudinally or smooth, brown when ripe.

Distribution

New Caledonia: Grande Terre, scattered throughout the island but more common in the southern half.
TDWG codes: 60 NWC

Ecology

This species occurs most often in 'maquis minier' on ultramafic soils derived from serpentine, peridotite or ironstone ('cuirasse de fer'), which may have weathered to brown laterite, and are very low in phosphorus and often contain nickel. Its altitudinal range is (150–)400–800(–1150) m a.s.l. The landscape is often described as (degraded) maquis with forest remnants in ravines, but *Araucaria rulei* does not occur in dense rain forest. It can be associated with *Agathis ovata*, another larger conifer that

dominates areas with shrubs rather than trees. A few collections were made in "forest", which would have been low evergreen forest that can be found in places with slightly better soil conditions. Some of the larger populations extend over several km², such as the one SE of Baie de Poro (Néjeré Dumwà); in other places only a few trees are present. They are almost always scattered and do not form closed forest stands.

Conservation

This species is fairly widespread, but unfortunately often occurs on sites that are subject to extensive nickel mining operations, which disturb all vegetation. One of the largest populations SE of Baie de Poro (Néjeré Dumwà), with many hundreds of trees, is located in such a mining area which has destroyed many trees. The trees, although regenerating, grow slowly, while the destruction of their habitat is complete when it has been stripped of all topsoil and much of the overburden of laterite to reach the mineral-richer bedrock underneath. Fires are also a hazard to this species as their incidence often increases with access provided by mining roads. Few populations are at present within protected areas.
IUCN: EN [A2ac, B2ab(ii,iii)]

Uses

This species is used in local ecological restoration projects, in which good results have been obtained. The wood is not exploited. Reports that it was in cultivation in Britain (Dallimore & Jackson, 1966), including cultivars, cannot be substantiated for lack of herbarium specimens and, in view of the limited knowledge the authors had of New Caledonia and its conifers, are likely to have pertained to another species.

Araucaria schmidii de Laub., Trav. Lab. Forest. Toulouse T. 1 (8, 5): 1. 1969. Type: New Caledonia: Grande Terre, Province Nord, Mt. Panié, *M. Schmid 858* (holotype P).

Etymology

This species was named after Maurice Schmid, who collected the holotype.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 30 m tall, to 0.8 m d.b.h.; trunk straight or curved, sometimes forked from near base and occasionally with three or as many as six trunks. Bark to 2.5 cm thick, exfoliating in horizontal strips; inner bark reddish; outer bark grey. Resin exudate not observed. Crown in mature trees columnar, branched along greater part of trunk, flat-topped; branching according to Massart's model. Primary first order branches of mature trees in pseudo-whorls of 5–7, 1–2 m long, spreading or ascending, slowly caducous beginning with branches lowest on the trunk. Adventitious foliage branches shorter than primary branches. Foliage branchlets strongly ascending or assurgent on distal parts of primary branches, of unequal length (7.5–25 cm), in two pectinate rows, shortening towards the end, 6–10 mm wide (including leaves), flexible; adventitious branchlets irregularly inserted and arranged. On mature trees leaves of two kinds: adult leaves and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets subulate-lanceolate, 5–9 × 1.2–2 mm, convex, 4-faced, keeled abaxially and often with a narrow groove adjacent to the keel; apex strongly incurved, acute. Stomata few near the abaxial leaf base; adaxial stomata in parallel rows from base to apex, indistinct. Leaves on adventitious branches acicular-linear, slightly incurved, 7–18 × 1–1.7 mm, keeled abaxially above base, pungent. Pollen cones terminal, initially erect but pendulous and curved at anthesis, 2–5 cm × 7–11 mm. Microsporophylls imbricate, spreading at 45° from a stout rachis, apically free at anthesis; stalk thin and weak, linear, 2 mm long; lamina triangular, 2–3 × 1.5–2.5 mm, terminating in an acuminate apex. Pollen sacs not observed. Seed cones terminal on short, stout foliage branches, erect, ovoid-oblong to broadly ovoid, 7–9 × 5–6 cm. Bracts flabellate, 2–2.5 × 2–2.5 cm including rounded, thin membranous wings, distally thickened and prominently keeled, ending in a rostrate, curved, 15 × 2.5 mm tip. Seed scales not wider than the seed; ligule fragile, 2 mm

long. Seeds obovoid-oblong, ca. 20 × 8 mm, smooth, brown when ripe.

Distribution

New Caledonia: Grande Terre, Province Nord, summit of Mt. Panié.
TDWG codes: 60 NWC

Ecology

Araucaria schmidii grows in dense humid montane cloud forest on steep slopes and exposed ridges at the edge of the summit plateau of Mt. Panié, on micaschist substrate and often directly from rock crevices. Its altitudinal range is 1400–1630 m a.s.l. This is the only New Caledonian *Araucaria* that grows exclusively on non-ultrabasic substrates. At its lowest limit on the mountain this species is still accompanied by *Agathis montana*, whereas near the summit it is the only tall tree, which is emergent above a dense undergrowth of evergreen angiosperm shrubs and small trees, as well as tree ferns (*Cyathea vieillardii*) and small palms. Mt. Panié's eastern slopes receive the highest rainfall on the island, estimated to exceed 8000 mm per year (Schmid, 1989; cited in Golte, 1993).

Conservation

The only confirmed population of this species, a few hundred trees, is that at Mt. Panié. It is the most inaccessible of all species due to its location on the summit of the highest mountain in New Caledonia, to which a primitive, very steep footpath through dense rain and cloud forest gives the only access. There is no prospect of mining due to the geology of this mountain massif. It occurs within an established nature reserve, for which there are expansion plans and, in future, to include it with the coastal reefs in a UN World Heritage Site (Henry Blaffart, pers. comm., 2005).
IUCN: VU (D2)

Uses

The wood is not exploited and no other uses have been recorded for this species.

Araucaria scopulorum de Laub., Trav. Lab. Forest. Toulouse T. 1 (8, 5): 1. 1969. Typ: New Caledonia: Grande Terre, Province Nord, Cap Bocage, *H. S. MacKee 18760* (holotype P). Pl. 7, Fig. 53, 54

Araucaria bernieri J. T. Buchholz var. *pumilio* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 21. 2000.

Etymology

The species epithet comes from the Latin *scopulorum* = of cliffs or crags.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 20 m tall, to 0.5 m d.b.h.; trunk straight. Bark to 2 cm thick, exfoliating in horizontal scales; inner bark reddish; outer bark grey with nearly white patches. Resin exudate clear or yellow, drying white or grey. Crown in mature trees irregular, open, branched along greater part of trunk, domed to flat-topped in older trees; branching according to Massart's model. Primary first order branches of mature trees in pseudo-whorls of 5–7, 1–2.5 m long, spreading nearly horizontally to ascending, caducous. Adventitious foliage branches similar to primary branches on mature trees but shorter. Foliage branchlets ascending or nearly erect near ends of primary branches, forming two pectinate rows, 10–20 cm long and shortening towards the end, 4–9 mm wide (including leaves), changing thickness along a single branchlet due to variable leaf sizes, flexible but standing nearly erect. On mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets ovate or obovate, 2.5–5.5(–6) × 2.5–3.5 mm, keeled abaxially; apex incurved, subacute; leaves subtending pollen cones spreading, straight, narrowly oblong-lanceolate, narrower than lower leaves on same branchlet and 2–3 times longer. Stomata mainly in 1–2(–3) rows nearest the keel on each abaxial face, extending ± to apex, on the

adaxial face in ca. 20 rows from near base to apex. Semi-juvenile leaves narrowly obovate to elliptic, 3.5–8 × 1.2–2.3 mm, curved and with an abaxial keel. Pollen cones terminal, solitary, initially straight but curved at anthesis, cylindrical, 2.5–5.5 cm × 10–12 mm. Microsporophylls spreading at 45° from a stout rachis; stalk thin and weak, 2–3 mm long; lamina ovate-triangular, appearing rhombic when connate, 2.5 × 2 mm; apex acute. Pollen sacs 6–8, linear, straight, 3 mm long. Seed cones terminal on short, stout foliage branches which widen below the cone, usually solitary, erect, broadly ovoid to subglobose, 5.5–9 × 4.5–7.5 cm. Bracts flabellate, 2–3(–3.4) × 1.8–2.5 cm including rounded, thin membranous wings, distally thickened and transversely keeled, ending in a 4–6 mm long, upturned, acute tip. Seed scales not or slightly wider than the seed; ligule fragile, 1.5–2 mm long. Seeds cuneate, 17–20(–24) × 6–9 (–10) mm, smooth, light brown when ripe.

Taxonomic notes

Small trees in the north (i.e. on Mt. Poum and Dôme de Tiébaghi), alluded to by de Laubenfels (1972) and previously regarded as *A. bernieri*, led Silba to describe *A. bernieri* var. *pumilio* based on MacKee 4832A. All trees from both localities that were previously considered to be *A. bernieri* belong to *A. scopulorum*.

Distribution

New Caledonia: Grande Terre, in two coastal areas, one along the central east coast and the other on the extreme NW coast (Mt. Poum, Dôme de Tiébaghi).
TDWG codes: 60 NWC

Ecology

Araucaria scopulorum occurs on rocky slopes and ridges, often wind-swept, on serpentine or peridotite, in degraded forest and in 'maquis minier'. Its altitudinal range is 5–600 m a.s.l. and it is predominantly coastal in its distribution. Especially typical of steep rocky slopes facing the sea in maquis or on nearly bare eroded rock and exclusively on ultramafic substrates.

Conservation

The distribution of this species nearly coincides with nickel mining areas and many populations are in or adjacent to active nickel mines. When compared with the distribution map given by the Laubenfels (1972) recent distribution data seem to register an increase, but this is an artefact due to more complete data, including collections made since 1972. In reality, numbers of trees and probably numbers of (sub-) populations are declining. Fire and erosion have also been noted as threats. None of the known populations of this species are within a protected area at present.
IUCN: EN [B1ab(ii–v)+2ab(ii–v)]

Uses

The wood is not exploited and no other uses are recorded in New Caledonia. This species is in cultivation in Tasmania.

Araucaria subulata Vieill., Ann. Sci. Nat. Bot., sér. 4, 16: 55. 1862. Type: New Caledonia: Grande Terre, Province Sud, Canala, ["Pleine de Canala"], *E. Vieillard 1278* (holotype P).

Etymology

The species epithet is from the Latin *subulata* = awl-shaped, in allusion to the leaf shape.

Vernacular names

No common names have been recorded for this species.

Description

Monoecious trees to 50 m tall, to 1.5 m d.b.h.; trunk straight. Bark to 3 cm thick, exfoliating in horizontal flakes and strips, scaly; inner bark red-brown; outer bark grey. Resin exudate white, very viscous. Crown in mature trees columnar but open, branched along greater part of trunk, often widest in top; branching according to Massart's model. Primary first order

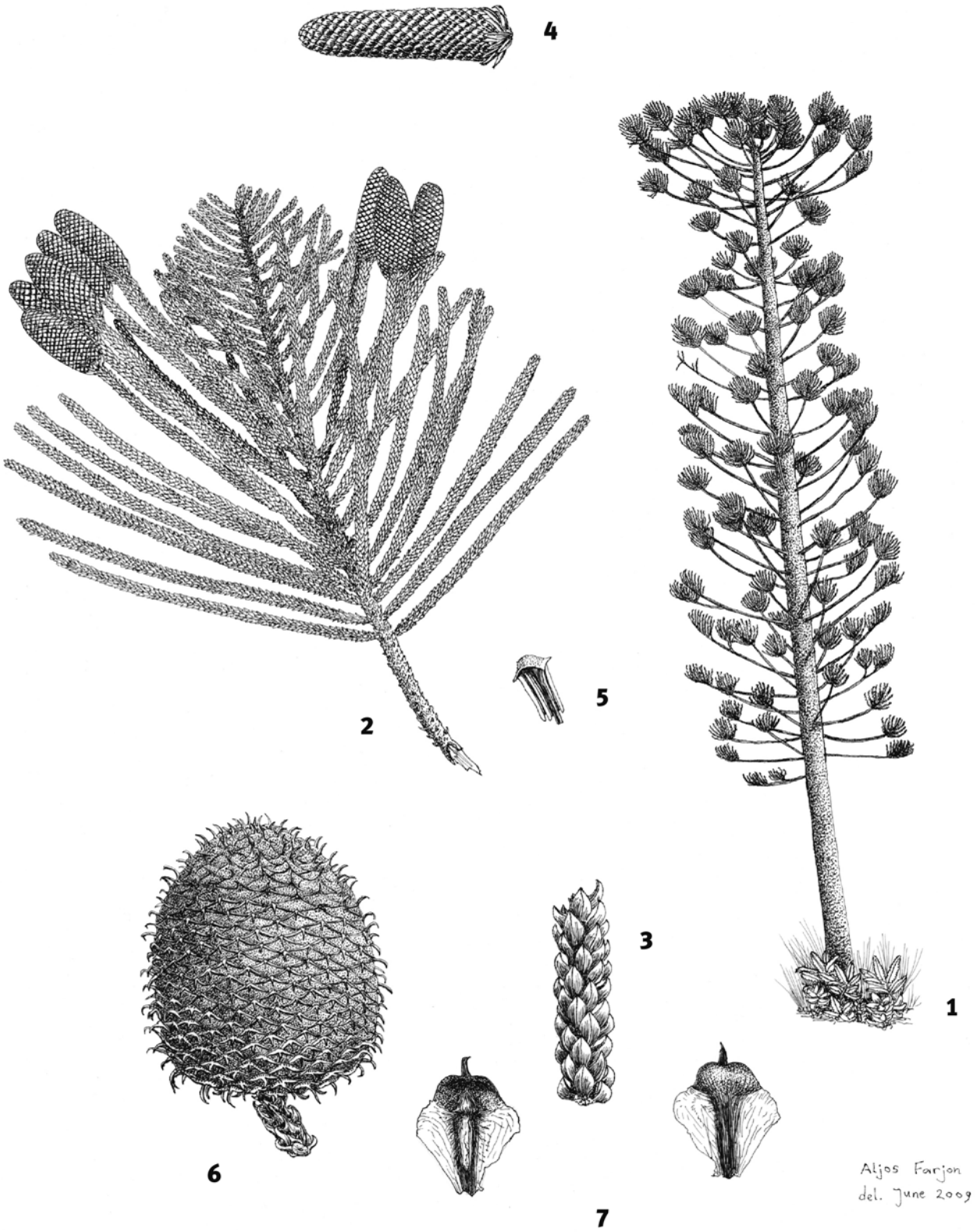


PLATE 7. *Araucaria scopulorum*. **1.** Habit of tree. **2.** Foliage branch with pollen cones. **3.** Section of branchlet with leaves. **4.** Pollen cone. **5.** Microsporophyll with pollen sacs. **6.** Seed cone. **7.** Seed cone scales.

branches of mature trees in pseudo-whorls of 5–7(–10) mostly restricted to the top of the tree, 0.5–1.5 m long, spreading or ascending, soon caducous. Adventitious foliage branches numerous. Foliage branchlets assurgent near ends of primary branches, of more or less equal length (30–50 cm) in two pectinate rows and shortening towards the end, 4.5–8 mm wide (including leaves), remaining of ± equal width from base to apex, flexible and whip-like. On mature trees leaves of two kinds: adult leaves on primary branches and semi-juvenile leaves on adventitious branches. Adult leaves on ultimate branchlets subulate to broadly lanceolate, (3–)4–6 × 1–2.5(–2.7) mm, very glossy abaxially, strongly incurved, acute, acuminate or obtuse. Stomata on the abaxial surface near leaf base, on the adaxial surface in several rows for most of leaf length. Semi-juvenile leaves awl-shaped or subulate, 4–8.5 × 0.5–1.2 mm; apex obtuse, non-pungent. Pollen cones terminal, cylindrical, initially erect and straight, pendulous and curved at anthesis, 5–10 cm × 12–14 mm. Microsporophylls imbricate, spreading at 45° from a stout rachis; stalk thin and weak, 5 mm long; lamina more or less triangular, 3–4 × 2–2.5 mm; apex acute or acuminate. Pollen sacs ca. 10, linear, 2.5–3 mm long. Seed cones terminal on short, stout foliage branches which widen below the cone, solitary, erect, subglobose or broadly ovoid, 7.5–12 × 6.5–10 cm. Bracts flabellate, 2.5–3 × 2.2–2.7 cm including rounded, thin membranous wings, distally thickened but thin-edged, ending in a caudate, upward curved, 8–10 mm long tip. Seed scales not wider than the seed; ligule fragile, 1–1.5 mm long. Seeds cuneate-oblong, 17–20 × 8–9 mm, striated longitudinally or smooth, light brown when ripe.

Distribution

New Caledonia: Grande Terre, Province Sud.
TDWG codes: 60 NWC

Ecology

Araucaria subulata is emergent in dense humid submontane to montane rainforest, at altitudes between 150 m and 1070 m a.s.l. It grows sometimes on cliffs; apparently always on ultramafic soils or rubble derived from peridotite or serpentine. It occurs frequently in ravines and steep valleys on the rainward side (E and SE) of mountains, with accumulation of litter and humus. This species is often co-dominant with *Agathis lanceolata* and *Montrouziera cauliflora* (*Guttiferae*) and emerges from a 12–30 m tall canopy of numerous evergreen angiosperms, among which sometimes *Nothofagus* sp. is abundant. *Podocarpus sylvestris* is another frequent coniferous tree in this forest type. Tree ferns (*Cyathea* sp.) and palms are also common, the former especially in clearings.

Conservation

This species is relatively common in the south, where it is associated with (remnants of) sub-montane rainforest. Outside protected areas, however, this type of forest is often threatened by deforestation and fires from already deforested surrounding areas. Mining is potentially of concern although at present no mining operations are known to exist in any of its localities. Several populations are within protected areas.
IUCN: NT

Uses

The wood is of high quality and has been locally exploited for use in carpentry.

Athrotaxis D. Don, Ann. Nat. Hist. 1: 234. 1838. *Arthrotaxis* Endl., Gen. Pl. Suppl. 1: 1372. 1841, orth. var. Type: *Athrotaxis selaginoides* D. Don (*Cupressaceae*).

Greek: *athroos* = crowded; *taxis* = arrangement; referring to the leaves or seed cone scales.

Description

Evergreen, monoecious trees to 30 m tall. Bark on young trees and branches smooth, flaking, on old trees furrowed, exfoliating in thin flakes and long, shredding strips, reddish to light brown. Branches forming a conical crown, sometimes layering to form satellite trees. Leaves helically arranged in ranks of 5, decurrent, imbricate, small and appressed or longer than 6 mm and spreading slightly or abruptly, rhombic-ovate to linear-lanceolate, keeled, lustrous green; margins entire; apex obtuse or acute. Pollen cones at base surrounded by shortened leaves, solitary, small; microsporophylls helically arranged, 10–15, broadly or narrowly triangular, bearing 2–4 oblong pollen sacs; pollen subspherical without a papilla. Seed cones terminal on foliage branchlets, solitary, globose or subglobose when opened, with to 30 helically arranged bract-scale complexes. Bract-scale complexes clavate-peltate, thin or thick woody, with a (prominently) exserted, incurved bract apex, adaxially without visible seed marks. Ovules in a single row adaxial on the narrowed base of each bract, anatropous. Seeds to 60 per cone, with two slightly unequal wings. Seedlings with 2 cotyledons.

3 species.

Distribution

Australia: Tasmania.

Key to the species of *Athrotaxis*

1a. Leaves scale-like, 3–6 × 2–3 mm. Seed cone scales with thickened, centrally depressed apex and small, protruding bract tip ***A. cupressoides***

1b. Leaves lanceolate to linear-lanceolate, (4–)7–18 × 2–4 mm. Seed cone scales with thin, not depressed apex and large, extended bract tip **2**

2a. Leaves 4–12 × 2–3 mm, mostly connate but with free apex ***A.* ×*laxifolia***

2b. Leaves 7–18 × 3–4 mm, the distal part spreading ***A. selaginoides***

Athrotaxis cupressoides D. Don, Ann. Nat. Hist. 1: 235. 1838. Type: Australia: Tasmania, ["VDLand" (Lindley's handwriting)], *R. C. Gunn [365] s.n.* (holotype CGE). Fig. 55

Etymology

The species epithet alludes to a resemblance with *Cupressus*.

Vernacular names

Pencil Pine

Description

Trees to 10–15 m, rarely 20 m tall; monopodial, erect, or very low branching to multi-stemmed; trunk up to 0.5–1 m diam. Bark on old trees furrowed, exfoliating in thin flakes and long, shredding strips, light brown. Branches thick, ascending or spreading, forming a conical crown, in old trees irregular and open, in multistemmed trees the lower branches form assurgent stems and separate crowns, layering is common in peaty, saturated soil. Foliage branches numerous, mostly alternate, spreading, scaly, angular with keeled leaves, ultimate branchlets 3–4 mm thick, mostly persistent. Leaves helically arranged in ranks of 5, 3–6 × 2–3 mm (larger on leading, older branchlets), fused at base, decurrent, imbricate, appressed, oblong, the visible part rhombic-ovate, keeled; margins thin hyaline, entire; apex obtuse, usually lustrous yellowish green to green; amphistomatic, with widely spaced stomata (on the adaxial face in two faint bands). Pollen cones terminal or subterminal, at base surrounded by shortened leaves, 3–5 mm long, yellowish, turning brown. Microsporophylls helically arranged, 10–15, broadly

triangular, obtuse, concave; upper margin denticulate; short pedicellate; pollen sacs (2–)3–4, oblong. Seed cones terminal on branchlets with normal scale leaves, solitary; mature cones globose or subglobose, 10–16 × 10–14 mm; with 10–15 helically arranged bract-scale complexes which slightly part at maturity. Bract-scale complex clavate-peltate, when fully grown thick woody, with centrally depressed apex with a protruding, recurved, acute bract tip; abaxial surface rough and wrinkled, reddish brown to dark brown; adaxial surface striated, dark brown without visible seed marks. Seeds 20–30 per cone, obovate-oblong, 1.5–2 mm long, with 2 wings of slightly unequal size and shape and ca. 1 mm wide positioned more or less in one plane.

Distribution

Australia: Tasmania, mainly on the Central Plateau, the Great Western Tier and westward mountains, more scattered in the S of the island.
TDWG codes: 50 TAS

Ecology

Commonly in the subalpine zone, where it often forms more or less dense stands, more scattered in the transition zone to montane *Eucalyptus* woodland; at higher altitudes often on lake shores or alongside streams and bordering 'Buttongrass moorland' or dwarf scrub. The altitudinal range is (700–)900–1300 m a.s.l. Associated with *Sphagnum cristatum, Gleichenia alpina, Leucopogon hookeri, Restio australis, Gymnoschoenus sphaerocephalus, Orites acicularis, Richea scoparia, R. pandanifolia, Nothofagus gunnii, Astelia alpina, Diselma archeri, Pherosphaera hookeriana, Athrotaxis selaginoides*, and *Eucalyptus coccifera*; at lower altitudes with *Eucalyptus* spp., *Nothofagus cunninghamii*, and *Phyllocladus aspleniifolius*. Soils are acidic, peaty or rocky and usually wet.

Conservation

This species is extremely fire sensitive and much of the total population was fire-killed mainly in widespread fires on the Central Plateau in 1960/61. All remaining areas of the species are now within IUCN Category I-IV reserves. Regeneration of the species is limited by grazing, mainly by introduced sheep and rabbits, of which the latter remain a problem. Dieback in which a species of the oomycete genus *Phytophthora* may be implicated occurs at some high altitude sites.
IUCN: VU [B1ab (ii, iii, v); B2ab (ii, iii, v)]

Uses

Usually a gnarled tree in its native habitat, this species never was a valuable timber tree. Its main importance is in horticulture, where it is sometimes offered in the trade, but more often encountered in arboreta and botanic gardens.

Athrotaxis* ×*laxifolia Hook., Icon. Pl., n.s., 2: t. 573. 1843. Type: Australia: Tasmania, *R. C. Gunn [369] s.n.* (holotype K).

Etymology

The species epithet refers to the 'lax' or easily bendable foliage.

Vernacular names

Not recorded.

Description

Trees to 10–15 m tall; monopodial, erect, in old trees up to 0.5 m diam. Bark on old trees furrowed, exfoliating in thin flakes and long, shredding strips, light brown. Branches thick, ascending or spreading, forming a conical, dense crown, in old trees irregular and open. Foliage branches numerous, mostly alternate, spreading, scaly, rough with free leaf apices, ultimate branchlets slender, of unequal length, mostly persistent. Leaves helically arranged in ranks of 5, 4–12 × 2–3 mm (larger on leading, older branchlets), decurrent, imbricate, the distal part spreading slightly, lanceolate, widest at the point of curvature, keeled; margins entire; apex incurved, obtuse, usually lustrous light green; leaves amphistomatic, with few stomata proximally on the abaxial face and two bands of widely spaced stomata adaxially, sometimes

epistomatic. Pollen cones terminal or subterminal, at base surrounded by shortened leaves, 3–5 mm long, up to 4 mm wide, yellowish, turning brown Microsporophylls helically arranged, ca. 15, narrowly triangular, curved, concave; upper margin denticulate, short pedicellate; pollen sacs 2, oblong. Seed cones terminal on branchlets with non-modified leaves, solitary; mature cones globose or subglobose, 15–26 × 14–20 mm, with 14–18 helically arranged bract-scale complexes which part widely at maturity. Bract-scale complex clavate-peltate, when fully grown thin woody, with slightly depressed apex and prominently extended, incurved, keeled bract apex; abaxial surface rough and wrinkled, reddish brown; adaxial surface striated, reddish brown without visible seed marks. Seeds 30–40 per cone, obovate-oblong, ca. 2 mm long, with 2 narrow wings of slightly unequal size and shape and 0.5–1 mm wide positioned more or less in one plane.

Taxonomic notes

In Tasmania, foresters and several botanists regard this species as a natural hybrid (F1) between the two other species. Flora of Australia 48 (1998) excluded it with this argument. Farjon (2005a) discussed the evidence and observed that it was inconclusive. This taxon may be of hybrid origin, as some other conifer species probably are, but it 'breeds true' and it is here maintained as a nothospecies.

Distribution

Australia: Tasmania, more scattered than the other two species, but sympatric with these.
TDWG codes: 50 TAS

Ecology

Commonly growing with *A. cupressoides* and/or *A. selaginoides* as single or scattered individuals.

Conservation

Because it occurs usually as solitary individuals, rarely in small groups, and generally with or near one or both of the other species *A. cupressoides* and *A. selaginoides*, it is at risk of extinction mainly because of its low number of individuals overall. Nearly all of these are now in reserves, where fire is the main threat.
IUCN: VU [B2ab (iii, v)]

Uses

This taxon has been taken into cultivation more often than its apparent rarity in the wild suggests and can be seen in several arboreta, especially, but not exclusively, in the British Isles.

Athrotaxis selaginoides D. Don, Ann. Nat. Hist. 1: 235. 1838. Type: Australia: Tasmania, ["VDLand" (Lindley's handwriting)], *R. C. Gunn [368] s.n.* (holotype CGE). Fig. 56, 57

Etymology

The species epithet alludes to similarity of the foliage with the lycopod genus *Selaginella*.

Vernacular names

King William Pine, King Billy Pine

Description

Trees to 20–30 m tall; monopodial, erect, in old trees up to 1.5 m diam., with a straight, clear bole in dense forest but stunted in exposed sites. Bark on on old trees shallowly furrowed, exfoliating in thin flakes and long, shredding strips, reddish to light brown. Branches thick, ascending or spreading, forming a conical, dense crown, in old trees irregular and open. Foliage branches numerous, mostly alternate, spreading, rough with spreading, stiff leaves, ultimate branchlets thick, of unequal length, mostly persistent. Leaves helically arranged in ranks of 5, 7–18 × 3–4 mm (larger on leading, older branchlets), decurrent, the distal part spreading abruptly, linear-lanceolate, widest at the point of curvature, keeled; margins entire; apex incurved, acute, usually lustrous light green; leaves amphistomatic, with few stomata proximally on the abaxial face and two broad and conspicuous bands of stomata separated by a midrib but uniting distally on the adaxial face, sometimes epistomatic. Pollen cones terminal or subterminal, at base surrounded by shortened leaves,

4–5 mm long, up to 5 mm wide, yellowish, turning brown. Microsporophylls helically arranged, ca. 15, narrowly triangular, curved, concave, short pedicellate; upper margin denticulate; pollen sacs 2, oblong. Seed cones terminal on branchlets with non-modified leaves, solitary; mature cones globose or subglobose, 15–25(–30) × 15–20(–30) mm, with 20–30 helically arranged bract-scale complexes which part widely at maturity. Bract-scale complex clavate-spathulate, when fully grown thin woody, with incurved apex and prominently extended, incurved, keeled bract apex; abaxial surface rough and wrinkled, dark brown; adaxial surface striated, dark brown without visible seed marks. Seeds 40–60 per cone, obovate, 2–3 mm long, with 2 narrow wings of slightly unequal size and shape and 0.5–1 mm wide positioned more or less in one plane.

Distribution

Australia: Tasmania, widely distributed in the highlands of W and SW parts of the island.
TDWG codes: 50 TAS

Ecology

Commonly in the transition zone to (above) montane *Eucalyptus* woodland; at higher altitudes less frequent, there often on lake shores or alongside streams in sheltered places. The altitudinal range is (400–)730–1200 m a.s.l. Associated with *Richea scoparia, R. pandanifolia, Nothofagus cunninghamii, N. gunnii, Atherosperma* spp., *Gahnia grandis, Telopea* spp., *Orites* spp., *Melaleuca* spp., *Leptospermum scoparium, Eucalyptus* spp., *Diselma archeri, Pherosphaera hookeriana*, and *Phyllocladus aspleniifolius*. Soils are more or less acidic, rocky (talus) or peaty and usually wet.

Conservation

The major cause of past decline has been fire, with about 1/3 of its habitat burnt in the 20th century. Like the other two species, *A. selaginoides* is sensitive to fire. Another cause of decline has been logging. Although 84% of forests are now in protected areas, fires still are a potential hazard. Tasmanian Government policy precludes logging of this species in and outside these reserves.
IUCN: VU [A2cd; B1ab (ii, iii, v)+2ab (ii, iii, v)]

Uses

King William pine provides some excellent wood for special uses like wood carving and turning. However, virtually all trees, including dead wood, are now within protected areas and removal is prohibited. In horticulture it is present only in arboreta and other botanical collections, especially in the British Isles, where several large trees can now be seen.

Austrocedrus Florin & Boutelje, Acta Horti Berg. 17 (2): 28. 1954. Type: *Austrocedrus chilensis* (D. Don) Pic. Serm. & Bizzarri [*Thuja chilensis* D. Don] (*Cupressaceae*).

Latin: *australis* = southern; *cedrus* = cedar; therefore 'southern cedar'.

Description

See the species description.

Distribution

As for the species.

Austrocedrus chilensis (D. Don) Pic. Serm. & Bizzarri, Webbia 32 (2): 482. 1978. *Thuja chilensis* D. Don, in Lambert, Descr. Pinus, ed. 8°, 2: 128. 1832; *Libocedrus chilensis* (D. Don) Endl., Syn. Conif.: 44. 1847. Type: Chile: ["Habitat in Andium Regni Chilensis montibus"], *J. A. Pavón y Jiménez [ex herb. A. B. Lambert] s.n.* (lectotype K).
Fig. 58, 59

Etymology

The species epithet refers to its country of origin.

Vernacular names

Chilean cedar, Cordilleran cypress; ciprès de la Cordillera, Ciprès (Spanish)

Description

Shrubs or trees to 15–20(–25) m tall, evergreen, dioecious, rarely monoecious; trunk multistemmed or monopodial to 1.5 m d.b.h. Bark smooth, soon flaking, orange-brown turning grey with brown inner bark, fissued and scaly, exfoliating in long strips. Branches numerous, spreading, assurgent in higher part of crown, persistent, forming a conical or pyramidal or more rounded crown in trees. Foliage branches dense, spreading in horizontal planes or assurgent, nearly erect in young trees, ultimate branchlets plagiotropic, opposite or nearly so, short, directed forward, covered by leaves, persistent, turning orange- to red-brown, soon grey. Leaves scale-like, decussate, in opposite ranks, dimorphic; facial leaves very small, ca. 1 mm, partly hidden by larger laterals, incurved-appressed, keeled, acuminate or obtuse; lateral leaves decurrent, bilaterally flattened, 3–4.5 mm long on ultimate branchlets, incurved; apex free or appressed, obtuse; margins entire; leaves (nearly) hypostomatic; stomata in depressed greenish white bands bordered by thick green margins on the abaxial side and in 2 small groups near base on the adaxial side; transitional leaf form on leading shoots (whip shoots) long decurrent (to 15 mm); laterals with a spreading, curved distal part terminating in an acute apex. Pollen cones terminal, solitary, 5–7 × 2–3 mm; microsporophylls 12–20, decussately arranged, imbricate, subpeltate with acuminate apex; pollen spherical, in 3–4 abaxial pollen sacs near the lower margin of the microsporophyll. Seed cones terminal, often numerous on ultimate branchlets with non-modified leaves, maturing in one year to ovoid-oblong, apically slightly flattened cones 7–14 × 4–7 mm. Bract-scale complexes 4, decussate, in pairs of very unequal size, the upper scales fertile and twice as large as the lower, ovoid-oblong, with a subapical curved umbo (bract tip), opening late, becoming woody, longitudinally striated or grooved abaxially, smooth adaxially, brown. Columella conical to more or less clavate, 2–3 mm long. Seeds 2–4 per cone, angular-ovoid, ca. 4 × 2.5 mm, brown with light yellowish hilum and 2 wings, one rudimentary, the other well developed, angular-oblong, 6–8 × 3–4 mm.

Taxonomic notes

First described as a species of *Thuja*, this taxon was transferred to *Libocedrus* by Endlicher (1847), then to a monospecific genus *Austrocedrus* by Florin & Boutelje (1954), who in creating the genus failed to cite the correct basionym. This error was corrected by Pichi Sermolli & Bizzarri, who thereby validated the currently used combination as cited above.

Distribution

Central and S Chile: Biobio, La Araucania, Los Lagos, Maule, O'Higgins, Santiago; S Argentina: Chubut, Neuquén, Rio Negro.
TDWG codes: 85 AGS-CB AGS-NE AGS-RN CLC-BI CLC-LA CLC-MA CLC-OH CLC-SA CLS-LL

Ecology

This species has a natural distribution accross nearly 12 degrees of latitude in the Andes, from 32° to 42°–44° S, thus ranging from a Mediterranean type climate to the cold montane Patagonian steppe climate. It generally shifts from N to S from the western slopes to the eastern slopes of the Andes, leaving more mesic conditions to other tree species. It often occurs in pure stands or mixed with *Nothofagus dombeyi* after quickly covering former disturbance areas (fire, earthquakes, volcanic deposits) but also grows associated with *Fitzroya cupressoides* in the coastal ranges and with *Nothofagus* spp. in the Andes. *Austrocedrus chilensis* gradually disappears in the wetter regions to the south where *Nothofagus* will eventually dominate after disturbances. Its tolerance to shade is relatively low, but apparently somewhat higher than of its common associate *Nothofagus dombeyi*, so that some individuals can persist in the understorey. It is longer-lived than its competitor, though not reaching more than 1000 years, usually around 500 years, so it can fill gaps left by fallen *Nothofagus dombeyi*. Its edaphic requirements are lower than for most tree species in the region, so it can occupy sandstone, volcanic, or granitic outcrops where other species will not establish, thereby extending its range into the wetter latitudes of the Southern Andes. Where it borders the Patagonian steppe it is the only tree species, but does not attain large size there.

Conservation

This species, though still wide spread, is under various pressures that make it potentially vulnerable to extinction. Felling, expansion of human habitation and agriculture, transformation of natural forest to plantation forest with exotic trees (*Eucalyptus, Pinus*), and fires have all played a role in the decline of its area of occupation. A dieback problem has been reported in the Argentinian populations (Havrylenko *et al.*, 1989). Seed viability is often low (down to less than 5%) due to insect predation (M. Gardner, pers. comm., 1996). Only a relatively small proportion of its populations is within protected areas in both countries (ca. 15% in Argentina). Grazing of livestock and feral deer is a problem both outside and inside these reserves. Large areas in which this species is abundant appear to exist in the Lake District of Argentina (AF pers. obs. Dec 2012).
IUCN: NT

Uses

Timber of Chilean cypress is used for general carpentry and furniture. Its fragrant and durable quality makes it especially suitable for panelling and for outdoor furniture. It is a useful species for horticulture, as in cultivation it usually grows a fastigiate, columnar habit (an as yet unexplained phenomenon seen also in other members of Cupressaceae, e.g. *Calocedrus decurrens*). Despite this it is still uncommon and largely confined to arboreta and other botanical collections. A few cultivars have been mentioned in the 19th century but may no longer be available.

Austrotaxus R. H. Compton, J. Linn. Soc., Bot. 45: 427. 1922. Type: *Austrotaxus spicata* R. H. Compton (*Taxaceae*).

Latin: *australis* = southern; *taxus* = yew; therefore 'southern yew'.

Description

See the species description.

Distribution

As for the species.

Austrotaxus spicata R. H. Compton, J. Linn. Soc., Bot. 45: 427. 1922. Type: New Caledonia: Grande Terre, Province Nord, Mt. Ignambi, *R. H. Compton 1155* (holotype BM). Fig. 60

Etymology

The species epithet (Latin *spicatus* = spike) refers to the pollen cones.

Vernacular names

New Caledonia yew.

Description

Trees to 25 m tall; trunk erect and straight to 60 cm d.b.h. in forest. Bark fibrous, exfoliating in short strips or on the lower trunk becoming tesselated, dark reddish brown weathering grey. Branches numerous, forming a dense crown. Foliage branchlets subopposite or more or less verticillate, spreading at 45–70° from the main branch, retaining leaves only towards ends, terete, with obtriangular to oval leaf scars. Terminal buds globose, ca. 3 mm wide and 2–3 mm long, with triangular, apiculate scales free at apex. Leaves alternate (helical), on juvenile plants longer than on mature trees, up to 17 cm long; on mature plants (4–)6–9(–12) cm long, spreading forward at 30–60° to shoot axis, crowded towards ends of branchlets except on vigorous leading shoots, narrowly lanceolate, 3.5–7(–9) mm wide near the middle, straight or slightly falcate, gradually widening from a 5–8 mm long petiolate base, gradually tapering to an acute apex; coriaceous, lustrous dark green above, light green below; margins slightly revolute. Midrib forming a narrow groove on the adaxial (upper) face from base to apex, on the abaxial side raised, 0.8–1.2 mm wide. Stomata in two broad bands of numerous wavy, intermittent lines on tha abaxial side only, bordered by narrow green margins and the midrib. Pollen cones axillary, solitary but aggregated near base of new foliage shoots, on a scaly short peduncle or dwarf shoot, elongating to 12–15 mm, catkin-like, creamy white, microsporophylls12–18, remote, spirally arranged, reniform, concave, on the adaxial side bearing two or three rows of globose pollen sacs, up to 8 sacs in the outer row and 2–3 larger ones in the inner row. Seed-bearing structures axillary, solitary near base of new foliage shoots, on a very short, scaly peduncle or dwarf shoot, the upper scales enlarged, imbricate, triangular, enclosing a single apical ovule. Aril almost entirely enclosing the seed, ovoid and slightly flattened when mature, 12–15 mm long, 7–9 mm wide, smooth, glaucous green ripening to orange, only leaving the seed apex free. Seed proper ovoid-oblong, yellowish brown with a darker apex and minute micropylar tip.

Distribution

New Caledonia: Grande Terre.
TDWG codes: 60 NWC

Ecology

Austrotaxus spicata is locally common in the montane tropical rainforests of the northern two thirds of the main island, Grande Terre. It has been found at altitudes between 500 m and 1350 m a.s.l. and appears on serpentine (ultramafic soils) as well as on acidic mica schist (Mt. Canala, Mt. Panié) or gneiss (Mt. Ignambi). It is associated with other conifers and angiosperms commonly found in the south of the island, so its (seeming?) absence there is somewhat mysterious. Its superficial resemblance to *Podocarpus* spp., with which it may occur together, makes it difficult to detect unless the tree is fertile, but other things being equal this applies to its entire range.

Conservation

This interesting species, an endemic to Grande Terre, appears to be relatively common and is not specifically exploited for its timber. It occurs often in inaccessible places and at least in several forest reserves, e.g. Table Unio, Mt. Panié, and Roches de Ouaième (proposed). The quest for anti-cancer drugs found in the alkaloid compounds of the family *Taxaceae*, which led to the exploitation of several species, does not seem to have affected this isolated species seriously. On the other hand, deforestation probably has had an impact on it, particularly in nickel mining concessions in the north of the island, and it is not safe from further developments in this increasingly spreading activity, particularly aimed at montane serpentine deposits (garnierite) within its altitudinal range.
IUCN: NT

Uses

No uses have been recorded of this species and it is not known to be in cultivation except as a few young plants in perhaps three botanic gardens (BGCI database, accessed May 2008). Its wood properties presumably resemble those of other members of *Taxaceae*, which are not commercial timber trees but can be put to specialized uses like furniture, wood turning and arts and crafts. This interesting species should be grown more in botanic gardens and other tree collections where climatic conditions are suitable.

Callitris Vent., Decas Gen. Nov.: 10. 1808. *Frenela* Mirb., Mém. Mus. Hist. Nat. 13: 30. 1825. [*Frenela triquetra* Spach] Type: *Callitris rhomboidea* R. Br. *ex* Rich. & A. Rich. (*Cupressaceae*).

Octoclinis F. Muell., Trans. & Proc. Philos. Inst. Victoria 2: 21. 1858. Type: *Octoclinis macleayana* F. Muell. [*Callitris macleayana* (F. Muell.) F. Muell.]. *Nothocallitris* A. V. Bobrov & Melikyan, Komarovia 4: 84. 2006. Type: *Nothocallitris sulcata* (Parl.) A. V. Bobrov & Melikyan [*Callitris sulcata* (Parl.) Schltr.].

Greek: *calli* = beautiful.

Description

Shrubs or trees, evergreen, monoecious. Resin cavities in leaves. Bark on trunks of large trees thick, deeply fissured, hard (soft and stringy in one species). Branches spreading or ascending, forming a bushy, conical, pyramidal or broadly domed crown. Fastigiate forms common in several species in nature. Ultimate branchlets covered with leaves, lateral branchlets shed continuously. Leaves scale-like, in alternate whorls of 3 (in one species also with acicular, spreading leaves in whorls of 4), decurrent, appressed, linear, abaxially convex or keeled, connate but parting with the thickening of branches, persisting several years, extremely variable in size dependent on growth of branches but on ultimate branchlets mostly less than 5 mm long; margins usually minutely denticulate, apical part slightly differentiated (e.g. thicker) from main length of the leaf. Pollen cones solitary or with 2–3 together at the tips of branchlets, small, short cylindrical; microsporophylls 8–20 in whorls of 3 or decussate, with 2–6 abaxial pollen sacs. Seed cones terminal on short leafy shoots, solitary or more often clustered and serotinous, (sub)globose when closed, early deciduous or more often persistent on branches and stems. Bract-scale complexes in two alternate whorls of 3 (in one species also in two whorls of 4), with the upper whorl usually the largest, valvate, thick, smooth, rugose or with verrucae on the abaxial surface and with light seed marks on the adaxial surface; bract tips subapical, small. Columella distinct, variably shaped, often trimerous, the lobes alternating with the upper whorl of scales. Seeds moderately numerous, with 2–3 wings. Seedlings with 2 cotyledons.

15 species.

Distribution

Australia including Tasmania; New Caledonia.

Synopsis

In the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a) two sections were accepted: section *Callitris* with 14 species and section *Octoclinis* with a single species, *Callitris macleayana*. A phylogenetic analysis based on multiple-gene DNA sequence data and comprehensive taxon sampling is still wanting. Despite this, the separation of the morphologically and ecologically distinctive species *C. macleayana* at section rank seems warranted and is here accepted.

Callitris sect. ***Callitris***
Species: *Callitris bailey* C. T. White, *C. canescens* (Parl.) S. T. Blake, *C. columellaris* F. Muell., *C. drummondii* ((Parl.) F. Muell., *C. endlicheri* (Parl.) F. M. Bailey, *C. monticola* J. Garden, *C. muelleri* (Parl.) Benth. & Hook. f. *ex* F. Muell., *C. neocaledonica* Dummer, *C. oblonga* Rich. & A. Rich., *C. preissii* Miq., *C. rhomboidea* R. Br. *ex* Rich. & A. Rich., *C. roei* (Endl.) F. Muell., *C. sulcata* (Parl.) Schltr., *C. verrucosa* (A. Cunn. *ex* Endl.) F. Muell.

Callitris sect. ***Octoclinis*** (F. Muell.) Benth. & Hook. f.
Species: *Callitris macleayana* (F. Muell.) F. Muell.

Key to the sections of the genus *Callitris*

1a. Seed cones with two whorls of ternate scales, only on branches with adult scale leaves. Bark smooth or hard and scaly **Section *Callitris***

1b. Seed cones with two whorls of ternate as well as quadrate scales, the latter on branches with juvenile needle leaves, both occurring in mature trees. Bark soft and stringy **Section *Octoclinis*, a single species *Callitris macleayana***

Key to the species of section *Callitris*

1a. Seed cones at the terminal end of thin foliage branchlets, solitary or a few together, caducous **2**
1b. Seed cones on short, thickened foliage branchlets, usually clustered, persistent **6**
2a. Dorsal surface of adult leaf rounded, not keeled **3**
2b. Dorsal surface of adult leaf distinctly (obtusely or acutely) keeled **4**
3a. Shrub or small tree. Seed cone scales narrowly oblong and nearly equal in size, ca. 3 mm wide. Endemic in New Caledonia ***C. sulcata***
3b. Tree. Seed cone scales unequal in size, wider than 4 mm. Widespread in mainland Australia ***C. columellaris***
4a. Shrub or small tree. Juvenile and transitional leaves persisting on young trees. Endemic to New Caledonia ***C. neocaledonica***
4b. Trees. Juvenile and transitional leaves restricted to seedlings. Native in mainland Australia **5**
5a. Bark of lower trunk thick, deeply fissured; leaves obtusely keeled ***C. endlicheri***
5b. Bark on lower trunk thin, shallowly fissured; leaves acutely keeled ***C. baileyi***
6a. Dorsal surface of adult leaf rounded, not keeled **7**
6b. Dorsal surface of adult leaf distinctly (obtusely or acutely) keeled **9**
7a. Seed cones verrucose when mature, more or less covered with small or large verrucae **8**
7b. Seed cones smooth or rugose when mature, verrucae absent ***C. canescens***
8a. Verrucae variable in density, often quite large in proportion to the cone, sometimes nearly absent ***C. preissii***
8b. Verrucae dense, equally distributed and never nearly absent, small in proportion to the cone ***C. verrucosa***
9a. Mature seed cones globose, smooth, with very small subapical bract tip not deforming the cone scale **10**
9b. Mature seed cones angular-globose or longer than wide, with large subapical bract tip deforming the cone scale **11**
10a. Seed cones (10–)12–15 mm wide, with tapering base from thickened shoot terminus; leaves obtusely keeled ***C. drummondii***
10b. Seed cones 15–25 mm wide, with abrupt base from shoot terminus; leaves acutely keeled ***C. muelleri***
11a. Seed cones mostly longer than wide, with markedly different lengths of scales in each whorl ***C. oblonga***
11b. Seed cones angular-globose; scales more equal in length **12**
12a. Seed cones whitish grey to metallic grey, weathering to dull grey. Restricted to SW Western Australia ***C. roei***
12b. Seed cones darker coloured. Eastern Australian species **13**
13a. Dwarf tree 1–3(–4) m tall; bark remaining smooth; leaves on ultimate branchlets 2–3 mm long. Restricted to a small area in NE New South Wales and SE Queensland ***C. monticola***
13b. Shrub or tree to 10–15 m; bark soon scaly, fissured; leaves on ultimate branchlets 3–6 mm long. Widespread from Queensland to Tasmania ***C. rhomboidea***

Callitris baileyi C. T. White, Proc. Linn. Soc. New South Wales 48: 449. 1923. Type: Australia: Queensland, Blackbutt Range, Benarkin, *W. D. Francis [BRI 192911] s.n.* (lectotype BRI).

Etymology

This species was named after Frederick M. Bailey (1827–1915) who collected the first specimens.

Vernacular names

Bailey's Cypress-pine

Description

Trees to 15–18 m tall, often less than 10 m; monopodial, usually branching low and often fastigiate, up to 50 cm d.b.h. Bark on trunk thin, shallowly furrowed

or fissured, hard, slowly exfoliating in small flakes and strips, greyish, inner layers light brown. Branches ascending at ca. 45° or steeper, slender, forming a conical or pyramidal, often symmetrical crown. Foliage branchlets sparse, ascending or erect, twisted and rigid, triangular in cross section, 0.8–1.2 mm diam., covered with closely appressed leaves. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or free on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 2–5(–7) mm long on ultimate branchlets, 0.7–1.2 mm wide, abaxially acutely keeled; margins denticulate near obtuse or acute apex; epistomatic, stomata in two narrow, marginal bands; abaxial surface smooth, green. Pollen cones solitary or 2–3 together and terminal on ultimate branchlets, oblong, 2–3 × 1–1.2 mm, yellowish green turning light brown; microsporophylls 8–14, in alternate whorls of 3 or decussate near apex, peltate, with hyaline, erose-denticulate margins, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thin, leafy shoots, solitary, maturing in 1–1.5 years, caducous, subglobose to broadly ovoid when closed, 10–13 × 9–12 mm, smooth but becoming rugose when open, brown or purplish brown weathering grey. Bract-scale complexes in 2 alternate whorls of 3, deeply incised towards cone base but not opening very wide; upper ones largest, ca. 10 × 5 mm, tapering to an obtuse apex; smaller ones narrowly triangular, acute; bracts largely included, showing a prominent apex below the apex of each scale; adaxial surface reddish brown or brown with light seed marks. Columella robust in comparison to small cone (as high as shortest scales in open cones), 3–4 × 2–2.5 mm, more or less triangular in cross-section, usually slightly narrowed at base, obtuse. Seeds 2–4(–5) on each scale, ovoid or triangular, flattened, up to 6–7 mm including wings (seed body 2–3 mm), brown with large, whitish concave hilum, wings 2, lateral, very unequal in size and shape, up to 4 mm long.

Distribution

Australia: SE Queensland (Blackbutt Range, Bunya Mts., Coast Range, Leichhardt Highway, West Moreton), NE New South Wales (Clarence River, Killarney, Tabulam).
TDWG codes: 50 NSW-NS QLD-QU

Ecology

In *Eucalyptus* forest or woodland, with *Eucalyptus crebra* or other species, often in small groups scattered through forest; in hills and low mountains on basalt and volcanic ash or in sandy soil with boulders. The climate is mild, with most rainfall in the summer.

Conservation

Decline has mainly come from changes in habitat due to pressures from grazing and increased hazard of fires. Several populations are now within protected areas (National Parks), but decline is likely to continue outside these localities.
IUCN: NT

Uses

The wood of this species was traditionally used for fence posts. It is extremely rare in cultivation, limited to a few botanic gardens.

Callitris canescens (Parl.) S. T. Blake, Proc. Roy. Soc. Queensland 70: 39. 1959. *Frenela canescens* Parl. in Candolle, Prodr. 16 (2): 448. 1868. Type: Australia: Western Australia, ["Int. S.W. Australia"], *J. S. Roe s.n.* (lectotype G?, *n.v.*, isolectotype K).
Fig. 61

Etymology

The species epithet means 'greyish' or 'turning grey' and may refer to the seed cones.

Vernacular names

Morrison's Cypress-pine

Description

Shrubs or small trees to 5–6 m; trunk short, usually branching low or monopodial. Bark on stems wrinkled, finally scaly near base, exfoliating in flakes, grey. Branches numerous, ascending or nearly erect (fastigiate), contorted, higher order branches slender, terete, forming a conical, pyramidal or bushy dense crown. Foliage branchlets numerous, erect,

ultimately very slender, terete, 0.6–0.7 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed; apices barely free, connate but parting with thickening of branches; persisting 3–4 years, linear, 1.5–3 mm long on ultimate branchlets, up to 1 mm wide, abaxially convex; margins denticulate near apex; epistomatic, stomata near the margins of leaves only; abaxial surface granulate with globular epidermal cells. Pollen cones terminal on ultimate branchlets, numerous, ovoid or subglobose, 1.5–2 × 1 mm, yellowish green turning brown; microsporophylls 9–12, in alternate whorls of 3, peltate, with erose margins, bearing 3(–4) abaxial pollen sacs near the lower margin. Seed cones terminal on short, thickened, leafy shoots, solitary or more commonly aggregated, persistent, depressed globose when closed, (10–)12–14(–16) × (11–)13–15(–19) mm, smooth to coarsely rugose when dry, light brown turning (metallic) grey. Bract-scale complexes in 2 alternate whorls of 3, the upper ones largest, 10–14 × 6–8 mm, tapering to an obtuse apex; the smaller ones narrower 8–10 × 5–7 mm, acute; bracts almost entirely included, showing a minute prickle below the apex of each scale; adaxial surfaces dark grey with whitish seed marks towards base. Columella simple, 2–3 mm long, obtuse or acute-triangular. Seeds 3–6 on each scale, of variable shapes and sizes up to 7 mm including wings (seed body 1–3 mm), blackish brown with light hilum, wings 2–3 surrounding the seed as a 2–3 mm wide margin, curved to accomodate neighbouring seeds when growing.

Distribution

SW and SE Western Australia, South Australia (Eyre Peninsula, Murray River, Nullarbor Plain, Yorke Peninsula).
TDWG codes: 50 SOA WAU-WA

Ecology

In dwarf scrubland ('kwongan') with *Myrtaceae* (*Melaleuca*), *Proteaceae* (e.g. *Banksia, Dryandra, Grevillea, Hakea*), or low *Eucalyptus* woodland ('mallee') with other *Myrtaceae* (e.g. *Melaleuca*), *Proteaceae* (e.g. *Banksia, Grevillea, Hakea*), *Acacia* spp., and *Allocasuarina* spp.; often in strips of natural vegetation between roads and ploughed fields or in disturbed vegetation; on plains or low ridges ('breakaways') in leached white, yellow or red (gravelly) sand or loam, or on laterite (hardpan) over granite, sandstone or limestone. The altitudinal range is from 250 m to 380 m a.s.l. The climate is characterized by warm, dry summers and winter rainfall.

Conservation

IUCN: LC

Uses

This species is not in cultivation outside botanical collections. Australian gardeners generally show little interest in the native flora and prefer to import shrubs and trees cultivated in Britain. In Mediterranean countries (and perhaps with a warming climate soon elsewhere in Europe?) this species should be cultivated more often.

Callitris columellaris F. Muell., Fragm. 5: 198. 1866. Type: Australia: New South Wales, Richmond River, ["Richmond River Entrance"], *J. A. Henderson [ex herb. F. von Mueller] MEL 1596576* (lectotype MEL). Fig. 62

Frenela robusta A. Cunn. *ex* Endl. var. *microcarpa* Benth., Fl. Austral. 6: 237. 1873; *Callitris columellaris* F. Muell. var. *microcarpa* (Benth.) Govaerts, World Checklist Seed Plants 3 (1): 12. 1999.
Callitris intratropica R. T. Baker & H. G. Smith, Res. Pines Austral.: 172. 1910; *Callitris columellaris* F. Muell. var. *intratropica* (R. T. Baker & H. G. Smith) Silba, Phytologia Mem. 7: 16. 1984.
Callitris columellaris F. Muell. var. *campestris* Silba, Phytologia Mem. 7: 16. 1984.
Callitris glaucophylla J. Thompson & L. A. S. Johnson, Telopea 2 (6): 731. 1986.

Etymology

The species epithet refers to a 'columella', i.e. the central, columnar structure in the seed cone.

Vernacular names

White Cypress-pine, White Pine, Murray River Pine, Murray Pine, Western Sand Cypress, Western Cypress, Cypress Pine, Northern Cypress-pine

Description

Trees to 20 m tall; trunk monopodial, usually branching low or occasionally forked, up to 50 cm d.b.h. Bark soon scaly, on trunk deeply fissured, hard, exfoliating in small flakes and strips, grey-brown. Branches spreading or near the top ascending, long, forming a conical, pyramidal or broadly domed, more or less open crown. Foliage branchlets numerous, spreading or ascending, ultimately very slender, terete, 0.7–1.0 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or free on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 2–6 mm long on ultimate branchlets, 0.4–0.8 mm wide, abaxially convex; margins denticulate near slightly broadened acute-acuminate apex; epistomatic, stomata in two marginal lines, abaxial stomata near base of leaves only or absent; abaxial surface weakly verrucose, green or glaucous, variable with many intermediate shades of colour. Pollen cones numerous, solitary or paired and terminal on ultimate branchlets, ovoid-oblong, 3–4 × 1.5 mm, yellowish green turning orange-brown; microsporophylls 10–18, in alternate whorls of 3, peltate, with erose margins, bearing 3(–4) abaxial pollen sacs near the lower margin. Seed cones terminal on short, thin, leafy shoots, solitary but often numerous on higher order branches, maturing in 1–1.5 years, caducous, globose when closed, (7–) 10–18 × (10–)12–20 mm, smooth or rugose to slightly pustulate, glaucous-brown or purplish brown weathering grey. Bract-scale complexes in 2 alternate whorls of 3, deeply incised towards cone base when opened; upper ones largest, 8–12 × 6–8 mm, tapering to an obtuse apex; smaller ones narrower 6–8 × 4–6 mm, acute; bracts almost entirely included, showing a minute prickle below the apex of each scale; adaxial surfaces reddish brown or dark brown with light seed marks towards base. Columella variably shaped, up to 6 mm long, obtuse or acute-triangular. Seeds 4–10 on each scale (the higer number on larger scales), triangular, flattened, up to 8 mm including wings (seed body up to 4–5 × 2–3 mm), dark brown with whitish concave hilum; wings 2 on opposite sides, 4–5 mm wide, more or less equal in shape and size.

Taxonomic notes

Treatment of *Callitris glaucophylla* and *C. intratropica* as taxonomic synonyms under a (slightly) broader circumscription of *C. columellaris* has been explained and justified in detail in the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a).

Distribution

Australia: In all states and territories except Tasmania, but absent from low lying deserts and moist coastal regions.

TDWG codes: 50 NSW-NS NTA QLD-QU SOA VIC WAU-WA

Ecology

In a wide range of semi-arid to more mesic habitats, from banks or dunes near the sea to rocky canyon bottoms and sandstone plateaux in the interior. In open *Eucalyptus* forest or low woodland ('mallee') with *Eucalyptus* spp., *Melaleuca* spp., *Allocasuarina* spp., *Acacia* spp., *Banksia* spp., *Grevillea* spp., *Triodia* spp., and *Callitris endlicheri*; in disturbed (grazed) open woodland; in the dry interior in *Acacia* low woodland or scrub ('mulga') with *A. aneura* and other *Acacia* spp., *Eremophila* spp., in hummock grassland/ scrub with 'spinifex' (*Triodia* sp.); and in rocky (sandstone) canyons and on ridges with *Eucalyptus* spp., *Acacia* spp., and *Macrozamia macdonnellii*. On (coastal) sand dunes near sea level, on plains, hills, tablelands, ridges and low mountains to 1300 m a.s.l. in white, yellow, brown or red sand or loam or on gravelly laterite (hardpan) over sandstone, ironstone, conglomerate, gypsum, shale, basalt or granite. The climate varies from mesic and mild on the coast of New South Wales to arid in the interior of Australia; for most of its range this species occurs within the zone with summer rainfall.

Conservation

IUCN: LC

Uses

Timber of this species was (is?) used for panelling in cabinet making, and also for fence posts when these

were still predominantly of wood. As with many species in *Cupressaceae*, the wood is resistant to rot and, in this case, also to termite attack. Baker & Smith (1910) reported a decline in its availability in many regions without efforts to restock it. Its exploitation is now much less intensive and regeneration is taking place in many localities. Its horticultural use is very limited. In Australia, there seems to be little interest in this and other native conifers, but its variability in foliage colour from dark green to extremely glaucous should afford scope for horticultural selection and planting in regions with a Mediterranean or even desert climate.

Callitris drummondii (Parl.) F. Muell., Syst. Census Austral. Pl. 1: 109. 1882. *Frenela drummondii* Parl. in Seemann, J. Bot. 1: 35. 1863. Type: Australia: Western Australia, Southern Coastal Region, ["In Nova Hollandia austro-occidentali ad Cynorem flumen legit Cl. J Drummond"], *J. Drummond [ex herb. F. von Mueller] 433* (holotype FI).

Etymology

This species was named after J. Drummond, who collected the type specimens.

Vernacular names

Drummond's Cypress-pine

Description

Shrubs or small trees to 5–6(–10) m; multistemmed or monopodial, usually branching low, up to 20 cm d.b.h. Bark smooth on young trees and branches, soon scaly, on the lower stem(s) fissured, hard, grey. Branches spreading to ascending, forming a conical or broad, rounded crown. Foliage branchlets numerous, ascending, ultimately relatively coarse, articulate and triangular in cross section, 1.5–2.2 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, connate but parting with thickening of branches, persisting several years, linear, 2–6 mm long on ultimate branchlets, 1–1.8 mm wide, abaxially keeled; margins denticulate near acute or obtuse apex; epistomatic, stomata in two marginal lines; abaxial surface weakly verrucose or smooth, yellowish green or green. Pollen cones solitary or in pairs and terminal on ultimate branchlets, ovoid-oblong, 3–6 × 1.5–2 mm, yellowish green turning light brown; microsporophylls 12–20, proximal ones in alternate whorls of 3, distal ones decussate, subpeltate, with hyaline-denticulate margins; apex acuminate; bearing 3 abaxial pollen sacs near the lower margin. Seed cones terminal on short, 5–6 mm thick, leafy shoots, solitary but often grouped along limited lengths of stems, maturing in 1–1.5 years, persistent, (depressed-)globose when closed, tapering at base to thickened terminus of shoot, (10–)12–15 × (10–)12–17 mm, smooth or rugose when dry with opened scales, purplish grey to metallic grey. Bract-scale complexes in 2 alternate whorls of 3, not deeply incised towards cone base and hence not opening widely; upper ones largest, 10–12 × 8–10 mm, tapering to an angular-obtuse apex; smaller ones narrower 8–10 × 6–8 mm, acute, all very thick; bract tip minute, only visible in smooth, closed cones below the apex of each scale; adaxial surfaces dark brown with light seed marks at margins near base. Columella very thick, 3–5 mm long and wide at base, (tri-)angular or terete, obtuse. Seeds usually only 2 on each scale, angular, flattened, up to 7 mm including wings (seed body 2–3 × 2 mm), brown with whitish concave hilum; wings 2 on opposite sides, 1–2 and 2–4 mm wide, unequal in shape and size.

Distribution

SW Western Australia, in a strip along or near the coast of the Southern Ocean from Albany to Cape Arid.
TDWG codes: 50 WAU-WA

Ecology

In scrubland ('*Melaleuca*-thicket') or low open *Eucalyptus* woodland ('mallee') with *Eucalyptus* spp., *Melaleuca* spp., and *Acacia* spp.; also along margins of (dry) salt lakes and flats, in dry stream beds and in disturbed vegetation on roadsides; on soils varying from white to dark brown sand, loam, silt or clay over sandstone, limestone or gravelly laterite (hardpan). Its altitude ranges from 10 m to 250 m a.s.l. The climate is characterized by warm, dry summers and winter rainfall.

Conservation

Outside reserves this species occupies mainly strips of (semi)natural vegetation left alongside roads, a situation which has made the species more vulnerable to fires in these areas as these now occur more frequently. Overgrazing is also a threat in some areas. On the other hand, several good size populations are within reserves where these factors can be managed to benefit the natural vegetation.

IUCN: NT

Uses

This species is not in cultivation outside botanical collections. In Mediterranean countries (and perhaps with a warming climate soon elsewhere in Europe?) this species should be cultivated more often since it grows into an attractive shrub.

Callitris endlicheri (Parl.) F. M. Bailey, Syn. Queensland Fl.: 497. 1883. *Frenela endlicheri* Parl., in Candolle, Prodr. 16 (2): 449. 1868. Type: Australia: Victoria, Murray Valley District, Warby Ranges, ["Futters Range"], *F. von Mueller MEL 503743* (lectotype MEL).

Etymology

This species was named after Stephan F. L. Endlicher (1804–1849) an Austrian botanist who published an early manual of conifers.

Vernacular names

Black Cypress-pine, Black Pine, Red Cypress-pine, Red Cypress, Red Pine, Mountain Pine, Scrub Pine, Murray Pine

Description

Trees to 15–20 m tall; monopodial, usually branching low and occasionally fastigiate, up to 50 cm d.b.h. Bark soon scaly, on lower trunk very thick, deeply fissured, hard, dark grey-brown, inner layers red-brown. Branches ascending usually at ca. 45°, short or long in fastigiate crowns, slender, forming a conical or pyramidal, more or less open crown. Foliage branchlets numerous, spreading or ascending, ultimately very slender, triangular in cross section, 0.6–1 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or free on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 2–6 mm long on ultimate branchlets, 0.3–0.7 mm wide, abaxially keeled; margins denticulate near slightly broadened acute-acuminate apex; episotomatic, stomata in two narrow, marginal bands; abaxial surface weakly verrucose, (dark) green. Pollen cones numerous, solitary or paired and terminal on ultimate branchlets, ovoid-globose to oblong, 1.5–2.5 × 1–2 mm, yellowish green turning orange-brown; microsporophylls 8–14, in alternate whorls of 3, peltate, with denticulate margins, bearing 2–4 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thin, leafy shoots, solitary but often grouped together in loose clusters, maturing in 1–1.5 years, caducous, ovoid-globose when closed, 13–20 × 10–16 mm, smooth or finely rugose when open, brown or purplish brown weathering grey. Bract-scale complexes in 2 alternate whorls of 3, deeply incised towards cone base when opened; the upper ones largest, 10–16 × 8–12 mm, tapering to an obtuse apex; the smaller ones narrower 8–10 × 5–7 mm, acute; bracts almost entirely included, showing a minute prickle below the apex of each scale; adaxial surface reddish brown or dark purplish brown with light seed marks. Columella trilobed to tripartite, 2–8 mm wide, obtuse. Seeds 5–9 on each scale, ovoid or triangular, flattened, up to 8 mm including wings (seed body ca. 3 × 2 mm), dark brown with large, yellowish concave hilum; wings 2–3 on sides, 2–3 mm wide, more or less equal in shape and size.

Distribution

Australia: New South Wales, Queensland, E Victoria.
TDWG codes: 50 NSW-NS QLD-QU VIC

Ecology

In open *Eucalyptus* woodland or forest, in secondary scrub or woodland, or in grassland, often in disturbed or altered vegetation with invasives like *Cytisus scoparia* and *Pinus radiata*. Associated with *Eucalyptus* spp., other *Myrtaceae* (e.g. *Callistemon, Kunzea, Leptospermum*), *Proteaceae* (e.g. *Banksia, Grevillea*), *Acacia* spp., *Allocasuarina* sp., *Bursaria*

lasiophylla, Daviesia sp., *Dodonaea viscosa*, and *Callitris rhomboidea*. On usually very shallow (gravelly) sand or loam, or in deep rock crevices, or amongst boulders over sandstone, conglomerate, slate, quartzite or granite, often on steep slopes; also in disturbed soil on roadsides. The altitude varies between 350 m and 1100 m a.s.l. The climate is mesic to summer dry; frost and snow occur occasionally at higher altitudes.

Conservation

Cutting for timber and fence posts has had an impact in the past, but these pressures are now substantially alleviated by an economic shift to other sources for these materials. The species is not substantially affected by conversion of its habitat to agriculture or plantation forestry due to its occurrence on poor sites.
IUCN: LC

Uses

Timber of this species was much used for fence posts in the past, the worked wood also for construction, and when finely figured it was and still is valued for indoor finishing of rooms (panelling, wainscoting), furniture and some decorative applications. The bark was used for tanning and some resin was tapped from the tree trunks. It is not considered attractive as an amenity tree in Australia, but some planting of stony wasteland with this undemanding tree has been successfully undertaken. It is present in a few botanic gardens in countries with a mild, summer-dry climate.

Callitris macleayana (F. Muell.) F. Muell., Rep. Burdekin Exped.: 17. 1860. *Octoclinis macleayana* F. Muell., Trans. & Proc. Philos. Inst. Victoria 2: 22. 1858. Type: Australia: New South Wales, Port Macquarie, Tacking Point, *W. S. Macleay s.n.* (holotype K). Fig. 63, 64

Etymology

This species was named after William John Macleay (1820–1891) parlementarian of New South Wales, Australia.

Vernacular names

Stringybark Pine, Port Maquarie Pine, Brush Cypress-pine

Description

Trees to 30(–39) m tall; monopodial, usually self-pruning forming a clear bole to 10 m or more, up to 1 m d.b.h. Bark soon scaly, on trunk deeply fissured, soft, stringy and fibrous, sometimes scaly, exfoliating in long strips, reddish brown or light brown. Branches spreading wide or ascending, long and thick, forming a pyramidal or broadly domed, more or less open crown. Foliage branchlets in tufts, spreading, ultimately slender, triangular in cross-section if with scale leaves and ca. 1 mm diam., covered with decurrent leaves, persistent. Leaves of two types on mature trees, scale leaves in alternate whorls of 3, acicular leaves mostly in whorls of 4, all decurrent. Scale leaves predominantly in upper parts of crown, closely appressed, apices appressed or free on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 1.5–3 mm long on ultimate branchlets, 0.6–0.8 mm wide, abaxially strongly keeled; margins erose-hyaline near acute apex. Acicular (juvenile) leaves predominantly in lower parts of crown, free part spreading, 8–15 mm long, abaxially keeled; margins entire; apex pungent. Leaves epistomatic, stomata in two marginal bands; abaxial surface smooth, green. Pollen cones solitary and terminal on ultimate branchlets with scale leaves, oblong, 4–6 × 2–2.5 mm (elongating to ca. 8 mm), yellowish green turning light brown; microsporophylls 15–20, in alternate whorls of 3, peltate, with erose margins and acute apex, bearing 3–4 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, recurved, leafy and often glaucous shoots, mostly solitary, maturing in 1 year, persistent, ovoid-conical or conical when closed, 15–35 × 18–35 mm, smooth becoming rugose, maturing dark brown. Bract-scale complexes in 2 alternate whorls of 3 on branches with scale leaves and of 4 on branches with acicular leaves, deeply incised towards cone base but not opening wide, very thick near base, nearly equal in size and shape, concave abaxially, tapering to an acute, slightly recurved apex; adaxial surfaces angular, reddish brown with light seed marks at the base.

Columella short, tri-lobed or 4-lobed, often reduced to low ridges. Seeds not exceeding 10–12 per cone, ovoid, flattened, up to 8 mm long, dark brown with whitish concave hilum; only one wing develops to a length of 8–10 mm, the other rudimentary.

Taxonomic notes

This species is unique in the genus in having polymorphism in mature trees in phyllotaxis and leaf shape. Small scale leaves occur in alternating whorls of three and are appressed, as in other species. Acicular leaves are arranged in alternating whorls of four and have spreading free parts. Because the number and arrangement of cone scales strictly follow shoot phyllotaxis and both types of shoot are fertile, both 6- and 8-scale cones occur, often on the same tree. Four-whorled phyllotaxis is restricted to the seedlings in other species of *Callitris* and does not reappear in the crown of mature trees. The only real distinction then is the persistence of juvenile traits in the foliage of this species; the difference in the number of cone scales follows from it and is not an independent character. The different bark structure, reminiscent of that found on *Sequoia* and *Sequoiadendron*, may be a more distinct feature. As an adaptive trait it is likely to be a parallelism, but a more detailed anatomical investigation or phylogenetic analysis would be necessary to confirm or refute this hypothesis.

Distribution

Australia: On the eastern slopes of the Great Dividing Range and along the coast in New South Wales N of Newcastle to extreme SE Queensland.
TDWG codes: 50 NSW-NS QLD-QU

Ecology

In subtropical rainforest remnants with *Ficus obliqua, Drypetes australasia, Archontophoenix cunninghamiana*, and *Podocarpus elatus*; also in wet sclerophyll forest bordering rainforest with *Eucalyptus microcorys, E. pilularis, Ceratopetalum apetalum, Allocasuarina torulosa, Acacia* spp., *Tristania* spp., and *Trochocarpa laurina*. In hollows, gullies, sheltered near-coastal flats, or rain-facing (E) slopes, on red-brown clay (dolorite) or loam. The altidudinal range is from near sea level to around 1000 m a.s.l. The climate is subtropical to warm temperate and mesic, with a rainfall peak during the summer (range 1000–2000 mm/a); frost does not occur in the northern localities and is rare and light in the N.S.W. upland localities.

Conservation

Large trees in more accessible terrain have in the past been logged more extensively than they have regrown to date, with the result that such trees have become very rare. However, the species has regenerated well in most of its natural localities. Forest fires are a potential threat that requires adequate management with the conservation of this species as an objective. Its thick bark may make large trees with branch-free boles resistant to light fires that only burn through the undergrowth.
IUCN: LC

Uses

The timber of this species is free of knots in large boles and has been used for shingles and weatherboards, and also for cabinet making and joinery. As in many species of *Cupressaceae* it is decay resistant and, especially relevant in Queensland, termite resistant as well, so it has been used for fence posts. The use of metal rods for agricultural fencing has largely replaced this application. Stringybark Pine is not known in horticulture outside a few botanic gardens.

Callitris monticola J. Garden, Contr. New South Wales Natl. Herb. 2 (5): 385. 1957. Type: Australia: Queensland, ["Wallangarra, Queensland"], *W. A. W. de Beuzeville NSW 22815* (holotype NSW).
Pl. 8

Etymology

The Latin species epithet *monticola* means 'living in mountains'.

Vernacular names

Steelhead

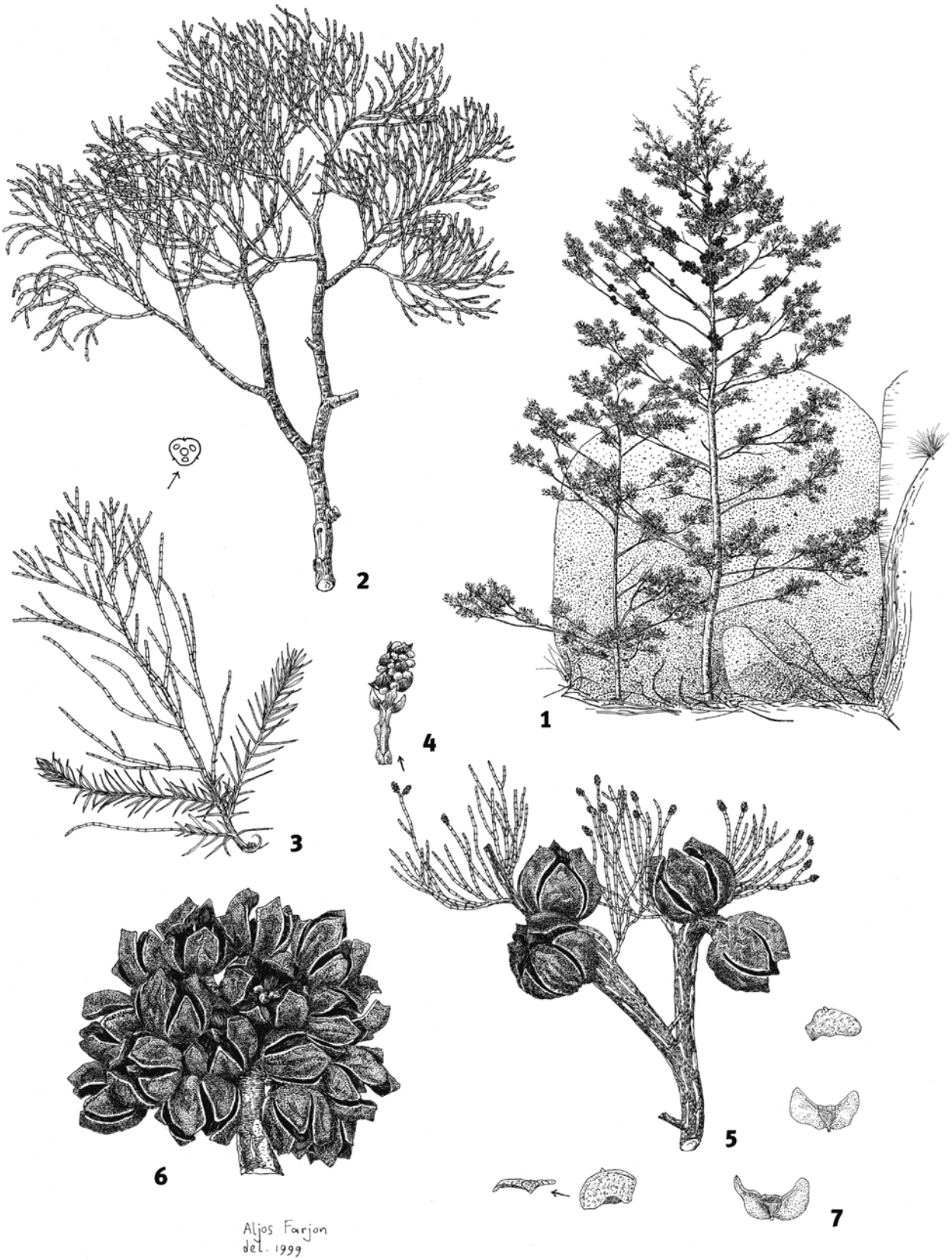


PLATE 8. *Callitris monticola*. **1.** Habit of trees. **2.** Foliage branch. **3.** Branchlet with juvenile and adult leaves. **4.** Pollen cone. **5.** Shoot with pollen cones and seed cones. **6.** Cluster of seed cones. **7.** Seeds.

Description

Dwarf trees 1–3(–4) m, sometimes a shrub, monoecious; trunk monopodial or multistemmed, branching low, up to 10 cm d.b.h. Bark smooth to slightly scaly, thin, slowly exfoliating in small flakes, grey. Branches spreading or ascending at ca. 45°, long and pliant, forming an open, irregular or pyramidal crown. Foliage branchlets sparse, spreading irregularly or more or less erect, arranged in more or less planated sprays towards ends of branches; ultimate branchlets very slender, triangular in cross section, 0.6–0.8 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or some free especially on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 2–3 mm long on ultimate branchlets, 0.5–0.6 mm wide, abaxially prominently keeled; margins denticulate near slightly broadened acute apex; epistomatic, stomata mainly in two narrow marginal bands; abaxial surface densely verrucose, yellowish green to glaucous. Pollen cones solitary and terminal on ultimate branchlets, ovoid-globose, 2.5 × 2 mm, yellowish green turning orange-brown; microsporophylls 9–12, in alternate whorls of 3, peltate, apiculate, with erose-denticulate margins, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, leafy shoots, mostly aggregated in dense, compact clusters on stems and branches, maturing in 1–1.5 years, persistent, subglobose when closed, 12–20 × 12–18 mm, verrucose or nearly smooth, slightly rugose when open, dull brown, weathering dull grey. Bract-scale complexes in 2 alternate whorls of 3, not deeply incised towards base and opening only slightly; upper ones largest, 10–16 × 6–10 mm, with parallel or slightly widening sides and obtuse apex; smaller ones wider at base, triangular, with acute apex; bract tip forming a small, acute umbo below the apex of each scale; abaxial surface convex, brown turning grey, with conspicuous white (dotted) margins; adaxial surface dark brown with inconspicuous seed marks. Columella large, mostly trilobed, up to 8 mm wide, obtuse. Seeds 3–5 on basal part of each scale, more or less triangular, flattened, up to 8 mm including wings (seed body 4–5 × 2–3 mm), dark brown, with concave hilum; wings 2 on each side, up to 4 mm wide, unequal or nearly equal in shape and size.

Distribution

Australia: SE Queensland, NE New South Wales, from ca. 28°S to ca. 30°S straddling the Great Dividing Range.
TDWG codes: 50 NSW-NS QLD-QU

Ecology

This species occurs in low *Eucalyptus* woodland or forest and is virtually restricted to rock outcrops and cliff edges thinly covered with scrub. Associated with *Eucalyptus* spp., *Allocasuarina rigida, Xanthorrhoea* sp., *Banksia* spp., *Leptospermum* spp., *Mirbelia confertifolia*, and *Restio stenocoleus*; in very shallow soil amongst boulders or in crevices in granitic rock (Adamellite), trachyte, or sandstone. The altitudinal range is from 560 m to 1360 m a.s.l. The climate is mild and mesic, with a peak of rainfall during the summer.

Conservation

This species has a restricted distribution with very localized populations in a vegetation type that is under increased threat of fires. On one locality (summit area of Bald Rock) it could not be found again despite a thorough search in 1997 by me and earlier searches by J. Williams from Armidale; only the common *C. rhomboidea* remains there.
IUCN: EN [B2ab (i–v)]

Uses

No uses are known of this species.

Callitris muelleri (Parl.) Benth. & Hook. f. *ex* F. Muell., Syst. Census Austral. Pl. 1: 109. 1882. *Frenela muelleri* Parl., in Candolle, Prodr. 16 (2): 450. 1868. Type: Australia: New South Wales, Sydney, Port Jackson, ["South Head"], *A. Thozet [ex herb. F. von Mueller] MEL 503745* (lectotype MEL). Fig. 65, 66

Etymology

This species was named after F. J. H. von Mueller (1825–1896), the famous German botanist working on the Australian flora.

Vernacular names

Illawarra Cypress-pine, Illawarra Pine

Description

Dwarfed trees or shrubs to 3–4.5(–6) m; monopodial or multistemmed, branching low and often fastigiate, up to 15 cm d.b.h. Bark smooth, not fissured, thin, slowly exfoliating in small flakes and strips, grey. Branches ascending at ca. 45° or erect, short or long in fastigiate crowns, slender, forming a conical to pyramidal, in fastigiate forms columnar crown. Foliage branchlets numerous, in dense tufts towards end of main branches, ultimately slender, triangular in cross section, 0.7–1 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or free on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 2–8 mm long on ultimate branchlets, 0.5–0.7 mm wide, abaxially keeled; margins denticulate near slightly broadened obtuse or sometimes acute apex; epistomatic, stomata in two narrow, marginal bands; abaxial surface minutely verrucose, green. Pollen cones numerous, solitary or with 2–3 together, terminal on ultimate branchlets, ovoid-globose to oblong, 2–3 × 1–1.5 mm, yellowish green turning orange-brown; microsporophylls 9–12, in alternate whorls of 3, peltate, with denticulate margins, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, leafy shoots, solitary but often grouped together in small clusters on branches and stems, maturing in 1–1.5 years, persistent, subglobose or globose when closed, 15–25 × 15–25 mm, smooth and lustrous when closed, coarsely rugose when open, greenish or glaucous when growing, maturing to brown or purplish brown weathering grey. Bract-scale complexes in 2 alternate whorls of 3, very thick, not deeply incised towards cone base when opened; upper ones much larger than the lower, to 20 × 13 mm, usually widest above the middle and tapering to an obtuse apex; smaller ones narrower and tapering to an acute apex; a minute prickle (bract tip) below the apex of each scale; adaxial surface red-brown or dark brown with numerous whitish seed marks. Columella triangular, sometimes flattened, ca. 3 mm long and wide, acute, dark brown to black. Seeds 5–10 on each scale, ovoid or triangular, flattened, up to 5 × 3 mm, dark brown with lighter coloured concave hilum; wings 2, 2–5 mm wide, more or less equal in shape and size.

Distribution

Australia: E-central New South Wales, from areas near the coast to the table lands of the Blue Mts. E of Sydney.
TDWG codes: 50 NSW-NS

Ecology

In scrub vegetation associated with *Myrtaceae* (e.g. *Calytrix, Eucalyptus apiculata, E. stricta, E. sieberi, Leptospermum*), *Proteaceae* (e.g. *Banksia, Grevillea*), *Allocasuarina distyla, Lomandra glauca*, and *Caustis pentandra*. On 'skeletal' sandy or gravelly soil and among boulders or in rock crevices of sandstone on cliffs or talus slopes, sometimes congregating on dirt road verges. The altitude ranges from 500 m to 1050 m a.s.l. The climate is temperate and mesic and frost can occur in winter at the higher altitudes.

Conservation

Some of the earlier populations reported from the Sydney (Port Jackson) area have undoubtedly been reduced in area of occupancy due to urbanisation. Fires, if too frequent, will threaten regeneration success. Away from the urbanised areas the species, though not widespread, seems to hold its own in sites that support no commercial land use of any kind.
IUCN: NT

Uses

There are no economic uses reported of this species.

Callitris neocaledonica Dummer, J. Bot. 52: 239. 1914. *Nothocallitris neocaledonica* (Dummer) A. V. Bobrov & Melikyan, Komarovia 4: 86. 2006. Type: New Caledonia: Grande Terre, Province Sud, Ngoye River, ["auf den Bergen am Ngoye"], *R. Schlechter 15179* (holotype K).

Etymology

The species epithet refers to its country of origin.

Vernacular names

Nié

Description

Shrubs or small trees 3–7(–10) m tall; trunk monopodial or very short, branching low, up to 50 cm diam. at base. Bark soon scaly, on lower trunk becoming shallowly fissured, rough, exfoliating in long strips, brown weathering grey. Branches spreading and assurgent, thick and long, often contorted, forming a sympodial, rounded and open crown. Foliage branchlets in dense tufts at ends of main branches, assurgent or erect, ultimate branchlets short, rigid, thick, appearing conspicuously articulate with scale leaves, triangular in cross section, 1.5–2 mm diam., covered with closely appressed leaves, green, persistent. Leaves of two types on plants up to 1 m tall. Mature (scale) leaves (and transitional leaves) in alternate whorls of 3, decurrent, closely appressed, apices appressed or some free especially on some leading shoots (whip shoots), connate but parting with thickening of branches, linear, 2.5–5 mm long on ultimate branchlets, ca. 1 mm wide, acutely keeled abaxially; margins erose-denticulate near obtuse or acute apex; epistomatic, stomata in two narrow marginal bands; abaxial surface smooth on keel, minutely verrucose on sides, green. Pollen cones solitary and terminal on ultimate branchlets, ovoid or subglobose, 2–3 × 2–2.5 mm, yellowish turning brown; microsporophylls 9–12, in alternate whorls of 3, peltate, with erose-denticulate margins, obtuse-acuminate, bearing 3–4 abaxial pollen sacs near the lower margin. Seed cones few, terminal on short, thin, scale-leaved shoots, solitary, maturing in 1 year, caducous (or persistent a short time after seed dispersal), ovoid when closed, 8–10 × 6–7 mm, with convex scales when open, smooth, greenish maturing to brown. Bract-scale complexes in two alternate whorls of 3, not opening very wide, nearly equal in size and shape, 7–8 × 3 mm, narrowly oblong, slightly tapering, rectangular in cross-section, with mostly included bracts forming a prominent and acute umbo below the apex of each scale; adaxial surface smooth, red-brown with inconspicuous seed marks. Columella very long, 5–6 × 1.5–2 mm, angular, with triangular apex. Seeds 1(–2) at base of each upper scale, ovoid or triangular, flattened, 5–7 × 2–2.5 mm, light brown, with small hilum; wings 2 on each side, up to 7 × 1.5 mm, unequal in shape and size.

Distribution

New Caledonia, Grande Terre, Province Sud.
TDWG codes: 60 NWC

Ecology

In scrub vegetation ('maquis minier') or low sclerophyll forest on slopes or along creeks, in shallow soil over ultramafic (serpentine) rocks. The altitudinal range is between 560 m and 1500 m a.s.l. The climate is low montane tropical with high rainfall throughout the year.

Conservation

This species has a limited distribution in localized populations in the southern massifs. It is protected in the Montagnes des Sources and Mt. Humboldt reserves, but fire is a hazard and adequate management of this increasing problem is urgently needed.
IUCN: NT

Uses

There are no commercial uses recorded of this species.

Callitris oblonga Rich. & A. Rich., in A. Richard (ed.) Comm. Bot. Conif. Cycad.: 49. 1826. Type: Australia: Tasmania, ["Nouvelle Hollande"], *J. L. C. Dumont d'Urville s.n.* (holotype P).

Callitris oblonga Rich. & A. Rich. subsp. *corangensis* K. D. Hill, Fl. Australia 48: 716. 1998.
Callitris oblonga Rich. & A. Rich. subsp. *parva* K. D. Hill, Fl. Australia 48: 717. 1998.

Etymology

The species epithet refers to the oblong (longer than wide) seed cones.

Vernacular names

Tasmanian Cypress-pine, Dwarf Cypress-pine, Native Cypress, River Pine, Pigmy Cypress-pine

Description

Shrubs or small trees to 7–8 m tall, often less than 4 m; monopodial or multistemed from a short basal trunk, usually branching low and often fastigiate, up to 20 cm d.b.h. Bark soon scaly, on the lower trunk of largest trees fissured, hard, slowly exfoliating in small flakes and strips, grey-brown. Branches ascending or erect, long in fastigiate crowns, slender, forming a conical or pyramidal, open or dense crown, or a more or less rounded shrub in less favorable sites. Foliage branchlets ascending to erect, ultimate branchlets triangular in cross section, 1–1.2 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or free on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 3–12 mm long on ultimate branchlets, 0.7–1 mm wide, abaxially keeled; margins denticulate near slightly broadened acute-acuminate apex; epistomatic, stomata in two narrow, marginal bands; abaxial surface weakly verrucose, green or glaucous green. Pollen cones subterminal in clusters of (2–)3–5(–6) on ultimate branchlets, ovoid-globose, 1–1.5 × 1 mm, yellowish green turning orange-brown; microsporophylls 8–12, in alternate whorls of 3, peltate, rounded, with entire margins, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on very short, thick, leafy shoots, rarely solitary and often grouped together in compact clusters on branches and stems, maturing in 1–1.5 years, persistent, ovoid-oblong or ovoid-utriculate when closed, (12–)15–20(–25) × (10–)12–16(–20) mm, smooth, rugose when dry, blackish brown or black, weathering grey. Bract-scale complexes in 2 alternate whorls of 3, deeply incised towards cone base when opened, thick, parting only slightly; upper ones largest, up to 20 × 10 mm, tapering to a (recurved) obtuse apex; smaller ones 1/2 to 3/5 the size of the larger ones, acute or obtuse; adaxial surfaces dark purplish brown with light seed marks. Columella small, triangular to trilobed, 2–3 mm long, obtuse. Seeds 5–15 on each scale, ovoid or triangular, flattened, up to 10 mm including wings (seed body 3–4 × 2–3 mm), dark brown to black with large, yellowish concave hilum; wings 2, lateral, 3–4 mm wide, more or less equal in shape and size.

Taxonomic notes

For a discussion of the two subspecies described in Flora of Australia 48 (1998), here treated as taxonomic synonyms of *Callitris oblonga*, the reader is referred to the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a).

Distribution

Australia: New South Wales, in two disjunct areas: in the New England Tablelands and adjacent mountains, and along the Corang River, a tributary of the Shoalhaven River; and in NE Tasmania along several rivers.

TDWG codes: 50 NSW-NS TAS

Ecology

Mostly riparian, in *Eucalyptus* woods or shrubland; in Tasmania often in disturbed vegetation with invasives like *Ulex europaeus, Rubus discolor*, and *Crataegus* sp. Associated taxa are *Eucalyptus* spp., *Acacia* spp., *Leptospermum* spp., *Allocasuarina* spp., *Bursaria spinosa, Callistemon paludosis, Jacksonia scoparia, Lomandra longifolia, Epacris microphylla, Hakea* spp., *Lomatia myrtifolia, Pteridium* sp., and grasses (*Poaceae*). The altitudinal range is from 10 m to 1300 m a.s.l., with the Tasmanian populations mostly below 100 m a.s.l. Soils are (gravelly) sand or loam, often rocky with granitic boulders or bedrock, acidic, and sometimes silt or clay, subject to regular flooding. In a few cases in Tasmania, *C. oblonga* appears to occur away from streams on floodplains, invariably on disturbed sites grazed by cattle, and in New South Wales on moderate slopes with seepage water. The climate is temperate and mesic, without prolonged periods of drought, but with higher rainfall levels in the uplands of New South Wales than in NE Tasmania.

Conservation

Briggs & Leigh (1988) list *Callitris oblonga* (N.S.W.) and "*Callitris* sp. 1" [= *C. oblonga* in Tasmania] as Vulnerable (3VCa in CSIRO conservation coding).

More recent research (Nadolny & Benson, 1993) has confirmed a wider occurrence in the New England Range of N.S.W. than was previously known. Some of the populations are in conservation areas, but most are outside these on rangeland or bushland. Threats are conversion to agriculture by clearance of natural vegetation (in particular Corang River and Tasmania), grazing of livestock, associated invasive species (especially *Ulex europaeus*) and fires if too frequent (with intervals of 3 years or less). Some populations are (now) very small and isolated. In Tasmania a recovery programme is under way using several approaches.

IUCN: VU [B1ab (iii)]

Uses

There is a limited ornamental use of this species in Tasmania. In cultivation, as with many species in *Cupressaceae*, Tasmanian Cypress-pine grows consistently in a fastigiate habit. In the wild, this habit is commonly found in Tasmania but, as far as I have seen, absent in New South Wales. It is possible that there is a genetic basis for this, but environmental factors also seem to play a role, although it remains unclear what these are specifically. From what I have seen in this species in both areas, it could be that more adverse conditions for fast growth prevent fastigiate branching and promote spreading branching instead. The fastigiate form should be cultivated more widely, as it forms a well shaped erect shrub or small tree.

Callitris preissii Miq., in Lehmann, Pl. Preiss. 1: 643. 1845. Type: Australia: Western Australia, Rottnest Island, *C. A. Gardner 175* (epitype PERTH), *L. Preiss 1310* (lectotype L). Fig. 67

Callitris tuberculata R. Br. *ex* R. T. Baker & H. G. Smith, Res. Pines Austral.: 99. 1910.

Callitris preissii Miq. subsp. *murrayensis* J. Garden, Contr. New South Wales Natl. Herb. 2 (5): 373. 1957; *Callitris preissii* Miq. var. *murrayensis* (J. Garden) Silba, Phytologia Mem. 7: 17. 1984; *Callitris gracilis* R. T. Baker subsp. *murrayensis* (J. Garden) K. D. Hill, Fl. Australia 48: 716. 1998.

Etymology

This species was named after Ludovicus (Ludwig) Preiss, who collected this species on Rottnest Island in 1839.

Vernacular names

Rottnest Island Pine, Mallee Pine, Murray Pine, Mountain Pine, Mountain Cypress-pine, Lachlan Pine, Light Pine, White Pine, Common Cypress-pine

Description

Shrubs or trees to 25 m tall; monopodial or multi-stemmed, usually branching low and frequently forked, up to 1 m d.b.h. Bark soon scaly, on large trunks thick, deeply fissured, stringy, exfoliating in large strips, light brown; outer bark grey. Branches spreading or ascending, long, forming a pyramidal or broadly domed, more or less open crown, or a pyramidal or rounded shrub. Foliage branchlets spreading or ascending, ultimately very slender, terete, 0.7–1.0 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed (except on some whip shoots), connate but parting with thickening of branches, persisting several years, linear, 1.5–5 mm long on ultimate branchlets, 0.5–1 mm wide, abaxially convex; margins denticulate near obtuse or acute apex; epistomatic, a few abaxial stomata near base of leaves only or absent, adaxial stomata in two marginal bands and a few below apex; abaxial surface verrucose, yellowish green or sometimes glaucous green. Pollen cones solitary or 2–3 together, terminal on ultimate branchlets, ovoid-oblong, 3–5 × 1.5–2.5 mm, yellowish green turning orange-brown; microsporophylls 15–20, in alternate whorls of 3 or decussate, peltate, ovate-orbicular, with entire or erose margins, bearing 2–4 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, leafy shoots, solitary or more often clustered on branches and stems, maturing in 1–1.5 years, persistent, (depressed-)globose to ovoid-globose when closed, (15–)20–30(–35) × (18–)22–35 mm, nearly smooth to coarsely rugose and variably covered with large verrucae, brown or

purplish brown to blackish, weathering grey. Bract-scale complexes in 2 alternate whorls of 3, not deeply incised towards cone base when opened, very thick; the upper ones largest, 12–30 × 8–13 mm, tapering to an obtuse apex; the smaller ones narrower, acute or obtuse; adaxial surfaces grey-brown or brown with light seed marks. Columella short, thick, up to 5 mm long and as wide at base, obtuse or acute-triangular. Seeds (7–)9–12(–16) on each scale, triangular to ovoid, flattened, up to 10 mm including wings (seed body up to 3–5 × 2–3 mm), dark brown or red-brown with whitish concave hilum; wings 2(–3) on opposite sides, 2–4 mm wide, more or less equal or unequal in shape and size.

Taxonomic notes

Flora of Australia 48 (1998) took a narrow view of *C. preissii* and included only the populations on Rottnest Island and "around Perth" in it. The Flora accepted *C. tuberculata* as a widespread species occurring along the coast and in the interior of Western Australia and *C. gracilis*, including subsp. *murrayensis*, occurring in South Australia, Victoria and New South Wales. Investigation of populations on sand dunes at Bremer Bay, Western Australia (which according to Flora of Australia taxonomy belong to *C. tuberculata*), and populations in similar habitat in two of the 'classical' localities of *C. preissii* (Garden Island and Woodman Point) by me in 1997 revealed that they are the same. Multistemmed shrubs are the dominant growth form at Woodman Point and common at Bremer Bay and on Garden Island. The wartiness of cones as well as their size are quite variable in all these populations. The plants in the interior are more distinct, especially those that grow on lateritic soil types, being (smaller) shrubs, never a tree, and having smaller cones. In Victoria, I observed a similar situation: on sand dunes in the Murray River Basin and in the 'Little' and 'Big' Deserts I found mostly trees, but in the hardpan areas between the dunes I found shrubs. Cones are less densely warty here than in Western Australia, but considering its variation in that state, I think this is insufficient evidence to separate *C. gracilis* from *C. preissii* and a broad concept of the species is here retained. Garden (1957) further confounded the taxonomy of this species by postulating two naturally occurring hybrids.

Distribution

Australia: New South Wales, South Australia, Victoria, Western Australia.
TDWG codes: 50 NSW-NS SOA VIC WAU-WA

Ecology

In coastal and inland dunes, as well as on sandy floodplains, hillsides, low ridges ('breakaways') and laterite (hardpan). In coastal dune areas it may form more or less dense stands excluding other trees and shrubs, or it associates with *Acacia* sp. and *Melaleuca lanceolata*; elsewhere it occurs in low *Eucalyptus* woodland ('mallee'), associated with other *Myrtaceae* (e.g. *Melaleuca, Leptospermum*), *Proteaceae* (e.g. *Banksia, Dryandra, Grevillea, Hakea*), *Acacia* spp., *Allocasuarina* sp., *Dodonaea* sp., and *Callitris* spp.; in (dwarf) scrubland ('kwongan' in SW Australia) with *Myrtaceae* ('*Melaleuca* thicket'), *Proteaceae*, and *Xanthorrhoea thorntonii*; in inland dunes and dune slacks with *Eucalyptus* spp., *Acacia* spp., *Myrtaceae*, and *Callitris verrucosa*; on sandstone hillsides and ridges with *Eucalyptus* spp., *Acacia* spp., *Allocasuarina cristata, Dodonaea* sp., *Callitris columellaris, C. rhomboidea*, and *C. endlicheri*. The altitude ranges from near sea level to 670 m a.s.l. Soils vary from calcareous, humus-rich old coastal or riparian sand dunes, (where it develops to a monopodial or multi-stemmed tree) to white, yellow, brown or red sand or loam flats over limestone, sandstone or laterite (hardpan; on this it develops only to a medium height shrub); also in disturbed road verges through arable land or pasture. The climate is mild to hot and characterized by dry periods (which can be extensive in the interior parts of the range) and winter rainfall.

Conservation

IUCN: LC

Uses

The larger trees with monopodial growth that occur locally have been used for timber in local construction, but its economic value is now limited and no commercial harvest occurs. It is only known in horticulture from arboreta and botanic gardens in

countries with mild winters, but it can endure light frost without much permanent damage. Its attractive, soft foliage makes it a desirable small tree and it should be cultivated more often.

Callitris rhomboidea R. Br. *ex* Rich. & A. Rich., in A. Richard (ed.) Comm. Bot. Conif. Cycad.: 47. 1826. Type: Australia: New South Wales, Sydney, Port Jackson, *R. Brown 3107* (holotype BM). Fig. 68

Etymology

The species epithet refers to the rhomboid shape of the seed cone scales.

Vernacular names

Port Jackson Pine, Oyster Bay Pine, Cypress-pine, Illawarra Mountain Pine

Description

Shrubs or trees to 10–15 m tall; multistemmed or monopodial, usually branching low and often fastigiate, up to 40 cm d.b.h. Bark soon scaly, on the lower trunk shallowly fissured, hard, slowly exfoliating in small flakes, dark grey-brown, inner layers brown. Branches spreading or ascending at ca. 45°, or fastigiate, long and slender, forming a conical or (broad) pyramidal, dense or more or less open crown. Foliage branchlets spreading or ascending to erect, ultimately very slender, triangular in cross section, 0.6–1 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or free especially on some leading shoots (whip shoots), connate but parting with thickening of branches, persisting several years, linear, 3–6 mm long on ultimate branchlets, 0.3–0.7 mm wide, abaxially keeled; margins denticulate near slightly broadened acute-acuminate apex; epistomatic, stomata in two narrow, marginal bands; abaxial surface weakly verrucose, yellowish green to glaucous green. Pollen cones solitary or paired and terminal on ultimate branchlets, ovoid-globose to oblong, 1.5–2.5 × 1–2 mm, yellowish green turning orange-brown; microsporophylls 8–14, in alternate whorls of 3, peltate, with denticulate margins, bearing 3–4 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, leafy shoots, solitary or more commonly aggregated in dense, compact clusters on branches, maturing in 1–1.5 years, persistent, depressed-globose when closed, 12–15 × 13–17 mm, angular with large, protruding umbos, smooth, often lustrous, becoming finely rugose when open, blackish brown or nearly black, weathering grey. Bract-scale complexes in 2 alternate whorls of 3, only partly incised towards cone base when opened; upper ones largest, 10–13 × 8–12 mm, tapering to an obtuse apex; smaller ones narrower 6–8 × 5–7 mm; forming a prominent and acute umbo below the apex of each scale; adaxial surface dark purplish brown with light seed marks. Columella trilobed to tripartite, 3–8 mm wide, obtuse. Seeds 4–10 on each scale, ovoid or triangular, flattened, up to 8 mm including wings (seed body ca. 3 × 2 mm), dark brown to black with large, greyish concave hilum; wings 2–3 on sides, 2–3 mm wide, more or less equal in shape and size.

Distribution

Australia: New South Wales, Queensland, South Australia, Tasmania, Victoria.
TDWG codes: 50 NSW-NS QLD-QU SOA TAS VIC

Ecology

Commonly in open woodland or scrubland on tablelands or mountains, locally on riparian or coastal sands, often amongst boulders; associated with *Eucalyptus* spp., other *Myrtaceae* (e.g. *Kunzea, Leptospermum*), *Proteaceae* (e.g. *Banksia, Conospermum, Hakea*), *Acacia* spp., *Allocasuarina* spp., *Daviesia ulicina, Dilwenia* sp., *Leucopogon* spp., *Prostanthera lasianthos, Spyridium* sp., *Hibbertia* sp., *Xanthorrhoea* sp., *Restio* sp., *Pteridium* sp., *Callitris endlicheri*, and *C. preissii*. Soils are ('skeletal') white or grey sand over sandstone, limestone, shale, granite (Adamellite), or it is growing in talus, rocky creek bottoms, or crevices of bedrock; also in fields (sheep pasture), with invasives (e.g. *Ulex europaeus* in Tasmania) as indicators of disturbance. The altitudinal range is from near sea level to ca. 1250 m a.s.l. The climate is mild to temperate, mesic or with summer rainfall in the north and winter rainfall in the south of its range; frost and snow can occur at higher altitudes.

Conservation

IUCN: LC

Uses

As a widespread species its timber, being relatively small, was mainly used for fence posts until metal replaced wood for this pupose in farming. It has been introduced in New Zealand, where it has become naturalized near Auckland. This introduction had no horticultural purpose as far as I know. The species remains relatively rare in botanic gardens and arboreta, although it is available in the UK nursery trade (Grimshaw & Bayton, 2009: 186).

Callitris roei (Endl.) F. Muell., Syst. Census Austral. Pl. 1: 109. 1882. *Frenela roei* Endl., Syn. Conif.: 36. 1847. Type: Australia: Western Australia, along the road from Newdegate to Lake King, 35 km E of Newdegate, *A. Farjon 375* (neotype K). Fig. 69, 70

Etymology

This species was named after J. S. Roe (1797–1878), who collected the original specimens, later destroyed at W.

Vernacular names

Roe's Cypress-pine

Description

Shrubs or small trees 1–5 m; multistemmed or monopodial, branching low, up to 20 cm d.b.h. Bark on the lower trunk thin, shallowly fissured, hard, slowly exfoliating in small flakes, grey. Branches spreading or ascending at ca. 45°, long and pliant, forming a broad, rounded, dense or more or less open crown. Foliage branchlets rigid and thick, ultimately twisted and of unequal length, triangular in cross section, 1.2–1.5 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or some free especially on some leading shoots (whip shoots), connate but parting with thickening of branches, linear, 2–5 mm long on ultimate branchlets, 1–1.5 mm wide, abaxially prominently keeled; margins denticulate near slightly broadened obtuse or acute apex; epistomatic, stomata in two narrow marginal bands, a few stomata visible near the apex; abaxial surface weakly verrucose, yellowish green to light green. Pollen cones solitary and terminal on ultimate branchlets, oblong to cylindrical, 3–6 × 1.2–2 mm, yellowish green turning light brown; microsporophylls 10–16, in alternate whorls of 3, peltate, broadly rhombic, with erose-denticulate margins, bearing 3–4 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, leafy shoots, mostly aggregated in dense, compact clusters on stems and branches, maturing in 1–1.5 years, persistent, depressed-globose when closed, (10–)12–18 × 12–20 mm, with concave lower parts of scales, smooth, finely rugose when open, whitish grey to metallic grey, weathering dull grey. Bract-scale complexes in 2 alternate whorls of 3, opening not very wide; upper ones largest, (10–)12–15 × 6–10 mm, with parallel sides and obtuse apex; smaller ones wider at base, triangular, with acute apex; a prominent and acute umbo below the apex of each scale; abaxial surface concave, becoming rugose, grey; adaxial surface yellowish or more often red-brown with light seed marks. Columella large, triangular or trilobed, 3–6 mm long and wide, obtuse. Seeds 3–6 on each scale, ovoid or triangular, flattened, up to 10 mm including wings (seed body 3–5 mm long), yellowish- or red-brown, with large, whitish concave hilum; wings 2 on each side, up to 8 × 4 mm, unequal in shape and size.

Distribution

SW Western Australia, near the south coast and in parts of the Wheat Belt region.
TDWG codes: 50 WAU-WA

Ecology

In low *Eucalyptus* woodland ('mallee') with *Eucalyptus* spp., other *Myrtaceae* (e.g. *Melaleuca*), *Proteaceae* (e.g. *Banksia, Dryandra, Hakea*), *Leschenaultia* sp., *Callitris preissii*, and occasionally in open dwarf scrubland ('kwongan'); on (gravelly) white or grey sand, loam or clay and on laterite (hardpan), also in

disturbed road verges. The altitudinal range is from 50 m to 350 m a.s.l. The climate is characterized by warm, dry summers and winter rainfall.

Conservation

Due to widespread conversion of the original vegetation cover to arable farming this species has suffered a substantial reduction in its area of occupancy in the 20th century. Remaining large reserves are mainly concentrated along the south coast, while in the interior these are small and scattered, or have a limited protective status as road verge 'reserves' of semi-natural vegetation. Habitat degradation is mainly caused by increasing salinity of soils in the region; along roads fires also have increased, but it is unknown how this species reacts to this. It appears in some situations to react positively to mechanical soil disturbance along roads (personal observations, 1997) and should be at least mildly tolerant of fire.
IUCN: EN [B2ab (i–v)]

Uses

There are no economic uses recorded of this species.

Callitris sulcata (Parl.) Schltr., Bot. Jahrb. Syst. 39: 16. 1906. *Frenela sulcata* Parl., Index Sem. Hort. Florent. 1862: 23. 1862; *Nothocallitris sulcata* (Parl.) A. V. Bobrov & Melikyan, Komarovia 4: 85. 2006. Type: New Caledonia: Grande Terre, Province Sud, *C. Moore 5* (holotype K).

Etymology

The species epithet (Latin *sulcatus* = 'grooved') refers to the appearance of the branchlets.

Vernacular names

Sapin de Comboui (French)

Description

Shrubs or small trees to 6–10(–12) m tall; trunk monopodial in trees, sometimes forked, branching low, up to 40 cm d.b.h. Bark soon scaly, to 10–20 mm thick, fissured, stringy, exfoliating in long strips, light brown weathering grey. Branches spreading or ascending, forming an irregular, broad and usually open crown. Foliage branchlets in tufts at ends of main branches, assurgent or erect, ultimate branchlets long, apprearing conspicuously articulate with scale leaves, triangular in cross section, ca. 1.5 mm diam., covered with closely appressed leaves, green, persistent. Leaves of two types on plants up to 1 m tall. Adult (scale) leaves in alternate whorls of 3, decurrent, closely appressed, apices appressed or some free especially on some leading shoots (whip shoots), connate but parting with thickening of branches, linear, 3–7 mm long on ultimate branchlets, 0.7–1 mm wide, obtusely keeled abaxially; margins erose-denticulate near obtuse or acute apex; epistomatic, stomata in two narrow marginal bands; abaxial surface smooth, green. Pollen cones solitary and terminal on ultimate branchlets, ovoid or ovoid-oblong, 3–5 × 1.5–2.5 mm, yellowish green turning light brown; microsporophylls 9–15, in alternate whorls of 3, peltate-triangular, with erose-denticulate margins, obtuse or acute, bearing 4–6 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thin, leafy shoots, solitary, maturing in 1 year, caducous (or persistent a short time after seed dispersal), ovoid-globose to subglobose when closed, 8–11 × 7–10 mm, with concave lower parts of scales when open, smooth, finely rugose when open, greenish maturing to dull brown. Bract-scale complexes in 2 alternate whorls of 3, not opening very wide; upper ones only slightly larger, 7–10 × 5–6 mm, oblong, thick; lower ones 4–5 mm wide; a prominent and acute umbo below the apex of each scale; adaxial surface rugose, red-brown or dark brown with inconspicuous seed marks. Columella relatively large, 3–4 mm long, irregularly angular, 1.5–2 mm wide, narrowed at base. Seeds usually 2 at base of each upper scale, ovoid or triangular, flattened, 4–5 × 3 mm, light brown, with very small hilum; wings 2 on each side, up to 7 × 2.5 mm, unequal in shape and size.

Taxonomic notes

The two species of *Callitris* in New Caledonia are probably relicts of the Australian connection about 80 Ma, and somewhat resemble *C. macleayana* in

foliage characters. They retain a 4-whorled phyllotaxis with juvenile acicular leaves into semi-mature or mature plants. In *C. sulcata* the transition between leaf types is abrubt, but phyllotaxis changes from 4 to 3 whorls earlier than leaf type. Cones are only borne on branchlets with 3-whorled phyllotaxis and mature type leaves.

Distribution

New Caledonia, Grande Terre, Province Sud, in valleys of the Comboui, Dumbea and Tontouta Rivers and some tributaries.
TDWG codes: 60 NWC

Ecology

On serpentine on slopes or in valleys close to rivers and creeks; in scrubland on ultramafic soils ('maquis minier') and in the ecotone towards low rainforest (gallery forest), at altitudes between 40 m and 200 m a.s.l. It grows in thickets, or scattered with other conifers e.g. *Dacrydium araucarioides, D. balansae, Neocallitropsis pancheri*, and *Podocarpus novae-caledoniae* and numerous ferns and angiosperms. The climate is tropical, with high levels of rainfall throughout the year.

Conservation

This species is limited to a few river valleys in S New Caledonia and their tributaries and headwaters, where it is rare. Timber extraction is reported from the Comboui Valley, and although this species is not an important timber tree, it is likely to be felled with other trees. It is vulnerable to fire and disturbance both of which have increased in recent years. Regeneration appears to be poor in several localities. Protection in ad hoc river bank reserves is inadequate and *ex situ* propagation is required to back up *in situ* regeneration in disturbed sites.
IUCN: EN [B1ab(iii)+2ab(iii), C2a(i)]

Uses

No uses of any kind have been reported of this species.

Callitris verrucosa (A. Cunn. *ex* Endl.) F. Muell., Rep. Burdekin Exped.: 19. 1860. *Frenela verrucosa* A. Cunn. *ex* Endl., Syn. Conif.: 37. 1847; *Callitris preissii* Miq. subsp. *verrucosa* (A. Cunn. *ex* Endl.) J. Garden, Contr. New South Wales Natl. Herb. 2 (5): 375. 1957; *Callitris preissii* Miq. var. *verrucosa* (A. Cunn. *ex* Endl.) Silba, Phytologia Mem. 7: 17. 1984. Type: Australia: New South Wales, Lachlan River, *A. Cunningham 372* (holotype K). Pl. 9

Etymology

The species epithet refers to the outer surface of the seed cone scales, which is covered with verrucae or small blisters.

Vernacular names

Mallee Pine, Cypress Pine, Turpentine Pine, Scrub Cypress-pine, Camphor Wood

Description

Shrubs or trees to 8–10(–15) m tall; multistemmed, or monopodial but then usually forked, up to 0.6 m d.b.h. Bark soon scaly, on large trunks thick, deeply fissured, stringy, exfoliating in large strips, light brown; outer bark grey. Branches spreading or ascending, long, forming a sympodial, broadly domed, more or less open and irregular crown, or a rounded shrub. Foliage branchlets ascending or erect, ultimately very slender, terete, 0.6–0.8 mm diam., covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, decurrent, closely appressed including apices (except on some whip shoots), connate but parting with thickening of branches, linear, 1.5–3 mm long on ultimate branchlets, 0.5–1 mm wide, abaxially convex; margins denticulate near obtuse or acute apex; mostly epistomatic, abaxial stomata near base of leaves only or usually absent, adaxial stomata in two marginal bands and a few below the apex; abaxial surface smooth, yellowish green or glaucous green. Pollen cones solitary or more often 2–3 together, terminal on ultimate branchlets, cylindrical, 2–3.5 × 1–1.5 mm, yellowish green turning light brown; microsporophylls 10–16, decussate or some in alternate

whorls of 3, peltate, orbicular, with erose-denticulate margins, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on short, thick, leafy shoots, solitary or more often clustered on branches and stems, maturing in 1–1.5 years, persistent, subglobose to ovoid-globose when closed, 18–30 × 15–25 mm, nearly smooth when immature, becoming densely covered with small (1.5–2.5 mm) verrucae, purplish grey to blackish, weathering grey. Bract-scale complexes in 2 alternate whorls of 3, deeply incised towards the cone base when opened, thick; upper ones largest, 15–25 × 7–12 mm, acute or obtuse; smaller ones narrower; bracts entirely included, rarely showing the bract tip below the scale apex; adaxial surfaces reddish brown or dark brown with light seed marks. Columella variable, conical, or bi- to tripartite, 2–3 × 1.5–2 mm, acute. Seeds 6–12(–16) on each scale, triangular to ovoid, flattened, up to 9 mm including wings (seed body up to 3–5 × 2–3 mm), dark brown or red-brown with whitish concave hilum; wings 2(–3) on opposite sides, 2–4 mm wide, more or less equal or unequal in shape and size.

Taxonomic notes

The species rank of this taxon has not been accepted by several authors (Garden, 1957; Harden & Thompson, 1990). Maiden (1907) included *C. tuberculata* in this species, while Baker & Smith (1910) treated the two as separate species, as has been done recently in Flora of Australia 48 (1998). The classification of *C. verrucosa* as an infraspecific taxon of *C. preissii* (Garden, 1957) is, in my view, based on a misinterpretation of morphological variability. While *C. preissii* is a species with high polymorphism, to some extend correlated with environmental factors, *C. verrucosa* is very constant in most of its morphological character states and traits throughout its range. It does not occur anywhere on the coast and its trees/shrubs on dunes are not dissimilar from those on level hardpan plains. While growth on dunes is often better than on hardpan, *C. verrucosa* never develops into a monopodial tree in either environment. The single true variation I have observed in the field is the occurrence of two foliage colour phases, yellowish green and glaucous green, growing even side by side in some populations in Wyperfeld National Park (field observations A. Farjon & A. Watt, 1997). The verrucae on the mature cones (growing cones are nearly smooth) are densely set, small and of near constant size in all live plants and herbarium specimens seen. These characters are good indicators of a good biological species that is partially sympatric with *C. preissii*, as here circumscribed, but remains separate. Some species are morphologically (and genetically) much less variable than others, even when they have an extensive range like this species.

Distribution

Australia: New South Wales, Queensland (Darling Downs), South Australia, Victoria, interior of Western Australia.

TDWG codes: 50 NSW-NS QLD-QU SOA VIC WAU-WA

Ecology

In low *Eucalyptus* woodland ('mallee') or in (open) scrubland, associated with *Eucalyptus* spp., other *Myrtaceae* (e.g. *Baeckea, Leptospermum, Melaleuca*), *Proteaceae* (e.g. *Banksia, Grevillea, Hakea*), *Acacia* spp., *Allocasuarina* sp., *Beyeria opaca, Leucopogon* sp., *Eriostemon* sp., *Dillwynia* sp., *Hibbertia* sp., *Spyridium* sp., *Lomandra juncea*, 'spinifex' hummocks (*Triodia* sp.), and *Callitris preissii*; on white, yellow, brown or red sand dunes and flats, sometimes on sand over limestone or granite. Its altitudinal range is from 30 m to 520 m a.s.l. The climate is warm temperate to subtropical and characterized by long dry periods and short periods of rainfall.

Conservation

This widespread species occurs mostly in semi-deserts and inland dune areas, where it is currently not threatened with extinction. In certain regions, e.g. on the Murray River plain, irrigation agriculture may have destroyed populations replacing the original vegetation with arable or viticulture. Clearance for wheat growing in Victoria and South Australia will have destroyed other populations. It is not possible with the available data to determine if the area of occupancy of this species has been significantly reduced, but its extensive range and inclusion in large protected and/or unused areas provides an assurance of continued survival.

IUCN: LC

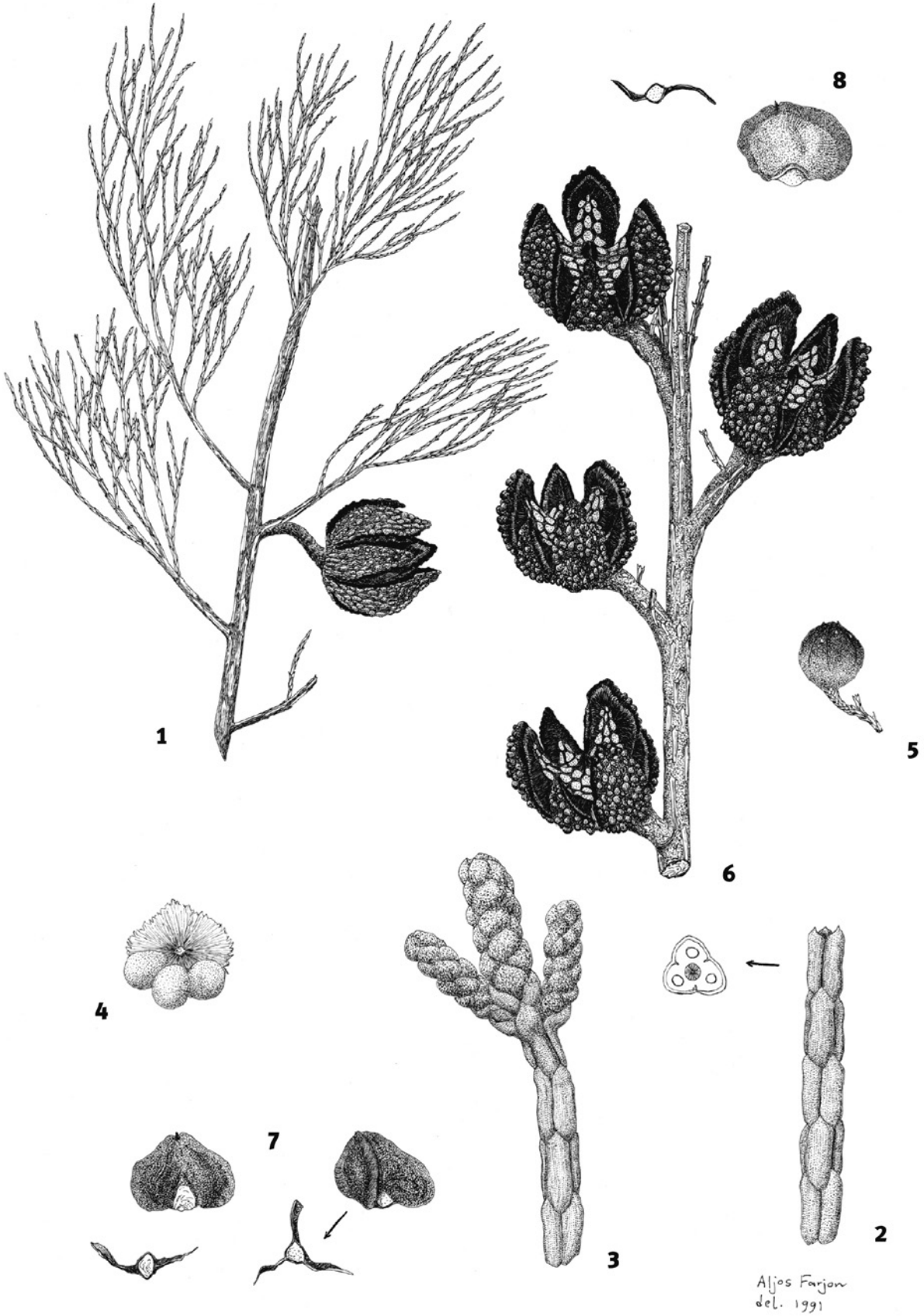


PLATE 9. *Callitris verrucosa*. **1.** Branch with foliage and seed cone. **2.** Section of branchlet with leaves. **3.** Branchlet with pollen cones. **4.** Microsporophyll with pollen sacs. **5.** Immature seed cone. **6.** Branch with seed cones. **7, 8.** Seeds.

Uses

The wood of this species has similar properties to that of its congeners, but the shrubby habit makes it unsuitable for timber. It is not known in cultivation outside a few botanic gardens. There are two foliage colour forms occurring in the wild, often together: yellowish green and glaucous green; these could be selected and enhanced under cultivation.

Calocedrus Kurz, J. Bot. 11: 196. 1873. Type: *Calocedrus macrolepis* Kurz (*Cupressaceae*).

Greek: *calo* = beautiful, so 'beautiful cedar'; *cedrus* is a classical name applied to certain conifers with fragrant wood, it is not clear which!

Description

Evergreen, monoecious trees with a monopodial trunk. Resin cavities in leaves. Bark fissured or furrowed, fibrous, stringy, exfoliating in long plates or strips. Branches curved down or spreading to assurgent, forming a pyramidal or sympodial crown. Fastigiate forms mostly restricted to trees in cultivation. Foliage branches plagiotropic; (sub)ultimate branchlets flattened, covered with scale leaves; lateral branchlets continually deciduous. Leaves decussate, appearing in whorls of 4, decurrent, imbricate, dimorphic, with oblong to obtrullate facials and slightly broader, conduplicate laterals, very variable in size dependent on growth of branchlets; margins entire; apices incurved or recurved, those of lateral leaves meeting those of facials; stomata mostly on the underside of lateral leaves in two lines or bands, glands inconspicuous near apex of facials, absent on laterals. Pollen cones solitary, terminal, cylindrical; microsporophylls (6–)8–14, decussate, with 3–5 abaxial pollen sacs. Seed cones solitary, terminal, 10–35 × 4–13 mm, caducous. Bract-scale complexes in 3(–4) decussate pairs, the proximal pair small, recurved, sterile, the middle pair spreading, fertile, the distal pair fused, sterile. Seeds 1–2 per fertile scale, with 2 very unequal wings. Seedlings with 2 cotyledons.

4 species.

Distribution

W coast of North America, from Oregon to Baja California; Taiwan, SW China, mainland SE Asia.

Key to the species of *Calocedrus*

1a. Seed cones when mature 20–35 mm long; normally 2 seeds developing on each fertile cale ***C. decurrens***

1b. Seed cones when mature (4–)5–22 mm long; 1 or 2 seeds developing on each fertile scale **2**

2a. Seed cones on long branchlets with numerous modified monomorphic scale leaves, 10–22 × 4–7 mm; normally 1 seed developing on each fertile scale ***C. macrolepis***

2b. Seed cones on short branchlets with few modified scale leaves, less than 16 mm long; 1 or 2 seeds developing on each fertile scale **3**

3a. Leaves and seed cones very small, the latter (4–)5–6(–7) × (2.5–)3–4 mm; normally 2 seeds developing on each fertile scale ***C. rupestris***

3b. Leaves and seed cones larger, the latter 10–15 × 4–6 mm; normally 1 seed developing on each fertile scale ***C. formosana***

Calocedrus decurrens (Torr.) Florin, Taxon 5 (8): 192. 1956. *Libocedrus decurrens* Torr., Smithsonian Contr. Knowl. 6 (2): 7. t. 3. 1853. Type: USA: California, Shasta Co., ["Upper waters of the Sacramento River"], *J. C. Frémont 492* (holotype US?, isotype MO). Fig. 71, 72

Etymology

The species epithet refers to the decurrent leaves on primary shoots.

Vernacular names

Incense Cedar, California Incense Cedar, White Cedar, Californian Post Cedar, Bastard Cedar; Cedro incienso (Spanish)

Description

Trees to 60(–69) m tall; trunk monopodial, broadly based or buttressed, up to 3–4.5 m d.b.h. Bark on lower trunk deeply furrowed, fibrous, stringy, exfoliating into long plates or strips, dark red-brown. Branches curved down below, then spreading, assurgent near the top, long persistent; higher order branches pendulous below, forming a columnar to pyramidal, eventually domed and more open crown.

Foliage branches numerous, plagiotropic, spreading or erect near the top, ultimately flattened, covered with green leaves, lateral branchlets deciduous in 2–3 years. Leaves decussate, appearing in whorls of 4, imbricate; laterals partly covering facials, decurrent, (weakly) dimorphic, conduplicate, linear-lanceolate, with slightly incurved acute apex; facials slightly shorter than laterals, oblong to obtrullate, obtuse-acuminate; leaves persisting several years, variable in size, from 2 × 1.5 mm on ultimate lateral branchlets to 15 × 3 mm on leading (whip) shoots; margins entire; amphistomatic, abaxial stomata on laterals in two narrow bands, more numerous on the underside, stomata on facials restricted to sides and hidden in grooves between leaves; glands weakly developed, most conspicuous near apex of facials, all exposed faces light green or sometimes dark green. Pollen cones solitary and terminal on more or less pendulous branchlets, oblong, 6–8 × 2–3 mm, yellow turning brown; microsporophylls 10–14, decussate, peltate-orbicular with denticulate margins and acutish apex, bearing 3–4 abaxial pollen sacs near lower margin. Seed cones terminal on more or less pendulous branchlets with mostly unmodified leaves (except for 3–4 subtending pairs of small scale leaves), solitary, often numerous, maturing within 1 year, caducous, ovoid-oblong or oblong when closed, (15–)20–35 × 8–13 mm, smooth or striated, turning red-brown. Bract-scale complexes in 3(–4) decussate pairs; proximal pair undeveloped and sterile, with recurved bracts; middle pair spreading wide, fertile, slightly curved, abaxially convex, with a minute subapical bract tip and 2 depressed seed marks near the base of each scale; distal pair infertile, straight, laterally flattened and fused to a flat plate with 2 small seed marks and apical bract tips; latter two pairs 18–30 × 7–10 mm, their adaxial faces rugose, light brown. Seeds oblong, slightly flattened, tapering to apex, 8–12 × 3–4 mm, light whitish brown, with 2 wings of unequal shape and size; largest wing 18–23 mm longwing; smallest a narrow strip with a free apex.

Distribution

USA: California, Oregon; NW Mexico: Baja California Norte.

TDWG codes: 73 ORE 76 CAL 79 MXN-BC

Ecology

In mixed conifer forest with *Pinus jeffreyi, P. ponderosa, P. lambertiana, P. monticola, Abies concolor, A. grandis, A. magnifica*, and *Pseudotsuga menziesii*, locally with *Sequoiadendron giganteum, Chamaecyparis lawsoniana, Tsuga heterophylla* or *Thuja plicata*, and in drier southern sites with *Pinus coulteri* and *Pseudotsuga macrocarpa*. The undergrowth of these mixed conifer forests varies mostly with altitude and edaphic conditions and is diverse, especially on ultramafic rocks, with *Arctostaphylos patula, A. viscida, Ceanothus cordulatus, C. integerrimus, C. parvifolius, Castanopsis sempervirens, Gaultheria shallon* and many other shrubby species. In most conifer forest associations *C. decurrens* is a relatively minor component, where it often occupies open canopy stands on hot, dry sites. In the Sierra Nevada Mixed Conifer Forest it may play a much greater role in the canopy locally. Other forest types include also *Quercus* spp., *Castanopsis chrysophylla, Lithocarpus densiflorus* and *Arbutus menziesii*, together with conifers. The altitudinal range of *Calocedrus decurrens* is from 50 m to 2010 m a.s.l. in the north and between 910 m and 2960 m a.s.l. in the south of its range. This species is rather tolerant to soil types, with a huge range of pH values, but the soil usually well drained; it is only rare on limestone. It tolerates hot, dry summers well, but is equally insensitive to frost and snow cover.

Conservation

IUCN: LC

Uses

Incense cedar is an important timber tree. The wood is used for the manufacture of pencils and in building for exterior siding and windows of houses and garden amenities like fences and trellises. As with many taxa in this family, the wood is decay resistant, which makes it especially useful for these purposes in the wetter coastal areas of the Pacific States in the USA. It is also widely planted as an ornamental tree and only then often grows into a fastigiate habit (probably mostly as the cultivar 'Columnaris' which was named by Beissner *Libocedrus decurrens*

var. *columnaris* but does not occur in nature). Incense cedar performs well in urban settings as it is relatively tolerant of air pollution. In horticulture a number of cultivars are known, especially with variegated or differently coloured foliage. Despite its common name, it is not used for incense burning, although its foliage is fragrant.

Calocedrus formosana (Florin) Florin, Taxon 5 (8): 192. 1956. *Libocedrus formosana* Florin, Svensk Bot. Tidskr. 24: 126. 1930; *Calocedrus macrolepis* Kurz var. *formosana* (Florin) W. C. Cheng & L. K. Fu, Fl. Reipubl. Pop. Sin. 7: 327. 1978. Type: Taiwan: ["Taihoku province" (planted)], *E. H. Wilson 10960* (lectotype K). Fig. 73

Etymology

The species epithet indicates Taiwan, formerly known as Formosa; see also Latin: *formosus* = handsome or well formed.

Vernacular names

Taiwan Incense-cedar; Taiwan cui bai (Chinese)

Description

Trees to 20–25 m tall; monopodial, up to 2–3 m d.b.h. Bark on lower trunk furrowed, fibrous, exfoliating into long plates or strips, red-brown. Branches often few and thick, spreading, ascending near the top, long persistent, higher order branches spreading, forming a pyramidal, eventually broad and more or less flat-topped crown. Foliage branches numerous, plagiotropic, branching alternately, ultimately flattened and articulate, covered with green leaves, lateral branchlets deciduous in 2–3 years. Leaves decussate, appearing in whorls of 4, imbricate, dimorphic; laterals partly covering facials, decurrent, conduplicate, linear-lanceolate, with recurved-incurved acute apex; facials oblong to obtrullate, obtuse-acuminate; leaves persisting several years; variable in size, 1–5 mm long on (sub) ultimate lateral branchlets to 15 × 3 mm on leading (whip) shoots; margins entire; amphistomatic, abaxial stomata on laterals in two lines or bands, very few or absent on upperside, much more numerous on underside, stomata on upperside facials restricted to hidden margins, on underside facials in two bands; glands inconspicuous near apex of facials or absent; exposed faces green or sometimes dark green, with glaucous green stomatal bands. Pollen cones solitary and terminal on ultimate branchlets, oblong, 4–5 × 2–2.5 mm, reddish turning brown; microsporophylls (6–)8–10, decussate, peltate-orbicular with denticulate margins and acutish apex, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on more or less pendulous branchlets with ultimately slightly modified (shortened) leaves, solitary, often numerous, maturing within 1 year, caducous, oblong when closed, 10–15 × 4–6 mm, smooth or slightly rugose, often glaucous, turning brown. Bract-scale complexes in 3 decussate pairs; proximal pair undeveloped and sterile, with recurved bracts; middle pair spreading slightly, fertile, slightly curved, abaxially convex, with a small subapical recurved bract tip and 1 depressed seed mark near base; distal pair infertile, straight, laterally flattened and fused to a flat plate with apical bract tips; latter two pairs 10–13 × 4–5 mm, their adaxial faces soft, smooth, light brown. Seeds 1(–2) per cone, ovoid, flattened, acutish at apex, 4–5 × 1.8–2 mm, brown, with 2 wings of unequal shape and size; largest wing 10–12 mm long; smallest wing a narrow strip with a free apex or virtually absent.

Taxonomic notes

This taxon was treated as a variety of *C. macrolepis* in Flora of China 4 (1999); in the Flora of Taiwan (Li, 1975) *C. formosana* is recognized as a species. The morphological differences are small but constant and *C. formosana* only occurs in Taiwan.

Distribution

Taiwan: central and northern mountains.
TDWG codes: 38 TAI

Ecology

This species occurs in mixed conifer-broad-leaved climax forest, often as an emergent, associated with *Pseudotsuga sinensis, Taiwania cryptomerioides, Castanopsis* spp., and *Cyclobalanus* (= *Quercus*) spp. in deep, rich forest soil over shalestone or schist; also in secondary forest and on cliffs and rocky ridges. Its altitudinal range is (300–)800–2000 m a.s.l.

Conservation

This species extends in an area of less than 8000 km² and is limited to under ten isolated locations while it suffers a continuing decline in its area of occupancy. The causes are timber cutting, transformation of old growth forest to managed production forest, and expansion of agriculture, especially livestock grazing. Some stands are now protected in reserves and there is a programme of *ex situ* conservation to back up the remaining populations.

IUCN: EN [B2ab (ii, iii, v)]

Uses

The valuable wood of this tree is in demand for construction purposes, mainly at a local or regional level. It is rare in cultivation despite the fact that it can survive winters in e.g. England provided it is planted in a sheltered spot; a few recently planted trees at the Royal Botanic Gardens, Kew have seed cones and are doing well. Although known botanically since 1930, it was apparently introduced to cultivation only recently (Grimshaw & Bayton, 2009: 187).

Calocedrus macrolepis Kurz, J. Bot. 11: 196., t. 133. 1873. *Libocedrus macrolepis* (Kurz) Benth. & Hook. f., Gen. Pl. 3 (1): 426. 1880. Type: China: Yunnan, Daying River, Hotha, *D. J. Anderson s.n.* (holotype K). Fig. 74

Etymology

The species epithet (Greek/Latin: *macro* = large; *lepis* = scale) refers to the size of the seed cone scales.

Vernacular names

Chinese Incense-cedar; cui bai (Chinese)

Description

Trees to 30–35 m tall; monopodial, up to 1.5–2 m d.b.h. Bark on lower trunk fissured, exfoliating into long plates or strips, pale grey-brown. Branches often few and thick, spreading, ascending near the top, long persistent, higher order branches spreading, forming a pyramidal, eventually sympodial, broad, rounded or flat-topped crown. Foliage branches numerous, plagiotropic, branching alternately, ultimately flattened and articulate, covered with green leaves, lateral branchlets deciduous in 2–3 years. Leaves decussate, appearing in whorls of 4, imbricate, dimorphic; laterals partly covering facials, decurrent, conduplicate, linear-lanceolate, with recurved-incurved acute apex; facials oblong to obtrullate, obtuse-acuminate; leaf size variable, 1.5–8 mm long on (sub)ultimate lateral branchlets to 15 × 3 mm on leading (whip) shoots; margins entire; amphistomatic, abaxial stomata on laterals in two lines or bands, very few or absent on upperside, much more numerous on underside, stomata on upperside facials restricted to hidden margins, on underside facials in two bands; glands inconspicuous near apex of facials or absent, exposed faces light green with whitish green stomatal bands. Pollen cones solitary and terminal on ultimate branchlets, oblong, 4–8 × 2–3 mm, purplish red turning light brown; microsporophylls (8–)10–14, decussate, peltate-orbicular with denticulate margins and obtuse-acuminate apex, bearing (3–)4(–5) abaxial pollen sacs near the lower margin. Seed cones terminal on pendulous (5–)10–20 mm long branchlets with modified (shortened) monomorphic leaves in decussate pairs, solitary, often numerous, maturing within 1 year, caducous, oblong when closed, 10–22 × 4–7 mm, smooth or slightly rugose, often glaucous, turning brown. Bract-scale complexes in 3(–4) decussate pairs; proximal pair undeveloped and sterile, with recurved bracts; middle pair spreading slightly, fertile, nearly straight, abaxially convex, with a small subapical recurved bract tip and 1(–2) depressed seed marks near the base; distal pair infertile, straight, laterally flattened and fused to a flat plate with apical, curved bract tips; the latter two pairs 10–20 × 4–6 mm, adaxial faces soft, smooth, light brown. Seeds 2(–4) per cone, ovoid-oblong, slightly flattened, acute at apex, 5–6 × 2–3 mm, brown, with 2 wings of unequal shape and size; largest wing 12–15(–20) mm long; smallest wing a narrow strip with a free apex or virtually absent.

Distribution

China: Guangxi (Jingxi Xian), Guizhou, Guangdong?, Hainan Island, Yunnan; Myanmar [Burma], Thailand, Lao PDR, Viet Nam.

TDWG codes: 36 CHC-GZ CHC-YN CHH CHS-GX 41 LAO MYA THA VIE

Ecology

Relatively common in montane mixed evergreen conifer-broad-leaved forest dominated by *Fagaceae* and with scattered conifers, e.g. *Cunninghamia, Dacrycarpus, Keteleeria* and *Pinus*; also in rocky places and much planted in roadsides and field margins. The altitudinal range is from ca. 800 m to 2000 m a.s.l.

Conservation

This species has been under threat from cutting for both timber and firewood, especially in more accessible areas in Yunnan. In that province it is still fairly common; in its outlying stations, e.g. Hainan Island and Viet Nam, it is more scarce to rare. Protective measures were suggested in the form of reserves as well as *ex situ* cultivation in Fu & Jin (eds., 1992).
IUCN: NT

Uses

In China this species is considered suitable for afforestation of deforested lands in its native area because of its easy germination and light-demanding properties combined with rapid growth. Its wood has good properties, e.g. durability, but trees tend to be much branched especially when grown in open vegetation. It is less hardy than *C. decurrens* or *C. formosana* but is in cultivation in parks and large gardens in China and elsewhere in SE Asia.

Calocedrus rupestris Aver., Hiep & L. K. Phan, Proc. Nat. Conf. Life Sci. Thai Nguyen Univ. Sept. 2004: 41. 2004. Type: Viet Nam: Bac Kan Prov., Na Ri District, Na Bo, *L. V. Averyanov et al. 5441* (holotype HN). Fig. 75

Etymology

The species epithet means 'rock-dwelling' and refers to the habitat in which it is invariably found.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 25 m tall; trunk to 1–1.2 m d.b.h. Bark 8–12 mm thick, fissured on large trunks, fibrous and exfoliating in longitudinal strips, resinous, greyish brown to brown. Branches spreading and ascending, forming a broadly rounded crown. Foliage branchlets spreading and ascending, arranged in a plane, covered with scale leaves, flattened, uniformly green or with very indistinct, whitened stomatal bands on the underside. Leaves scale-like, decussate, in whorls of 4, decurrent at base, broadly obtuse to obtuse at apex, dimorphic; facial pair flattened, (1–)2–6(–7) mm long, (1.5–)2–2.5 mm wide; lateral pair conduplicate, boat-shaped, (1.5–)2–6(–7) mm long, (0.3–)0.5–0.75(–1) mm wide, their margins overlapping with facial leaves, eglandular. Pollen cones terminal, solitary, cylindrical, (4.5–)5–6 mm long, 1.5–2(–2.2) mm wide; microsporophylls decussate, in 8–11 pairs (the lowest 2–4 pairs sterile), 0.8–1.2 mm long, 1–1.2 mm wide, with minutely erose margins, broadly obtuse or rounded at apex, light green turning light brown, each with 2–6 broadly ovoid to subglobose, 0.3–0.4 mm wide pollen sacs. Seed cone-bearing branchlets terete or 4-angled, 0.5–1.5 mm long, with 6–8(–12) imbricate, obtuse scales. Seed cones subterminal, solitary or paired at apex of lateral branchlets, ovoid, (4–)5–6(–7) mm long, (2.5–)3–4 mm wide, dehiscent when mature (in first year), with 4 decussate, flattened scales (very rarely with 2 additional, basal scale rudiments). Bract-scale complexes somewhat coriaceous, green, becoming woody and brown, broadly ovate, 4–6 mm long, 2.5–4 mm wide; basal 2 scales fertile, dehiscent, normally 2-seeded, rarely with 1 seed; apex rounded, incurved, sometimes with an indistinct, slightly flattened or concave, subapical plate with a rugose surface, rarely with a small central umbo (bract tip); apical pair of scales sterile, connate. Seeds ovoid or sub-ovoid, acute at apex, slightly flattened, including the two relatively large but very unequal wings 4–5 mm long.

Taxonomic notes

Ongoing surveys of the rich flora of Viet Nam result in the frequent discovery of new taxa, new to the country or even to science, and this includes conifers. This is a new species in the genus *Calocedrus*, which seems to be restricted to the karst limestone

formations of northern Viet Nam, already renowned for its diversity and endemism. This species differs from *C. macrolepis*, also in Viet Nam, mainly in the much smaller leaves and (consequently) cones, with the seed cones having only two pairs of scales instead of three. The tree is not dwarfed and can attain considerable size, though due to growth conditions it is often small and even stunted. The two species clearly occupy different habitats and are also geographically nearly separated.

Distribution

Viet Nam, N of the 17th parallel to the Chinese border. So far it has been found in seven provinces: Bac Kan, Cao Bang, Ha Giang, Hoa Binh, Nghe An, Quang Binh, and Son La. It may be present across the borders of Lao PDR and China (Yunnan).
TDWG codes: 41 VIE

Ecology

Calocedrus rupestris occurs on rocky limestone mountains in northern Viet Nam. These mountains are the eroded remains of a vast plateau of karst limestone that extends into China. This plateau is in many places sharply dissected, leaving tower-like formations with steep, narrow ridges at altitudes from 600 m to 1600 m a.s.l. These ridges and summit areas bear a dense vegetation of small to medium-size trees, shrubs, epiphytes, ferns and mosses. Common conifers are *Pinus kwangtungensis, Pseudotsuga sinensis, Tsuga chinensis, Keteleeria davidiana* (locally), *K. evelyniana* (*Pinaceae*), *Fokienia hodginsii*, locally *Xanthocyparis vietnamensis* (*Cupressaceae*) and *Amentotaxus hatuyensis*, and more widespread *A. yunnanensis* (*Taxaceae*), *Cephalotaxus mannii* (*Cephalotaxaceae*), *Dacrycarpus imbricatus, Dacrydium elatum, Nageia fleuryi*, and *Podocarpus neriifolius* (*Podocarpaceae*). There are many, mainly small-leaved, broad-leaved trees (angiosperms) e.g. *Quercus* spp., *Acer tonkinense, Cinnamomum* sp., *Machilus* sp., *Carpinus* sp., and *Celtis* sp., and epiphytic as well as lithophytic orchids. These karst mountains are rich in endemic species and receive high levels of rainfall (1200–3000 mm p.a.) and fog.

Conservation

This species is apparently more widespread than the recently discovered species *Xanthocyparis vietnamensis*, also belonging to the *Cupressaceae*. It occupies the same or similar habitats and while locally common, in other regions it is rare. As with other members of the *Cupressaceae* in this part of the world, the fragrant and durable wood is highly prized and logging of the larger trees, even from inaccessible sites, is a problem for the conservation of the species. The timber is marketed locally as well as across the border into China. Recruitment from seedlings is reported to be low, with very few seedlings observed in most of the explored localities (Averyanov *et al.*, 2005). Due to deforestation and logging observed in many areas within the range and in the habitat of this species, a serious reduction estimated at 50% or more in population size has been inferred in many localities where this species has so far been found by botanists. The total number of mature trees is estimated to be below 2500. This species is still common, with well structured age distributions in the population, within the limestone areas of Phong Nha – Ke Bang National Park and in Bat Dai Son Nature Reserve.
IUCN: EN (A2cd)

Uses

The wood of this species is valued for its fragrance and durability and is used for carpentry, interior finishing and furniture. This species, recently discovered and described, is not yet in cultivation.

Cathaya Chun & Kuang, Acta Bot. Sin. 10 (3): 245. 1962. Type: *Cathaya argyrophylla* Chun & Kuang (*Pinaceae*).

Cathay is an old name for (northern) China.

Description

See the species description.

Distribution

As for the species.

Cathaya argyrophylla Chun & Kuang, Acta Bot. Sin. 10 (3): 246. 1962. *Pseudotsuga argyrophylla* (Chun & Kuang) Greguss, Bot. Közlem. 57: 54. 1970; *Tsuga argyrophylla* (Chun & Kuang) de Laub. & Silba, Phytologia Mem. 7: 75. 1984. Type: China: Guangxi, Guangfu, ["ad regionem sylvaticam Kwangfuensem"], *Kwangfu Lingchü Exped 198* (holotype IBSC, isotype PE). Fig. 76, 77

Etymology

The species epithet is derived from the Greek *argyr-* = silver and *phyla* = leaf.

Vernacular names

yin shan (Chinese)

Description

Trees to 20 m tall, d.b.h. to 40–60 cm; trunk monopodial, straight, columnar, sometimes forked in the top; crown pyramidal, often irregular, open. Bark grey, becoming scaly, lower down the trunk of older trees breaking into irregular plates. Branches of first order long, heavy, spreading horizontally or slightly ascending; branches of second order slender, branching irregularly. Branchlets slender, firm, yellowish, becoming grey in second year; surface with ridges ending in weak pulvini, divided by grooves, glabrous, but very young shoots puberulent; leaf scars angular circular; no real short shoots (weak dimorphism), but alternately long and short growth of shoots, the lateral (weaker) shoots forming 1–3 sequences with fewer and shorter leaves. Vegetative buds ovoid conical, 6–8 mm long, not resinous; bud scales ovate; basal scales smaller than the apical scales, light yellowish brown, deciduous. Leaves spirally arranged, on short shoots seemingly in tufts, spreading radially, densely crowded near shoot apex, directed forward, (1.8–)2.8–4.5(–5.5) cm long, (2.2–)2.5–3 mm wide, more or less petiolate at base, linear, flattened, longitudinally grooved and green above, with 2 glaucous white bands below; margins slightly recurved, ciliate in young leaves; apex obtuse. Stomata in two bands separated by a midrib below, in ca. 15 rows on each side. Pollen cones lateral, near shoot apex, pendant, with involucre of light brown, large scales, 3–6 cm long, yellowish. Seed cones lateral, at about right angles from shoot, short pedunculate, ovoid oblong, with acute apex, 3–5 cm long, 1.5–2.5 cm wide with slightly opened seed scales, greenish, maturing to orange brown, ripening to chestnut brown. Bracts triangular, with a long point, 5–8 mm long, included. Seed scales 13–16, orbicular or ovate, 1.5–2.5 cm long and 1–2 cm wide at mid-cone; surface longitudinally striated or furrowed, initially puberulent, later glabrous; upper margin entire, soon becoming erose; base very short pedicellate. Seeds obovoid, with an acutish base, 5–6 × 3–4 mm, dark olive with pale green spots; seed wings adnate, obovate cuneate, 10–15 mm long and 4–6 mm wide, light brown.

Taxonomic notes

Cathaya argyrophylla is one of the prime examples of a relict conifer which had a very much wider distribution in the geologic past. In the Tertiary *Cathaya* occurred in Europe, Russia, and Canada, and the genus is rather common as a fossil in the Miocene lignite ('brown coal') deposits of Germany. Its taxonomic position has been the subject of some dispute in the past, but more recent phylogenetic studies in the *Pinaceae* have confirmed its status as a genus, probably related to *Pseudotsuga* in a 'pinoid' clade.

Distribution

China: Chongqing (Nanchuan Xian, Wulong Xian), NE Guangxi (Jingxiu Yaozu Zizhixian, Longsheng Gezu Zizhixian), Guizhou (Daozhen Xian, Jiangkou

Xian, Tongzi), S Hunan (Chengdu, Guidong Xian, Luohandong, Xinning Xian, Zixing Shi).
TDWG codes: 36 CHC-CQ CHC-GZ CHS-GX CHS-HN

Ecology

On medium high mountains, at elevations between (900–)1200 m and 1900 m a.s.l. The soils are the widely distributed red and yellow earths of humid, warm temperate to subtropical China. Wang (1961) has mentioned *C. argyrophylla* as a rare conifer occurring in the evergreen sclerophyllous broad-leaved forest type. This forest type is dominated by numerous species of *Fagaceae* with mostly small, ovate lanceolate, coriaceous leaves. However, from the altitudinal range of the species it is likely that it occurs in an ecotonal type between the sclerophyllous and deciduous broad-leaved forest types. Other conifers with which it occurs are almost certainly *Pinus fenzeliana* (syn. *P. kwangtungensis*), and possibly also *Tsuga chinensis* and *Nothotsuga longibracteata*.

Conservation

After its discovery in the 1950s, for many years this monotypic genus was considered to be an extremely rare conifer. Even herbarium specimens were very few and virtually nothing of it had reached botanic gardens and institutional herbaria outside China until very recently. It is a relatively rare conifer, but its extent of occurrence (EOO) is now known to encompass four provinces in south-central China and herbarium collections (in China) are known from at least 10 localities. It is usually growing on inaccessible slopes and ridges and is not considered to be a valuable timber resource due to small or medium size and 'poor shape' in logging terms. Several localities are within reserves and enjoy legal protection. A re-assessment in 2010 established its conservation status as Vulnerable on the basis of limited known distribution.
IUCN: VU (D1)

Uses

This species is in cultivation through several forestry institutes and botanic gardens in China; outside China it is still very rare in collections and no mature plants exist in these. It has only recently been freed of its official embargo, which was not based in considerations of conservation of a rare species but in geopolitics. Lifting of these strictures may have begun with the donation of some seedlings by Prof. Fu Likuo when he visited the Royal Botanic Garden, Edinburgh in 1998 for work on Volume 4 of the Flora of China. Although the species is now available in the trade in both Europe and the USA, it will probably remain a tree for collector's gardens only, as it has no remarkable horticultural merit.

Cedrus Trew, Traité Arbr. Arbust. 1: 139. 1755 (*nom. cons.*). Type: *Cedrus libani* A. Rich. (*Pinaceae*).

Cedrus is the classical Latin name for the (true) cedars; however, it was also in use for (fragrant) wood of other conifers.

Description

Monoecious evergreen trees with a columnar trunk. Resin canals in bark, leaves, and seed cones, resin cysts in wood. Young trees branching at regular intervals, later several branches of the first order become codominant with the main stem, except in *C. deodara*, where the apical dominance is maintained (Massart's model). Bark on large trunks breaking into small, irregular plates and becoming longitudinally fissured. Shoot dimorphism pronounced, with long, slender leading shoots and lateral, short spur shoots; a terminal bud forming a long shoot, and several lateral buds forming short shoots. Leaves linear-acicular, rigid, usually slightly narrowed near base and tapering towards an acute apex, amphistomatic, diamond shaped in cross section. Pollen cones solitary and more or less erect from apex of short shoots, large, catkin-like; pollen bisaccate; phenology marked by late shedding of pollen (September to November), related to late development of the female strobilus. Seed cones similarly situated, distinctly erect, requiring about 17–18 months for full development, becoming ovoid to barrel shaped when full grown. Bracts small and hidden, not growing with the seed scales. Seed scales helically arranged on a narrowly conical rachis and extremely imbricate, large, flabellate, coriaceous or thin woody, dismembering from the persistent rachis by abcission at maturity. Seeds fully covered by a membrane on one side and partly covered with a small portion at other side, membrane continuing in a very large, broad seed wing. Seedlings with (5–)8–10(–14) cotyledons.

Taxonomic notes

As will be discussed in more detail below with the species, the morphology commonly deployed to circumscribe and differentiate the constituent species of the genus *Cedrus* is on critical examination not very convincing. The three (or four) species traditionally recognized occur, however, in vastly separate (disjunct) regions. If the genus once had a more continuous distribution, with populations bridging the great gaps now extinct, it is evident that this fragmentation happened long ago. Such separation leads inevitably to genetic differences between the remnant populations, and eventually to separate species. A comprehensive genetic (DNA based) study of the genus is necessary, but has not yet been undertaken and published.

3 species.

Distribution

Disjunct: Atlas Mountains of Morocco and Algeria; Lebanon, Syria, SE Turkey, Cyprus; Himalaya.

Key to the species of *Cedrus*

1a. Leading shoot and tips of branches drooping. Leaves on short shoots 2–4.5 cm long. Pollen cones usually longer than 5 cm ***C. deodara***

1b. Leading shoot and tips of branches erect or spreading. Leaves on short shoots less than 3 cm long. Pollen cones shorter than 5 cm **2**

2a. Seed cones when fully mature up to 12 cm long (but sometimes not exceeding 10 cm). Pollen cones up to 5 cm long. Indigenous to E Mediterranean ***C. libani***

2b. Seed cones when fully mature up to 8 cm long. Pollen cones up to 4 cm long. Indigenous to W Mediterranean (Algeria and Morocco) ***C. atlantica***

Cedrus atlantica (Endl.) Manetti *ex* Carrière, Traité Gén. Conif.: 285. 1855. *Cedrus libani* A. Rich. var. *atlantica* (Endl.) Hook. f., [Cedars Lebanon] Nat. Hist. Rev., ser. 2, 2: 15. 1862; *Cedrus libani* A. Rich. subsp. *atlantica* (Endl.) Batt. & Trab., Fl. Algérie Tunisie: 397. 1905. Type not designated. Fig. 78

Etymology

The species epithet means 'from the Atlantic' contrasting the species with the cedars that grow in the eastern Mediterranean.

Vernacular names

Atlas cedar; Cèdre de l'Atlas (French)

Description

Trees to 30–35(–40) m tall, but at higher elevations usually lower, d.b.h. to 1.5–2 m; trunk usually monopodial, columnar, massive, often forked above the middle. Bark on trunk cracked and fissured, rough, dark grey, breaking into flaking plates revealing reddish brown bark. Branches of first order massive, the upper ones ascending, the lower horizontal or bent downward; branches of second order crowded, spreading in horizontal or descending planes, ascending near the top of the tree; crown in young trees broadly conical, in old trees spreading laterally, becoming flat topped. Branchlets short, firm, except leading shoot, which is longer and slender, grey green or grey brown, soon turning grey and flaking, densely blackish pubescent at first; pulvini on long shoots small, prominent; short shoots thick, scaly, of variable length with age (0.5–3 cm), assurgent or erect. Vegetative buds ovoid globular, 2–3 × 1.5–2 mm, not resinous; bud scales broadly ovate, red brown, dark brown or blackish at apex, deciduous. Leaves on long shoots spirally arranged, remote, near base of long shoot more crowded, radially spreading, falling in 2nd or 3rd year; on short shoots densely crowded in false whorls, 20–45, spreading radially, (1–)1.5–2.5(–3) cm long, 1–1.5 mm wide, narrowly linear, straight or curved, diamond shaped in cross section; apex acute or acuminate; stomata on all sides, more numerous on two adjacent sides; leaf colour glossy dark green or glaucous. Pollen cones terminal on short shoots, erect, subtended by leaves, numerous, soon falling after shedding pollen, 3–4 cm long, straight, later curved, first rose yellow, later pale brown. Seed cones terminal on short shoots, erect, sessile, becoming woody in 2nd year, ovoid or barrel shaped; apex obtuse or retuse, 5–8 × 3–5 cm, light green, maturing to pale green, with purplish edges of seed scales, ripening to light (purplish) brown; cone rachis persistent, narrowly conical. Seed scales broad flabellate, thin, coriaceous, length × width 2–3 × 2.5–3.5 cm; surface smooth, orange-brown pubescent at base, glabrous on exposed parts; upper margin entire, slightly incurved; base pedicellate. Seeds ovoid conical, 8–13 × 4–6 mm, brown; seed wings broad cuneate, 18–25 × 12–17 cm, (light) brown.

Taxonomic notes

The taxonomic distinction between *Cedrus atlantica* and *C. libani* is at best inconsistent and, when evaluated critically based on the populations growing in the wild, probably non-existent. Much has been made of glaucousness of foliage, but this is based on trees selected for horticulture; glaucous as well as green leaved trees occur in Morocco as well as in Turkey, often in the same populations. Numbers of leaves on short shoots and length of leaves not only vary, the values often cited as distinct between the two species can be found in both distant areas. The smaller maximum size of seed cones in *C. atlantica* may be correct, but to emphasize this hides the substantial overlap in cone sizes actually observed in natural populations. Crown shape is entirely a question of age and of growing conditions; roughly speaking: the older the tree the flatter the crown in both species. In Turkey, trees with pyramidal crowns are known as *C. libani* subsp. or var. *stenocoma*, but that distinction is taxonomically doubtful, too. Should we therefore unite the Mediterranean Cedars under a single species, *C. libani*? Should we recognize subspecies or varieties? The only true distinction is the great geographical separation, which rules out gene flow between *C. atlantica* and *C. libani* in nature. They may become truly distinct species in the future.

Distribution

NW Africa: Algeria, Morocco (Atlas Mts.).
TDWG codes: 20 ALG MOR-MO

Ecology

The Atlas cedar occurs on the high maritime ranges of the Atlas Mountains, at elevations between 1370 m and 2500 m a.s.l., especially on N and NW exposed slopes receiving 1000 to 2000 mm precipitation annually, mostly during the winter. At the high ridges much snow accumulates. The summers are warm and dry. The soil is usually rocky, calcareous and well drained. The species grows in pure stands, reaching tree limit on high, exposed ridges, or is

locally mixed with *Abies numidica, Taxus baccata, Quercus faginea, Acer obtusatum, Populus tremula, Sorbus aria*, and *S. torminalis* (Algeria) or *Abies pinsapo* var. *marocana, Juniperus communis, Taxus baccata, Populus tremula, Quercus ilex*, and *Acer granatense* locally in Morocco.

Conservation

While still abundant in some parts of the Atlas Mountains, more recent surveys by Moroccan foresters have revealed that a reduction of >50% has occurred in recent times (since 1940) and that decline is continuing. This species had to be 'uplisted' as a result.
IUCN: EN (A2cd)

Uses

Atlas cedar is an important tree for timber in North Africa, providing strong and durable wood for construction purposes as well as for the manufacture of furniture. In the 19th century it was introduced in Europe (France, 1839) and rapidly spread as an ornamental tree desirable for landscape gardens, often supplanting the much earlier introduced Lebanon cedar. Despite claims to the contrary, which are mostly based on perceptions, not on knowledge of characters of natural populations, the two putative species are extremely difficult, if not impossible, to distinguish as mature trees in cultivation. A very glaucous leaved form is particularly in demand for horticulture and is based on selections ('Glauca' or 'var. glauca') of individuals found in nature. Several other cultivars are known, based on habit and foliage characteristics.

Cedrus deodara (Lamb.) G. Don, in Loudon, Hort. Brit. 1: 388. 1830. *Pinus deodara* Lamb., Descr. *Pinus* 2: 8. 1824; *Cedrus libani* A. Rich. subsp. *deodara* (Lamb.) P. D. Sell, Watsonia 18 (1): 92. 1990. Type not designated. Pl. 10, Fig. 79

Etymology

Deodar is the vernacular name for this species in India.

Vernacular names

Deodar cedar, Himalayan cedar; deodar (India); xuesong (Chinese)

Description

Trees to 40–50(–65) m tall, d.b.h. to 2.5–3 m; trunk usually monopodial, straight, columnar, sometimes forked in several stems above 2/3 of bole. Bark soon cracked and flaking, breaking into small plates, fissured, dark blackish grey. Branches of first order massive, spreading horizontally or almost erect near the top, the lower branches curved downward; branches of second order crowded, usually spreading in horizontal or descending planes, the leading shoots drooping; crown of young trees conical, with drooping leader, old trees conical. Branchlets short, firm, but leading shoots long and slender, pale (pinkish) fawn brown, becoming grey brown; surface smooth, soon breaking, showing green bark in cracks, densely light brown pubescent at first; pulvini small, prominent on long shoots; short shoots thick, scaly, of variable length with age (0.5–4 cm), assurgent or erect. Vegetative buds ovoid, acute, 1–2 mm long, not or slightly resinous; bud scales ovate, orange brown, with pale brown apex, deciduous. Leaves on long shoots spirally arranged, remote, more crowded at base of long shoot, falling after 2–2.5 years; buds of short shoots axillary; leaves on short shoots densely crowded in false whorls, 20–30, spreading radially, 2.5–4.5 cm long (2–6 cm on long shoots), 1–1.5 mm wide, narrowly linear, straight or slightly curved, diamond shaped in cross section, abruptly acute; more or less amphistomatic, but stomata on two adjacent sides more numerous; leaf colour green to grey green. Pollen cones terminal on short shoots, erect, subtended by leaves, numerous, soon falling after shedding pollen, (4–)6–7 cm long, immature greenish, ripening to rose brown. Seed cones terminal on short shoots, erect, sessile, becoming woody in 2nd year, usually barrel shaped or ovoid; apex obtuse or retuse; 7–13 × 5–9 cm, pale grey green, maturing to glaucous green, sometimes with purple, ripening to dark brown; cone rachis persistent, narrowly conical. Seed scales broad flabellate or rectangular flabellate, thin, coriaceous, length × width 3–4 × 3.5–4.5 cm; surface smooth, yellowish

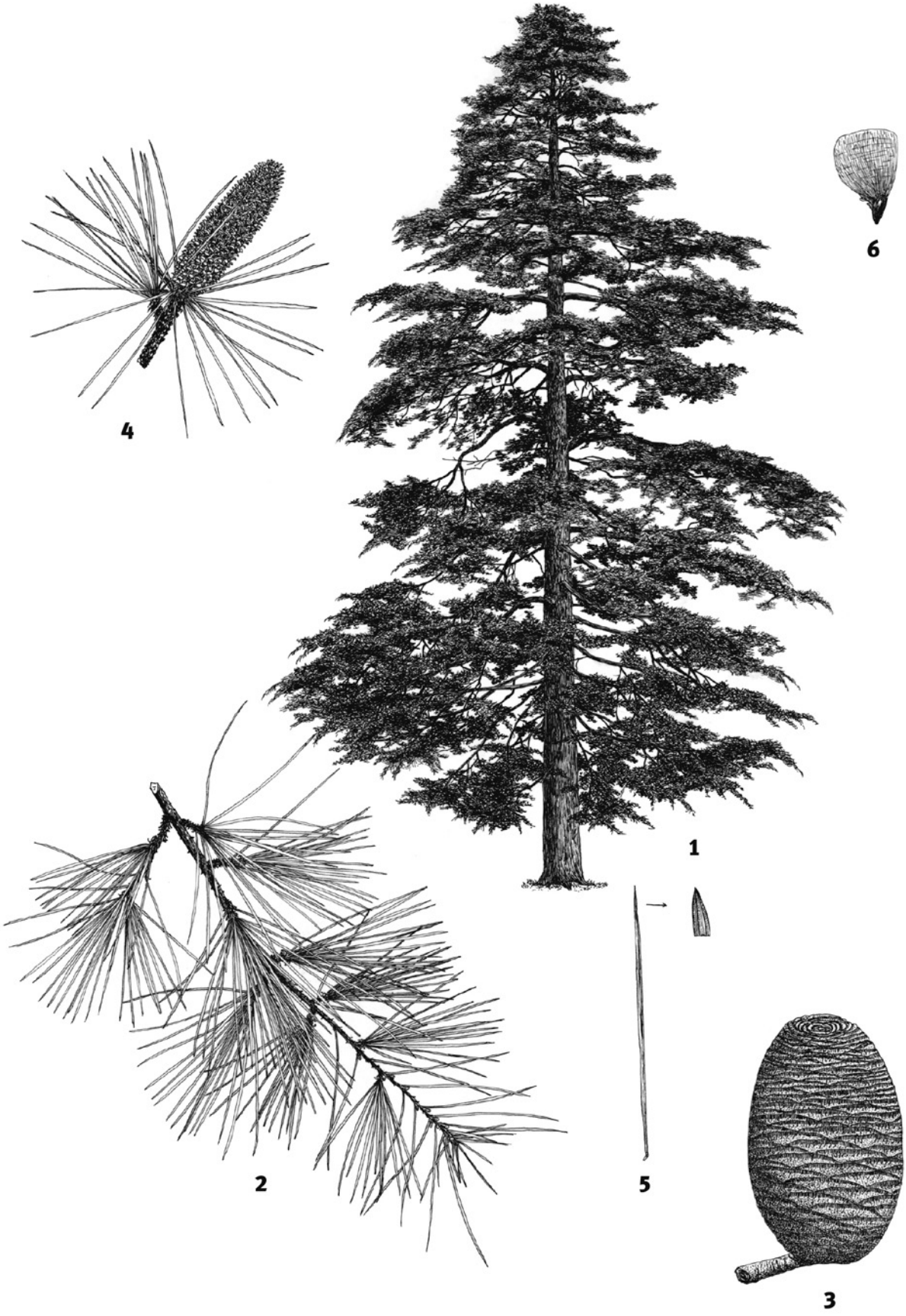


PLATE 10. *Cedrus deodara*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Seed cone. **4.** Pollen cone and leaves. **5.** Leaf. **6.** Seed.

brown pubescent at base; upper margin entire, thin, slightly incurved; base pedicellate. Seeds ovoid conical, 10–15 × 5–7 mm, brown; seed wings broad cuneate, 20–30 × 15–21 mm, light brown.

Taxonomic notes

Reducing *Cedrus deodara* to a subspecies of *C. libani*, as was proposed by Peter Sell (*op. cit.*), would presumably reduce *Cedrus* Trew to a monotypic species, with only a few varieties or subspecies recognized under that species. Based on morphology, there is merit in this view, but it may not be the entire truth about what in this case actually constitutes a distinct species. Unlike between *C. atlantica* and *C. libani*, there are consistent, albeit small, morphological differences between these two species and *C. deodara*. More research into genetic aspects of the problem is needed before such a far reaching conclusion can be drawn.

Distribution

E Afghanistan (Hindu Kush), NW Pakistan (Karakoram), China: extreme SW Xizang [Tibet], Kashmir to W Nepal.
TDWG codes: 34 AFG 36 CHT 40 NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

Cedrus deodara is a high mountain tree, but it occurs in a wide range of habitats in the Himalaya. It grows in a belt at elevations between 1700 m and 3000 m a.s.l. in the western part of its range and between 1300 m and 3300 m in the eastern part, where the climate is less dry. It grows on a variety of alpine lithosols. The climate is moist monsoon, but the increasing moisture in the E Himalayas is a limiting factor; towards the west it becomes moderately dry, with annual precipitation less than 750 mm in the most western part of its range. At higher elevations it forms a coniferous forest belt with, among other species, *Abies pindrow, A. spectabilis* in Nepal, *Pinus wallichiana, Picea smithiana*, and *Cupressus torulosa*, but forms often also pure stands. At the highest limits of *Cedrus, Juniperus squamata* is the only accompanying conifer species. At lower elevations first *Quercus* spp., then *Aesculus indica, Betula* sp., *Corylus jaquemontii, Acer* spp., *Prunus* spp. and shrubs mark the transition towards a broad-leaved forest.

Conservation

IUCN: LC

Uses

Himalayan cedar is a very important timber tree in Pakistan, Kashmir and NW India. Its strong and durable wood is mostly used for construction. Other uses are general carpentry and furniture. A fragrant oil can be distilled from wood chips and sawdust. It was first introduced in England in 1822 as an ornamental tree, but as a park tree it remains less common than the two Mediterranean species. It is generally more susceptibe to 'late' frost than these and also requires more moisture. Young trees especially have a distinct habit with drooping leaders and are commonly used in gardens. This use has led to the selection of several cultivars, with different habit including dwarf forms and/or with varying foliage colours; most of these are in cultivation in Central Europe.

Cedrus libani A. Rich., in Bory, Dict. Class. Hist. Nat. 3: 299. 1823.

Etymology

The species epithet denotes the Lebanon from where this species was first described and named.

Vernacular names

Cedar of Lebanon, Lebanon Cedar

Description

Trees to (20–)35–40 m tall, d.b.h. to 1.5- 2.5 m; trunk usually monopodial, columnar, massive, often forked or branched below 1/3 of the bole. Bark soon cracked and scaly, rough, with flaking small plates and deep, longitudinal fissures, dark grey to blackish brown. Branches of first order massive, often erect, eventually spreading horizontally, the lowest often weighed down at ends; branches of second order crowded, spreading in horizontal planes; crown in young trees conical (sometimes retaining a narrow habit longer), but later spreading horizontally, often several boles forming crowns at different levels, flat topped, but in forest stands more pyramidal. Branchlets short, firm,

but leading shoot long and slender, (pale) brown, turning grey, shallowly grooved, soon flaking, at first with dark brown pubescence; pulvini small, on long shoots; short shoots thick, scaly, of variable length with age (0.5- 4 cm), assurgent or erect. Vegetative buds ovoid, 2- 3 × 1.5- 2, not or slightly resinous; bud scales broadly ovate, free at tips, pale brown with dark apex, deciduous. Leaves on long shoots spirally arranged, remote, radially spreading, more crowded at base of the long shoot; short shoots emerging in leaf axils, leaves densely crowded in false whorls, (15–)20–35, most numerous on older short shoots, spreading radially, (0.5–)1–2.5 cm long (on long shoots 1–3.5 cm), 1–1.5 mm wide, narrowly linear, straight or curved, in cross section diamond shaped, acute or acuminate; more or less amphistomatic; leaf colour light or dark green, sometimes glaucous. Pollen cones terminal on short shoots, erect, subtended by leaves, numerous, 4–5 cm long, cylindrical, curved when ripe, pale green at first, ripening to pale brown. Seed cones terminal on short shoots, erect, sessile, becoming woody in 2nd year, ovoid, ovoid oblong or barrel shaped, with obtuse or retuse apex, (5–)8–12 × 3–6 cm, first light green, maturing to greyish or purplish green, ripening to grey brown with purplish edges of seed scales; cone rachis persistent, narrowly conical. Seed scales broad rectangular flabellate, thin, coriaceous, soon breaking up below, length × width 3–3.5 × 3.5–4 cm; surface smooth, orange-brown pubescent at base; upper margin entire, thin, slightly incurved; base pedicellate. Seeds ovoid conical, 10–14 × 4–6 mm, brown; seed wings broad cuneate, 20–30 × 15–18 mm, light brown.

Taxonomic notes

The variety *C. libani* var. *stenocoma*, in earlier botanical literature usually recognized as a subspecies and said to be intermediate between *Cedrus atlantica* and *Cedrus libani*, is probably more accurately merely an ecotype. Given variability of morphology in *C. libani* (and *C. atlantica*) among trees with spreading to flat-topped crowns, there are no characters that differ in this variety, and we are left with its habit. As it often occurs in relatively dense stands mixed with *Abies cilicica* or in pure stands of relatively young trees, it is probably assuming this growth form due to competition. Such trees would be understood as ecotypes and not as proper taxa.

Distribution

Lebanon, Syria, Turkey.
TDWG codes: 34 LBS-LB LBS-SY TUR

Ecology

In high mountains around the eastern Mediterranean basin, especially on N-facing slopes, at elevations between 1100 m and 3000 m a.s.l. The soils are usually well drained, calcareous lithosols on rocky slopes and ridges. The climate has cool, moist winters (annual precipitation 1000 mm to 1500 mm) and warm, dry summers; at the highest elevations there is abundant snow in winter. *Cedrus libani* occurs in pure stands or mixed with *Abies cilicica* in Turkey, in which are also common *Juniperus excelsa* and locally *J. foetidissima*, at lower elevations it is replaced by *Pinus nigra* and *Pinus brutia*.

Uses

Cedar of Lebanon is a timber tree used since the dawn of civilization. About 4600 years ago King Snefru of the Fourth Dynasty of ancient Egypt, who ordered the building of the pyramids of Dahsjur and Meidum, used 40 shiploads of cedar timber for shipbuilding and for the heavy doors of the king's palace. It was undoubtedly used in similar ways before this earliest written record. Solomon's temple in Jerusalem is reputed to have been built with its timbers. Subsequent civilizations plundered the Lebanon cedar forests to almost depletion. A tree of this species appears as a symbol in the flag of Lebanon. In Turkey, where it is much more abundant, forests are now mostly well managed to provide a renewable resource of strong, hard, and durable timber for construction, boat building and furniture. It was introduced in Europe as early as 1638 (England) and became a major tree in the landscaped parks around stately homes in much of Europe, but especially in Britain. Many trees at these locations are now majestic specimens, often with multiple stems and huge, spreading flat crowns. Cultivars have been selected, but are less numerous than those derived from Atlas and Himalayan cedars.

2 varieties are recognized:

Cedrus libani A. Rich. var. ***libani***. Type: Illustration of "*Cedrus*" in Belon, Plur. Rer. Obs.: 162. 1605 (lectotype). Fig. 80

Cedrus libanitica Trew *ex* Pilg. subsp. *stenocoma* O. Schwarz, Fedde's Repert. Sp. Nov. Regni Veg. 54 (1): 26. 1944; *Cedrus libani* A. Rich. subsp. *stenocoma* (O. Schwarz) P. H. Davis, J. Roy. Hort. Soc. London 74: 113. 1949; *Cedrus libani* A. Rich. var. *stenocoma* (O. Schwarz) Frankis, Fl. Turkey & E. Aegean Is. 11: 5. 2001.

Description

Trees pyramidal when young, older trees developing broad and eventually flat-topped crowns. Leaves (1–)2–2.5(–3.5) cm long, green, grey-green, or glaucous green.

Distribution

Lebanon, Syria (Djebel el Ansiriya), Turkey (Taurus and Anti-Taurus Mts., disjunct in northern Turkey).
TDWG codes: 34 LBS-LB LBS-SY TUR

Conservation

IUCN: VU [B2ab (ii, iii, v)]

Cedrus libani A. Rich. var. ***brevifolia*** Hook. f., J. Bot. 18: 31. 1880. [J. Linn. Soc., Bot. 17: 518. 1880] *Cedrus brevifolia* (Hook. f.) A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 3: 467. 1908; *Cedrus libani* A. Rich. subsp. *brevifolia* (Hook. f.) Meikle, Fl. Cyprus 1: 22. 1977. Type: Cyprus: Southern Cyprus, Troödos Mts., Troödos Forest, *S. Baker s.n.* (holotype K).

Description

Trees to 15–20 m tall, d.b.h. 1–1.2 m, eventually flat-topped. Leaves 0.5–1.6(–2) cm long, (sometimes longer in cultivation), the longest at base of long shoots, width 1–1.5 mm.

Taxonomic notes

This taxon, although often recognized as a distinct species, is on critical examination of doubtful distinction. Many trees appear to have very short leaves, but some (and not only young trees) have leaves as long as those found on many trees of var. *libani* in Turkey, Syria and Lebanon. Also, in var. *libani* forms with short leaves can be found in Turkey, and if short leaves are the only distinctive character, var. *brevifolia* could be more widespread or both varieties not taxonomically distinct. Trees taken into cultivation may be of limited provenance and therefore not show the same variation as is found in natural populations; taxa should always be circumscribed according to characters observed in wild populations, if possible. It can be maintained as a variety but merely on the basis of a trait: often shorter leaves than in *C. libani* var. *libani*.

Distribution

Cyprus, Troodos Mountains, Mt. Triphylos.
TDWG codes: 34 CYP

Ecology

Cedrus libani var. *brevifolia* occurs on medium high mountains at elevations between 900 m and 1525 m a.s.l. in two separated populations on N-facing slopes, where the soils are calcareous and rocky. The climate is mild and wet in winter, with ca. 1000 mm annual precipitation, and warm and dry in summer. The two almost pure, scattered stands have been much degraded by cutting, fire and goats and are only remnants of formerly more extensive forests.

Conservation

This variety of *C. libani* has a limited distribution and is known from two populations in the mountains of Cyprus. The geographical isolation on the island of Cyprus could have led to genetic distinctions not expressed in the morphology; if so we would be dealing with a threatened genotype isolated from its main congeners. However, the same would probably be true of the remnant population of var. *libani* in the mountains of Lebanon, further (and perhaps longer) disjunct from the main range of the species than that of Cyprus, but in which no morphological distinctions are discernible.
IUCN: VU (D2)

Cephalotaxus Siebold & Zucc. *ex* Endl., Gen. Pl. Suppl. 2: 27. 1842. Type: *Cephalotaxus harringtonii* (Knight *ex* J. Forbes) K. Koch (*Taxus harringtonii* Knight *ex* J. Forbes) [*Cephalotaxus pedunculata* Siebold & Zucc. *ex* Endl. (*nom. illeg.*)] (*Cephalotaxaceae*).

Greek: *kephalos* = head; referring to the structure (cone) onto which the seed is attached; *Taxus* is the classical Latin name for yews.

Description

Dioecious evergreen shrubs or small trees. Resin canals (1) in the leaves only. Bark thin, smooth, exfoliating in narrow strips. Branches spreading and plagiotropic or ascending, foliage branches terminating in conical, scaly buds. Leaves spirally inserted, spreading in all directions on erect shoots, pectinately arranged on lateral, plagiotropic shoots by alternately twisting of petiolate leaf bases, becoming subopposite, flattened, linear-lanceolate, with two prominent stomatal bands separated by a raised midrib on the abaxial side. Pollen cones aggregated in pendulous, more or less globose, short-stalked clusters (capitulae) in the axils of leaves, forming opposite or subopposite rows on the underside of lateral foliage branchlets; each small cone consiting of a short rachis with up to 15 peltate microsporophylls in spiral arrangement, each with 2–4 pollen sacs containing spherical pollen. Seed cones in clustered pairs or groups from axillary buds situated distally from lateral shoots, (long) pedunculate, consisting of two sterile and several decussate fertile bracts, the fertile bracts with two axillary, erect ovules, somewhat swollen at pollination and at that time still lacking an arillus, developing much later. Seeds from 1–2 fertilized ovules per cone, large, obovoid to ellipsoid, surrounded by a fleshy, green aril ripening from green to yellowish, reddish or purplish brown. Seed proper large, with a hard, sclerified seed coat.

8 species.

Distribution

NE India (Arunachal Pradesh, Assam); Myanmar [Burma]; China; Korea; Japan; Taiwan; Lao PDR; Thailand; Viet Nam.

Key to the species of *Cephalotaxus*

The number of lines of stomata in a stomatal band is not necessarily correlated with the width of that band, so a magnifying lens 10–20 × is required to observe this character. The disposition of leaves (in a horizontal plane or in a V-formation) can vary between fertile and infertile shoots and between sun-exposed and shaded shoots and is by itself not a reliable character.

1a. Leaves convex, touching each other closely, cordate or truncate at base; apex minutely cuspidate or mucronate ***C. oliveri***

1b. Leaves more or less flat, separately disposed, cuneate to nearly truncate or twisted petiolate at base; apex acuminate or cuspidate, sometimes mucronate **2**

2a. Leaves mostly 3.5–10(–12.5) cm long, curved upward and outward or downward, forming a V-formation. Peduncle of seed-bearing structure variable in length, but up to 20–25 mm long **3**

2b. Leaves mostly 2–5(–7) cm long, spreading horizontally or forming a V-formation on shoots with pollen cones. Peduncle of seed bearing structure up to 10(–15) mm long **4**

3a. Leaves (1.5–)3–5 mm wide. Seed-bearing structures 3–6 together; seeds including the striated or ridged aril 14–25 × 9–15 mm ***C. fortunei***

3b. Leaves 4–7 mm wide. Seed-bearing structures solitary; seeds including the indistinctly striated aril 35–45 × 20–25 mm ***C. lanceolata***

4a. Stomatal bands with 10–15 lines of stomata; leaf bases cuneate **5**

4b. Stomatal bands with 20–25 lines of stomata; leaf bases obtuse to nearly truncate **6**

5a. Pollen cones 6–7 per capitulum, to 3 mm diam. Seeds including the aril ellipsoid, with 6 longitudinal ridges ***C. sinensis***

5b. Pollen cones 6–12 per capitulum, 3–4 mm diam. Seeds including the aril obovoid, smooth or striated **7**

6a. Leaves spreading at 45–80° to shoot axis, linear and abruptly narrowing to a mucronate apex ***C. hainanensis***

6b. Leaves spreading at 70–90° to shoot axis, widest below the middle and gradually tapering to a cuspidate apex ***C. mannii***

7a. Leaves on shoots with pollen cones forming a V-formation. Peduncle of seed-bearing structure 5–15 mm long ***C. harringtonii***

7b. Leaves on shoots with pollen cones (as other leaves) spreading more or less horizontally Peduncle of seed-bearing structure 2–5 mm long ***C. latifolia***

Cephalotaxus fortunei Hook., Curtis's Bot. Mag. 76: t. 4499. 1850.

Etymology

This species was named after Robert Fortune, who introduced it to England in 1848.

Vernacular names

Fortune's plum yew; san jian shan (Chinese)

Description

Shrubs or trees 1–20 m tall; trunk to 40 cm d.b.h. or more, often multi-stemmed. Bark thin, exfoliating in strips, reddish brown. Branches spreading or ascending, forming a broad crown in trees; shrubs often as wide or wider than tall. Foliage branchlets slender, terete, glabrous, finely grooved between decurrent leaf bases, green turning yellowish to light brown. Leaves mostly spreading in two rows in a semi-pectinate arrangement, diverging at various angles between 30°–110° to shoot axis, commonly curved upward and down towards apex; (1.5–)3.5–10(–12.5) cm long, linear-lanceolate, straight or slightly falcate, (1.5–)3–5 mm wide, with a short, twisted petiolate base, gradually tapering to an acute to cuspidate apex, coriaceous but flexible, dark dull green above, with two whitish green bands below. Midrib on the adaxial (upper) side in a shallow depression, 0.5 mm wide, obtusely raised, continuous from base to apex, obtusely raised and continuous on the abaxial side. Stomata in two broad bands of 17–24 intermittent white lines separated by a green midrib and bordered by green, slightly revolute leaf margins. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a 3–7 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate, incurved bracts with entire or erose, more or less hyaline margins, bearing 6–14 small, sessile or short pedunculate, globose cones 3–4 mm diam. Microsporophylls 6–16 per cone, each with 3–4 globose, cream coloured pollen sacs. Seed cones borne 3–6 together at base of lateral foliage branchlets, on 5–25 mm long, slender peduncles. Bracts several per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an ellipsoid, green or yellow aril, enclosing the ripening seed, becoming 14–25 × 9–15 mm, turning soft, purple and indistinctly striated or longitudinally ridged, with a short mucronate apex. Seeds ellipsoid or sometimes globose, 13–24 × 7–14 mm.

Distribution

SW, Central and SE China; N Myanmar [Burma].
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HK CHS-HN CHS-JS CHS-JX CHS-ZJ
41 MYA

Ecology

Cephalotaxus fortunei occurs as an understorey tree or shrub in mixed broad-leaved (angiosperm) forests, in mixed conifer-broad-leaved forests and in coniferous forests (*Abies* and *Picea*). It is also common as a shrub or small tree in open thickets and on roadsides in secondary vegetation. Its altitudinal range is great and extends from 200 m to 3700 m a.s.l., with *C. fortunei* var. *alpina* at the higher range between (1100–)1800 m and 3700 m a.s.l. In the Lower Yangtze Valley var. *fortunei* occurs in remnants of mixed mesophytic forest with *Acer* spp., *Catalpa ovata, Fraxinus chinensis, Ilex latifolia, Liquidambar formosana, Nyssa sinensis, Quercus* spp., and many other angiosperm trees. Most of these forest remnants are disturbed and/or replaced by secondary shrubby vegetation, in which *C. fortunei* may recur. In the evergreen broad-leaved forests of Fujian, which are also remnants, *C. fortunei* var. *fortunei* occurs in the understorey of oaks (*Quercus* spp.) but mixed with many other tree species, some of which are conifers like *Nageia nagi, Keteleeria*

fortunei and *Fokienia hodginsii*. In S Gansu, Shaanxi and Sichuan var. *alpina* occurs in very different forests dominated by *Abies, Picea* or *Larix*, or a mixture of these conifers, between 1800 m and 3600 m a.s.l. Here it is a subcanopy tree or shrub, often accompanied by *Taxus chinensis* and shrubs like *Eurya* and *Rhododendron*.

Uses

The wood of this species is of limited economic value; the main uses are in horticulture. It grows into a large shrub or small tree and the long leaves of this species are decorative. It is suitable for pruning and hedge clipping. The hardiness will much depend on provenance, given the wide range of the species in China. A limited number of cultivars, some of doubtful validity and originally described as varieties with shorter or longer leaves "than the type", are known and may still be in cultivation. Long-leaved forms seem to be especially popular with gardeners and the Hillier Nurseries in Hampshire, England, have developed several cultivars with such leaves in recent years. In China oil extracted from the succulent aril enclosing the seed was traditionally used as lamp oil.

2 varieties are recognized:

Cephalotaxus fortunei Hook. var. ***fortunei***. Type: China: ["200 miles N of Shang-see"], *R. Fortune s.n.* (holotype K). Fig. 81, 82

Cephalotaxus fortunei Hook. var. *globosa* S. Y. Hu, Taiwania 10: 28. 1964.

Description

Leaves (2.2–)3.5–5 mm wide. Pollen cone capitula on 3–7 mm long peduncles. Aril covering seed with numerous indistinct striations.

Distribution

China: S Anhui, Chongqing, Fujian, S. Gansu, N Guangdong, N Guangxi, Guizhou, SW Henan, W Hubei, Hunan, Jiangxi, S Shaanxi, Sichuan, Yunnan, Zhejiang; N Myanmar [Burma].

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HN CHS-JS CHS-JX CHS-ZJ 41 MYA

Conservation

IUCN: LC

Cephalotaxus fortunei Hook. var. ***alpina*** H. L. Li, Lloydia 16 (3): 164. 1953. *Cephalotaxus alpina* (H. L. Li) L. K. Fu, Acta Phytotax. Sin. 22 (4): 282. 1984.

Description

Leaves 1.5–3.5(–4) mm wide. Pollen cone capitula sessile or very short pedunculate, peduncle 0–2 mm long. Aril covering seed with longitudinal ridges.

Distribution

China: S Gansu, Sichuan, N Yunnan.
TDWG codes: 36 CHC-SC CHC-YN CHN-GS

Ecology

An understorey shrub or small tree in mixed conifer forests, e.g. with *Abies* spp., and along mountain streams. Elevation (from GIS) 885–2554 m, from herbarium specimens 1100–3520 m a.s.l.

Conservation

The range of this variety indicates LC and no threats or decline are known to occur. Probably confined to the higher parts of SW China, true range may be poorly known due to difficulty of identification and relatively inconspicuous habit. Extent of occurrence (EOO) based on herbarium specimens calculated as 261,512 km² and area of occupancy (AOO) as 588 km² but probably larger. This variety is not known by its herbarium collections from protected areas, although some collections were made near the Three Parallel Rivers Protected Area in Yunnan and the variety may occur there, too.
IUCN: NT

Uses

An ornamental shrub in horticulture.

Cephalotaxus hainanensis H. L. Li, Lloydia 16 (3): 164. 1953. Type: China: Hainan Island, ["Fan Yah" = Fanyang?], *N. K. Chun* & *C. L. Tso 44183* (holotype US).

Etymology

The species epithet derives from Hainan, the island (and now province) of China where this species is native and perhaps indigenous.

Vernacular names

Hainan plum yew; hai nan cu fei (Chinese, includes *C. mannii* in Flora of China 4, 1999).

Description

Trees to 20 m tall; trunk to 70 cm d.b.h. Bark thin, exfoliating in small or large flakes and strips, light brown to reddish brown, weathering grey. Branches spreading or ascending, forming a rounded or narrow crown. Foliage branchlets up to 15 cm long, slender, grooved between decurrent leaf bases, green turning orange-brown. Leaves arranged in two pectinate rows, spreading horizontally and at 45–80° to shoot axis, subopposite, (1.5–)2–4 cm long, slightly falcate, 2.5–4 mm wide, flat, base very short petiolate or sessile, broadly obtuse to nearly truncate, leaf blade linear and abruptly narrowing to a mucronate apex. Midrib thin but prominent and continuous from base to apex on the adaxial (upper) side, 0.3 mm wide, conspicuous but more flattened on the abaxial side; leaf colour dark green or olive-green above, two white or glaucous white bands below. Stomata in two broad bands of ca. 20 intermittent, white lines, separated by the green midrib and bordered by slightly revolute leaf margins. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a (1–)3–5 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate, incurved bracts with entire or erose, more or less hyaline margins, bearing 6–8 small, sessile, globose, cream or light yellow cones up to 4 mm diam. Microsporophylls 6–12 per cone, each with 3–4 globose, cream coloured pollen sacs. Seed cones solitary at base of lateral foliage branchlets, on 4–10 mm long peduncles. Bracts few per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an ellipsoid, green aril, enclosing the ripening seed, becoming 20–30 × 10–15 mm, turning soft, red with longitudinal striation. Seeds (ob)ovoid to ellipsoid, sometimes laterally compressed, 18–28 × 8–14 mm, with a mucronate or cuspidate apex.

Taxonomic notes

In Flora of China 4: 87 (1999), this species is treated as a synonym of *Cephalotaxus mannii*. However, in a note the co-author Robert Mill considered the plants from Hainan to be separable as the species named and described by H. L. Li, i.e. *C. hainanensis*. Mill gives a statement of morphological differences between the two species. Under this narrower species circumscription it is possible that other specimens from southern China and northern Viet Nam would have to be included under *C. hainanensis*, with consequences for its distribution and hence conservation status. Ying *et al*. (2004) map this species as occurring in W Guangdong, Hainan, SE and W Guanxi, W Yunnan, and even SE Xizang [Tibet]. The populations of Yunnan and Tibet are here treated as belonging to *C. mannii*. A critical modern revision of the genus to resolve these issues is lacking at present.

Distribution

China: Hainan Island (Jianfeng Ling, Limu Ling, Wuzhi Shan, Dawang Ling, Diao Luo Shan).
TDWG codes: 36 CHH

Ecology

Cephalotaxus hainanensis occurs in mixed warm temperate to subtropical rainforests in mountainous areas of the island of Hainan, where it attains tree habit and size (10–20 m). Nothing has been recorded in non-Chinese literature about associated species at present, presumably these forests are diverse. It occurs from sea level to about 1700 m a.s.l. and can be the dominant tree in some places.

Conservation

Under the narrower circumscription accepted here this species is probably restricted to Hainan but its entire range remains uncertain. It is threatened by timber harvesting and especially stripping of bark.
IUCN: EN [B2ab (iii)]

Uses

The bark of this and other species is stripped to be used for medicinal purposes in China. It is not known to be in cultivation outside a few botanic gardens.

Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch, Dendrol. 2 (2): 102. 1873.

Etymology

This species commemorates the Earl of Harrington, who gave a specimen to the Duke of Bedford, from whose pinetum at Woburn Abbey James Forbes described and named it.

Vernacular names

Harrington's plum yew, Japanese plum yew; inugaya (Japanese); Picha-nam (Korean)

Description

Shrubs to small trees 0.5–10 m tall; trunk d.b.h. of monopodial trees to 40 cm. Habit prostrate to erect and spreading; trees with a wide, open and rounded crown. Bark thin, exfoliating in narrow strips, grey-brown. Branches spreading, drooping or ascending, or prostrate in one variety; foliage branchlets short, stout or slender, glabrous, grooved between decurrent leaf bases, green turning orange-brown. Leaves more or less disposed in two ranks, often upright forming a V-formation especially on branchlets with male cones, but variable and not limited to this species, straight or curved down towards apex, (1–)2.5–4(–5) cm long, with a short, twisted petiole and cuneate base, linear-lanceolate, 2.5–4 mm wide, gradually or more abruptly tapering to an acuminate or cuspidate apex, coriaceous and more or less rigid, green above, with two pale green bands below. Midrib on the adaxial (upper) side prominent, 0.5 mm wide, obtusely raised and continuous from base to apex, on the abaxial side nearly flat, 0.5–0.7 mm wide and continuous. Stomata in two broad bands on the abaxial side, each with 10–15 intermittent white lines, separated by the midrib and bordered by flat leaf margins. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a 3–7 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate, incurved bracts with entire or erose, more or less hyaline margins, bearing 6–12 small, sessile or short pedunculate, globose cones 3–4 mm diam. Microsporophylls 5–15 per cone, each with 2–3 globose, cream coloured pollen sacs. Seed cones borne 3–6 together at base of lateral foliage branchlets, on 5–15 mm long, slender peduncles with small scale leaves. Bracts several per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an obovoid, green or purplish aril, enclosing the ripening seed, becoming 15–20(–25) × 12–18 mm, turning soft, orange-red to purple and smooth or striated, with a short mucronate apex. Seeds (ob)ovoid to subglobose, 12–18 × 8–12 mm.

Taxonomic notes

This species has long been known as *Cephalotaxus drupacea* Siebold & Zucc. and it was introduced to cultivation in the Netherlands by Von Siebold under that name. However, this name was only validly published in 1846, by which time the same species (introduced by Von Siebold as stated) had been named and published as *Taxus harringtonii* ["*harringtonia*"] by James Forbes in 1839, based in part on a manuscript received from the nurseryman Joseph Knight. It was later transferred to *Cephalotaxus* by Karl Koch. *Cephalotaxus koreana* Nakai was described as a 1–1.5 m tall, caespitose but non-layering shrub with "red [and] most delicious palatable fruits." Those of *C. drupacea* (= *C. harringtonii*) were said to be bitter with a disagreeable smell. Otherwise the two taxa are similar and the assertion about edibility apparently being based on the experience and by its nature subjective opinion of one observer is here not considered to be a valid taxonomic character. *Cephalotaxus koreana* was said by its author to occur in Korea as well as in Japan, where *C. harringtoni*i can be a shrub as well as a small tree. Probably the sugar content of the aril varies among individuals or (sub)populations of this species.

Distribution

North and South Korea, Japan, Taiwan.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH KOR-NK KOR-SK TAI

Ecology

Cephalotaxus harringtonii in its tree form is a component of both broad-leaved (angiosperm) forest and coniferous forest, or mixed forest, occurring in the understorey. *Cephalotaxus harringtonii* var. *nana* is a spreading shrub on seaside cliffs as well as in mountains over rocky terrain; var. *harringtonii* can also occur as an upright shrub in dense thickets. Only var. *wilsoniana* in Taiwan is invariably a small tree in mixed montane forests. It appears that tree forms of this species are increasingly common in more southern regions where the winters are milder. The altitudinal range of var. *harringtonii* is not well documented; one herbarium collection was made at 600 m a.s.l. Variety *nana* occurs from 10 m near the coast to 1900 m a.s.l. in the mountains. In Taiwan, var. *wilsoniana* is recorded from 1800 m to 2700 m a.s.l., so this is a high montane forest tree. In Japan, var. *harringtonii* is common in the undergrowth of forests dominated by *Abies sachalinensis* and in open moorland in colder, northern regions. In S Japan var. *harringtonii* occurs in mixed forests with *Acer, Quercus, Tsuga, Chamaecyparis, Abies*, and sometimes, also as a smaller subcanopy tree, *Podocarpus macrophyllus*.

Uses

In Japan, the wood of Harrington's plum yew is of minor commercial importance and traditionally used for tool handles and household utensils. The seed arils contain oil which was formerly pressed from them and used in lamps. This species has long been cultivated for gardens in Japan, where two of the three varieties here recognized are native. It was sent to the Leiden Botanical Garden by Philipp von Siebold in 1829 as *C. drupacea* and soon distributed from there by cuttings, arriving in Ghent, Belgium in 1830. The type of the species *C. harringtonii* is (was) a plant cultivated in the gardens of the Duke of Bedford at Woburn Abbey, Bedfordshire, England and represented by plate 66 in the book Pinetum Woburnense (Forbes, 1839). It was obtained from Japan by the nursery of Knight & Perry, Chelsea, London, most likely from seeds obtained from plants in cultivation. It has now been spread throughout the northern hemisphere and beyond and is quite commonly seen in gardens and parks, including its var. *nana* and several cultivars. It is suitable for hedges, especially the smaller var. *nana*, which spreads readily by suckers.

3 varieties are recognized:

Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. ***harringtonii***. *Taxus harringtonii* Knight *ex* J. Forbes, Pinetum Woburn.: 217, t. 63. 1839, ["*harringtonia*"]; *Cephalotaxus drupacea* Siebold & Zucc. var. *harringtonii* (Knight *ex* J. Forbes) Pilg., in Engler, Pflanzenr. IV.5 [18]: 102. 1903. Type: Illustration in J. Forbes, Pinetum Woburnense, t. 66. 1839 (holotype). Fig. 83, 84

Cephalotaxus drupacea Siebold & Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4 (3): 234. 1846. *Cephalotaxus koreana* Nakai, Bot. Mag. (Tokyo) 44: 508. 1930.

Description

Shrub to small tree 10 m tall. Leaves often in an upright V-formation, especially on shoots with pollen cones, (2.5–)3–4.5(–5) cm long, 3–4 mm wide, gradually or sometimes more abruptly tapering to an acuminate or cuspidate apex.

Distribution

North and South Korea; Japan.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH KOR-NK KOR-SK

Conservation

IUCN: LC

Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. ***nana*** (Nakai) Rehd., J. Arnold Arbor. 22: 571. 1941. *Cephalotaxus nana* Nakai, Bot. Mag. (Tokyo) 33: 193. 1919. Type not designated.

Description

Shrubs with upright, suckering stems and layering lower branches; leaves more or less horizontally arranged, 1–3(–3.5) cm long, 2–3.5 mm wide, abruptly cuspidate.

Distribution

Japan: Honshu, Hokkaido.
TDWG codes: 38 JAP-HK JAP-HN

Conservation

IUCN: LC

Uses

This variety is well represented in cultivation, both in Japan and abroad, especially in the USA and Europe. It retains the layering habit in cultivation and therefore will spread out widely if not checked.

Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. ***wilsoniana*** (Hayata) Kitam., Acta Phytotax. Geobot. 26 (1–2): 9. 1974. *Cephalotaxus wilsoniana* Hayata, Icon. Pl. Formos. 4: 22. 1914; *Cephalotaxus sinensis* (Rehd. & E. H. Wilson) H. L. Li var. *wilsoniana* (Hayata) L. K. Fu & Nan Li, Novon 7 (3): 263. 1997. Type: Taiwan: Nantou, Chia-i Pref., A-li Shan ["Mt. Arisan"], *K. Uyematsu 18* (holotype TI).

Description

Small trees to 10 m tall; branches drooping or sometimes pendulous. Leaves mostly spreading horizontally, (1.5–)3–5 cm long, 3–4 mm wide, straight or slightly falcate, gradually tapering to an acuminate apex.

Taxonomic notes

In the second edition of Flora of Taiwan 1 (1994), as well as in a horticultural compilation (Tripp, 1995) this taxon was treated at species rank. In Flora of China Vol. 4 (1999) it is treated as a variety under *C. sinensis*. The morphology of these species is rather similar, but evidence from DNA appears to point to a closer affinity with the Japanese species *C. harringtonii*. This classification, first proposed by the Japanese botanist Siro Kitamura, is here accepted as the most likely true reflection of relationships.

Distribution

Taiwan.
TDWG codes: 38 TAI

Ecology

Cephalotaxus harringtonii var. *wilsoniana* occurs in deciduous/evergreen forest at middle elevation (ca. 1500–2000 m). These forests are dominated by *Fagaceae, Lauraceae, Pinaceae* (*Pinus, Pseudotsuga, Tsuga*), and a variety of other trees; *C. harringtonii* var. *wilsoniana* forms a small understorey tree tolerant of shade. In more open situations, e.g. after forest disturbance, it can hold its own and resprout from base or roots to form a dense bush.

Conservation

The native forests, in which *C. harringtonii* var. *wilsoniana* is a rare tree, have been under pressure of conversion after logging to plantations with mainly *Cryptomeria japonica*. The species is known from several localities concentrated, but not restricted, to the northern part of Taiwan, where such conversions have been widespread. It occurs in several reserves, among which is Taroko National Park.
IUCN: NT

Uses

This endemic variety from Taiwan is rare in cultivation and probably restricted to a few botanic gardens.

Cephalotaxus lanceolata K. M. Feng, Acta Phytotax. Sin. 13 (4): 86. 1975. *Cephalotaxus fortunei* Hook. var. *lanceolata* (K. M. Feng) Silba, Phytologia 68: 27. 1990. Type: China, NW Yunnan, Gongshan, upper Dulongjiang (river), 1900 m a.s.l., *G. M. Feng* 24347 (holotype PE).

Etymology

The species epithet refers to the shape of the leaves, resembling the point of a lance.

Vernacular names

Gongshan plum yew; gong shan san jian shan (Chinese)

Description

Trees to 20 m tall; trunk to 40 cm d.b.h. Bark thin, smooth, exfoliating in thin flakes, purplish weathering grey-brown. Branches spreading, drooping or pendulous, forming an open or rounded crown. Foliage branchlets slender, with grooves between decurrent leaf bases, green turning reddish brown. Leaves pectinately arranged in two rows, separated from each other, forming a V-shape, spreading at 45–70° from shoot axis, 4.5–10 cm long, narrowly lanceolate to linear-lanceolate, straight or slightly falcate, 4–7 mm wide, very short petiolate, obtuse at base, very gradually tapering from shortly above base to an acuminate or cuspidate apex, leaf texture thin coriaceous, dark green above, pale green with two whitish bands below. Midrib obtusely raised and continuous on the adaxial (upper) side, 0.6 mm wide, flat and slightly wider on the abaxial side. Stomata in two broad bands of 15–20 intermittent white lines separated by the abaxial green midrib and bordered by slightly revolute, green leaf margins. Pollen cones unknown. Seed cones solitary at base of lateral foliage branchlets, on 15–20 mm long, slender peduncles. Bracts several per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by a green aril, enclosing the ripening seed, becoming 35–45 × 20–25 mm, turning soft, greenish brown and indistinctly striated longitudinally, with a short mucronate apex. Seeds obovoid or ellipsoid, 30–40 × 16–20 mm.

Taxonomic notes

The reduction of this species to a variety of *C. fortunei* by Silba (*op. cit.*) is unwarranted; the characters compared between the two species as given in Flora of China 4: 85 (1999) are distinct. There seem to be few herbarium specimens; the type collection G. M. Feng 24347 (KUN, PE) can be accessed via the Chinese Virtual Herbarium www.cvh.org.cn with an image of the PE specimen. The Flora Reipublicae Popularis Sinicae (FRPS) 7: 425 (Cheng & Fu, 1978) gives a line drawing with foliage and a seed; this illustration was reproduced in the recently issued illustrations volume accompanying Flora of China 4.

Distribution

China: NW Yunnan (Gongshan Drungzu Nuzu Zizhixian, banks of the upper Dulongjiang); N Myanmar [Burma] (?).
TDWG codes: 36 CHC-YN 41 MYA

Ecology

This species occurs scattered in evergreen broad-leaved forest at ca. 1450–1900 m elevation. Little else is know about its ecology.

Conservation

Forests have been exploited for timber in the area where this species occurs, and it is estimated that it has declined by more than 50% as a result. It should easily meet the D criterion for Vulnerable (fewer than 1000 mature individuals) but because the decline has not ceased this species meets a criterion for Endangered.
IUCN: EN (A2cd)

Uses

No specific uses have been recorded, but due to its potential size as a tree to 20 m tall and 40 cm d.b.h. it must have been logged with the rest for timber.

Cephalotaxus latifolia L. K. Fu & R. R. Mill, Novon 9 (2): 185. 1999. Type: China: Chongking Municipality, Nanchuan Xian, Jinfo Shan, *X. Q. Chen & K. Y. Liang 2463* (holotype PE).

Cephalotaxus sinensis (Rehd. & E. H. Wilson) H. L. Li var. *latifolia* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 86. 1975.

Etymology

The species epithet describes the broad leaves of this species.

Vernacular names

Broad-leaved plum yew; kuan ye cu fei (Chinese)

Description

Shrubs to small trees 0.5–6 m tall; trunk d.b.h. to 20 cm. Bark thin, exfoliating in narrow strips, grey-brown. Branches spreading or ascending; foliage branchlets to ca. 10 cm long, stout, glabrous, grooved between decurrent leaf bases, green turning orange-brown. Leaves more or less disposed in two ranks, spreading horizontally at 65–80° to shoot axis, (1.5–)2–4(–5) cm long, sessile or with a very short, twisted petiole and cuneate base, linear to linear-lanceolate, 3–4.5(–5.5) mm wide, gradually or more abruptly tapering to an acuminate or mucronate apex, coriaceous and rigid, dark olive green above, with two whitish bands below. Midrib on the adaxial (upper) side prominent, 0.4 mm wide, lying in a channel and continuous from base to apex, on the abaxial side raised, 0.5–0.6 mm wide and continuous. Stomata in two broad bands on the abaxial side, each with 10–15 intermittent white lines, separated by the midrib and bordered by flat or slightly revolute leaf margins. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a 1.5–3 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate bracts with entire or erose, more or less hyaline margins and a mucronate apex, bearing 6–10 small, sessile or short pedunculate, globose cones 3–4 mm diam. Microsporophylls 5–15 per cone, each with 2–3 globose, cream coloured pollen sacs. Seed cones borne 2–6 together at base of lateral foliage branchlets, on 2–5 mm long peduncles with small scale leaves. Bracts several per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an obovoid, green or purplish aril, enclosing the ripening seed, becoming 17–20 × 12–15 mm, turning soft, orange-red to purple and smooth or striated, with a short mucronate apex. Seeds (ob)ovoid to subglobose, 12–16 × 9–12 mm, with a small mucro.

Taxonomic notes

The taxonomic status of this species has been disputed by some authors, who united it with *C. sinensis*, to which it bears less resemblance than to *C. harringtonii*. The latter species commonly has leaves terminating in a relatively long cusp (as in *C. sinensis*), while leaves of *C. latifolia* have an abruptly narrowed apex with a short cusp being less than 0.5 mm long. However, variants tending towards either form of leaf apex occur in *C. harringtonii* as well as *C. latifolia*, making the distinction less reliable. A comprehensive revision that would include molecular evidence is much needed. This investigation should, where possible, refrain from sampling among cultivated plants, as their identity or provenance can be muddled to start with.

Distribution

China: Chongqing, NW Fujian, N Guangdong, NE Guangxi, SE Guizhou, SW Hubei, Hunan, W Jiangxi.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHS-GD CHS-GX CHS-HN CHS-JX

Ecology

Cephalotaxus latifolia is a species occurring in mountainous areas at altitudes between 900 m and 2400 m a.s.l. It grows in secondary vegetation ("thickets" according to Flora of China 4: 86, 1999) usually forming a shrub. It may well be more common than previously thought; recent inventories in the new Chongqing Municipality (an administrative split from Sichuan Province) have found it there in several new locations.

Conservation

This species seems to be widespread in S Central and S China but less common than *C. fortunei, C. oliveri*, and *C. sinensis*. However, taxonomic recognition may also play a role; this species has formerly been confused with *C. harringtonii*, which does not occur in China, or with *C. sinensis*, and only more recent revision of in particular the Chinese herbarium collections has begun to sort out the correct identity of specimens and therefore of localities.
IUCN: NT

Uses

No uses have been recorded of this species.

Cephalotaxus mannii Hook. f., Hooker's Icon. Pl. 16: t. 1523. 1886. Type: India: Meghalaya, Khasi Hills, Lankhla Woods, *G. Mann s.n.* (holotype K). Fig. 85

Cephalotaxus griffithii Hook. f., Fl. Brit. India 5: 648. 1888. [Icon. Pl., ser. 3, 10 (2): t. 1933. 1890].

Etymology

This species was named after George Mann, who collected the type specimen.

Vernacular names

Mann's plum yew; hai nan cu fei (Chinese), Đinh tùng, Phi ba mũi (Vietnamese)

Description

Trees to 30(–50?) m tall; trunk to 70(–120) cm d.b.h. Bark thin, exfoliating in small or large flakes and strips, light brown to reddish brown, weathering grey. Branches spreading or ascending, forming a rounded or narrow crown. Foliage branchlets up to 25 cm long, slender, grooved between decurrent leaf bases, green turning orange-brown. Leaves arranged in two pectinate rows, spreading horizontally and at 70–90° to shoot axis, subopposite, (1.5–)2.5–5(–6) cm long, straight or commonly slightly falcate, (2–)2.5–4 mm wide, flat, base very short petiolate or sessile, broadly obtuse to nearly truncate, leaf blade widest below the middle and gradually tapering to a cuspidate apex. Midrib thin but prominent and continuous from base to apex on the adaxial (upper) side, 0.4 mm wide, conspicuous but more flattened on the abaxial side; leaf colour dark green or olive-green above, two white or glaucous white bands below. Stomata in two broad bands of ca. 20–25 intermittent, white lines, separated by the green midrib and bordered by slightly revolute leaf margins. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a (1–)3–5 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate, incurved bracts with entire or erose, more or less hyaline margins, bearing 6–8 small, sessile, globose, cream or light yellow cones up to 4 mm diam. Microsporophylls 6–12 per cone, each with 3–4 globose, cream coloured pollen sacs. Seed cones solitary or borne 2–3 together at base of lateral foliage branchlets, on 4–10 mm long peduncles. Bracts few per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an ellipsoid, green aril, enclosing the ripening seed, becoming 20–30 × 10–15 mm, turning soft, red with longitudinal striation. Seeds (ob)ovoid to ellipsoid, sometimes laterally compressed, 18–28 × 8–14 mm, with a mucronate or cuspidate apex.

Taxonomic notes

This species has sometimes been treated in a wider sense to include *C. hainanensis*, e.g. in Flora of China 4 (1999), but this taxon is here treated as a distinct species. *Cephalotaxus* is a difficult genus morphologically and a comprehensive critical revision including DNA-based analyses is long overdue.

Distribution

China: Guangdong (Xingyi), Guangxi, Hainan, SE Yunnan, SE Xizang [Tibet]; N Myanmar [Burma]; NE India: Arunachal Pradesh, Megalaya (Khasi Hills, Jaintia Hills), Assam (Manipur, Nagaland); NW Thailand; Viet Nam; Lao PDR.
TDWG codes: 36 CHC-YN CHH CHS-GD CHS-GX CHT 40 ASS-MA ASS-ME ASS-MI ASS-NA EHM-AP 41 LAO MYA THA VIE

Ecology

This widespread species occurs in mixed evergreen or deciduous forests, often in ravines. Its altitudinal range is from 500 m to 2000 m a.s.l. In China trees are described as not reaching taller than 20 m (Flora of China 4: 87, 1999), but in Thailand trees up to 50 m tall have been reported. That maximum figure is certainly in need of verification, but trees to 30 m tall commonly occur in the undisturbed evergreen submontane rainforests of Thailand and Viet Nam. *Cephalotaxus mannii* can occur on both silicate rocks and limestone. It is often associated with *Nageia wallichiana, Taxus wallichiana, Dacrycarpus imbricatus* and *Podocarpus neriifolius* on soils derived from the silicate rocks, and with *Pseudotsuga sinensis, Nageia fleuryi, Pinus kwangtungensis, Podocarpus pilgeri, Taxus chinensis, Fokienia hodginsii*, and *Amentotaxus* spp. on karst limestone in N Viet Nam and S China.

In both types of habitat angiosperms play an important role with numerous tree and shrub species as well as epiphytes.

Conservation

Globally this species is considered Vulnerable; in China it is considered Endangered, due to the range-wide reduction of forests. Throughout its range, *C. mannii* is restricted to small populations in which the largest trees (to 30 m tall and over 100 cm d.b.h.) are often targeted for their timber. Stripping of bark is often fatal to the trees and this type of harvest, like logging due to slow growth, is unsustainable. The principal threat, however, is conversion of habitat to agriculture and resulting severe forest fragmentation. There are not enough forest reserves of sufficient size and integrity to safeguard this species at present (Fu & Jin, 1992; Nguyen Tien Hiep *et al.*, 2004).
IUCN: VU (A2cd)

Uses

This conifer produces high quality insect resistant timber which is used for quality furniture, fine crafts and tool handles. The seeds have medicinal qualities and in Hainan the bark is used to treat fever. The species is eminently suitable for use in horticulture, but is seldom seen in cultivation outside Asia. Some plants may be grown under its taxonomic synonym, *C. griffithii* Hook. f., which was originally described from the Mishmi Hills in Assam, India. At the Royal Botanic Garden, Edinburgh cuttings are being propagated from sources in Viet Nam.

Cephalotaxus oliveri Mast., Bull. Herb. Boiss. 6: 270. 1898. Type: China: Hubei, Changyang T. Z., *A. Henry 7479* (lectotype K, designated here).

Etymology

The species epithet commemorates F. W. Oliver, a botanist who collected in China.

Vernacular names

Oliver's plum yew; bi zi san jian shan (Chinese)

Description

Shrubs or small trees to 4 m tall. Bark thin, becoming scaly with thin flakes, yellow weathering greyish brown. Branches spreading to ascending, forming a bushy crown. Foliage branchlets slender, lateral branchlets (sub)opposite, often in a plane, up to 15 cm long but usually shorter than 10 cm, grooved between decurrent leaf bases, yellowish green turning yellow to light brown. Leaves in two opposite, distichous ranks at 60–80° to shoot axis, mostly of equal length and touching each other from base to near apex, (1.5–)2–3(–3.5) cm long, (2.3–)2.7–3.5(–4) mm wide, straight or slightly falcate and convex, sessile or nearly so, base truncate or weakly cordate, flat margins parallel to near the short, minutely cuspidate or mucronate apex, leaf texture coriaceous, slightly rugose, stiff; leaf colour dull green above, pale green below with two whitish bands. Midrib on the adaxial (upper) side narrow (less than 0.4 mm wide), raised but fading towards apex, on the abaxial side 0.7–0.8 mm wide, flat. Stomata in two broad bands of 13–17 intermittent lines separated by the abaxial midrib and two 0.7 mm wide margins and of equal width to these. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a 1–3 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate, incurved bracts with entire or erose, more or less hyaline margins, bearing 3–6 small, sessile, globose, pink or light brown cones up to 2 mm diam. Microsporophylls 4–9 per cone, each with 3(–4) globose, pink coloured pollen sacs. Seed cones solitary or in groups at base of lateral foliage branchlets, on 3–7 mm long, curved peduncles. Bracts several per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an obovoid, green or grayish aril, enclosing the ripening seed, becoming 22–27 × 14–18 mm, turning soft, orange-red to red with longitudinal striation. Seeds (ob)ovoid to ovoid, sometimes subglobose, 18–23 × 10–15 mm, with a mucronate apex.

Taxonomic notes

Records of this species from Viet Nam are referable to *C. mannii.*

Distribution

China: Chongqing, N Guangdong, Guizhou, W Hubei, Hunan, E Jiangxi, S and W Sichuan (especially Emei Shan), E Yunnan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHS-GD CHS-HN CHS-JX

Ecology

Cephalotaxus oliveri occurs in evergreen and deciduous broad-leaved forests, coniferous forests, and mixed forests, at altitudes between 300 m and 1800 m a.s.l. As it apparently never grows taller than about 4 m, it is an understorey shrub, occurring in the shrub layer mixed with several genera of angiosperms such as *Rhododendron, Camellia, Cotoneaster, Deutzia, Lonicera, Berberis, Buddleia, Euonymus, Hydrangea, Prunus* and many other species.

Conservation

This species has a relatively wide geographical range and broad ecological amplitude, yet it has suffered from widespread deforestation for agricultural expansion and logging of the forests for timber and fuelwood (bycatch) as well as direct exploitation for its bark and other plant parts (all ongoing threats). The clearance of forests has resulted in reduced regeneration of this species, it prefers shady areas for germination and growth. The species has low genetic diversity which also reduces its ability to adapt to changing environmental conditions. This is not a protected species in China, but it occurs in several protected areas.
IUCN: VU (A2cd)

Uses

This shrubby species is being exploited for its bark, which contains anti-carcinogenic alkaloids, for medicinal purposes; it is also in cultivation as an ornamental shrub both in and outside China. It was introduced to Britain and the USA by E. H. Wilson but apparently has not been successful, probably due to cold winters. It should certainly be suitable as a garden shrub in countries with mild and (nearly) frost-free winters.

Cephalotaxus sinensis (Rehd. & E. H. Wilson) H. L. Li, Lloydia 16 (3): 162. 1953. *Cephalotaxus drupacea* Siebold & Zucc. var. *sinensis* Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 3. 1914; *Cephalotaxus harringtonii* (Knight *ex* J. Forbes) K. Koch var. *sinensis* (Rehd. & E. H. Wilson) Rehd., J. Arnold Arbor. 22: 571. 1941. Type: China: W Sichuan, Baoxing, ["Mupin"], *E. H. Wilson 1115* (holotype A).

Etymology

The species epithet refers to China, its native country.

Vernacular names

Chinese plum yew; cu fei (Chinese)

Description

Shrubs to small trees 1.5–15 m tall; trunk d.b.h. of monopodial trees to 120 cm. Habit of shrubs erect and spreading; trees with a wide, open and rounded crown. Bark thin, exfoliating in narrow strips, reddish to grey-brown. Branches spreading, drooping or ascending; foliage branchlets short or long and slender, glabrous, grooved between decurrent leaf bases, green turning yellowish brown. Leaves more or less disposed in two ranks, sometimes upright forming a V-formation especially on branchlets with male cones, straight or slightly falcate, (1–)1.8–5(–7) cm long, with a short, twisted petiole and cuneate base, linear-lanceolate or linear, 2–4 mm wide, more or less abruptly tapering to a long acuminate or cuspidate apex, coriaceous but relatively soft, green above, with two white or rarely pale green bands below. Midrib on the adaxial (upper) side prominent, 0.4 mm wide, obtusely raised and continuous from base to apex, on the abaxial side nearly flat, 0.5–0.6 mm wide and continuous. Stomata in two broad bands on the abaxial side, each with 12–15 intermittent white lines, separated by the midrib and bordered by flat or slightly revolute leaf margins. Pollen cones situated in rows of capitula on the underside of lateral foliage branchlets; each capitulum on a 1–3 mm long, scaly peduncle inserted in the upper axil of a leaf, subtended by ovate, incurved bracts with entire or erose, more or less hyaline margins, bearing

6–7 small, sessile, globose, pink or light brown cones up to 3 mm diam. Microsporophylls 4–11 per cone, each with 2–3(–4) globose, pink coloured pollen sacs. Seed cones solitary or borne 2–6 together at base of lateral foliage branchlets, on 3–8 mm long, curved peduncles. Bracts several per cone, reduced, 1–1.5 mm long; fertilized ovules surrounded by an ellipsoid, green or grayish aril, enclosing the ripening seed, becoming 18–25 × 9–16 mm, turning soft, red or purple with 6 longitudinal ridges. Seeds (ob) ovoid to ellipsoid, rarely subglobose, 16–22 × 8–14 mm, with a mucronate or cuspidate apex.

Distribution

S Central, S (including Hainan), SW, and SE China.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHH CHN-SA CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HK CHS-HN CHS-JS CHS-JX CHS-ZJ

Ecology

Cephalotaxus sinensis is very widespread in SE China and occurs in a range of habitats between 200 m a.s.l. on the eastern coast to 2800(–3200) m a.s.l. in the mountains of Sichuan and Yunnan. It is common in moist woodlands along streams at lower altitudes, as well as in montane coniferous or mixed forests and in shrubby thickets on mountain slopes, on granite, sandstone or limestone. In Zhejiang Province, in the far east of its range, it is a minor component in diverse mixed mesophytic forest below 750 m a.s.l. with e.g. *Acer, Carya, Celtis*, and *Quercus s. l.* (including *Castanopsis*) as well as the rare conifer *Pseudolarix amabilis* and, in the Tienmu Shan, perhaps the last wild-growing *Ginkgo biloba* trees.

Conservation

IUCN: LC

Uses

Given the reported size of the diameter (d.b.h.) of some tree trunks, it is obvious that its wood is put to use, but it is not commercially important beyond local trade, largely because sizable trees are very scattered. The wood is used to make furniture, farm tools such as handles, other utensils and crafts like wood turning. Similarly to the other species, the seed arils yield oil that was traditionally burnt in lamps. Alkaloids in the foliage, roots and seeds are extracted for medicinal purposes, e.g. as treatment of leukemia. This species is in cultivation in China on a limited scale, mainly in botanic gardens. Outside China it is rarely cultivated, but plants belonging to this species may have been confused with *C. harringtonii*. Its long acuminate leaf tips, however, should distinguish even sterile plants from *C. harringtonii*. Being often from more southerly regions it is not as hardy, but this may depend on provenance and some of the high altitude populations of Sichuan and Yunnan can be grown as far north in the USA as Massachussetts, where Ernest Wilson first introduced the species as *C. drupacea* var. *sinensis*.

Chamaecyparis Spach, Hist. Nat. Vég. Phan. 11: 329. 1841. Type: *Chamaecyparis thyoides* (L.) Britton, Sterns & Poggenb. (*Cupressus thyoides* L.) [*Chamaecyparis sphaeroidea* (Spreng.) Spach (*nom. illeg.*) (*Thuja sphaeroidea* Spreng.)] (*Cupressaceae*).

Retinispora Siebold & Zucc., Fl. Japon. 2 (5): 36. 1844. Type: *Retinispora obtusa* Siebold & Zucc. [*Chamaecyparis obtusa* (Siebold & Zucc.) Endl.]

Greek: *chamae-* = lowly, creeping; *cyparis* = cypress.

Description

Evergreen, monoecious trees; trunk monopodial. Resin cavities in leaves. Bark fissured, fibrous or scaly, exfoliating in long strips or flakes, reddish brown. Branches slender, persistent, forming a pyramidal, conical or rounded crown (Massart's model). Fastigiate forms restricted to cultivation. Foliage branches plagiotropic, drooping or pendulous, (sub) ultimate branchlets flattened, covered with scale leaves. Leaves decussate, imbricate, dimorphic, with facials smaller than laterals, appressed, with apices of laterals spreading above apices of facials; margins entire; stomata inconspicuous, mostly on the underside of the (leaf-covered) branchlets. Pollen cones terminal, solitary, very small, short cylindrical; microsporophylls 8–16, decussate, bearing 2–3 abaxial, yellow or red pollen sacs. Seed cones terminal, solitary, globose to ellipsoid-ovoid, small, with peltate, parting scales. Bract-scale complexes (6–)8–12(–16), decussate, peltate, with a quadrangular, rhombic or polygonal outline, abaxially depressed with a small central umbo (bract tip), adaxially with faint seed marks near base; the ultimate pair sterile. Seeds moderately numerous, with 2 lateral, narrow wings. Seedlings with 2 cotyledons.

5 species.

Distribution

North America: (disjunct) E North America; in W North America in Oregon and California. Asia: Japan, Taiwan.

Key to the species of Chamaecyparis

1a. Seed cone scales 4–8(–10) in number, mature cones 4–8 mm diam **2**
1b. Seed cone scales 8–14(–16) in number, mature cones 7–14 mm diam **3**
2a. Smallest branchlets plagiotropic (in flat sprays); ultimate branchlets often unilateral ***C. pisifera***
2b. Smallets branchlets irregularly disposed; ultimate branchlets alternating… ***C. thyoides***
3a. Seed cones widely open, with gaps between scales as wide as or wider than scales. Leaf gland present; leaf apices of laterals more or less acute ***C. lawsoniana***
3b. Seed cones not widely open, with gaps between scales narrower than scales. Leaf gland absent or very obscure; leaf apices of laterals obtuse **4**
4a. Seed cones longer than wide when closed; seed wings nearly equal ***C.formosensis***
4b. Seed cones always globose; seed wings often unequal ***C. obtusa***

Chamaecyparis formosensis Matsum., Bot. Mag. (Tokyo) 15: 137. 1901. *Retinispora formosensis* (Matsum.) A. V. Bobrov & Melikyan, Komarovia 4: 74. 2006. Type: Taiwan: Nantou, Chia-i Pref., Yu-Shan, ["Mt. Morrison"], *S. Honda s.n.* (lectotype TI). Fig. 86, 87

Etymology

The species epithet indicates its origin as from Formosa, an earlier name for Taiwan; perhaps with a pun to Latin: *formosus* = handsome or well formed.

Vernacular names

Taiwan Cypress, Formosan Cypress; Beniki; hong gui (Chinese)

Description

Trees to 55–60 m tall; trunk monopodial, branching low, occasionally forked, up to 6–7 m d.b.h. in a few very old trees. Bark soon flaky, on large trees more than 20 cm thick towards base of trunk, fissured, fibrous, exfoliating in long strips, light reddish brown weathering grey. Branches spreading or curved down, higher order branches drooping, forming a dense pyramidal crown in young trees, eventually becoming broadly conical or sympodial and domed in very old specimens. Foliage branches numerous, spreading and drooping; plagiotropic branchlets alternating, smallest ones often unilateral on second highest order, gradually shortening forming tapering planate sprays, covered with green leaves; ultimate lateral branchlets partly deciduous after 4–6 years. Leaves decussate, imbricate, decurrent, scale-like, 1–3 × 0.5–1 mm on ultimate branchlets, up to 10 mm long on leading shoots, dimorphic; facials smaller than laterals, rhombic to lanceolate, carinate, obtuse-acuminate, appressed or with a free apex, with an inconspicous abaxial gland; laterals connate proximally, spreading above the apex of facials, conduplicate, lanceolate, recurved and incurved at the mostly free apex, eglandular or obscurely glandular; margins entire; leaves amphistomatic, stomata inconspicuous except for a few exposed lines on underside of facials; leaf colour light grey-green or dull green. Pollen cones terminal, solitary, ovoid-oblong, 2–3 × 1–1.5 mm, yellowish green turning brown; microsporophylls 8–12, decussate, peltate, suborbicular, with minutely denticulate margins, with 3 abaxial yellow pollen sacs on the lower margin. Seed cones terminal on branchlets with unmodified leaves, solitary, maturing within one year, caducous, subglobose to ellipsoid-ovoid, (6–)10–12 × 5–8 mm with opened scales, from purplish ripening to brown. Bract-scale complexes (8–)10–14(–16), decussate, parting and spreading at right angles from axis when mature, subpeltate to peltate, rhombic in outline, 3–5.5 mm wide; abaxial surface depressed, with a central recurved umbo (bract tip 0.5–0.7 mm); margin undulating; base conical; adaxial face grooved and striated, lustrous brown, lacking seed marks. Seeds (1–)2(–3) at the basis of each scale (15–20 develop per cone), slightly flattened, oblong, 1.5–2.5 mm long, reddish brown, surrounded by 2 lateral, nearly equal thin wings 0.5–1 mm wide.

Taxonomic notes

This species may be more closely related to *Chamaecyparis pisifera* of Japan than to its congener on the island of Taiwan: *C. obtusa* var. *formosana*. The two species in Taiwan, *C. formosensis* and *C. obtusa*, are sympatric but stay well separate taxonomically. The much greater size of *C. formosensis* is related to longevity and this is probably genetically determined; its seed cones are also larger and more ellipsoid and the seed wings are more developed and presumably more effective in dispersal as a result. It is the largest conifer (measuring stem diameter) growing in Asia and possibly the longest-lived as well. A detailed study of its biology is very desirable.

Distribution

Taiwan: central mountains.
TDWG codes: 38 TAI

Ecology

In mixed coniferous forest of the cool temperate coniferous forest belt between 1700 m and 2900 m a.s.l., with *Chamaecyparis obtusa* var. *formosana* and *C. formosensis* as the dominant species, associated with *Calocedrus formosana, Cunninghamia konishii*, and *Taiwania cryptomerioides*, in the upper part of the zone also *Tsuga chinensis*; in the understorey occur *Photinia davidiana* var. *niitakayamensis* and the bamboo *Yushania niitakayamensis*, but often little else. *Chamaecyparis formosensis* is exceptionally long-lived, estimated in excess of 3000 years, and has a regeneration strategy similar to e.g. *Sequoiadendron*, although the disturbance factors are not well known. Soils are usually slightly acidic, derived from igneous rock or shale. The climate is cool and wet, with abundant rainfall throughout the year and occasional snowfall in winter.

Conservation

The number of mature trees in natural forest stands has been greatly reduced by felling. The species occurs as scattered individuals in mixed coniferous forest and has been selectively logged for its desirable wood used in traditional oriental building. Growth is slow, especially in mature to over-mature phases

of its long life cycle. Several very large, senescent individuals remain as 'natural monuments' forming a tourist attraction, but protection of more old growth forests containing this species is urgently needed. The species is being grown in plantations.
IUCN: EN (A2d)

Uses

The wood (timber) of this species is highly prized for traditional oriental buildings such as temples and shrines. It is uncommon in cultivation outside Taiwan, where this species is now being replanted in attempts to restore it from excessive logging in the past. As an ornamental it is attractive, but slow growing and similar to Sawara cypress (*C. pisifera*) from Japan, which is much more common as a tree for the garden. To increase its use as an ornamental requires marketing efforts and with so many cultivars already available from other species in the genus, this is not an easy task, and one which commercial growers will be reluctant to undertake. Outside Taiwan, fine specimen trees grow at Hillier's Arboretum in the south of England, where ground frost is quite common; this species is apparently not as tender as is commonly believed.

Chamaecyparis lawsoniana (A. Murray bis) Parl., Ann. Mus. Imp. Fis. Firenze 1: 181. 1864. *Cupressus lawsoniana* A. Murray bis, Edinburgh New Philos. J., n.s., 1: 292. 1855; *Retinispora lawsoniana* (A. Murray bis) A. V. Bobrov & Melikyan, Komarovia 4: 74. 2006. Type: Illustration in A. Murray, Edinburgh New Philos. J. n.s. 1, t. 10, f. 1–4. 1855 (lectotype); USA: California, *W. Murray s.n. [3]* (epitype E). Fig. 88, 89

Etymology

This species was named after Charles Lawson (1794–1873), an English nurseryman who grew several early introductions of conifers.

Vernacular names

Port-Orford-Cedar, Port Orford White-cedar, Oregon Cedar, Lawson Cypress

Description

Trees to 60–70 m tall; trunk monopodial, large trees can be buttressed at base, up to 4–4.5 m d.b.h. Bark soon flaky, on large trees to 35–40 cm thick towards base of trunk, deeply fissured, fibrous, exfoliating in long strips, dark red-brown weathering grey-brown. Branches slender, curved down; higher order branches drooping or pendulous, forming a dense conical crown in young trees, eventually becoming broadly columnar in large trees. Foliage branches numerous, drooping or pendulous, plagiotropic branchlets alternating and smallest ones often unilateral, gradually shortening forming tapering planate sprays, covered with green leaves; ultimate lateral branchlets partly deciduous after 4–6 years. Leaves decussate, imbricate, decurrent, scale-like, 2–3 × 1–1.5 mm on ultimate branchlets, up to 20 mm long on leading shoots, dimorphic; facials smaller than laterals, rhombic to lanceolate, obtuse-acuminate, appressed, with a conspicous, oval, yellowish, transparant, non-active abaxial gland; the laterals connate proximally, spreading above apex of facials, conduplicate, broadly falcate to lanceolate, recurved and incurved at the appressed apex, less conspicuously glandular; margins entire; leaves amphistomatic, stomata inconspicuous, concentrated on the partly hidden bases and margins of leaves; leaf colour light green or lustrous dark green; margins more or less glaucous, stomatal zones greenish white. Pollen cones very numerous, terminal, solitary, ovoid-oblong, 3–4 × 1.5–2 mm, yellowish green turning purplish black; microsporophylls 12–16, decussate, peltate, with minutely denticulate margins, with 2–3 abaxial large, red pollen sacs on the lower margin. Seed cones terminal on branchlets with unmodified leaves, solitary, maturing within one year, caducous, subglobose, (6–)7–11(–14) mm with opened scales, from glaucous-purplish (bracts) and yellow ripening to grey-brown. Bract-scale complexes 8–10(–12), decussate, ultimate pair often sterile and fused, parting and spreading at varying angles from axis when mature, subpeltate to peltate, polygonal (4–5 angular) in outline, up to 6–7 mm wide, abaxial surface slightly depressed, rugose, with a central small umbo (bract tip 0.5–1 mm); base conical; adaxial surface grooved and striated, pinkish brown, with faint seed marks near the base. Seeds 2–4 at the basis of each

scale (15–30 develop per cone), slightly flattened, ovoid, with acute apex, 2.5–3 × 2 mm long, yellowish, with 2 oblong, darker resin glands on each side, surrounded by 2 lateral, nearly equal thin wings 1–1.5 mm wide.

Distribution

USA: SW Oregon, NW California, more extensively in Oregon (especially Coos Co., Curry Co.), from the Pacific coast to W of Mt. Shasta.

TDWG codes: 73 ORE 76 CAL

Ecology

This species is usually growing in mixed coniferous forest of different types, with e.g. *Abies concolor, A. grandis, Picea sitchensis, P. breweriana, Pinus* spp., *Pseudotsuga menziesii, Sequoia sempervirens*, and *Tsuga heterophylla*, in various mixtures; also in mixed conifer/ angiosperm forest with e.g. *Quercus chrysolepis* and *Lithocarpus densiflorus*. Understorey vegetation is usually made up of the ericaceous shrubs *Rhododendron* and *Vaccinium, Rhamnus* spp., *Rubus spectabilis, Gaultheria shallon* and *Quercus* spp. and more locally *Taxus brevifolia*; a herbaceous flora is also commonly present. Except when growing with a dominance of *Pinus*, the forests are dense. Habitats less favourable to forest development, e.g. bogs and dry sand dunes, can still be occupied by *Chamaecyparis lawsoniana*, which will then grow much slower and less tall in the communities that prevail there. Best development is on wet soil types with subsurface seepage, where the species can become dominant; on drier sites the underlying rock is often ultramafic. Its altitudinal range is from near sea level to ca. 1950 m a.s.l. The climate is strongly oceanic but summers tend to be warm and dry (June-August); total precipitation ranges from 1000–2250 mm annually, at higher altitudes a substantial part is snow.

Conservation

Over-exploitation of mature and old growth stands, exacerbated with a more recent infestation by the oomycete pathogen *Phytophthora lateralis*, which was accidentally introduced in 1952, has led to a steady decline over more than 150 years. Opening up areas formerly inaccessible with vehicles is part of the problem, as the pathogen gets transported by vehicles into new stands more quickly than would otherwise have been possible. For this reason the establishment of some 12 Research Natural Areas on National Forest lands has been only partly effective in halting the decline. Plantation forestry will largely have to replace harvesting natural stands despite relatively slow early growth rates, in order to separate forestry from areas of infestation and to allow natural stands to recover. The major conservation effort now undertaken concerns research to find and select genotypes that are resistant to the pathogen causing root rot, to produce seed from these genotypes, to test the field performance of these genotypes on sites with the pathogen present, and finally the reintroduction of the resistant genotypes into the forests where the species has been eliminated or reduced by the disease.

IUCN: NT

Uses

The timber of this species is highly valued in East Asian countries, especially Japan, for construction of traditional buildings. There was a major international trade up to around 1990, especially with Japan, where it fetched extremely high prices. There is probably no other conifer species which has given rise to more cultivar forms than *C. lawsoniana*, several hundred of which are listed in recent compilations (Leslie, 1992; Welch & Haddow, 1993). These lists were outdated upon publication as the number of new cultivar forms arising and sold by nurseries seems to grow exponentially. Registration of these by the Conifer Registrar of the Royal Horticultural Society in England, the acknowledged authority in the world of conifer horticulture, has become an almost impossible task. Many older cultivars only exist, if at all, as one or a few surviving individual shrubs or trees in gardens or parks and will become 'extinct' if not vegetatively propagated. Despite this, several cultivars are widely propagated and used, while the species itself is widely grown from seed.

Chamaecyparis obtusa (Siebold & Zucc.) Endl., Syn. Conif.: 63. 1847.

Etymology

The species epithet refers to the obtuse (blunt) leaf apices.

Vernacular names

Hinoki Cypress; hinoki (Japanese)

Description

Trees to 40–50 m tall; trunk monopodial, large trees can be buttressed at base, up to 2 m d.b.h. Bark soon flaky, on large trees fissured, scaly, exfoliating in strips and flakes, red-brown weathering grey-brown. Branches long, slender, ascending, spreading or curved down in lowest part of crown; higher order branches drooping or pendulous, forming a dense pyramidal crown in young trees, eventually becoming broadly rounded in large trees. Foliage branches numerous, drooping or pendulous; plagiotropic branchlets alternating and smallest ones often unilateral, forming irregularly tapering planate sprays, covered with green leaves; ultimate lateral branchlets partly deciduous after 4–6 years. Leaves decussate, imbricate, decurrent, scale-like, coriaceous, 0.8–3 × 0.5–1.5 mm on ultimate branchlets, up to 10 mm long on leading shoots, dimorphic; facials smaller than laterals, rhombic to oblong, obtuse, appressed, eglandular; laterals connate proximally, spreading above apex of facials, conduplicate, broadly falcate to lanceolate, recurved and incurved at the appressed obtuse apex, eglandular; margins entire; leaves amphistomatic, stomata concentrated on the partly hidden bases and margins of leaves; leaf colour green or grey-green, stomatal zones greenish white on underside of branchlets. Pollen cones terminal, solitary, subglobose, 2–3 mm, orange-brown or purplish turning dark brown; microsporophylls 6–8, decussate, peltate, with entire, rounded margins, with 3 abaxial large, yellow or reddish pollen sacs on the lower margin. Seed cones terminal on branchlets with unmodified leaves, solitary, maturing within one year, caducous, subglobose or globose, (7–)8–11(–13) mm with opened scales, from yellowish green (bracts) and yellow ripening to reddish brown or dark brown. Bract-scale complexes 8–10, decussate, parting and spreading at varying angles from axis when mature; distal 2 connate and usually sterile, peltate, polygonal (4–5-angular) in outline, 3–6 mm wide; abaxial surface depressed, rugose, with a central small umbo (bract tip 0.5–1 mm); base conical; adaxial surface grooved and striated, red-brown, with light grey seed marks near base. Seeds 2(–3) at the basis of each scale (15–20 develop per cone), flattened, ovoid, with resin vescicles or longitudinal grooves, 2.5–4 × 2 mm long, lustrous reddish brown, surrounded by 2 lateral, unequal or nearly equal thin wings 1–1.5 mm wide.

Distribution

Japan: Honshu, Kyushu; Taiwan.
TDWG codes: 38 JAP-HN JAP-KY TAI

Ecology

The two varieties of this species occur in different (micro)habitats: *C. obtusa* var. *obtusa* is generally occupying more xeric sites on ridges or slopes; *C. obtusa* var. *formosana* forms extensive forests in atmospherically damp and often edaphically wet sites. Both occur in mixed conifer/angioserm forests, in which the conifers are mostly emergents and the angiosperms form lower layers of canopy. More specific information is given with the descriptions of each variety.

Uses

The wood of *Chamaecyparis obtusa* has been used for centuries in construction of temples and other traditional buildings because of its fine quality and high durability in outdoor conditions. The Japanese have largely turned to sources outside Japan to obtain timber of related species, especially those occurring on the Pacific coast of North America. This species is among the most widely used in horticulture and numerous cultivars, obtained in Japan, Europe, the United States. and New Zealand, are in the trade. The species is particularly suitable for the clonal propagation of dwarf forms ('tennis ball conifers') with compact growth selected from cuttings from witches brooms; these grow often very slowly and are therefore considered ideal for pot-grown

patio plants, rockeries, etc. The number of cultivar names under this species is rapidly outgrowing the capacity to list them and even the most comprehensive register of cultivated conifers, so far compiled and published by the Royal Horticultural Society in England for the names from letters A-J (Leslie, 1992), cannot claim to be nearly complete.

2 varieties are recognized:

Chamaecyparis obtusa (Siebold & Zucc.) Endl. var. ***obtusa***. *Retinispora obtusa* Siebold & Zucc., Fl. Japon. 2 (5): 38, t. 121. 1844. Type: Japan: Honshu, [locality not stated], *P. F. von Siebold s.n.* (holotype not located, isotype K). Pl. 11

Description

Leaves on ultimate branchlets 1.5–3 mm long, 1–1.5 mm wide. Seed cones subglobose, 9–12(–13) mm diam. when open. Larger seeds are correlated with greater cone size.

Distribution

Japan: S Honshu, Shikoku, Kyushu.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Ecology

In mixed coniferous and conifer-broad-leaved forest with *Chamaecyparis pisifera, Pinus densiflora, P. parviflora, Abies firma, Pseudotsuga japonica, Tsuga sieboldii, Sciadopitys verticillata* (locally), *Aesculus turbinata, Acanthopanax sciadophylloides, Acer* spp., *Fagus japonica, Quercus* sp., *Stewartia monadelpha*, and *Magnolia obovata*, on Yakushima with *Cryptomeria japonica*. Variety *obtusa* is widespread on older montane formations, but virtually absent from (recent) volcanoes (Wilson, 1916), indicating its niche in the late phases of mountain forest succession, where if undisturbed it becomes a canopy emergent rising above most other conifers. It occurs in cool, moist ravines and on slopes with a northerly aspect, as well as on more xeric ridges, in relatively deep, rich loams over sedimentary or metamorphic or old volcanic rock. The altitudinal range is from 80 m to 2500 m a.s.l.

Conservation

IUCN: NT

Chamaecyparis obtusa (Siebold & Zucc.) Endl. var. ***formosana*** (Hayata) Hayata, Fedde's Repert. Sp. Nov. Regni Veg. 8 (23–25): 365. 1910. *Chamaecyparis obtusa* (Siebold & Zucc.) Endl. var. *obtusa* f. *formosana* Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25 (19): 208. 1908; *Chamaecyparis obtusa* (Siebold & Zucc.) Endl. subsp. *formosana* (Hayata) H. L. Li, Taiwania 1: 305. 1950. Type: Taiwan: ["Shinko, Shirakku"], *T. Kawakami & U. Mori 1329* (lectotype TI). Fig. 86

Chamaecyparis taiwanensis Masam. & S. Suzuki, Sylvia 4: 57, t 1, f. B3–4, t. 2, f. B54. 1933; *Retinispora taiwanensis* (Masam. & S. Suzuki) A. V. Bobrov & Melikyan, Komarovia 4: 74. 2006.

Vernacular names

Taiwan bian mai (Chinese)

Description

Leaves of ultimate branchlets 0.8–1.5 mm long, 0.5–1 mm wide. Seed cones globose, 7–9 mm in diam. when open. Smaller seeds are correlated to smaller cone size.

Distribution

Taiwan.
TDWG codes: 38 TAI

Ecology

In mixed coniferous or conifer-broad-leaved forest in the cool temperate coniferous forest belt at altitudes from 1800 m to 3000 m a.s.l., with *Chamaecyparis formosensis, Calocedrus formosana, Cunninghamia konishii, Taiwania cryptomerioides, Alnus henryi, Schima superba, Photinia davidiana, Rhododendron formosanum, Pasania* sp., and the alpine bamboo *Yushania niitakayamensis*. Soils are relatively deep and well-drained loams or loamy sand. The climate is cool, very moist, with cloud-cover resulting in fog

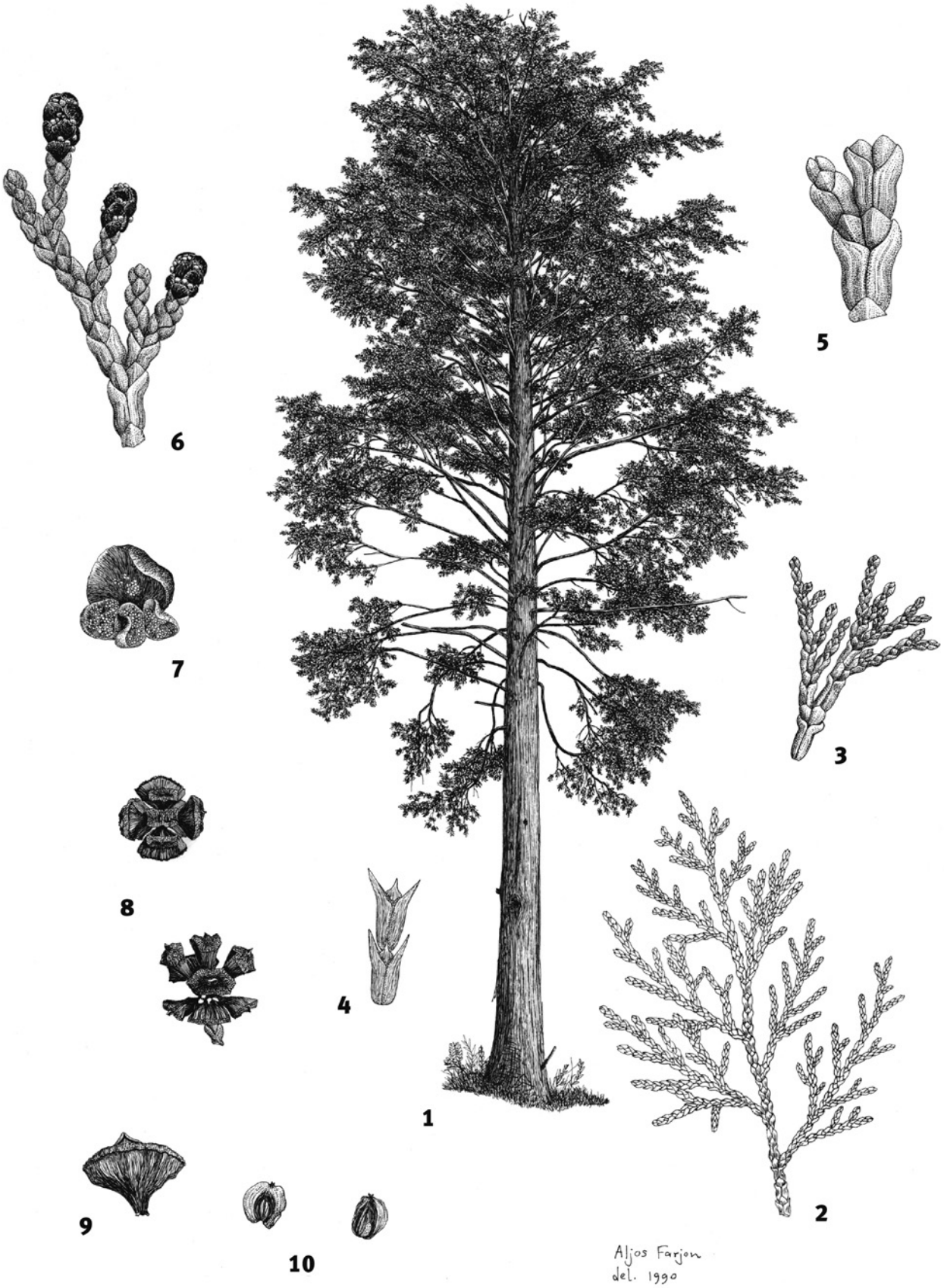


PLATE 11. *Chamaecyparis obtusa* var. *obtusa*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Branchlet with leaves. **4.** Juvenile leaves. **5.** Adult leaves. **6.** Branchlet with leaves and pollen cones. **7.** Microsporophyll with open pollen sacs and pollen. **8.** Seed cones. **9.** Seed cone scale. 10. Seeds.

and rain much of the year and very high precipitation exceeding 4000 mm per year.

Conservation

Logging has caused a considerable decline in many of the more accessible stands. After massive but unquantified destruction the total area of occupancy (AOO, in mixed stands with other conifers) 50 years ago was ca. 50,000 ha for *C. obtusa* var. *formosana* and *C. formosensis* combined (Lee, 1962). It is almost certainly less than that now, as the decline of natural forest has continued from 66% to 52% of the land surface (Yang & Pan, 1996). Old growth forest is being replaced by secondary vegetation; where active reforestation is undertaken the emphasis is usually on faster growing conifers (*Cryptomeria, Cunninghamia, Pinus*). Important stands of *Chamaecyparis* spp. are protected in the Yuanyang Lake Reserve.
IUCN: VU (A2d)

Chamaecyparis pisifera (Siebold & Zucc.) Endl., Syn. Conif.: 64. 1847. *Retinispora pisifera* Siebold & Zucc., Fl. Japon. 2 (5): 39, t. 122. 1844. Type: Japan: Honshu, [loc. unknown], *P. F. von Siebold s.n.* (holotype not located, isotype K).

Etymology

The species epithet may refer to "pear-shaped" seeds.

Vernacular names

Sawara Cypress; Sawara (Japanese)

Description

Trees to 40–50 m tall; trunk monopodial, large trees buttressed at base or not, up to 2 m d.b.h. Bark soon flaky, on large trees fissured, fibrous, exfoliating in long strips, reddish brown weathering grey-brown. Branches slender, ascending, spreading or curved down; higher order branches spreading or drooping, forming a dense conical crown in young trees, eventually becoming broadly columnar in large trees. Foliage branches numerous, drooping or pendulous; plagiotropic branchlets alternating and smallest ones often unilateral, gradually shortening forming tapering planate sprays, covered with green leaves; ultimate lateral branchlets partly deciduous after 4–6 years. Leaves decussate, imbricate, decurrent, scale-like, coriaceous, 1.5–2 × 1 mm on ultimate branchlets, up to 15 × 4 mm on leading shoots, dimorphic; facials smaller than laterals, rhombic to obovate, sometimes obtusely keeled, obtuse-acuminate, appressed, with a conspicous, circular, slightly elevated, non-active abaxial gland; laterals connate proximally, spreading above apex of facials, conduplicate, broadly falcate, recurved and incurved at appressed apex or convex on ultimate branchlets, less conspicuously glandular; margins entire; leaves amphistomatic, stomata concentrated on the underside of laterals in depressed central region and on partly hidden bases and margins of leaves; leaf colour lustrous light or dark green, stomatal zones glaucous white. Pollen cones numerous, terminal, solitary, ovoid-oblong, 2–3 × 1 mm, yellowish green turning purplish brown; microsporophylls 8–12, decussate, peltate, subcordate, with erose margins, with 2–3 abaxial, yellow pollen sacs on the lower margin. Seed cones terminal on branchlets with unmodified leaves, solitary, maturing within one year, caducous, subglobose or irregular, 5–7(–8) mm with opened scales, from yellowish green (bracts) and purplish blue ripening to brown or blackish brown. Bract-scale complexes (6–)7–8(–10), decussate, parting and spreading at varying angles from axis when mature; distal pair usually connate, subpeltate to peltate, quadrangular or irregular in outline, up to 5 mm wide; abaxial surface centrally depressed, rugose, sometimes with a central small umbo (bract tip 0.5 mm or invisible); base conical; adaxial surface striated, light brown, with faint seed marks near base. Seeds 1–2 at base of each scale (10–15 develop per cone), slightly flattened, ovoid, 2 × 1.3 mm; apex acute; brown, with 3–6 lighter resin vesicles on each side and a concave hilum at base; wings 2, lateral, nearly equal thin, translucent, 1.5–2 mm wide.

Distribution

Japan: Honshu, Kyushu.
TDWG codes: 38 JAP-HN JAP-KY

Ecology

This species has a more scattered distribution in the forests than *C. obtusa* and is likely to be a palaeorelict. It usually occurs, where sympatric with the more ubiquitous *C. obtusa*, on wetter sites e.g. near mountain streams or in hollows with ground water near the surface. In those wet places trees can spread by the layering of branches to form small groves of clonal individuals. It is a minor constituent in mixed conifer/angiosperm forests. Its altitudinal range is from 280 m to 2600 m a.s.l.

Conservation

Although being more scattered in its (original) distribution than *C. obtusa*, this species has not been exploited anywhere nearly as intensively (its timber value is limited) and, as a minor constituent, it survives where the natural forest containing it survives. **IUCN:** LC

Uses

This species is limited as a source of timber, but widely cultivated as an ornamental, with many named cultivars. As of other members of the genus, the wood is valued in Japan for traditional construction work, but its relative scarcity and the often poor shape of layering trees limit its commercial use. However, its ornamental merits are considered substantial due to the many cultivars with different habits and foliage (among which are forms that retain juvenile type leaves) selected in Japan and Europe. Sarawa cypress is sensitive to drought and urban air pollution, but is hardy in climates with not too long and severe winters.

Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb., Prelim. Cat. Anth. Pter. New York: 71. 1888.

Etymology

The classical Greek name for the Sandarac tree (*Tetraclinis articulata*) or its wood was *thyon*, hence *thyoides* = similar but not equal to *thyon*.

Vernacular names

Atlantic White-cedar, Atlantic White Cypress, White Cypress

Description

Trees to 30–35(–40) m tall; trunk monopodial, up to 1.5–2 m d.b.h. Bark soon flaky, on large trees to 5 cm thick, deeply fissured and with connecting ridges, sometimes spirally twisted from torqued wood, fibrous, exfoliating in long strips, reddish brown weathering grey-brown. Branches slender, persistent, spreading or ascending; higher order branches ascending, forming a conical crown in young trees, eventually becoming broader and more open. Foliage branches numerous, slender, drooping or pendulous; plagiotropic branchlets alternating, but smallest ones more irregularly disposed, only slightly planated, forming 'tufts' of foliage, covered with green leaves; ultimate lateral branchlets partly deciduous after 4–5 years. Leaves decussate, imbricate, decurrent, scale-like, coriaceous, 1.5–2.5 × 1–1.5 mm on ultimate branchlets, up to 10 mm long on leading shoots, dimorphic, but facials on higher order branchlets only slightly shorter than the laterals, rhombic to ovate-oblong, sometimes keeled, obtuse or acuminate, appressed, with or without a raised, active abaxial gland in the centre; laterals connate proximally, spreading at or less often above the apex of facials, conduplicate, broadly falcate to lanceolate, recurved and incurved at the appressed apex, less conspicuously glandular; margins entire; leaves amphistomatic, stomata inconspicuous, concentrated on the partly hidden bases and margins of leaves; leaf colour yellowish green or greyish green. Pollen cones numerous, terminal, solitary, ovoid, 1.5–3 × 1–2 mm, yellowish turning light brown or dark brown to blackish brown; microsporophylls 8–12, decussate, peltate, subcordate, with minutely erose margins, with 2(–3) abaxial large, yellow pollen sacs on the lower margin. Seed cones terminal on branchlets with unmodified leaves, solitary, maturing within one year, caducous, subglobose, 4–7(–8) mm with opened scales, from glaucous-purplish ripening to reddish brown or dark brown, often glaucous. Bract-scale complexes (4–)6–8(–10),

usually 6 in decussate pairs, parting and spreading at varying angles from the axis when mature, peltate, irregularly angular with curved margins, up to 3–5 mm wide; abaxial surface depressed, rugose, with a central curved, spiny umbo (bract tip ca. 1 mm long); base narrowing; adaxial surface striated, reddish brown, with faint seed marks near the base. Seeds 2 at base of each scale (8–12 develop per cone), slightly flattened, ovoid, shallowly grooved, with concave light coloured hilum and acutish apex, 2–2.5 × 2 mm, lustrous dark brown, surrounded by 2 lateral, nearly equal wings 1 mm wide.

Distribution

E and SE USA, from Maine south to N Florida, west to S Mississippi.
TDWG codes: 75 CNT MAI MAS MRY NWH NWJ NWY RHO 78 ALA DEL FLA GEO MSI NCA SCA VRG

Ecology

Chamaecyparis thyoides usually grows in more or less pure stands in bogs and swamps and along streamside corridors of lowland rivers surrounded by other tree species, which form the main forest types of the region where it occurs. Due to its great latitudinal range it is associated with different species from N to S. The majority of these are angiosperms, which also occupy the greater total area, associated conifers are mainly *Pinus* spp. and *Taxodium distichum*. The soil types under stands of *C. thyoides* are acid organic ('muck') or sandy, with the water table reaching the surface and prolonged seasonal periods of inundation. It avoids salinity although it is known to border tidal marshes in New Jersey. It is likely that recurring fire would historically have been the disturbance agent preventing *Acer rubrum* from eventually replacing *C. thyoides* in the succession. Apart from the species composition of the vegetation due to latitude, the ecology of the two varieties in this species is similar.

Conservation

This species has been heavily exploited for its timber and 'total volume' is considered to have been much reduced during the 20th century (Little & Garrett in Burns & Honkala, 1990). However, the species is still very widespread (though scattered) and common in most swamp forests on the Atlantic Coastal Plain and Mexican Gulf coast in Florida and Alabama, and is likely to have recovered in numbers if not yet in 'volume'.
IUCN: For ratings see under varieties.

Uses

The wood of this species is light, decay resistant, and is still widely used in the SE USA for many purposes involving outdoor utilities. Trees are occasionally cultivated and sold as ornamentals but there is no substantial horticultural trade. A limited number of cultivars is known and most of the plants in cultivation belong to one of these. Among these are some dwarf forms and one of these, 'Andelyensis' has incorrectly been described as a botanical variety by the German horticultural botanist Camillo Karl Schneider. Forms originating in cultivation are not botanical varieties (or species) and under the rules of horticultural nomenclature are now to be given non-latinized cultivar names.

2 varieties are recognized:

Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. var. ***thyoides***. *Cupressus thyoides* L., Sp. Pl. 2: 1003. Type: USA: [locality unknown], *P. Kalm LINN 1137.4* (lectotype LINN). Fig. 90

Description

Scale leaves on ultimate branchlets conspicuously glandular, especially facials, these not keeled. Pollen cones at maturity dark brown or blackish brown.

Distribution

Eastern USA: coastal plain from Maine to Alabama.
TDWG codes: 75 CNT MAI MAS MRY NWH NWJ NWY RHO 78 DEL FLA GEO NCA SCA VRG

Conservation

IUCN: LC

Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. var. ***henryae*** (H. L. Li) Little, Madroño 18: 165. 1966. *Chamaecyparis henryae* H. L. Li, Morris Arbor. Bull. 13 (3): 43. 1962; *Chamaecyparis thyoides* (L.) Britton, Sterns & Poggenb. subsp. *henryae* (H. L. Li) E. Murray, Kalmia 12: 19. 1982. Type: USA: Florida, Escambia Co., Perdido River, at Barineau Park, *M. G. Henry 23* (holotype PH).

Description

Scale leaves on ultimate branchlets eglandular or inconspicuously glandular, facials often distinctly keeled abaxially. Pollen cones at maturity light brown.

Distribution

SE USA: along the Gulf Coast from Florida to Mississippi.
TDWG codes: 78 ALA FLA MSI

Conservation

IUCN: LC

Cryptomeria D. Don, Ann. Nat. Hist. 1: 233. 1838. Type: *Cryptomeria japonica* (Thunb. *ex* L. f.) D. Don [*Cupressus japonica* Thunb. *ex* L. f.] (*Cupressaceae*).

Greek: *kryptos* = covered, hidden; *-meros* = share (parts or their number); referring to seeds hidden by bracts.

Description

See the species description.

Distribution

As for the species.

Cryptomeria japonica (Thunb. *ex* L. f.) D. Don, Trans. Linn. Soc. London 18: 167. 1839. *Cupressus japonica* Thunb. *ex* L. f., Suppl. Pl.: 421. 1781. Type: Japan: Honshu, ["Habitat in Japonia"], *C. P. Thunberg UPS 22564* (lectotype UPS). Fig. 91

Cryptomeria fortunei Hooibr., Wiener J. Gesammte Pflanzenr. 1: 22. 1853, *nom. nud.* ["*fortunini*"]; *Cryptomeria japonica* (Thunb. *ex* L. f.) D. Don var. *fortunei* (Hooibr.) Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 1: 129. 1906 (*nom. inval.*, Art. 34.1). *Cryptomeria japonica* (Thunb. *ex* L. f.) D. Don var. *sinensis* Miq., in Siebold & Zuccarini, Fl. Japon. 2: 52. 1870; *Cryptomeria japonica* (Thunb. *ex* L. f.) D. Don subsp. *sinensis* (Miq.) P. D. Sell, Watsonia 18 (1): 92. 1990.

Etymology

The species epithet refers to Japan, the country of origin of this species.

Vernacular names

Japanese cedar; sugi, omote-sugi, yaku-sugi, (Japanese)

Description

Trees to 50–60 m tall, evergreen, monoecious; trunk straight, columnar, usually monopodial, in old trees massive, buttressed, 4–5 m (formerly to 8 m) diam. Bark on large trees 2–3 cm thick, reddish brown, weathering grey, exfoliating in long, shredding strips. Branches spreading to assurgent, forming a conical crown in young trees and a rounded crown in mature trees, self-pruning to leave a clear bole in large trees. Foliage branches dense, shedding not individual leaves but ultimate lateral branches which persist 4–8 years. Leaves helically arranged in ranks of 5, decurrent, free for 1/2–3/4 of length, spreading but incurved in various degrees, directed forward, linear-subulate, slightly flattened laterally, distinctly keeled abaxially, stiff, green, 3–20(–25) × 1–2 mm; margins entire; apex acute; amphistomatic, stomata in 4 greenish bands separated by green ribs, usually on entire length of leaf. Pollen cones numerous, axillary and crowded towards ends of 2nd-year branchlets, 3–6 × 2–3 mm, elongating to 10 mm at anthesis; microsporophylls 15–30, the first 2 opposite and green, then helically arranged, imbricate, peltate, with 4–6 connate pollen sacs on the lower abaxial margin. Seed cones terminal on down-curved branchlets with normal leaves, often aggregated or solitary, occasionally with proliferating vegetative short shoot at apex, globose to subglobose, squarrose with spreading bract-scale complexes, soft woody, 12–20(–25) mm diam. Bract-scale complexes helically arranged on a very short axis, 25–40, connate but parting at maturity, cuneate-rhombic, narrowly based; apex a curved, triangular, thin bract; teeth adaxial to the bract below the upper margin of the scale, (1–)3–5(–6) in number, acute to rostrate, (2–)2.5–5(–6) mm long. Seeds (1–)2–5 per bract-scale complex (some ovules may abort) depending on space available when intercalary scale tissue develops, 4–5 × 3 mm, flattened, irregularly ovate with 2 wings; wings unequal, 1–1.5 mm wide, forming a strip around the seed.

Taxonomic notes

Well before *Cryptomeria* was introduced into Europe in 1842 (England), there were two provenances known: China and Japan. European knowledge of the Japanese trees goes back to Engelbert Kaempfer (1690–92), that of the Chinese trees to

James Cunningham (1701–02). They have long been regarded as two distinct species, or sometimes as different varieties, but the minor morphological differences ascribed to the Chinese taxon can be found in specimens that originate from Japan as well. The opposite is also the case and in conclusion all one can say is that plants from China more often have short 'teeth' and plants from Japan usually have longer 'teeth' on the seed cones. The explanation for this is probably that the short-toothed form in China is based on an early introduction of limited provenance with that cone form; later repeated introductions came from a wider range of trees and included the more common form with longer teeth. There can be little doubt that *Cryptomeria* was introduced long ago to China (Farjon, 1999), and that its inclusion in Floras and other accounts is based on uncritical assessment of data on distribution despite earlier doubts expressed by Wilson (1926) and Florin (1963). Even in Japan, where *Cryptomeria* is endemic, the natural distribution is apparently now very difficult to establish. This species has not been mapped in the Atlas of the Japanese Flora (Horikawa, 1972), presumably because of these problems.

Distribution

Japan: Honshu, Shikoku, Yakushima.
TDWG codes: 38 JAP-HN JAP-SH

Ecology

Natural forests that include this species are now very rare (Tomaru *et al.*, 1994) and those forests in which it still occurs have been greatly altered; the description is largely based on observations by E. H. Wilson made in 1914 on Yakushima (Wilson, 1916), where an old growth forest still exists. The forest vegetation is mixed evergreen forest, with ca. 50% *Cryptomeria*, growing mixed or in groves; angiosperm evergreen trees are *Trochodendron aralioides, Distylium racemosum, Camellia japonica, C. sasquana, Daphniphyllum* spp., *Michelia compressa, Myrica rubra, Quercus* spp., *Ilex* spp., and *Lauraceae*; conifers are *Abies firma, Tsuga sieboldii, Chamaecyparis obtusa*, and *Torreya nucifera*; a few deciduous angiosperm trees, e.g. *Stewartia monadelpha* and *Acer* spp., make up less than 1% of tree cover. There is a diverse shrub-layer and some common climbers, e.g. *Hydrangea petiolaris* and *Rhus orientalis*; a rich cryptogamic flora covers the forest floor as well as trees, with abundant ferns, e.g. *Hymenophyllum*, mosses, and liverworts. The mountains on this island are of granite; the soils are well drained yellow loam or clay, often quite deep. The climate is mild temperate, with abundant rainfall.

Conservation

Extensive logging has removed trees of this species in much of its natural range and few old growth forests with *Cryptomeria* remain. On the other hand, plantation forestry in Japan has made extensive use of the species, bringing it back to many areas where it had been greatly depleted. The species is undoubtedly regenerating naturally from this stock in many forests, so that the distinction between its natural distribution and anthropogenic occurrences can only be ascertained by a detailed study of forest history in Japan that would distinguish between primary and secondary occurrence.
IUCN: NT

Uses

The timber of this species is regarded in Japan as being highly valuable for construction because of its size, workability, and durability. This species is the principal conifer in Japanese forestry and almost all timber now comes from plantations. It has been introduced to China many centuries ago; in Taiwan the Japanese established extensive plantations replacing natural forest. The wood is rather coarse grained, with reddish heartwood and light yellowish sapwood, and a typical coniferous fragrance due to volatile terpines. It is used in house construction, panelling, flooring, carpentry, joinery, and furniture making. The fibrous bark was traditionally used for roofs of houses but is now more often processed as a general fibre or composted. There are several hundred cultivars known of this species, in Japan and in Europe and North America, and the species as well as many of these cultivars are widely used in gardens and parks.

Cunninghamia R. Br., in Richard, Conif. Cycad.: 80, 149. 1826 (*nom. cons.*). Type: *Cunninghamia lanceolata* (Lamb.) Hook. [*Cunninghamia sinensis* R. Br. (*nom. illeg.*) (*Pinus lanceolata* Lamb.)] (*Cupressaceae*).

Named after Allan Cunningham (1791–1839), English traveller and botanist.

Description

Evergreen, monoecious trees; trunk monopodial, readily resprouting. Resin ducts in leaves. Bark fissured, fibrous, exfoliating in long strips, reddish brown. Branches in whorls, long, slender, higher order branches spreading or drooping to pendulous, plagiotropic (Massart's model); capacity to coppice profound. Foliage branches slender, branching (nearly) opposite, lateral branchlets deciduous. Leaves helically arranged, decurrent at distinctly narrowed base, free part curved or twisted into a more or less pectinate arrangement with primary stomatal face on underside, coriaceous, flattened, linear-lanceolate, gradually tapering to an acute apex; margins serrulate; amphistomatic or hypostomatic; abaxial stomata in 2 broad glaucous white bands separated by a green elevated midrib; adaxial stomata in two narrow bands (3–5 lines) along margins or absent. Pollen cones subterminal on foliage branches, numerous in clusters subtended by a pseudo-whorl of bract-like short leaves, cylindrical; microsporophylls numerous, helically arranged, peltate, bearing 3(–4) abaxial pollen sacs. Seed cones subterminal, solitary or paired, persistent (falling with foliage branches); mature cones ovoid-globose. Bract-scale complexes numerous, helically arranged, imbricate, appressed at base, spreading distally at maturity, more or less triangular with a pedicellate base and an apiculate to cuspidate apex, coriaceous; abaxial surface smooth; adaxial surface with 2–3 seed marks at the distal end of the seed-bearing tissue. Seeds 2–3 per fertile scale, with 2 marginal, 1 mm wide wings. Seedlings with 2 cotyledons.

2 species.

Distribution

China, Lao PDR, Taiwan, Viet Nam.

Key to the species of *Cunninghamia*

1a. Leaves 12–30 × 2–3 mm, conspicuously amphistomatic; adaxial stomata in continuous narrow bands from base to apex of the leaf ***C. konishii***

1b. Leaves 30–60 × 3–5(–6) mm, hypostomatic, or at most with a few intermittent or incomplete lines of stomata adaxially ***C. lanceolata***

Cunninghamia konishii Hayata, Gard. Chron., ser. 3, 43: 194. 1908. [J. Linn. Soc., Bot. 38: 299. 1908]. Type: Taiwan: Chiayi Co., Luan-ta Shan, ["Mt. Rantaizan"], *N. Konishi s.n.* (holotype TI). Fig. 92

Etymology

The species epithet commemorates N. Konishi, the collector of the type specimen.

Vernacular names

Taiwan shan mu (Chinese)

Description

Trees to 40–50 m tall; trunk monopodial, often buttressed in old trees, readily resprouting (coppice or pollard trees), to 3(–4.5) m d.b.h. Bark on trunk fissured, fibrous, exfoliating in long strips, reddish brown weathering dull brown. Branches in whorls, long, slender, spreading to ascending near the top, forming a pyramidal to finally irregular, rounded crown; higher order branches spreading or drooping to pendulous, 3rd and 4th order branches plagiotropic (but profuse reiteration after damage obscures this arrangement). Foliage branches numerous, slender, branching (nearly) opposite, lateral branchlets deciduous. Leaves decurrent at distinctly narrowed base, free part curved or twisted into a more or less pectinate arrangement with the primary stomatal face on the undersides, flattened, narrowly lanceolate or linear-lanceolate, straight or s-curved, gradually

tapering to an acute apex; margins serrulate, 12–30 × 2–3 mm; amphistomatic, abaxial (lower) stomata in 2 broad glaucous white bands of 10–20 irregular lines separated by a green elevated midrib; adaxial stomata in two narrow bands (3–5 lines) along margins; adaxial surface smooth, glaucous green or green. Pollen cones subterminal on foliage branches, in clusters subtended by a pseudo-whorl of bract-like short leaves, 10–15 × 3–4 mm; microsporophylls 50 or more, helically arranged on a slender axis, peltate; margins erose-denticulate; apex acute; bearing 3 abaxial, large, oblong pollen sacs on the lower margin. Seed cones subterminal, solitary or paired, maturing within 1 year, persistent (falling with foliage branchlets); mature cones ovoid-globose, 15–25 × 15–20 mm, turning lustrous brown. Bract-scale complexes numerous, helically arranged on a thin axis, persistent, imbricate, appressed at base, spreading distally at maturity, more or less triangular with a pedicellate base, coriaceous; margins entire or denticulate near apiculate apex; abaxial surface smooth, more or less keeled towards apex. Seeds usually 2 per fertile scale, obovate, flat, 4–6 × 3–4 mm, brown with a light hilum near the base and 2 marginal wings 1 mm wide leaving an emarginate seed apex. Teratism in the form of 'shoot proliferation common.

Taxonomic notes

Lu *et al.* (1999) investigated molecular data from a small part of the chloroplast genome (*trn*D-*trn*T spacer) in four samples from Taiwan and four from mainland China and found the sampled populations to be paraphyletic. This of course means in evolutionary terms that this still extant species may have been the ancestor of its also extant congener. It does not mean that *C. konishii* and *C. lanceolata* cannot be distinct species, unless one insists that species be monophyletic, which this author does not. Phylogenetic inference from such a limited sample base is questionable anyway. In addition, there is a compounding problem with the provenance of especially *C. lanceolata*, as few trees in China are truly originating from wild populations in undisturbed forests. In contrast, *C. konishii* is known from remote forest sites, at least in Taiwan, Lao PDR, and Viet Nam. If more becomes known about these and other, disjunct populations of *C. konishii*, it is possible that we must conclude that it is a montane form of a widespread, polymorphic species, or perhaps that we are dealing with a few 'cryptic' species.

Distribution

Taiwan (N-central); China, Fujian; Lao PDR, Houaphan Province; Viet Nam (Bu Huong Mountain, Phu Hoat Mountain).

TDWG codes: 36 CHS-FJ 38 TAI 41 LAO VIE

Ecology

In mixed coniferous or conifer-broad-leaved forest in the cool temperate coniferous forest belt, with *Chamaecyparis formosensis, C. obtusa* var. *formosana, Calocedrus formosana, Pinus taiwanensis, Pseudotsuga sinensis, Taiwania cryptomerioides, Acer morrisonense, A. kawakamii, Schima superba, Photinia davidiana, Rhododendron formosanum, Pasania* sp., and the alpine bamboo *Yushania niitakayamensis*. The altitudinal range is from (600?)1000 m to 2200 m a.s.l. Soils are relatively deep and well-drained loams or loamy sand. The climate is cool, very moist, with cloud-cover resulting in fog and rain much of the year and very high precipitation exceeding 4000 mm per year.

Conservation

This species is now known from very disjunct localities in warm temperate E Asia, but outside Taiwan its conservation status, and indeed its areas of occupancy and abundance, are poorly known. In Taiwan, substantial decline has occurred in the populations due to felling of original forests, which are being replaced by plantations if not converted to other land uses. In those cases where *Cunninghamia* has been replanted, use has mostly been made of *C. lanceolata*, which shows faster growth than. *C. konishii*. This poses another threat: genetic contamination. A magnificent stand of giant trees of *C. konishii* is protected in Taroko National Park, far from any planted trees. Most recently, surveys in Lao PDR and Viet Nam indicated a past decline in excess of 50% that has not ceased.

IUCN: EN [A2cd; B2ab (ii, iii, v)]

Uses

The timber of this species is valued for its durability under wet climate conditions. As a rare tree its commercial exploitation is now negligeable, but in the past is was logged and large trees were very valuable. In cultivation it is uncommon, mainly restricted to botanical collections in arboreta and botanic gardens.

Cunninghamia lanceolata (Lamb.) Hook., Bot. Mag. 54: sub t. 2743. 1827. *Pinus lanceolata* Lamb., Descr. Pinus 1: [52], t. 34. 1803. Type: Illustration in Lambert, Descr. Pinus 1, t. 34. 1803 (lectotype). Fig. 93

Cunninghamia unicanaliculata D. Y. Wang & H. L. Liu, Acta Phytotax. Sin. 20 (2): 230. 1982.
Cunninghamia unicanaliculata D. Y. Wang & H. L. Liu var. *pyramidalis* D. Y. Wang & H. L. Liu, Acta Phytotax. Sin. 20 (2): 231. 1982.

Etymology

The species epithet refers to the shape of the leaves resembling the point of a lance.

Vernacular names

Chinese fir; shan mu (Chinese)

Description

Trees to 30–40 m tall; trunk monopodial, often buttressed in old trees, readily resprouting (coppice or pollard trees), up to 2.5–3(–6?) m d.b.h. Bark on trunk fissured, fibrous, exfoliating in long strips, reddish brown weathering to dull brown. Branches in whorls, long, slender, spreading to ascending near the top,), forming a pyramidal to finally irregular, rounded crown; higher order branches spreading or drooping, 3rd and 4th order branches plagiotropic (but profuse reiteration after damage obscures this arrangement). Foliage branches numerous, slender, branching (nearly) opposite; lateral branchlets deciduous. Leaves decurrent at slightly narrowed base, free part curved or twisted into a more or less pectinate arrangement with stomatal face on underside, flattened, lanceolate-linear, straight or curved, gradually tapering to a pungent apex; margins serrulate; 30–60 × 3–5(–6) mm; hypostomatic, with stomata in 2 broad glaucous white bands of 10–35 irregular lines separated by a green slightly elevated midrib; adaxial surface smooth, with 2 shallow lateral grooves, lustrous green. Pollen cones (sub)terminal on foliage branches, numerous in clusters subtended by a pseudo-whorl of bract-like short leaves, 10–20 × 3–5 mm, yellowish green turning brown; microsporophylls 50 or more, spirally arranged on a slender axis, peltate; margins erose-denticulate; apex obtuse to acute; bearing 3(–4) abaxial, large, oblong pollen sacs on lower margin. Seed cones subterminal, solitary or in clusters of 2-several, maturing within 1 year, persistent (falling with foliage branches); mature cones ovoid-globose, 25–40 × 25–35 mm, turning lustrous reddish brown. Bract-scale complexes spirally arranged on a thin axis, persistent, imbricate, appressed at base, spreading distally at maturity, more or less triangular with a pedicellate base, coriaceous; margins denticulate; apex cuspidate to rostrate; abaxial surface smooth, more or less keeled towards apex; adaxial surface with 2–3 seed marks at the distal end of the seed-bearing tissue. Seeds usually 2 per fertile scale, obovate, flat, 6–7 × 4–5 mm, brown with a light hilum near base and 2 marginal wings 1–2 mm wide leaving an emarginate seed apex. Teratism in the form of 'shoot proliferation frequent.

Taxonomic notes

The new species *C. unicanaliculata* and its variety *pyramidalis* (the latter based on a tree with slender habit), described by Wang & Liu (*op. cit.*) were sunk into synonymy in Flora of China 4 (1999). Wang & Liu stated that the new species differs from *C. konishii* by "frequent" single resin canals in the leaves, but there is no indication of what higher numbers, if any, they observed in other leaves belonging to *Cunninghamia*. Both *C. konishii* and *C. lanceolata* normally have a single resin canal in the leaves.

Distribution

China: from Sichuan to the coast, mainly in SE China; Lao PDR, Viet Nam (doubtfully indigenous).
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHH CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HN CHS-JS CHS-JX CHS-ZJ 41 LAO VIE

Ecology

Wang (1961) considered *C. lanceolata* to be a coniferous constituent of the Mixed Mesophytic Forest Formation of the warm temperate regions of China. This is predomiantly a deciduous angiosperm-dominated forest in which no particular species dominate and conifers form a minor but fairly constant component. Almost all of the original forest has disappeared under the long-lasting influence of a dense rural population. In remnants of natural vegetation, e.g. Tienmu Shan in Zhejiang, it occurs with numerous species in *Acer, Magnolia, Quercus*, and other angiosperms. The conifers mentioned for this mountain are in part natural understorey species of this forest type, i.e. *Cephalotaxus fortunei, Pseudotaxus chienii, Taxus chinensis*, and *Torreya grandis*. However, most of the other conifers mentioned to occur in it are either introduced in Zhejiang (*Cryptomeria japonica* (Farjon, 1999), *Cupressus funebris*, or not typical for old growth of this forest type, but for secondary vegetation (e.g. *Juniperus formosana, Pinus massoniana*, and *P. tabuliformis*). Many habitat notes on herbarium sheets of *C. lanceolata* mention forest, forest edges, light woodland, rocky slopes, and scrub, most of which indicate secondary vegetation. The capacity to coppice and relative intolerance to shade will ensure its survival in cutover forest areas. It is also widely planted in afforestation projects throughout warm temperate China and beyond.

Conservation

IUCN: LC

Uses

Uses of this tree vary, from timber to firewood and horticultural, with amenity planting in Chinese cities and parks as well as botanical collections and gardens in other countries. The wood is light, soft, fragrant, almost white, and durable. Large sizes are milled for construction timber in houses, for masts, carpentry and planks for coffins. In the past, wood buried in landslides was reported to be dug up and as it was darker, was much valued for coffins. In Europe a few cultivars, primarily producing dwarfed habits, have been selected but the tree is most commonly seen in arboreta as the species. In China advantage is taken of its capacity to coppice, i.e. grow new stems from cut tree stumps and roots, and much of this is used as firewood.

Tassilicyparis A. V. Bobrov & Melikyan, Komarovia 4: 72. 2006. Type: *Tassilicyparis dupreziana* (A. Camus) A. V. Bobrov & Melikyan [*Cupressus dupreziana* A. Camus]. *Platycyparis* A. V. Bobrov & Melikyan, Komarovia 4: 73. 2006. Type: *Platycyparis funebris* (Endl.) A. V. Bobrov & Melikyan [*Cupressus funebris* Endl.]. *Hesperocyparis* Bartel & R. A. Price, Phytologia 91 (1): 179. 2009. Type: *Hesperocyparis macrocarpa* (Hartw. *ex* Gordon) Bartel [*Cupressus macrocarpa* Hartw. *ex* Gordon].

Cupressus is the classical Latin name for cypresses.

Description

Shrubs or trees to 40(–95) m, evergreen, monoecious; trunk usually monopodial, sometimes buttressed. Resin cavities in leaves. Bark smooth or more commonly fissured and fibrous, hard or soft, exfoliating in small flakes or long strips. Branches long and spreading or ascending, eventually drooping or pendulous in several species, forming conical, pyramidal or rounded crowns. Fastigiate forms mostly restricted to cultivation. Foliage branches irregularly disposed and spreading or plagiotropic and pendulous, also intermediate forms. Leaves scale-like, monomorphic or dimorphic, appressed or with free apices, on ultimate branchlets 1–3 × 0.8–1.2 mm, on leading shoots larger, triangular to rhombic or, in branchlets with dimorphic leaves, with laterals slightly larger than facials and conduplicate, glandular or eglandular; margins minutely denticulate or erose-hyaline, sometimes entire. Pollen cones terminal, solitary, 3–7 × 2–3 mm, with 10–20 decussate microsporophylls bearing 3–6 abaxial yellow pollen sacs. Seed cones solitary on short branchlets, often grouped close together or clustered, caducous or persistent, globose to ovoid-oblong 10–40 × 10–30 mm, with parting woody scales. Bract-scale complexes in (3–)4–7 decussate pairs, peltate, quadrangular, rhombic or polygonal in outline, with well developed umbos (bract apices) in most cases; adaxially with light seed marks towards narrowing base. Seeds numerous, in two or more rows on bases of scales, small, angular, with rudimentary wings. Cotyledons 2–5, juvenile leaves only on seedlings, in whorls of 3–4, acicular-linear.

15 species.

Distribution

SW North America, S to Honduras; North Africa and Mediterranean to Middle East; Himalaya to SW China.

Taxonomic notes

In a recent paper, Little (2006) used (mainly) DNA nucleotide sequence data in a phylogenetic analysis and followed the cladistic paradigm to classify the species. *Juniperus* appeared to be derived from ('nested within') *Cupressus*. To avoid paraphyly of *Cupressus*, the genus had therefore to be split into two (the alternative under cladisitic insistence on monophyletic taxa would be to sink *Juniperus* with its more than 50 species into *Cupressus*). In a response it was argued (Farjon, 2007) that it is possible to recognize that *Juniperus* might indeed have evolved from an ancestor which, had we known it, would be classified as a species of *Cupressus* based on the morphological circumscription of that genus. Evolutionary (phyletic) classification accepts but does not insist on Hennigian monophyletic (= holophyletic) taxa. More recently, another cladistic analysis using molecular data (Adams *et al*., 2009) gave similar results, but with the New World species of *Cupressus* now (again) separated from the two species of *Xanthocyparis* as here recognized (these were included in the New World Cypresses in Little's 2006 paper, but not in an earlier analysis based on nuclear ITS data). Little had 'resurrected' the forgotten name *Callitropsis* Oerst. for all these and made the appropriate new combinations, but that name has subsequently been proposed and accepted (subject to ratification at the International Botanical Congress in 2011) for official rejection because of ambiguity and other reasons causing disruption of names. So, again adhering to the cladistic principle of monophyly, a new name was now proposed for the New

World Cypresses (*sensu stricto*): *Hesperocyparis* Bartel & R. A. Price, with the appropriate new combinations. It is admitted by these authors, that "the new genus is cryptic in its macromorphology", although unconvincing attempts were made to list some differences. Very few of these differences apply to *Cupressus macrocarpa* (the type of the new genus *Hesperocyparis*) and *C. sempervirens* (the type of *Cupressus*) and if taken across the genus *Cupressus* as commonly circumscribed, none of them are consistent. Another contentious issue appears to be the generic placement of the Leyland Cypress (as such not treated in this Handbook as it is not a taxon that occurs in the wild). If its parents both belong to *Cupressus*, then it is not an intergeneric hybrid, but just a hybrid between two species of that genus. Both parents, Monterey cypress and Nootka cypress, have been removed from *Cupressus* (the first by Little and by Adams *et al*., cited above, the latter in the 19th century to *Chamaecyparis* and recently to *Callitropsis* and, as accepted here, to *Xanthocyparis*). The controversy here is not purely one of taxonomy; it has a direct bearing upon the (correct) botanical name of this economically important cultivated conifer. Horticulturists could be tempted, after reading all of this, to forgo on botanical names altogether; to them the Leyland Cypress will remain the Leyland Cypress.

Key to the species of *Cupressus*

1a. Leaves on ultimate branchlets dimorphic; laterals larger than facials; glands present on facials **2**
1b. Leaves on ultimate branchlets all of similar shape and size, or if dimorphic, eglandular **3**
2a. Seed cones with 6–8 scales. Lateral leaves usually with appressed apex ***C. funebris***
2b. Seed cones with (8–)10 scales. Lateral leaves with free apex ***C. cashmeriana***
3a. Seed cones usually in dense, serotinous clusters. Pollen sacs often 5 or more per microsporophyll **4**
3b Seed cones solitary or in groups, not densely clustered. Pollen sacs up to 4 per microsporophyll **8**
4a. Glands present on scale leaves **5**
4b. Leaves, at least those of ultimate branchlets, eglandular **6**
5a. Seed cones with 6, rarely up to 8 scales ***C. macnabiana***
5b. Seed cones with 8 or more scales… ***C. arizonica***
6a. Bark remaining smooth and scaly even on very large shrubs or trees ***C. guadalupensis***
6b. Bark becoming fissured, hard fibrous **7**
7a. Seeds with rudimentary wings or unequal wings, brown, often glaucous ***C. goveniana***
7b. Seeds with equal wings, brown or blackish brown, not glaucous ***C. macrocarpa***
8a. Pollen sacs 2–3 per microsporophyll. American species **9**
8b. Pollen sacs 4–5, if 2–3, then Eurasian / North African species **11**
9a. Bark smooth, exfoliating in numerous, papery flakes ***C. bakeri***
9b. Bark becoming fissured, hard fibrous **10**
10a. Seed cones 15–30 mm diam, often irregular in shape. Californian species ***C. sargentii***
10b. Seed cones 10–18(–20) mm diam., usually globose and regular in shape. Species distributed from Mexico to Honduras ***C. lusitanica***
11a. Foliage branchlets slender, lax **12**
11b. Foliage branchlets thick, rigid **14**
12a. Seeds fewer than 10 on each cone scale **13**
12b. Seeds more than 10, at least on the middle cone scales ***C. duclouxiana***
13a. Seed cone scales with prominent, curved bosses caused by protruding bract tips ***C. torulosa***
13b. Seed cone scales with small, inconspicuously protruding bract tips ***C. chengiana***
14a. Seed cones 15–27 × 13–21 mm. North African species ***C. dupreziana***
14b. Seed cones 20–35 × 20–25 mm. Species distributed in E Mediterranean and Middle East ***C. sempervirens***

Cupressus arizonica Greene, Bull. Torrey Bot. Club 9: 64. 1882.

Etymology

The species epithet refers to the US State of Arizona where this species is native.

Vernacular names

Arizona cypress; Cedro, Cedro blanco (Spanish)

Description

Large shrubs or trees 5–20(–30) m tall; trunk monopodial or multistemmed from near the ground, to 40–100 cm d.b.h. Bark smooth on branches and younger trees, soon turning grey, then exfoliating with thin scales and strips, exposing cherry-red or purplish red bark, remaining smooth on large stems (except eventually near base) and shaggy with exfoliating thin strips, or becoming rough, scaly or fibrous, to 4 cm thick, fissured, breaking into irregular, small flakes or long, fibrous strips, brown or blackish brown. Branches long and spreading, or more often ascending or erect, forming a conical, broad conical, pyramidal, or oval and round-topped crown. Foliage branches spreading or ascending, forming tufts of coarse, rigid foliage, ultimate branchlets numerous, spreading outward at 45–80 degrees, (5–)8–12(–20) mm long, quadrangular in cross-section, 1.3–1.6(–2) mm diam., persistent. Leaves decussate, decurrent, imbricate, appressed or on older branchlets and whip shoots several with spreading apex, of equal size and shape on ultimate branchlets, triangular-rhombic, more or less gibbous or more often with a central depression, (1–)1.4–2 × 1–1.3 mm (much larger on whip shoots); margins hyaline-serrulate or denticulate; apex obtuse to acute; stomata on the abaxial side near base, on the adaxial side scattered from base to apex; glands central, circular, conspicuous and active with a resin drop, or inconspicuous and inactive, or absent on some branchlets; leaf colour variable, dull green, grey-green, glaucous green, in young trees often strongly glaucous, often covered with thick cuticular wax. Pollen cones numerous, terminal, solitary, subglobose, elliptic-oblong or cylindrical, 3–5 × 1.7–2.2 mm; microsporophylls (8–)12–14(–16), decussate, peltate, each bearing abaxially (2–)3–5(–6) subglobose-angular pollen sacs. Seed cones terminal, often grouped or clustered, maturing in two growing seasons, serotinous or opening within a year, subglobose to irregularly broad ovoid, 15–27(–30) mm, while growing with prominent bosses on the scales. Bract-scale complexes decussate, (6–)8–10(–12), with 1–2 basal pairs usually fused or connate, the others parting at maturity, peltate, the distal part irregularly 4–6 sided, smooth, becoming coarsely rugose, with a subapical to central, curved boss 2–6 mm long formed by the partly emerging bract, proximal part abruptly constricted, pedicellate, grooved, with light seed scars towards base. Seeds 90–120 per cone, irregularly orbicular or oval, (3–)4–5(–6) mm long, more or less flattened; hilum (nearly) basal; wings 2, ca. 1 mm wide, surrounding the seed.

Taxonomic notes

A discussion of the taxonomy of the *Cupressus arizonica* 'complex' with comprehensive reference to the literature on this subject can be found in the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a).

Distribution

SW USA: California, Arizona, New Mexico, Texas; Mexico: Baja California Norte, Sonora, Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León, San Luis Potosí, Tamaulipas.

TDWG codes: 76 ARI CAL 77 NWM TEX 79 MXE-CO MXE-CU MXE-DU MXE-NL MXE-SL MXE-TA MXE-ZA MXN-SO

Ecology

In montane coniferous forest, mixed broad-leaf-coniferous woodland, Pinyon-Juniper woodland, sclerophyllous scrubland ('chaparral'), and valley scrub-grassland. The altitudinal range is between 750 m and 2700 m a.s.l. Associated species in these vegetation types are *Pseudotsuga menziesii, Abies concolor, Calocedrus decurrens, Pinus ponderosa, P. jeffreyi, P. arizonica, P. leiophylla, P. lambertiana, P. sabiniana, P. coulteri, P. cembroides, P. edulis, P. monophylla, Juniperus deppeana* var. *pachyphlaea, J. californica, Fraxinus velutina, Quercus* spp., *Garrya* sp., *Cercocarpus* sp., *Platanus* sp., *Populus tremuloides, Salix* sp. (along creeks), *Rhus ovata, Fremontia californica, Yucca whippleyi, Adenostoma fasciculatum, Arctostaphylos glandulosa, Ceanothus* spp., and *Rhamnus* sp. It is usually 'gregarious' and occurs on ridges, slopes and in canyons, sometimes in creek beds, in rocky terrain in yellow or red-brown loam, sand or gravel, or among boulders over limestone, sandstone, slate or granite. The climate is characterized by warm to hot, dry summers and winter rainfall.

Uses

There are no known commercial uses of the wood at the present time. The species, in particular var. *glabra* from Arizona, has for a considerable time been cultivated in gardens and parks in Europe and the USA as an ornamental. Young trees have a naturally conical habit and several cultivars have been selected to enhance this shape; other cultivars emphasize juvenile leaf type and extreme glaucousness of foliage. This species is tolerant of draught and grows well on chalk in full sun.

5 varieties are recognized:

Cupressus arizonica Greene var. ***arizonica***. *Callitropsis arizonica* (Greene) D. P. Little, Syst. Bot. 31 (3): 473. 2006 (*nom. ut. rej.*, Art. 56); *Hesperocyparis arizonica* (Greene) Bartel, Phytologia 91 (1): 180. 2009. Type: USA: Arizona, Greenlee Co., Clifton, ["on the mountains back of Clifton"], *E. L. Greene s.n.* (holotype NA). Fig. 94

Description

Bark becoming fissured or fibrous on larger trunks, to 4 cm thick, exfoliating slowly in small chips or shreddy strips. Leaves inconspicuously glandular or eglandular, or occasionaly conspicuously and actively glandular. Boss on cone scales usually large. Seeds red-brown to dark brown, not glaucous.

Distribution

USA: Arizona, New Mexico, W Texas (Chisos Mts.); N and NE Mexico: Chihuahua, Coahuila, Durango, Nuevo León, San Luis Potosí, Sonora, Tamaulipas, Zacatecas.
TDWG codes: 76 ARI 77 NWM TEX 79 MXE-CU MXE-CO MXE-DU MXE-NL MXE-SL MXE-TA MXE-ZA MXN-SO

Conservation

IUCN: LC

Cupressus arizonica Greene var. ***glabra*** (Sudw.) Little, Madroño 18: 162. 1966. *Cupressus glabra* Sudw., Amer. Forestry 16: 88. 1910; *Callitropsis glabra* (Sudw.) D. P. Little, Syst. Bot. 31 (3): 473. 2006 (*nom. ut. rej.*, Art. 56); *Hesperocyparis glabra* (Sudw.) Bartel, Phytologia 91 (1): 181. 2009. Type: USA: Arizona, Yavapai Co., Verde Canyon, ["William A. Tinsley's Ranch"], *G. B. Sudworth s.n.* (holotype US).

Description

Bark on trunks smooth and exfoliating in thin flakes and strips, exposing reddish bark, remaining smooth well into maturity of trees, eventually near base of large trunks becoming fissured, up to 1 cm thick, exfoliating with small flakes. Leaves usually conspicuously and actively glandular. Boss on cone scales large or small. Seeds red-brown, not glaucous or slightly glaucous.

Distribution

USA: Arizona (Coconino, Gila, Maricopa and Yavapai Co.).
TDWG codes: 76 ARI

Conservation

IUCN: NT

Uses

This variety is in cultivation as a decorative tree for large gardens and parks and is valued for its decorative smooth bark and attractive green or glaucous foliage.

Cupressus arizonica Greene var. ***montana*** (Wiggins) Little, Madroño 18: 163. 1966. *Cupressus montana* Wiggins, Contr. Dudley Herb. 1 (5): 161. 1933; *Callitropsis montana* (Wiggins) D. P. Little, Syst. Bot. 31 (3): 474. 2006 (*nom. ut. rej.*, Art. 56); *Hesperocyparis montana* (Wiggins) Bartel, Phytologia 91 (1): 182. 2009. Type: Mexico: Baja California Norte, Sierra San Pedro Martír, La Encantada, *I. L. Wiggins &; D. Demaree 4990* (holotype DS).

Description

Bark on trunks becoming fissured, exfoliating slowly in shreddy flakes and strips. Leaves conspicuously and actively glandular. Boss on cone scales usually small and obtuse. Seeds red-brown or dark brown, not glaucous.

Distribution

Mexico: Baja California Norte (Sierra San Pedro Martír).
TDWG codes: 79 MXN-BC

Conservation

In most localities in the Sierra San Pedro Martír where this variety still occurs, the (meta)populations are very small. Fires, but especially grazing by herds of cattle, are threatening this variety. Even though most known trees are within a National Park, 'traditional' land use like cattle grazing is still continuing within its boundaries as much as without. It is likely that there are more stands than presently known in these still largely roadless mountains.
IUCN: CR [B1ab (iii, v)]

Cupressus arizonica Greene var. ***nevadensis*** (Abrams) Little, Madroño 18: 164. 1966. *Cupressus nevadensis* Abrams, Torreya 19: 92. 1919; *Callitropsis nevadensis* (Abrams) D. P. Little, Syst. Bot. 31 (3): 474. 2006 (*nom. ut. rej.*, Art. 56); *Hesperocyparis nevadensis* (Abrams) Bartel, Phytologia 91 (1): 182. 2009. Type: USA: California, Kern Co., Bodfish, Bald Eagle Peak (Clear Creek) ["Red Hill" in Wolf, 1948: 119], *L. R. Abrams 5368* (holotype DS).

Vernacular names

Piute Cypress

Description

Bark on trunks becoming fissured and fibrous, 1–2 cm thick, exfoliating in long strips. Leaves conspicuously and actively glandular. Boss on cone scales usually small and obtuse. Seeds red-brown to dark brown, more or less glaucous.

Distribution

USA: California, in Kern, Los Angeles and Tulare counties, mostly in the Kern River drainage.
TDWG codes: 76 CAL

Conservation

This variety has a limited distribution in ca. 12 (meta) populations (groves) of different size in 4 localities, the largest being on the N slope of Bald Eagle Peak S of the little town of Bodfish, covering more than 200 ha with several thousand trees. These populations occur both on private and public lands. Fire, cutting or clearing of 'brush' to extend pasture, and competition by shrubs and trees are some of the major factors that negatively influence the abundance of Cypresses. A major burn all but destroyed the Cannell Creek grove several years ago (J. A. Bartel, e-mail comm. May 2000).
IUCN: EN [B2ac (iv)]

Uses

In the past, trees were cut for fence posts, chosen for the small size and straight habit of most trees and the durability of its wood. Changes in fencing techniques on ranches have made this use largely redundant.

Cupressus arizonica Greene var. ***stephensonii*** (C. B. Wolf) Little, Madroño 18: 164. 1966. *Cupressus stephensonii* C. B. Wolf, Aliso 1: 125. 1948; *Callitropsis stephensonii* (C. B. Wolf) D. P. Little, Syst. Bot. 31 (3): 474. 2006 (*nom. ut. rej.*, Art. 56); *Hesperocyparis stephensonii* (C. B. Wolf) Bartel, Phytologia 91 (1): 183. 2009. Type: USA: California, San Diego Co., King Creek, upper drainage of creek, *C. B. Wolf RSA 9467* (holotype RSA).

Cupressus arizonica Greene var. *revealiana* Silba, Phytologia 49 (4): 393. 1981.

Vernacular names

Cuyamaca Cypress

Description

Bark on trunks smooth and exfoliating in thin flakes and strips, exposing cherry-red bark, remaining smooth even on large trunks. Leaves variably glandular, from eglandular on some branchlets to conspicuously and actively on (fewer) others, but mostly inconspicuous. Boss on cone scales large or small. Seeds red-brown to dark brown, not or more or less glaucous.

Distribution

Mexico: Baja California Norte (Sierra Juárez), USA: S California (Cuyamaca Mts.).
TDWG codes: 76 CAL 79 MXN-BC

Conservation

The two known populations of this variety are very restricted. Fires swept the upper King Creek drainage in 1950 and 1970 reducing the size of the population. A later fire in 2003 further destroyed most of the remaining mature trees, but regeneration by seed is expected to occur after these events. The populations in the Sierra Juarez appear to extend as far as the vicinity of Santa Catarina, with the nearest to King Creek ca. 50 km and the farthest ca. 150 km to the south. Fires are probably less frequent and less severe in Mexico, but there is little or no monitoring of the situation.
IUCN: CR [B2ab (iii), c (ii, v) and C2b]

Cupressus bakeri Jeps., Fl. Calif. 1 (1): 61. 1909. *Callitropsis bakeri* (Jeps.) D. P. Little, Syst. Bot. 31 (3): 473. 2006 (*nom. ut. rej.*, Art. 56); *Hesperocyparis bakeri* (Jeps.) Bartel, Phytologia 91 (1): 180. 2009. Type: USA: California, Siskiyou Co., Timbered Crater, between Hills Farm (near Dana) and Little Hot Springs Valley, *M. S. Baker s.n.* (holotype JEPS).

Cupressus bakeri Jeps. subsp. *matthewsii* C. B. Wolf, Aliso 1: 83. 1948.

Etymology

This species was named after M. S. Baker, who collected the type specimen.

Vernacular names

Baker Cypress, Siskiyou Cypress, Modoc Cypress

Description

Trees 10–15(–25) m tall; trunk branching low, to 60–100(–140) cm d.b.h. Bark smooth, exfoliating with thin flakes exposing reddish, purplish red or red-brown bark, giving a shaggy appearance, on lower trunk to 2 cm thick and breaking into small plates with upcurled edges, grey. Branches spreading, upper branches ascending, persistent, with foliage towards end, giving a tufted appearance to the often sparse, conical or pyramidal crown. Foliage branches lax or rigid, ultimate branchlets opposite or alternate, spreading at 30–60 degrees, variable in length (4–25 mm) but many ca. 10 mm, slender, 0.6–1.2 mm diam., quadrangular in cross-section, persistent. Leaves decussate, imbricate, on (sub)ultimate branchlets appressed, rhombic, 1.2–2 × 1 mm, keeled with a central depression; margins hyaline-denticulate or serrulate, obtuse or acute, on whip

shoots up to 10 × 3–4 mm, often with a spreading apex; stomata few near base abaxially, scattered from base to apex adaxially; glands conspicuous, central on rhombic leaves, producing resin droplets; leaf colour grey-green to dark green. Pollen cones terminal, solitary, subglobose or ovoid, 2–3 × 2 mm, more or less 4-sided; microsporophylls 8–12(–14), decussate, peltate, bearing abaxially 2–3(–4) subglobose-angular pollen sacs. Seed cones terminal, solitary, grouped but not densely clustered, maturing in two seasons to grey-brown or (silver-)grey subglobose cones of 10–18(–22) mm diam. when slightly opened, persistent. Bract-scale complexes (4–)6–8(–10), decussate, peltate, when growing with a prominent boss, when full grown abaxially rugose, often verrucate, with a near-central, 2–3 mm long, triangular, or obscure, umbo (bract tip), adaxially constricted to a narrow base, grooved and ridged, dark brown, with lighter seed scars. Seeds 40–60(–85) per cone, 3–4 × 3 mm, oval to triangular, more or less flattened, brown or red-brown, often glaucous, wings 2, forming thin, narrow margins up to 0.5 mm wide.

Distribution

USA: N California (Siskiyou Co., Modoc Co., Shasta Co., Plumas Co.), S Oregon (Jackson Co., Josephine Co.).
TDWG codes: 73 ORE 76 CAL

Ecology

In *Pinus-Quercus* woodland and, more commonly, above that zone in mixed conifer forest or woodland with *Pinus ponderosa, P. jeffreyi, Abies concolor, Pseudotsuga menziesii, Calocedrus decurrens, Arctostaphylos patula*, and *Seriphidium* sp. (*Artemisia*); predominantly on old lava flows in rocky or sometimes sandy soil. The altitudinal range is between ca. 800 m and 2100 m a.s.l.

Conservation

This species occurs in 9 sites, some quite disjunct; one of these comprises a population more than 3 km across, the others are smaller or of unknown size, and one population has become extinct in the 20th century. Wildfires are the major hazard and difficult to fight due to the inaccessible terrain of the lava fields in which several of the populations occur. More accessible populations are also threatened because National Forest fire suppression policy in the past has allowed the build-up of a dangerous fuel load, making fires when they occur much more destructive.
IUCN: EN [B2ab (ii, iii, iv, v)]

Uses

No commercial uses are known of this species; like other cypresses trees may have been felled for fence posts in the past. Although trees retain a conical crown which is attractive in gardens, it is little used in horticulture, presumably because it is not strikingly distinct from other Californian species.

Cupressus cashmeriana Royle *ex* Carrière, Traité Gén. Conif., ed. 2, 1: 161. 1867. Type: United Kingdom: [cult. at the Royal Botanic Gardens, Kew ("Himalayan House")], *W. J. Bean & [?] Foster s.n.* (neotype K).

Cupressus pendula Griff., Itin. Pl. Khasyah Mts.: 131. 1848, *non* Thunb. (1783).
Cupressus tortulosa Griff., Not. Pl. Asiat. 4: 26. 1854 [*et in* Icon. Pl. Asiat. t. 372. 1854] ["*tortulosus*" or "*torulosis*", *nom. ut. rej.* (proposed 2010)].
Cupressus himalaica Silba, Phytologia 64: 80. 1987.

Etymology

The species epithet means 'from Kashmir' which was an erroneous conjecture by the author of the species. [Under the Botanical Code, no name shall be changed because it has the wrong meaning.]

Vernacular names

Bhutan Cypress, Weeping Cypress

Description

Trees to 85–95 m tall (D. B. Gurung & S. Miehe, unpubl. data); trunk often buttressed in large specimens, to at least to 3.5 m diam. above the buttress. Bark becoming fibrous, reddish brown with purplish brown inner bark, exfoliating in long shaggy strips. Branches relatively long, spreading or ascending, often S-curved, ending drooping to pendulous,

forming a conical or pyramidal or in old trees irregular and broad, dense crown. Foliage branches (long) pendulous or more rarely drooping-pendulous, very slender, lax, ultimate branchlets alternating, distichous, pendulous, gradually decreasing in length towards tip, together forming planate frondose sprays, ultimate branchlets semi-deciduous. Leaves decussate, imbricate, decurrent (long decurrent on whip shoots with spreading apices) dimorphic (monomorphic on whip shoots), scale-like, with facials slightly smaller than laterals, on ultimate branchlets 1.4–3 × 0.5–1 mm, on whip shoots up to 12 × 2 mm; laterals conduplicate, curved, their free part spreading at or below the apex of facials, with incurved or more rarely spreading acute apex; facials partly covered by laterals, with acute, appressed or free apex; margins entire; glands conspicuous on facials, inconspicuous on laterals; stomata few, scattered primarily on margins near leaf bases; leaf colour green or glaucous green, sometimes very glaucous. Pollen cones solitary and terminal on ultimate branchlets, oblong, 4–6 × 2–2.5 mm; microsporophylls 10–16, decussate, peltate with erose-denticulate margins and more or less acute apex, bearing 4 abaxial globose pollen sacs near the lower margin. Seed cones solitary or in groups near upper ends of pendulous branches, occasionally in persistent clusters, terminal on leafy branchlets with unaltered leaves, maturing in 2 growing seasons, (sub)globose to ovoid, (10–)12–21 × 10–19 mm., green or glaucous green maturing to brown with parting scales. Bract-scale complexes 8–10 in decussate pairs, of more or less equal size except for smaller connate proximal pair, peltate, 4–5-angular in outline, centrally depressed with protruding 1 mm long bract tip, rugose, abruptly narrowing towards the cone axis; adaxial surfaces striated, (red-)brown with light grey seed marks near base. Seeds 10–15 on each scale (fewer on the proximal pair), closely packed, angular-ovoid, slightly flattened, ca. 4 × 2.5 mm, reddish brown with whitish concave hilum at base, wings 2 on opposite sides, unequal in size and shape, 1–1.5 mm wide to nearly absent.

Taxonomic notes

The taxonomy and nomenclature of this species have been confusing ever since Carrière (1855, 1867) described two new cypresses with slender, lax foliage based on young plants cultivated in the Jardin des Plantes, Paris. Having received these plants from another horticulturist without sufficient evidence of provenance, his statements about origin were speculative. No original material survives, but of the several competing names originally available for the Weeping Cypress of Bhutan (*C. pendula* Griff. 1848 unfortunately being a later homonym of *C. pendula* Thunb. 1783 and *C. tortulosa* Griff. now proposed for official rejection for being obscure as well as ambiguous in its original spelling), *C. cashmeriana* Carrière could be traced back to 19th century cultivated plants in Kew that may have the same origin as Carrière's plant (Farjon, 1994). This material is also conspecific with Griffith's collections of *C. pendula* Griff. and a neotype was therefore selected from it. *Cupressus corneyana* Carrière remains *incertae sedis* and its usage in Flora of Bhutan (Grierson & Long, 1983) is incorrect. There are apparently very glaucous, less glaucous, and non-glaucous forms with long, pendulous or shorter, more drooping foliage branches. Horticulturists tend to make much of this, but we must realise that in almost all cases we are dealing with consciously or unconsciously selected plants and their mostly clonal offspring. Trees growing in the wild in Bhutan have greener, less pendulous foliage, and *C. pendula* Griff. and *C. cashmeriana* Carrière as originally seen and described by these authors are probably planted selections (cultivars). I see no merit in recognizing the form in nature as a distinct species *C. himalaica* Silba (e.g. in Grimshaw & Bayton, 2009: 299–300).

Distribution

Indigenous in Bhutan, NE India: Arunachal Pradesh; planted widely in the region near Buddhist monasteries and temples in E Nepal, Sikkim, Bhutan, Xizang [Tibet], and Arunachal Pradesh.
TDWG codes: 40 EHM-AP EHM-BH

Ecology

A very large emergent in evergreen angiosperm forest dominated by *Quercus*, with lauraceous trees in the understorey; also with *Tsuga dumosa* near the upper limit, and on rocky (limestone) cliffs in pure stands. There are two possible strategies involved: late successional stands depend on episodal disturbance

for regeneration, and extra-zonal avoidance of competition on exposed cliffs. The altitudinal range is from 1250m to 2670 m a.s.l. The climate in optimal stands is strongly influenced by summer monsoon rains, with ca. 800–2000 mm annual precipitation.

Conservation

The scarcity of localities where this species appears to grow naturally, with often few large trees present, as well as the general desirability of cupressaceous wood in E Asia in connection with religious and other traditional buildings, indicate a serious vulnerability of the remaining wild populations. However, its natural distribution has only recently been evaluated and there is no clear evidence of serious decline over the past three generations.
IUCN: NT

Uses

The uses of this tree are ornamental, religious, possibly medicinal; timber harvesting may now have ceased largely due to scarcity and inaccessability of remaining wild populations. This species is commonly planted in Buddhist monasteries and temple grounds in Bhutan (from where it was first described by William Griffith), NE India, Sikkim, and near Darjiling. It is surely the most ornamental of the true cypresses and the monks undoubtedly are responsible for unnamed cultivars with especially drooping branches and glaucous foliage known to Europeans prior to their discovery of populations in the wild, which show a mixture of these and other characters. Some of these forms are quite hardy, others only survive in areas with mild, virtually frost-free winters such as in southern Europe. Probably the most famous tree in Europe is a very broadly crowned, multi-stemmed specimen on the Isola Madre in Lake Maggiore, northern Italy, now sadly in a poor state after a storm.

Cupressus chengiana S. Y. Hu, Taiwania 10: 57. 1964.

Etymology

The species epithet commemorates the Chinese botanist W. C. Cheng.

Vernacular names

Cheng cypress; min jiang bai mu (Chinese)

Description

Trees to 30 m tall; monopodial; trunk to 1.5 m d.b.h. Bark eventually becoming fibrous, reddish brown with purplish brown inner bark, exfoliating in long strips. Branches spreading, assurgent or ascending, often ending drooping, forming a conical or pyramidal or in old trees irregular and broad, dense crown. Foliage branches drooping-pendulous, slender, ultimate branchlets alternating, more or less distichous, (sub)pendulous, forming short feathery sprays, 1–1.5(–2) mm diam., torose, persistent. Leaves decussate, imbricate, decurrent, (nearly) monomorphic, scale-like, with facials equal in size to laterals, on ultimate branchlets 1–1.5 mm long and rhombic-gibbous, on whip shoots up to 7 mm long, with incurved and appressed obtuse apex; margins minutely erose-hyaline; glands conspicuous on all scale leaves; stomata few, scattered primarily on margins near leaf bases; leaf colour dull green or greyish green, often covered in thick cuticular wax. Pollen cones solitary and terminal on ultimate branchlets, ovoid-oblong, 2–4 × 1–2 mm; microsporophylls 12–16, decussate, peltate, bearing 4–5 abaxial pollen sacs near the lower margin. Seed cones solitary or in groups near upper ends of lateral branches, terminal on leafy branchlets up to 10–15 mm long with unaltered leaves, maturing in 2 growing seasons, persistent, (sub)globose to ovoid-oblong when closed, (8–)10–25 mm long, maturing to (purplish) brown with parting scales. Bract-scale complexes 8–14 in decussate pairs, of more or less equal size (6–15 mm wide), peltate, polygonal (4–5-angular) in outline, centrally depressed, flat, or bossed, with protruding minute bract tip, rugose, abruptly narrowing towards cone axis; adaxial surfaces striated, brown with whitish seed marks near base. Seeds 4–6(–8) on each scale, closely packed, ovoid-triangular, slightly flattened, 3–5 × 2–3 mm, reddish brown or yellowish brown with whitish hilum at base; wings 2 on opposite sides, more or less equal in size and shape, dependent on room for growth 1–2 mm wide.

Distribution

China: S Gansu, N & W Sichuan.
TDWG codes: 36 CHC-SC CHN-GS

Ecology

In small, pure stands in some valleys, but more commonly on rocky slopes or cliffs associated with *Koelreuteria paniculata, Morus mongolica, Campylotropis delavayi, Bauhinia faberi, Cotoneaster multiflorus*, and *C. gracilis*; in non-acidic brown soils over granites, quartzites and limestones. Based on verified herbarium collections, the altitudinal range is extensive, ranging from ca. 1200 m to 2750 m a.s.l. The climate is characterized by cold winters and cool to warm summers, with a distinct alternation of dry and rainy seasons; annual precipitation varies between 500–750(–1000 mm), with a 50–70% moisture deficit. There is no recorded difference in ecology for the two varieties.

Uses

Timber of this species is valued for building and the species has been exploited for its larger, more or less straight trunks for many centuries. On a small scale trees have been planted as individuals or in groups in villages.

2 varietis are recognized:

Cupressus chengiana S. Y. Hu var. ***chengiana***. Type: China: Sichuan, Wenchuan Xian, (Min River), *W. C. Cheng 2066* (holotype A).

Cupressus fallax Franco, Portugaliae Acta Biol., sér. B, Sist. 9: 190. 1968.

Description

Seed cones (sub)globose, very variable in size; bract-scale complexes 8–14.

Distribution

China: S Gansu, N & W Sichuan.
TDWG codes: 36 CHC-SC CHN-SA

Conservation

This variety is known from ca. 9 different locations where natural populations are now mostly restricted to more inaccessible sites such as canyons and exposed cliffs. Overcutting is the main cause of its decline. A collection from Hunan Province (*L. B. Hu 1233*, seen in E) is most likely from an introduced tree. Cypresses of this species are planted in villages within its natural range in Sichuan and possibly in Gansu as well.
IUCN: VU [B2ab (v)]

Cupressus chengiana S. Y. Hu var. ***jiangensis*** (N. Zhao) Silba, Phytologia 49: 394. 1981. *Cupressus jiangensis* N. Zhao, Acta Phytotax. Sin. 18 (2): 210. 1980, ["*jiangeensis*"]. Type: China: Sichuan, Longmen Shan, Jiange Xian, *L. S. Cai & T. Z. Min 101–104* (holotype SCFI).

Description

Seed cones ovoid-oblong, more equal in size; bract-scale complexes 10–12.

Distribution

China: Sichuan (Longmen Shan, Jiange Xian).
TDWG codes: 36 CHC-SC

Conservation

Only known from a single monoecious tree well to the E of the main populations of var. *chengiana*.
IUCN: CR (D)

Cupressus duclouxiana Hickel, in Camus, [Les Cyprès] Encycl. Econ. Sylvicult. 2: 91, f. 419–424. 1914. Type: China: Yunnan, Kunming Xian, (introduced), *F. Ducloux 3452* (lectotype P).

Etymology

The species epithet commemorates the French missionary and plant collector F. Ducloux, who was based in Kunming.

Vernacular names

Yunnan Cypress; gan xiang bai (Chinese)

Description

Trees to 30(–45) m tall; monopodial; trunk to 1(–1.6) m d.b.h. Bark eventually becoming fibrous, fissured, reddish brown, several cm thick on lower trunk, slowly exfoliating in long strips. Branches spreading horizontally or ascending in younger trees, forming a conical or pyramidal or in some trees flat-topped, dense crown. Foliage branches spreading to drooping-pendulous, very slender, ultimate branchlets irregularly disposed, (sub)pendulous, forming lax, short bushy sprays, 0.8–1 mm diam., torose, persistent. Leaves covering branchlets decussate, imbricate, decurrent, monomorphic, scale-like, with facials equal in size to laterals, on ultimate branchlets 1–2 × 0.8 mm (on whip shoots up to 12 mm long, often with free apex), rhombic, gibbous or not, with incurved and appressed obtuse or acute apex; margins minutely erose-hyaline; glands conspicuous or inconspicuous; stomata few, scattered primarily on margins near leaf bases; leaf colour greyish green or glaucous green; gland sometimes yellowish and resinous. Pollen cones solitary and terminal on ultimate branchlets, obovoid-oblong, (4–)5–7 × 2–3 mm, yellowish green turning light brown; microsporophylls (12–)16–20, decussate, peltate, bearing 4–6 abaxial pollen sacs near the lower margin. Seed cones solitary or in groups near upper ends of slender branches, terminal on very short branchlets, maturing in 2 growing seasons, persistent, globose to angular-globose when open, 15–32 mm diam., maturing to (purplish) brown with parting scales. Bract-scale complexes (6–)8–10 in decussate pairs, of more or less equal size (up to 15 mm wide) except for smaller proximal and distal (often connate) pairs, peltate, polygonal (4–5-angular) in outline; abaxial face nearly flat, rugose, often pustulate, with grooves radiating from the inconspicuous bract tip in the centre, abruptly narrowing towards cone axis; adaxial surfaces grooved, with whitish seed marks near the base. Seeds 10 or more around each scale base, closely packed, ovoid-oblong, slightly flattened, 4–5 × 2–3 mm, reddish brown or chestnut-brown with whitish hilum at base; wings 2 on opposite sides, more or less equal in size and shape, up to 1 mm wide.

Distribution

China: SW Sichuan and NW Yunnan, in the deep gorges of the Jinsha (Yangtse), Langcang (Mekong), and Nu (Salween) Rivers, also along some western tributaries of the Yalong River in S Sichuan. All other references to localities in Yunnan are based on introduced trees. The Abbé Delavay understood this well; he notes with his coll. No. 6805: "grande arbre cultivé partout aux environs d'Yunnan-sen." It apparently has established itself successfully in the Western Hills S of Kunming and probably elsewhere in the dry hills of central Yunnan, but that is well outside its natural range. With man's help (cupressaceous trees have been transported all over China and beyond for centuries) the species got out of the gorges and onto the presently mild plains and hills near Lijiang, Dali, and Kunming.

TDWG codes: 36 CHC-SC CHC-YN

Ecology

In mountain forests dominated by *Pinus densata* and/or deciduous or evergreen *Quercus, Castanopsis*, or *Castanea*, often gregarious. In many areas introduced and under deforestation and grazing pressures invading into scrubland and grassland; also widely planted in or near villages. Trees of this species observed on steep slopes above the Mekong (Langcang) River in NW Yunnan were not associated with other trees and appeared to grow in the wild. There were trees in all age classes including senescent; a grove of very large trees near the river bridge NW of Dêqên is probably a remnant of old growth forest now protected by the local Buddhist people. This species grows naturally in rocky or gravelly loamy sand or scree over limestone or metamorphic rocks on the lower slopes of the deep V-shaped river valleys under semi-xeric conditions. Its altitudinal range in natural stands is probaly between 1900 m and 3300 m a.s.l.

Conservation

The truly wild and natural (old growth) stands of this species are extremely rare and scattered in the deep gorges of the great rivers in NW Yunnan, a few on tributaries. Some are protected by local Buddhist tradition as holy trees or groves, but adequate reserves and/or legislation to protect these trees from logging and firewood collecting are absent at present. The scant information available, the lack of any specific research, and the fact that this species is so widely cultivated throughout Yunnan and

Sichuan all indicate the need for further research to ascertain the true extent of the distribution of natural populations and their conservation status, and consequently more reliable EOO and AOO figures.
IUCN: DD

Uses

Although it is difficult to prove, widespread logging may well have depleted forests once more widespread in the river gorges. The wood is similar to that of *Taiwania* and trees can attain considerable height and size. It would produce highly valuable timber for local and regional use. This species is also of high horticultural merit and has been planted extensively in the hills around Kunming, where it attains a fastigiate habit quite different from the wild growing trees in the great river gorges to the NW. In Europe it has been introduced in the milder parts of England, Ireland and France; new provenances from the Kunming trees prove to be hardier and this attractive species deserves a wider use in horticulture.

Cupressus dupreziana A. Camus, Bull. Mus. Hist. Nat. (Paris) 32: 101. 1926.

Etymology

This species was named after "M. le Capitaine Duprez, commandant l'annexe de Djanet" who guided the collector of the type specimen to the trees.

Vernacular names

Saharan Cypress, Moroccan cypress; Cyprès de Duprez, Cyprès de l'Atlas (French); tarout (Berber, Tuareg [Tamashek]), azel (Berber?)

Description

Trees to 16–18(–20) m tall; monopodial; trunk to 2–3 m d.b.h. Bark eventually becoming thick, deeply fissured, hard, grey-brown, exfoliating slowly in small strips. Branches long, spreading or ascending, sometimes fastigiate, forming a conical or pyramidal, or in old trees sympodial, irregular and broad, dense crown. Foliage branches spreading or drooping-pendulous, slender, ultimate branchlets irregularly spreading or (sub)pendulous, subterete to slightly flattened in cross section, 1–1.5(–2) mm diam., slightly torose, persistent. Leaves covering branchlets decussate, imbricate, decurrent, (nearly) monomorphic, scale-like, with facials equal in size to laterals, on ultimate branchlets 1–1.2 mm long and rhombic, slightly gibbous, with appressed obtuse or acute apex (on whip shoots up to 5 mm long); margins minutely denticulate-hyaline; glands on all scale leaves (most conspicuous on facials; stomata few, scattered primarily on margins near leaf bases; leaf colour lustrous greyish green or glaucous green, often covered in thick cuticular wax. Pollen cones solitary and terminal on ultimate branchlets, ovoid-oblong, 4–6 × 2–3 mm; microsporophylls 12–16, decussate, peltate, bearing 3–4 abaxial pollen sacs near the lower margin. Seed cones mostly solitary on lateral branches, terminal, maturing in 2 growing seasons, persistent, subglobose to ovoid-oblong when closed, 15–27 × 13–21 mm, maturing to light brown with mostly parting scales. Bract-scale complexes (8–)10–12 in decussate pairs, of more or less equal size except for smaller proximal and distal connate pairs, peltate, polygonal (5–6-angular) in outline; abaxial surface flat, convex or bossed, with protruding minute bract tip, (finely) rugose, abruptly narrowing towards cone axis; adaxial surfaces grooved, with whitish seed marks near base. Seeds 6–8(–10) on each scale, closely packed, flattened, 5–6 × 4–5 mm, dark brown with whitish hilum at base; wings 2 on opposite sides, more or less equal in size and shape, 1–2 mm wide.

Taxonomic notes

The two cypresses indigenous in Algeria and Morocco have been described seperately as two distinct species: *Cupressus dupreziana* A. Camus and *C. atlantica* Gaussen. The only morphological differences are the shapes of mature seed cones and seeds. However, even these distinctions are less clear than Gaussen (1968) maintained: in *C. atlantica* they vary from ovoid to subglobose and are rarely if ever globose as described in the protologue. Gaussen's description was based on a specimen with a globose cone with only 8 seed scales, which is somewhat extreme for this taxon. The ultimate branchlets are not thinner than in *C. dupreziana* in most specimens seen. Both taxa are also close to *C. sempervirens*; in fact some specimens seen from western Asia belonging to the natural form of that species ('*horizontalis*')

have similar small cones. However, *C. sempervirens* does not occur naturally west of Crete and Cyrenaica in Lybia and may have been separated from these taxa since the early Pleistocene. The disjunction between the western North African taxa is likely of a more recent date, with forests of *Cedrus* and *Cupressus* still existing in the highlands of the Sahara connecting these with the Atlas Range during the last Ice Age. On these grounds both taxa are here recognized at infraspecific rank.

Distribution

Algeria, Morocco; in Algeria restricted to one very limited area in the Sahara.
TDWG codes: 20 ALG MOR-MO

Ecology

Virtually without any associated vegetation and widely scattered in canyons and dry stream beds (wadis) in sandstone plateau; one variety (var. *atlantica*) in very open shrubland or degraded woodland with *Juniperus phoenicea, Tetraclinis articulata*, and *Pistacio lentiscus* (in valley bottoms); on rocky limestone slopes and in dry, sandy stream beds. The altitudinal range of var. *dupreziana* is 1700–1900 m and of var. *atlantica* 900–2220 m a.s.l.

Uses

(Illegal) recent use for firewood has been recorded; in Morocco also for timber. This species is in cultivation but at present only as *ex situ* conservation attempts (mainly concentrated on var. *dupreziana* from the Sahara) and probably in a few collections. From observations made on some trees in the wild of both varieties, it should be possible to select shoots that grow into a fastigiate habit as with *C. sempervirens*; this could lead to cultivars of interest to horticulture. Young trees planted in the Royal Botanic Gardens, Kew have a columnar shape with short, more or less ascending branches.

2 varieties are recognized:

Cupressus dupreziana A. Camus var. ***dupreziana***.
Cupressus sempervirens L. var. *dupreziana* (A. Camus) Silba, Phytologia 49: 398. 1981; *Tassilicyparis dupreziana* (A. Camus) A. V. Bobrov & Melikyan, Komarovia 4: 72. 2006. Type: Algeria: Oasis, Tassili-n-Ajjir, Tamrit (Wadi), *L. Lavauden s.n.* (holotype P). Fig. 95

Description

Seed cones ovoid-oblong, with (10–)12 bract-scale complexes; seeds not angular.

Distribution

SE Algeria (Tassili Plateau: Tamrit).
TDWG codes: 20 ALG

Conservation

This cypress is one of the most extreme examples of a relict conifer seemingly on its way out to extinction. The causes of this are primarily natural climate change, but the remaining trees were also cut occasionally for firewood by wandering Tuareg people and there are tales about caravans that carted off wood. In all, 233 living individuals are now known to exist, with 20 trees dead since 1972 also found (Abdoun & Beddiaf, 2002). The remaining trees are often senescent and natural regeneration appears to be sporadic. The most recent census of trees in the area showed a continuous range of tree sizes and found more seedlings, indicating slow but continuous natural regeneration. Tourism is providing an increasing incentive for protection and the Tassili n'Ajjer has been designated a World Heritage Site. However, adequate protection *in situ* is still wanting. *Ex situ* cultivation is now well established in several countries. An International Arboretum is being established in Canberra, Australian Capital Territory (ACT), within which will be established forests of rare and endangered species from throughout the world. One of these forests is dedicated to *Cupressus dupreziana* var. *dupreziana* and 1300 of the trees have been propagated for planting in late 2007.
IUCN: CR (A2c, C1)

Cupressus dupreziana A. Camus var. ***atlantica*** (Gaussen) Silba, J. Int. Conifer Preserv. Soc. 5 (2): 29. 1998. *Cupressus atlantica* Gaussen, Monde Pl. 45: 55. 1950; *Cupressus sempervirens* L. var. *atlantica* (Gaussen) Silba, Phytologia 49: 398. 1981. Type: Morocco: Haut Atlas, Marrakech, Oued N'Fis, *[?] Idni s.n.* (holotype TLF).

Description

Seed cones globose to ovoid-globose, with (8–) 10–12(–11) bract-scale complexes; seeds more or less angular.

Distribution

Morocco (Oued-n'Fis valley).
TDWG codes: 20 MOR-MO

Conservation

The main population occurs in the Oued-n'Fiss valley between Asni and Ijoukak, where many old trees still survive. Estimates indicate however that the total area of occupancy (AOO) suffered a reduction from ca. 5500 ha in 1950 to 1460 ha in 1986. More recent surveys by Griffiths *et al.* in 1997 (unpubl. exped. rep. Univ. of Reading, UK) failed to observe natural regeneration even within an experimental enclosure designed to fence out the sheep and goats. Exploitation for timber and firewood has certainly slowed down under current awareness programmes by the regional authorities, but protection is still inadequate and further decline seems inevitable. Afforestation to provide alternatives for local use of wood is needed, but great care must be taken with the risk of genetic introgression from closely related species, e.g. *C. sempervirens*.
IUCN: CR [A2acd; B2ab (iii)]

Cupressus funebris Endl., Syn. Conif.: 58. 1847. *Chamaecyparis funebris* (Endl.) Franco, Agros 24: 93. 1941; *Platycyparis funebris* (Endl.) A. V. Bobrov & Melikyan, Komarovia 4: 73. 2006. Type: China: Zhejiang, ["China, prov. of Chekiang, Sir. Geo. Staunton" (introduced)], *G. L. Staunton s.n.* (lectotype BM).

Etymology

The epithet means: 'of the funeral' (Latin *funus* = death) and indicates its traditional use in China.

Vernacular names

Funereal Cypress, Chinese Weeping Cypress; bai mu (Chinese)

Description

Trees to 30–35 m tall; monopodial; trunk up to 2 m d.b.h. Bark eventually becoming shallowly fissured, grey-brown, exfoliating in long strips. Branches relatively long, spreading or ascending, ending drooping to pendulous, forming a conical or pyramidal or in old trees irregular and broad crown. Foliage branches pendulous, slender, lax, ultimate branchlets distichous, pendulous, forming planate frondose sprays, slightly flattened (subtetragonous) in cross section, ultimate branchlets semi-deciduous. Leaves covering decussate, imbricate, decurrent, dimorphic (monomorphic on whip shoots), scale-like, with facials slightly smaller than laterals, on ultimate branchlets 1.5–3.5 × 0.5–1 mm, on whip shoots up to 10 × 2 mm; laterals conduplicate, straight or curved, with appressed or more rarely free acute apex; facials partly covered by laterals, with acute, appressed apex; margins entire; glands on facials and laterals (often more conspicuous on facials), linear; stomata few, scattered primarily on margins near leaf bases; leaf colour lustrous green. Pollen cones solitary and terminal on ultimate branchlets, ovoid-oblong, 3–5 × 2–2.5 mm; microsporophylls 10–14, decussate, peltate, bearing 4 abaxial pollen sacs near the lower margin. Seed cones solitary or in groups on pendulous branches, terminal, maturing in 2 growing seasons, caducous, (sub)globose when closed,

(8–)10–15 mm diam., maturing to dark brown with parting scales. Bract-scale complexes 6–8(–12) in decussate pairs, of more or less equal size except the smaller connate proximal pair, (5–10 mm wide), peltate, polygonal (4–5(–6)-angular) in outline; abaxial face more or less umbilicate, with a central curved boss surrounding the protruding bract tip, finely rugose, abruptly narrowing towards cone axis; adaxial surfaces angular, striated, chestnut-brown with whitish seed marks at base. Seeds 3–5(–6) on each scale, closely packed, angular-ovoid, slightly flattened, 3 × 2.5 mm, dark brown with whitish hilum at base; wings 2 on opposite sides, unequal in size and shape, depending on room for growth 1 mm wide to nearly absent on one side.

Taxonomic notes

This species has often been classified in the genus *Chamaecyparis* on the basis of its flattened foliage (dimorphic facial and lateral leaves on foliage sprays) and small cones. The ontogeny of its seed cones, which mature in two years, and the higher number of ovules/seeds, which arise in two successive rows axillary to each bract, place it in *Cupressus*. The dimorphic leaves are also found in other taxa in the family adapted to higher athmospheric moisture, and are likely the result of convergent evolution.

Distribution

China: S Gansu (?), Guizhou, W Hubei (?), W Hunan, Shaanxi (?), Sichuan, Chongqing; widely cultivated in Central and S China.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHS-HN

Ecology

In mixed mountain forest or (degraded) woodland associated with *Platycarya strobilacea, Vitex negundo, Ligustrum* sp., *Viburnum* sp., *Pittosporum* sp., *Myrsine africana*, and *Vitex negundo*; in calcareous soil or in sandy loam over sandstone; also widely planted and probably invading into disturbed vegetation locally. The altitudinal range of this species is between 300 m and 2260 m a.s.l.

Conservation

The wide distribution of this species cited in the Chinese literature (including Flora of China 4: 67. 1999) is to a large extent based on planted or introduced trees outside the indisputably wild populations. Occurrence in natural forests is rare due to widespread deforestation and alteration of natural vegetation in much of central China. The possibility of secondary establishment from cultivated trees outside its original range makes evaluation of threat to wild populations of this species extremely difficult. The extent (and indeed existence) of natural populations of *C. funebris* is unknown at the current time.
IUCN: DD

Uses

This species is widely planted in China as an ornamental, especially common in Buddhist temple grounds. Its wood is also considered valuable due to its durability and traditionally it was used for coffins for this reason. In Europe it is uncommon in cultivation and most of the older extant trees are based on seed collection by Ernest Wilson made in Hubei Province, China, in 1907. In horticulture it is often referred to as *Chamaecyparis funebris* due to the flattened foliage and small cones.

Cupressus goveniana Gordon, J. Hort. Soc. London 4: 295. 1849.

Etymology

This species was named after James R. Gowen, at the time Secretary of the Horticultural Society of London.

Vernacular names

Gowen Cypress, Mendocino Cypress, North Coast Cypress, Pygmy Cypress, Dwarf Cypress, Santa Cruz Cypress

Description

(Dwarf) trees to 10(–50) m tall; monopodial; trunk to 1(–2.4) m d.b.h. Bark eventually becoming

fibrous, greyish brown to grey, hard, fissured, with anastomosing ridges, exfoliating in shreddy strips, to 2–3 cm thick. Branches ascending or spreading, short or long, slender, often sparse, forming a conical or pyramidal crown, or in certain conditions dwarfed. Foliage branches spreading, slender, ultimate branchlets irregularly disposed, spreading, short (3–5 mm) or longer (10–20 mm) and rigid forming dense tufts, subterete in cross section, 1–1.5 mm diam., torose, persistent. Leaves covering branchlets decussate, imbricate, decurrent on whip shoots and then with recurved, free distal parts, on ultimate branchlets appressed, monomorphic, scale-like, with facials equal in size to laterals, on ultimate branchlets 1–1.5 × 1–1.3 mm and rhombic-gibbous, on whip shoots up to 5 mm long, with incurved and appressed obtuse or more or less apiculate apex, sometimes slightly keeled; margins minutely denticulate; glands inconspicuous; stomata few, scattered primarily on margins near leaf bases; leaf colour yellowish green or dark green. Pollen cones numerous, solitary and terminal on ultimate branchlets, ovoid-oblong, 3–4 × 1.5–2 mm; microsporophylls 12–14, decussate, peltate, bearing 3–5(–6) abaxial pollen sacs near lower margin. Seed cones in groups or clusters on lateral branches, terminal, maturing in 2 growing seasons, persistent, (sub)globose when closed, 13–30 × 12–25 mm, maturing to lustrous brown and finally grey-brown or grey with parting scales. Bract-scale complexes 6–10, usually 8, in decussate pairs, of more or less equal size, 8–15(–18) mm wide, peltate, polygonal (4–6-angular) in outline, nearly flat or more often bossed, with protruding bract tip, abruptly narrowing towards cone axis; abaxial surface rugose; adaxial surfaces striated, brown or red-brown with whitish seed marks near base. Seeds 8–10 on each scale, closely packed, usually angular, slightly flattened, 3–5 × 2–4 mm, (blackish) brown or glaucous-brown with whitish hilum at base; wings 2 on opposite sides, unequal in size and shape or discontinuous, depending on room for growth to 1 mm wide.

Distribution

USA: California, Mendocino, Sonoma, Santa Cruz, San Mateo and Monterey Counties.
TDWG codes: 76 CAL

Ecology

In chaparral, 'pine barrens', and open pine woodland with *Pinus attenuata, P. contorta, P. muricata, P. ponderosa, P. radiata, Pseudotsuga menziesii, Arctostaphylos, Quercus*, and *Rhododendron*, often in groves of up to 1000 trees or more; on sandstone outcrops, white or yellow sandy slopes, and leached, virtually sterile sandy 'hardpan', where it becomes dwarfed. The altitudinal range is from near sea level to 1200 m a.s.l. The climate is of the Mediterranean type with dry, hot summers, but in a narrow coastal strip cooled by frequent fog, and winter rain.

Uses

Although introduced by C. T. Hartweg to England in 1848, this species soon turned out to be tender in NW Europe and its cultivation outside collections ceased. In southern Europe it is grown more widely in gardens and parks and a few cultivars are known, some with doubtful affinity to this species (see Vidaković, 1991: 193).

2 varieties are recognized:

Cupressus goveniana Gordon var. ***goveniana***. *Callitropsis goveniana* (Gordon) D. P. Little, Syst. Bot. 31 (3): 473. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis goveniana* (Gordon) Bartel, Phytologia 91 (1): 181. 2009. Type: USA: California, Monterey Co., Huckleberry Hill, ["discovered by Mr. Hartweg on the western declivity of the mountains of Monterey in Upper California"], *C. T. Hartweg s.n.* (holotype K).

Cupressus goveniana Gordon var. *pigmaea* Lemmon, Handb. W. Amer. Cone-bearers, ed. 3: 77. 1895; *Cupressus pigmaea* (Lemmon) Sarg., Bot. Gaz. (Crawfordsville) 31: 239. 1901; *Cupressus goveniana* Gordon subsp. *pigmaea* (Lemmon) A. Camus, [Les Cyprès] Encycl. Econ. Sylvicult. 2: 50. 1914, ["*pygmaea*"]; *Callitropsis pigmaea* (Lemmon) D. P. Little, Syst. Bot. 31 (3): 474. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis pigmaea* (Lemmon) Bartel, Phytologia 91 (1): 182. 2009 ("*pygmaea*").

Description

Seed cones 13–20 mm long; seeds (blackish) brown, not or only slightly glaucous.

Distribution

USA: California, Mendocino, Sonoma and Monterey Counties.
TDWG codes: 76 CAL

Conservation

Only known from a few scattered locations in a limited area, some of which are very close to continuing urban development.
IUCN: EN [B2ab (ii, iii, v)]

Cupressus goveniana Gordon var. ***abramsiana*** (C. B. Wolf) Little, Phytologia 20: 435. 1970. *Cupressus abramsiana* C. B. Wolf, Aliso 1: 215. 1948; *Callitropsis abramsiana* (C. B. Wolf) D. P. Little, Syst. Bot. 31 (3): 473. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis abramsiana* (C. B. Wolf) Bartel, Phytologia 91 (1): 180. 2009. Type: USA: California, Santa Cruz Co., Bonnie Doon, ca. 1 km E of public School, *C. B. Wolf RSA 6235* (holotype RSA).

Description

Seed cones (15–)20–30 mm long; seeds brown, often glaucous.

Distribution

USA: California, San Mateo and Santa Cruz Counties.
TDWG codes: 76 CAL

Conservation

Restricted to four populations in the Santa Cruz Mountains; two were located or found since the field studies by Wolf (in Wolf & Wagener, 1948). Some, like the one near Eagle Rock, consist of only a few score mature trees surrounded by highly flammable chaparral, and/or are inaccessible to fire fighters other than from the air. The population near Bonnie Doon is partly in an area with private real estate development and fire prevention here will allow pines like *Pinus attenuata* and *P. ponderosa* to crowd out the cypresses. The main population here is within the Bonny Doon Ecological Reserve, several others remain unprotected.
IUCN: CR [B2ab (ii, iii, v)]

Cupressus guadalupensis S. Watson, Proc. Amer. Acad. Arts 14: 300. 1879.

Etymology

The species epithet refers to Guadalupe Island, where this species (var. *guadalupensis*) is indigenous.

Vernacular names

Guadalupe Cypress, Tecate Cypress, Forbes Cypress; ciprés (Spanish)

Description

Large shrubs or small trees 10–15 m tall, rarely to 20 m; trunk short, branching with several leaders low above ground, or sometimes monopodial with an unbranched trunk 2–3 m tall, to 1.2–1.5 m diam. Bark remaining smooth and thin (to ca. 1 cm) even on lower part of large trunks, exfoliating in small flakes, or occasionally in long strips remaining partly attached, exposing reddish or purplish brown to light chocolate-brown bark; outer bark weathering whitish grey. Branches numerous, long, thick, spreading, ascending or erect, forming in free standing trees with short trunks a wide and rounded, but in more crowded conditions a narrower or irregular crown. Foliage branches lax or rigid, ultimate branchlets 3–15 mm long, slender or thicker, 1.2–1.7 mm diam., quadrangular in cross-section, becoming thicker and subterete on older branchlets, covered with leaves. Leaves decussate, imbricate, on ultimate branchlets appressed, rhombic, 1–1.5 × 1 mm, gibbous or with a slight central depression; margins hyaline-denticulate; apex obtuse, up to 15 × 3–4 mm on some vigorous whip shoots; stomata on abaxial side scattered in lower part, on the adaxial side from base to apex; leaves eglandular (ultimate branchlets) or with an inconspicuous, inactive gland,

covered with a thick cuticular wax layer, glaucous green to light green. Pollen cones numerous, terminal, solitary, ovoid-oblong, terete or quadrangular in cross-section, 4–7 × 2–3 mm; microsporophylls 12–18(–20), decussate, imbricate, peltate-cordate, abaxially bearing 3–4(–5) angular-globose, yellow pollen sacs. Seed cones terminal, not aggregated in dense clusters but often grouped with up to 20 cones, growing in two seasons to globose or subglobose cones, 15–35 mm diam. (some subglobose cones to 45 mm long), serotinous, coarsely rugose, sometimes with prominent bosses on the scales. Bract-scale complexes (6–)8–10, decussate, peltate, 4–5 sided or partially more or less rounded in outline, abaxially with a prominent and upcurved or flat and inconspicuous boss near the centre, coarsely rugose to verrucose, adaxially abruptly constricted, dark brown with light seed scars towards base. Seeds up to 100–120 per cone, irregularly shaped, slightly flattened, 4–7 × 2–3.5 mm, dark brown, the hilum conspicuously lighter; wings 2 narrow, irregular strips on either side, 0.5–1 mm wide.

Distribution

Mexico: Baja California Norte, Guadalupe Island, also along the border with California; USA: SW California, a few localities in Orange Co. and San Diego Co.
TDWG codes: 76 CAL 79 MXI-GU MXN-BC

Ecology

In chaparral on slopes with *Adenostoma* spp., *Arctostaphylos* sp., in ravines in the Upper Sonoran Life Zone associated with *Acer* sp., *Rhus laurina, Quercus* spp., and *Arctostaphylos* sp., also locally associated with *Pinus radiata* var. *binata*; often along intermittent streams on loamy, sandy, gravelly or rocky soils (or 'adobe soil') over sandstone or granite in full sun. The altitudinal range of var. *guadalupensis* is from 800 m to 1280 m and of var. *forbesii* from 210 m to 1400 m a.s.l. The climate is of the Mediterranean type with dry, hot summers and winter rain; with frequent fog on Guadalupe Island.

Uses

No uses are known of this species and its varieties. Only a few botanical collections in California (e.g. Rancho Santa Ana Botanical Garden) have grown this species successfully. It should be taken into cultivation more widely especially for reasons of *ex situ* conservation of the variety native to Guadalupe Island.

2 varieties are recognized:

Cupressus guadalupensis S. Watson var. ***guadalupensis***. *Callitropsis guadalupensis* (S. Watson) D. P. Little, Syst. Bot. 31 (3): 473. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis guadalupensis* (S. Watson) Bartel, Phytologia 91 (1): 181. 2009.
Type: Mexico: Baja California Norte, Guadalupe Island, *E. J. Palmer 92* (lectotype K).

Description

Pollen cones 5–7 mm long, before dehiscence distinctly quadrangular in cross-section, microsporophylls 16–18(–20) per cone. Seed cones up to 45 mm long but size highly variable.

Distribution

Mexico: Baja California Norte, restricted to Guadalupe Island.
TDWG codes: 79 MXI-GU

Conservation

The situation with the variety of *C. guadalupensis* that is restricted to the island of Guadalupe in the Pacific Ocean is extremely critical due to overgrazing by feral goats. The population may not exceed 200 mature trees in two small, separate stands. Recent fires have destroyed many trees. No permanent residents live on the island, which is visited only occasionally.
IUCN: EN [B2ab (ii–v), c (iv)]

Cupressus guadalupensis S. Watson var. ***forbesii*** (Jeps.) Little, Phytologia 20: 435. 1970. *Cupressus forbesii* Jeps., Madroño 1: 75. 1922; *Cupressus guadalupensis* S. Watson subsp. *forbesii* (Jeps.) Beauch., Aliso 9: 191. 1978; *Callitropsis forbesii* (Jeps.) D. P. Little, Syst. Bot. 31 (3): 473. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis forbesii* (Jeps.) Bartel, Phytologia 91 (1): 181. 2009. Type: USA: California, San Diego Co., Otay Mt., ["Cedar Canyon, between El Nido and Dulzura"], *C. N. Forbes s.n.* (lectotype JEPS). Fig. 96

Description

Pollen cones 4–5 mm long, usually terete or sometimes slightly angular; microsporophylls 12–14 per cone. Seed cones globose, 15–30 mm diam.

Distribution

Mexico: Baja California Norte (from US border to Arroyo Hediondo); USA: SW California, one locality in Orange Co. and a few in San Diego Co. down to the Mexican border.
TDWG codes: 76 CAL 79 MXN-BC

Conservation

Tecate Cypress has a restricted distribution in San Diego County and one disjunct population in Orange County. The largest population is on Otay Mountain close to the Mexican border; several populations are known from the Mexican side as well, mostly occurring in isolated canyons. Urbanisation in the region has brought an increased risk of wildfires and the prevention as well as the attempts to put these down or restrict them will be concentrated around urban properties, not in the first place populations of rare trees. Like its congeners in California, this cypress will regenerate after fire but there is a definite risk to survival if frequency or intensity of fires are increasing due to human impact factors.
IUCN: EN [B2ab (ii–v), c (iv)]

Cupressus lusitanica Mill., Gard. Dict., ed. 8: Cupressus No. 3. 1768.

Etymology

The species epithet derives from the Latin name for Portugal, *Lusitania*, where it was first noticed by botanists.

Vernacular names

Mexican Cypress, Cedar of Goa; Cedro blanco, Cedro blanco del deserto, Cedro, Ciprés (Spanish)

Description

Trees to 30–35 m tall, monopodial, large trees buttressed; trunk up to 2 m d.b.h. Bark eventually becoming fissured and fibrous, brown weathering to dark grey-brown, exfoliating in long strips. Branches long, spreading or ascending, often ending drooping-pendulous, forming a pyramidal or in old trees sympodial, rounded or flat-topped crown. Foliage branches numerous, spreading or drooping, slender, ultimate branchlets irregularly disposed or more or less distichous, ± quadrangular in cross section or slightly flattened, 1–2 mm diam., persistent. Leaves covering branchlets, decussate, imbricate, decurrent, monomorphic to slightly dimorphic, scale-like; facials equal or somewhat unequal in size to laterals, on ultimate branchlets 1–2.5 mm long and rhombic, on whip shoots up to 10 mm long; margins minutely erose-hyaline; apex incurved and appressed acute (or obtuse); laterals similar or conduplicate, with appressed or free apex; glands inconspicuous or absent esp. on laterals; stomata few, scattered primarily on margins near leaf bases; leaf colour green or glaucous green. Pollen cones solitary and terminal on ultimate branchlets, slightly oblong, more or less quadrangular, 3–5 ± 2–2.5 mm; microsporophylls 10–16(–18), decussate, peltate, bearing 3–4 abaxial pollen sacs near lower margin. Seed cones solitary or in groups near the upper ends of lateral branches, terminal, maturing in 2 growing seasons, persistent, (sub)globose-angular when closed, 10–18(–20) mm diam., maturing to brown with parting scales. Bract-scale complexes 6–8(–10) in decussate pairs, of more or less equal size, peltate, polygonal (4–6-angular) in outline, bossed, with protruding recurved bract tip

3–5 mm long, abruptly narrowing towards the cone axis, rugose abaxially; adaxial surfaces striated, with whitish seed marks near base. Seeds 8–12 on each scale, closely packed, slightly flattened, 3–4.5 × 3–4 mm, brown or yellowish brown with whitish hilum at base; wings 2 on opposite sides, sometimes absent, depending on room for growth 1–1.5 mm wide.

Taxonomic notes

See the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a) for a discussion of the identity and provenance of the 'Bussaco cypresses' in Portugal (*Cupressus lusitanica* Mill.) and a comprehensive citation of the pertinent literature.

Distribution

Mexico: from the Sierra Madre Occidental and S.M. Oriental down to Chiapas; highlands of Guatemala, Belize, Honduras, El Salvador and Nicaragua.
TDWG codes: 79 MXC-DF MXC-ME MXC-PU MXE-AG MXE-CO MXE-CU MXE-DU MXE-HI MXE-QU MXE-SL MXG-VC MXN-SI MXS MXT-CI 80 BLZ ELS GUA HON NIC

Ecology

Forming pure, dense stands or scattered in mixed montane conifer forest or pine forest, also in pine-oak forest and woodland, associated with *Abies* spp., *Pinus ayacahuite, P. hartwegii, P. maximinoi, P. montezumae, P. patula, P. pseudostrobus, Pseudotsuga menziesii* var. *glauca, Juniperus* spp., *Quercus* spp., *Alnus* spp., *Clethra* sp., *Persea* sp. and ericaceous and theaceous undershrubs; in disturbed (grazed) woodland with *Arbutus* sp., *Baccharis* sp., *Buddleia* sp., and *Leucena* sp. This species occurs on various usually nutrient-poor rocky soils over limestone or various igneous rocks; it is also spreading in scrub on rocky slopes or cliffs in canyons. The altitudinal range of this species is from ca. 1000 m to nearly 4000 m a.s.l.

Uses

Mexican cypress is a valuable timber tree where it grows tall and straight, but not used extensively in its native range. It is planted as a 'village tree' throughout Mexico and Guatemala; it has also been introduced in many countries, especially in Andean South America and E Africa and to a limited extent in SE Asia, as a plantation forest tree. Still known in some quarters as the 'Cedar of Goa' its true provenance was long a mystery. The Portuguese had a colony of that name on the west coast of India and the species was first described from Portugal but later understood not to be native there: 1 + 1 = 2 seems to have been the reasoning. In horticulture several cultivars are known, while var. *benthamii*, with more flattened foliage sprays, is also being planted in countries with mild winters. The latter produces a narrowly conical habit in cultivation.

2 varieties are recognized:

Cupressus lusitanica Mill. var. ***lusitanica***.
Callitropsis lusitanica (Mill.) D. P. Little, Syst. Bot. 31 (3): 474. 2006, (*nom. ut. rej*., Art. 56); *Hesperocyparis lusitanica* (Mill.) Bartel, Phytologia 91 (1): 181. 2009. Type: Portugal: Bussaco, [type locality (introduced)], *leg. ign. [ex herb. Ph. Miller] s.n.* (holotype BM).

Cupressus lindleyi Klotzsch *ex* Endl., Syn. Conif.: 59. 1847.
Cupressus lusitanica Mill. var. *hondurensis* Silba, Phytologia 68: 30. 1990.

Description

Trees, when mature, developing broad crowns. Foliage branches not in more or less planate sprays but irregularly arranged; ultimate branchlets irregularly decreasing in length, more or less quadrangular in cross section. Leaves monomorphic, apices of facials appressed, of laterals often free; glands present on all scale leaves.

Distribution

Mexico: from the Sierra Madre Occidental and S.M. Oriental down to Chiapas; highlands of Guatemala, Belize, Honduras, El Salvador and Nicaragua.
TDWG codes: 79 MXC-DF MXC-ME MXC-PU MXE-AG MXE-CO MXE-CU MXE-DU MXE-HI MXE-QU MXE-SL MXG-VC MXN-SI MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 BLZ ELS GUA HON NIC

Conservation

IUCN: LC

Cupressus lusitanica Mill. var. ***benthamii*** (Endl.) Carrière, Traité Gén. Conif., ed. 2, 1: 155. 1867. *Cupressus benthamii* Endl., Syn. Conif.: 59. 1847; *Callitropsis benthamii* (Endl.) D. P. Little, Syst. Bot. 31 (3): 473. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis benthamii* (Endl.) Bartel, Phytologia 91 (1): 181. 2009. Type: Mexico: Hidalgo, El Banco, ["from the Banco"], *C. T. Hartweg 434* (holotype BM). Fig. 97

Description

Trees usually with conical crowns. Foliage branches forming more or less planate sprays; ultimate branchlets more or less distichous, gradually decreasing in length, slightly flattened. Leaves slightly dimorphic; apices of facials and laterals appressed; laterals mostly eglandular.

Distribution

Mexico: Chiapas, Guerrero, Hidalgo, México, Puebla, Veracruz; probably scattered in forests with var. *lusitanica* elsewhere.
TDWG codes: 79 MXC-ME MXC-PU MXE-HI MXG-VC MXS-GR MXT-CI

Conservation

IUCN: NT

Cupressus macnabiana A. Murray bis, Edinburgh New Philos. J., n.s., 1: 293. 1855, ["*M'Nabiana*"]. *Callitropsis macnabiana* (Hartw.) D. P. Little, Syst. Bot. 31 (3): 474. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis macnabiana* (A. Murray bis) Bartel, Phytologia 91 (1): 182. 2009. Type: USA: California, ["Habitat in California, circa lat. 41 Bor."], *W. Murray & A. F. W. Beardsley s.n.* (holotype E). Pl. 12

Etymology

This species was named after William McNab (1780–1848) a Scottish botanist.

Vernacular names

MacNab Cypress, Shasta Cypress, Fragrant Cypress

Description

Large shrubs to small trees to 10–15 m tall; trunk short, branching very low or from ca. 1 m above ground, to 80–100 cm diam. Bark on trunk to 3 cm thick, fissured, hard, very slowly exfoliating, eventually more or less fibrous, grey. Branches numerous, long, slender, spreading, assurgent to erect, foliage with long, assurgent whip shoots, forming a spreading, round crown with branches near the ground. Foliage branches spreading or assurgent, the highest order branchlets more or less in one plane but not plagiotropic, mostly ascending, rigid, ultimate branchlets fine, spreading, 3–7(–10) × ca. 1 mm, torulose, on thicker, older branchlets rough with numerous spreading leaf tips, covered with leaves, persistent. Leaves decussate, slightly imbricate, appressed on smallest branchlets, rhombic to oblanceolate, rounded or keeled abaxially, 1–1.5(–2) × 1 mm, with a near central depression or subapical pit; margins remotely denticulate; apex obtuse; on thicker branches and whip shoots to 12 × 3 mm, linear-lanceolate, with a reflexed, apiculate or acute distal part to 3 mm long; stomata near base abaxially, scattered from base to apex adaxially; gland mostly present and conspicuous, active; leaf colour grey-green to green, new foliage sometimes yellow-green. Pollen cones numerous, terminal, solitary, angular-ovoid, 3–4 × 2–2.5 mm; microsporophylls (8–)10–12, decussate, more or less flat or slightly convex, on the abaxial lower side bearing (3–)4–6(–7) yellow pollen sacs. Seed cones terminal, often clustered and appearing sessile, in two growing seasons maturing to dark brown, eventually grey, subglobose, serotinous and persistent cones 15–25 × 13–20 mm. Bract-scale complexes (4–)6(–8), decussate, connate, parting very slowly, peltate, irregularly 4–5(–6) sided, abaxially with a subapical, broadly based, upcurved boss 3–6 mm long, terminating in an acute bract tip 1 × 2 mm; outer surface rugose; inner part abruptly constricted, angular, dark brown, with lighter coloured seed scars. Seeds 70–100 per cone, 3–4(–5) × 2–3 mm, irregularly shaped, slightly flattened, sometimes more or less verrucose, brown,

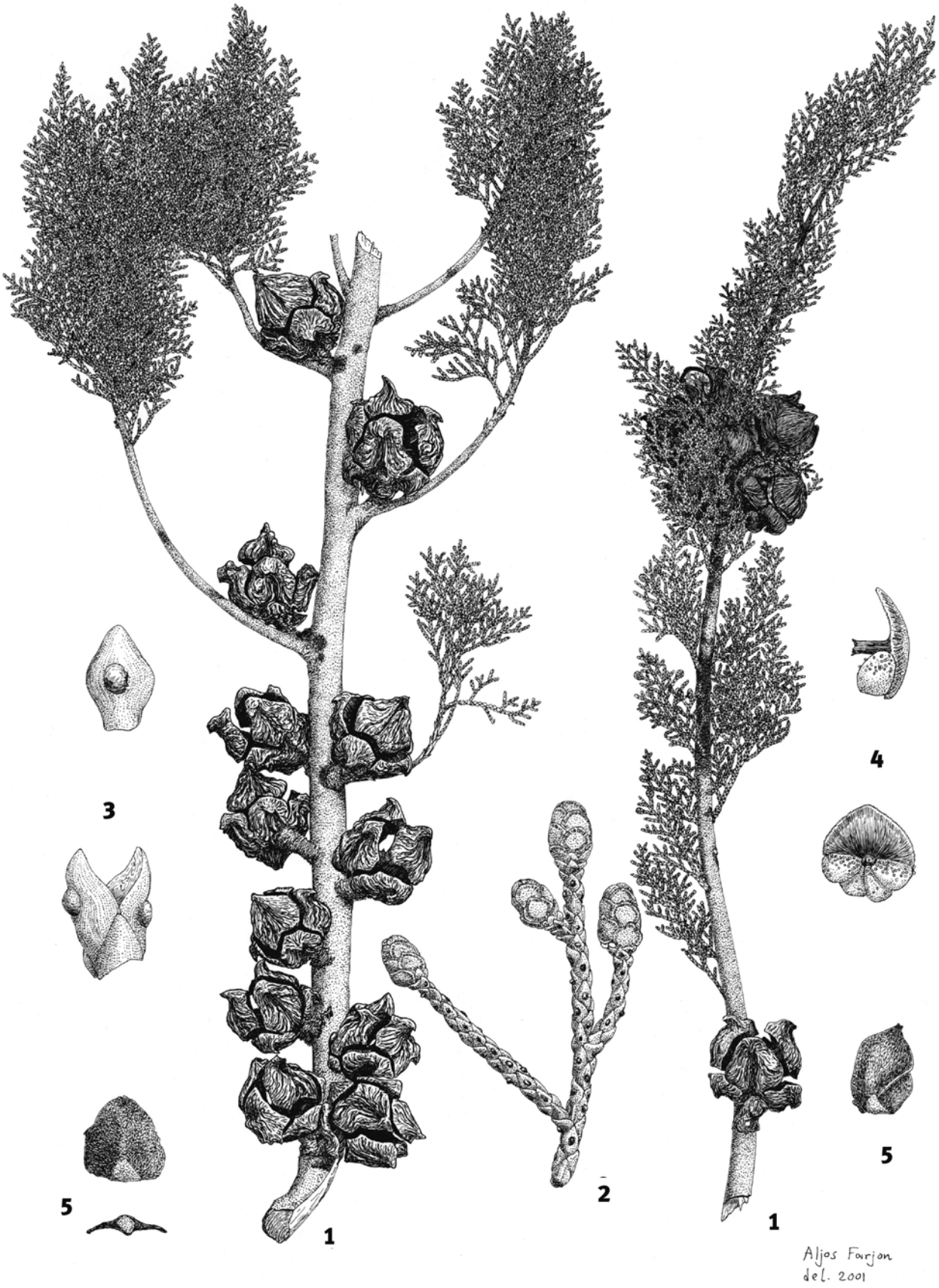


PLATE 12. *Cupressus macnabiana*. **1.** Branch with foliage and seed cones. **2.** Branchlet with leaves and pollen cones. **3.** Leaves with gland. **4.** Microsporophylls with pollen sacs and pollen. **5.** Seeds.

with a lighter 1–1.5 mm long hilum; wings 2, forming very narrow strips around the seed.

Distribution

USA: California, Coast Ranges, mountains of N California, Sierra Nevada.
TDWG codes: 76 CAL

Ecology

Cupressus macnabiana occurs in the Upper Sonoran Life Zone in chaparral or woodland, associated with *Pinus attenuata, P. sabiniana*, less commonly *P. ponderosa, Quercus* spp., and *Arctostaphylos* sp., often forming groves on rocky slopes and in ravines in clay, loam or sand over serpentine. The altitudinal range is from 300 m to 1200 m a.s.l. The climate is of the Mediterranean type with dry, hot summers and winter rain.

Conservation

IUCN: LC

Uses

This relatively small tree may have been locally used for fence posts by ranchers; today its wood is not considered to be of any commercial value. It is rare in horticultural cultivation but would be suitable as an amenity tree in dry climate. Cultivars are scarcely known; Vidaković (1991) listed 'Sulphurea' with yellow-tipped foliage branches.

Cupressus macrocarpa Hartw. *ex* Gordon, J. Hort. Soc. London 4: 296. 1849. *Callitropsis macrocarpa* (Hartw.) D. P. Little, Syst. Bot. 31 (3): 474. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis macrocarpa* (Hartw. *ex* Gordon) Bartel, Phytologia 91 (1): 182. 2009. Type: USA: California, Monterey Co., ["near Carmel Bay, Monterey"], *C. T. Hartweg 143* (holotype K). Fig. 98

Etymology

The species epithet (Latin *macro* = large; *carpos* = fruit) refers to the relatively large seed cones.

Vernacular names

Monterey Cypress, Ciprés Monterrey, Ciprés de California (Spanish)

Description

Trees to 20–25 m tall; trunk straight, monopodial in sheltered places, branching very low from less than 1 m above ground in exposed places, to 150–170 cm diam. Bark on trunk to 4–5 cm thick, fissured, hard, with anastomosing ridges, very slowly exfoliating, grey or ash-grey. Branches long, spreading or ascending, forming a conical or pyramidal crown, in old, exposed trees very dense, forming horizontal canopies and a broad, flat-topped crown. Foliage branches in tapering or flattened foliage sprays, the highest order branchlets irregularly disposed at various angles and mostly ascending, rigid, ultimate branchlets 3–10(–15) × 1.2–1.8(–2) mm, quadrangular in cross-section, covered with leaves, persistent. Leaves decussate, imbricate, appressed on smallest branchlets, on ultimate and penultimate branchlets (broadly) rhombic, 1–2 × 1 mm, rounded or keeled abaxially, with a near central or two lateral depressions; margins hyaline-denticulate; apex obtuse; leaves on whip shoots to 20 × 4 mm, long decurrent, linear-lanceolate, with a reflexed, apiculate to pungent distal part to 5 mm long; stomata scattered or in two short bands to below apex abaxially, scattered from base to apex adaxially; glands absent or inconspicuous and inactive; leaf colour green to dark green. Pollen cones terminal, solitary, angular-ovoid to oblong, 3–6 × 2.5–3 mm; microsporophylls 12–14, decussate, more or less flat or slightly convex, on the abaxial lower side bearing 6–8(–10) crowded, oblong, yellow pollen sacs. Seed cones terminal, often clustered and appearing sessile, in two growing seasons maturing to dark brown, eventually grey-brown, subglobose to broadly ovoid, serotinous and persistent cones 20–35(–40) × 18–30 mm. Bract-scale complexes 8–12(–14), decussate, connate, parting very slowly, peltate, of unequal size (but pairs usually similar) irregularly 4–5(–6) sided or with more or less rounded upper margin, abaxially with a relatively small, broadly based, upcurved boss 2–4 mm long, terminating in an acute bract tip 1 × 2 mm, eroding away in old cones; outer surface

rugose; inner part abruptly constricted, angular, dark brown to blackish, with conspicuous, white seed scars. Seeds 100–150 per cone, 3–5(–6) × 2–4 mm, slightly flattened, angular, brown to blackish brown, with a whitish hilum; wings 2, forming narrow, irregular strips ca. 1 mm wide.

Distribution

USA: California (near Monterey).
TDWG codes: 76 CAL

Ecology

Restricted to a narrow coastal strip on rocky cliffs, slopes and headlands, forming pure stands or associated with *Pinus radiata*, in loam or sand over granitic rocks or in rock crevices. The climate is of the Mediterranean type, with dry summers cooled by frequent fog, within reach of ocean salt sprays, and winter rain.

Conservation

The limited distribution of this species in its natural habitat consists of two main 'groves' and a few scattered metapopulations. These are mostly situated in reserves (Del Monte Forest, Point Lobos), but also on private lands in the vicinity of ongoing urban and leisure development. As recreation and tourism are intensive in the area, there is a great risk from fires.
IUCN: VU (D2)

Uses

This species of cypress has been widely introduced in California and around the world, in some African countries as a timber tree, but mostly as an ornamental tree and to act as wind shelter belts both in argiculture and horticulture. The wood from closed-grown trees in plantations can be used for carpentry and furniture. The tree is extremely resistant to wind and tolerant of salty ocean wind and is not easily affected by drought or pests. Its use as a hedge plant has largely been superseded by the vigorous garden hybrid Leyland cypress, of which Monterey cypress is one of the parents. Several cultivar forms, notably with yellow-green foliage, have been developed. It is of interest to note that this is one of the two conifers in nature (virtually) confined to Monterey County in California, that are among the most widely planted conifers in the world; the other species is *Pinus radiata*.

Cupressus sargentii Jeps., Fl. Calif. 1 (1): 61. 1909. *Callitropsis sargentii* (Jeps.) D. P. Little, Syst. Bot. 31 (3): 474. 2006, (*nom. ut. rej.*, Art. 56); *Hesperocyparis sargentii* (Jeps.) Bartel, Phytologia 91 (1): 183. 2009. Type: USA: California, Mendocino Co., Mayacamas Range, Red Mountain, *W. L. Jepson 3027* (holotype JEPS).

Etymology

This species was named after Charles S. Sargent (1841–1927), Director of the Arnold Arboretum.

Vernacular names

Sargent Cypress

Description

Trees to 20–25(–30) m tall, usually not taller than ca. 10 m; monopodial; trunk straight, or short, contorted, branching low, up to 100–120 cm diam. Bark on trunks to 4 cm thick, deeply fissured, with anastomosing ridges, fibrous, exfoliating in elongated strips, grey-brown to grey. Branches spreading nearly horizontally, lower branches often down-curved, persisting along much of the trunk, foliage dense and bushy, forming a pyramidal or more rounded or irregular crown. Foliage branches spreading or ascending, ultimate branchlets irregularly disposed, rigid, 3–10(–15) × 1.2–1.6 mm, quadrangular or torulose, covered with scale leaves. Leaves decussate, imbricate, appressed, on ultimate branchlets broadly rhombic to more or less triangular, 1–2 × 1–1.2 mm, gibbous or keeled below the obtuse or acute apex, on whip shoots to 10 × 3 mm, with free, acute-apiculate or pungent apex; margins hyaline-denticulate; stomata on abaxial side restricted to base, on adaxial side scattered or in two lateral bands from base to apex; glands absent or inconspicuous, inactive; leaf colour dull green, rarely grey-green. Pollen cones numerous, terminal, solitary, ovoid-oblong,

3–5 × 2 mm, more or less quadrangular or terete; microsporophylls (8–)10–14(–16), decussate, peltate, flattened or convex, bearing 3–4 abaxial, angular-globose, yellow pollen sacs. Seed cones often grouped but not densely clustered, terminal, growing in two seasons to mature, globose to subglobose, brown or grey-brown cones 15–30 mm diam., which are persistent and variably serotinous. Bract-scale complexes 6–8(–10), decussate, slowly parting, but the lowest pairs often remaining connate; the ultimate pair in cones with 10 scales usually very reduced; other scales peltate, 4–5 sided, angular, abaxially convex with a more or less prominent boss or without a boss except for a minute curved bract tip; abaxial surface nearly smooth to strongly rugose, when still growing with a large, upcurved boss, usually disappearing in mature cones but sometimes retained; adaxially abruptly constricted, grooved, brown, usually glaucous, with lighter coloured seed scars. Seeds 80–120 per cone, 3–5 mm long and wide, irregular, angular, slightly flattened, brown, lustrous, often glaucous, with a lighter hilum; wings 2, forming a thin strip 0.5(–1) mm wide around the seed.

Distribution

USA: California, Coast Ranges, divided into a northern and a southern group of populations. The northern group is more widespread and is mostly found north of the San Francisco Bay area to ca, 40° N; the southern group occurs mostly in the Santa Lucia Range. The distance between the two main groups is more than 250 km.
TDWG codes: 76 CAL

Ecology

In the Upper Sonoran Life Zone, occasionally up to the Transition Life Zone, in chaparral or pine-oak woodland associated with *Pinus attenuata, P. sabiniana, P. lambertiana, Pseudotsuga menziesii, Quercus* spp., *Arbutus menziesii, Arctostaphylos* spp., *Ceanothus* spp., *Adenostoma* sp., and *Yucca whipplei*; on dry hillsides, in ravines and canyons in clay, loam or sandy soil over serpentine. The altitudinal range is from 50 m to 915 m a.s.l. The climate is of the Mediterranean type with hot, dry summers and winter rain.

Conservation

Although extending over a long distance and still abundant, the AOO is calculated, with a grid of 4×4 km (four times the IUCN recommended size) to fall within the threshold for Vulnerable, while a continuing decline is inferred from the fact that fires will be either suppressed or too intense to benefit this species.
IUCN: VU [B2ab (ii–v)]

Uses

No uses have been recorded of this species; in the past farmers and ranchers may have utilised the wood for fenceposts.

Cupressus sempervirens L., Sp. Pl. 2: 1002. 1753. Type: Greece: Crete, ["Habitat in Creta"], *Herb. Clifford 449* (lectotype BM).

Cupressus horizontalis Mill., Gard. Dict., ed. 8: Cupressus No. 2. 1768; *Cupressus sempervirens* L. var. *horizontalis* (Mill.) Loudon, Hort. Brit. 1: 388. 1830; *Cupressus sempervirens* L. subsp. *horizontalis* (Mill.) A. Camus, [Les Cyprès] Encycl. Econ. Sylvicult. 2: 33. 1914.

Etymology

The Latin species epithet means 'evergreen'; Linnaeus also classified *Taxodium distichum*, which is deciduous, as belonging to his genus *Cupressus*.

Vernacular names

Mediterranean Cypress (and numerous local names in different languages)

Description

Trees to 40 m tall (usually smaller); monopodial; trunk to 2 m d.b.h. Bark eventually becoming thick, deeply fissured, hard, grey-brown, exfoliating slowly in small strips. Branches long, spreading or ascending, sometimes fastigiate (the familiar 'Italian cypress' of the Mediterranean is a selected/cultivated fastigiate form), forming a conical or pyramidal or

in old trees more or less sympodial, irregular and broad, dense crown. Foliage branches spreading or drooping, slender, ultimate branchlets subterete to slightly flattened in cross section, 1–1.5(–2) mm diam., slightly torose, persistent. Leaves covering decussate, imbricate, decurrent, (nearly) monomorphic, scale-like, on ultimate branchlets 1–1.8 mm long and rhombic, slightly gibbous, with appressed or free obtuse or acute; margins minutely denticulate-hyaline; glands on all scale leaves; stomata few, scattered primarily on margins near leaf bases; leaf colour greyish green or green, sometimes covered in thick cuticular wax. Pollen cones solitary and terminal on ultimate branchlets, ovoid to ovoid-oblong, 3–6 × 2–3 mm; microsporophylls 8–16, decussate, bearing 3–6 abaxial pollen sacs near the lower margin. Seed cones solitary or grouped on lateral branches, terminal, maturing in 2 growing seasons, persistent, subglobose to ovoid-oblong when closed, (15–)20–35(–40) × (15)20–25(–30) mm, maturing to light brown or reddish brown with mostly parting scales. Bract-scale complexes (8–)10–14 in decussate pairs, of more or less equal size except for smaller proximal (connate) and distal pairs, peltate, polygonal (5–6-angular) in outline; abaxial surface flat, convex or bossed, with protruding small bract tip, (finely) rugose, abruptly narrowing towards cone axis; adaxial surfaces grooved, dark brown with whitish seed marks near the base. Seeds 8–20 on each scale, closely packed, flattened, 3–6 × 3–4 mm, brown or red-brown with whitish hilum at base; wings 2 on opposite sides, more or less equal in size and shape, as narrow strips surrounding the seed, 0.6–1 mm wide.

Taxonomic notes

Traditionally, the Mediterranean Cypress has been divided into two elements, one with a fastigiate and one with a horizontally growing habit. The name *Cupressus horizontalis* Mill. has been given to trees with a (horizontally) spreading branching habit: Miller clearly distinguished the two growth forms as species. Various authors, as recently as Grilli Caiola *et al.* (2000) have recognized the 'horizontal form' at an infraspecific rank under *C. sempervirens*. These authors accept *C. sempervirens* var. *pyramidalis* for the fastigiate form, but if it is meant that this includes the type of *C. sempervirens* that name is illegitimate. *Cupressus pyramidalis* Targ.-Tozz. in Ann. Mus. Imp. Fis. Firenze 2 (2): 73 (1810) pertains to the widely cultivated fastigiate growth form common throughout the Mediterranean. That form is considered to be a cultivated form ('cultigen') and not a taxon.

Distribution

E Mediterranean: Crete, Cyprus, East Aegean Is., Greece (?); N Africa: Libya, Tunisia; Western Asia: Iran, Israel, Jordan, Lebanon, Syria, and Turkey [W Mediterranean distribution based on cultigens].
TDWG codes: 13 KRI 20 LBY TUN 34 CYP EAI IRN LBS-LB LBS-SY PAL-IS PAL-JO TUR

Ecology

In maquis and in pine or juniper woodland associated with *Pinus brutia, Juniperus excelsa, J. foetidissima, J. drupacea, J. phoenicea, Quercus* spp., *Pistacia atlantica, Amygdalus scoparia*, and *Poterium spinosum*; in rocky soil mostly over limestone on slopes and in gorges, occasionally igneous rock. In its natural habitat is occures from 90 m to 1700 m a.s.l. The climate is Mediterranean with dry, hot summers and winter rain, or semi-arid in more interior (eastern) parts of its range.

Conservation

IUCN: LC

Uses

There is a long history of exploitation going back to the times of the ancient East Mediterranean and Levantian civilisations. First, its wood was valued for its resistance to decay, later it also became an ornamental. This latter use has led to widespread introduction throughout the Mediterranean at least from Roman times to the present. In many villages and towns the fastigiate, columnar, or conical form is a very characteristic feature of the coastal and urban landscapes. In several localities it regenerates spontaneously, but the fastigiate habit betrays its cultivated

origin. These old cultivars can be quite hardy and withstand snow and frost to -20° C or even lower. A few modern cultivars, some dating from the 19th century, are known but rare in cultivation.

Cupressus torulosa D. Don, in Lambert, Descr. Pinus 2: 18. 1824.

Etymology

The species epithet (from Latin *torosus* or *torulosus*) means 'cylindrical with bulges or contractions at intervals' (W. T. Stearn, Botanical Latin ed. 3, 1983), and is perhaps referring to the ultimate branchlets.

Vernacular names

Himalayan Cypress; Gulla, Gubraî (India, Nepal); xi zang bai mu (Chinese)

Description

Trees to 35–40 m tall; trunk monopodial, up to 1.5 m d.b.h. Bark smooth, orange-brown to red-brown, becoming fibrous, greyish brown, exfoliating in long strips. Branches spreading, assurgent or ascending, often ending drooping, forming a conical or pyramidal or in old trees irregular and broad, dense crown. Foliage branchlets alternating, irregularly disposed, spreading, lax or rigid depending on thickness, quadrangular to subterete in cross section, 0.8–1.5 mm diam., torose, persistent. Leaves covering branchlets monomorphic, scale-like, on ultimate branchlets 1–1.8 × 0.7–1.3 mm and rhombic-gibbous, on whip shoots up to 5 mm long, with incurved and appressed obtuse apex; margins entire or minutely erose-hyaline; glands inconspicuous or absent; stomata few, scattered primarily on margins near leaf bases; leaf colour green or glaucous green. Pollen cones solitary and terminal, oblong, 3–6(–8) × 1.5–2.5 mm; microsporophylls (8–)12–18(–20), decussate, bearing 3–4(–5) abaxial pollen sacs. Seed cones solitary or in groups near upper ends of lateral branches, terminal, maturing in 2 growing seasons, persistent, (sub)globose when closed, 12–20(–22) × 10–18 mm, maturing to (purplish) brown with parting scales. Bract-scale complexes (8–)10–12 in decussate pairs, peltate, polygonal (4–5-angular) in outline, nearly flat or more often bossed, with protruding small bract tip, rugose, abruptly narrowing towards cone axis, with whitish seed marks near base. Seeds (4–)6–8 on each scale, ovoid-triangular, slightly flattened, 3–5 × 2–3 mm, brown or yellowish; wings 2 on opposite sides, more or less equal in size and shape, to 1.2 mm wide.

Taxonomic notes

In recent years, reports of a cypress occurring in Lang Son Province in the far northeast of Viet Nam have been made from botanical surveys. Sometimes the name *Cupressus tonkinensis* Silba is applied to these. Trees found there appeared to be planted, or did occur in secondary vegetation giving rise to suspicion about the indigenity of this plant. In Flora du Cambodge, Laos et Vietnam 28: 79. (1996) this taxon is treated as *C. torulosa* D. Don "originaire de l'Himalaya occidental", but occuring on limestone hills between 250–1500 m a.s.l. in N Viet Nam (and in S China?), presumably naturalized from introduction in the past but not explicitly designated as such. Native people appear to have cut most trees due to a high demand for 'incense' from across the Chinese border, so that perhaps only a few shrubs clinging to steep rocks presently survive. As I had concluded earlier, they are morphologically identical with *C. torulosa* var. *torulosa* (Farjon, 2005a) and most likely represent an introduced and naturalized occurrence of that taxon far to the east of its natural range.

Distribution

Himalaya, from the Indus to the Brahmaputra; China: SE Xizang [Tibet], Yunnan.

TDWG codes: 36 CHC-YN CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP WHM-JK

Ecology

In the Himalaya, *Cupressus torulosa* is a codominant with *Juniperus* in the dry inner valleys and semi-arid high mountain environments towards the Tibetan side of the main range, where this open forest or woodland type occupies S-facing slopes. The altitudinal range is 1560–3670 m a.s.l. Annual precipita-

tion does not exceed 300 mm, most of which falls in summer and autumn. North of the Himalaya, in the Tibetan valleys that drain south through the Himalaya chain or north and east into the Zhangbo system, conditions are too dry, but eastwards along the Zhangbo River downstream from Gyangze *C. torulosa* is again found in isolated stands. Here we also find *C. torulosa* var. *gigantea* which is perhaps a xeromorphic form of *C. torulosa* (S. Miehe, pers. comm. May 2001, who claims to have seen both forms growing together).

Uses

As of all *Cupressaceae* in Asia, the wood of this species is valued for many uses, primarily to do with its durability (rot resistance). Traditionally it has been used for the construction of Buddhist temples and religious wood carving. Accessible stands are rare and in these straight trees have often been removed long ago. This species has been introduced in various countries in Asia, either as an amenity tree in temple grounds and monasteries or later as a plantation forestry tree. It is also used in horticulture, especially in southern Europe, where it is well established in larger gardens and parks. A limited number of cultivars is known of this species.

2 varieties are recognized:

Cupressus torulosa D. Don var. ***torulosa***. *Cupressus lusitanica* Mill. subsp. *torulosa* (D. Don) Silba, Acta Phytol. Yunnanica 28 (5): 470. 2006. Type: India: Himalaya, ["Sooreh"], *W. S. Webb W 6046A* (lectotype K-W). Fig. 99

Cupressus austrotibetica Silba, Phytologia 65: 334. 1988.
Cupressus karnaliensis Silba, J. Int. Conifer Preserv. Soc. 1 (1): 19. 1994.
Cupressus karnaliensis Silba var. *mustangensis* Silba, J. Int. Conifer Preserv. Soc. 1 (1): 22. 1994.
Cupressus tonkinensis Silba, J. Int. Conifer Preserv. Soc. 1 (1): 23. 1994.
Cupressus tongmaiensis Silba, J. Int. Conifer Preserv. Soc. 1 (1): 24. 1994.
Cupressus tongmaiensis Silba var. *ludlowii* Silba, J. Int. Conifer Preserv. Soc. 1 (1): 24. 1994.
Cupressus pakistanensis Silba, J. Int. Conifer Preserv. Soc. 15 (1): 4. 2008.

Description

Trees to 35 m tall, up to 1.5 m d.b.h. Ultimate branchlets lax or rigid depending on thickness, 0.8–1.5 mm diam., torose, persistent. Leaves on ultimate branchlets 1–1.8 × 0.7–1.3 mm, rhombic-gibbous, glandular or eglandular; glands inconspicuous, in central depression, elliptic.

Taxonomic notes

For comments on several of Silba's species names, here cited in synonymy, see Farjon (2005a).

Distribution

Himalaya: from the Indus (or N Pakistan?) to the Brahmaputra; China: SE Xizang [Tibet].
TDWG codes: 36 CHC-YN CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP WHM-JK

Conservation

IUCN: LC

Cupressus torulosa D. Don var. ***gigantea*** (W. C. Cheng & L. K. Fu) Farjon, Monogr. *Cupressaceae & Sciadopitys*: 224. 2005. *Cupressus gigantea* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 85. 1975. Type: China: Xizang [Tibet], ["22 km from Jiamei-xi, Lang-bei Dong"], *Qinghai-Xizang Exped. 3318* (holotype PE).

Description

Trees to 30–40 m tall, up to 3.5 m d.b.h.. Ultimate branchlets short, usually thick, quadrangular to subterete in cross section, (1–)1.5–2 mm diam., torose, persistent. Leaves on ultimate branchlets 1–1.8 × 0.7–1.3 mm, rhombic-gibbous, glandular or eglandular; glands inconspicuous, in central depression, elliptic.

Distribution

China: S Xizang [Tibet] (Zangbo River Valley, from ca. 93° to ca. 96° E); extreme NW Yunnan (vicinity of Dêqên on the Langcang [Mekong] River).
TDWG codes: 36 CHC-YN CHT

Conservation

Due to the scarcity of timber in the region where scattered groves of var. *gigantea* occur, there is continuous pressure for exploitation. Regeneration is often poor due to grazing of livestock. Several groves are protected as 'sacred forest' by Buddhist monks and some of the largest trees are on grounds used as a cemetery, where any cutting is prohibited.
IUCN: VU (A1d)

Uses

Timber and firewood are locally taken. Large trees are often venerated in local traditions and religion.

Dacrycarpus (J. J. Bennett) de Laub., J. Arnold Arbor. 50: 315. 1969. *Podocarpus* sect. *Dacrydioideae* J. J. Bennett in J. J. Bennett & R. Brown, Pl. Jav. Rar. 41. 1838. Type: *Dacrycarpus dacrydioides* (A. Rich.) de Laub. [*Podocarpus dacrydioides* A. Rich.] (*Podocarpaceae*).

Bracteocarpus A. V. Bobrov & Melikyan, Byull. Moskovsk. Obshch. Isp. Prir., Otd. Biol. 103 (1): 58. 1998. Type: *Bracteocarpus imbricatus* (Blume) A. V. Bobrov & Melikyan [*Podocarpus imbricatus* Blume].

Greek: *dakryon* = a tear; *karpos* = fruit.

Description

Dioecious or rarely monoecious evergreen shrubs or trees. Resin canals in leaves and seed cones. Bark hard, occasionally with lenticels, becoming scaly. Leaves trimorphic, with small scale leaves, acicular leaves and flattened, linear-falcate leaves, spirally inserted, decurrent at base, appressed to widely spreading; in some species distichous, flattened linear-falcate leaves on juvenile plants and on determinate vegetative lateral shoots of mature plants, but these absent in other species. Small scale leaves on fertile shoots and on determinate vegetative lateral shoots in some species; acicular leaves in the same positions in other species, both leaf types not distichous, variously appressed to spreading. Stomata on both sides of the leaves (leaves amphistomatic). Pollen cones single or in pairs on axillary short shoots, at first nearly globular but elongating to short cylindrical, to ca. 10 × 3 mm; microsporophylls spirally attached to a slender rachis, with triangular heads and two basal pollen sacs containing bisaccate pollen. Seed cones single on axillary short shoots with scale leaves and often surrounded by an 'involucrum' of acicular leaves at ends of foliar branchlets, consisting of several spirally arranged bracts; only a single subterminal one becoming fertillized and forming an inverted seed; the remainder becoming fused and partly swollen, forming a verrucose receptacle ripening to red or purple and becoming succulent. Seeds completely surrounded by the soft epimatium being partly fused with the fertile bract, forming a grooved or shallow crest on one side of apex.

9 species.

Distribution

Continental SE Asia: Myanmar [Burma]; S & SW China; Indochina. Malesia: from Peninsular Malaysia to New Ireland (PNG). SW Pacific: New Caledonia; Vanuatu; Fiji; New Zealand.

Key to the species of *Dacrycarpus*

Transitional forms between the two kinds of leaves described in the key may exist in a single tree; it is therefore necessary to consider the 'extremes' of both forms where available in young trees and mature trees alike. The two kinds are: scale-like, subulate or acicular (not wider than thick), and linear to S-curved, foliar (bilaterally flattened).

1a. All foliage branchlets with leaves of a similar kind, shape acicular or subulate, sometimes slightly S-curved, 1.6–6(–10) mm long, 0.4–1 mm wide **2**

1b. Leaves of different kind on different foliage branchlets at least in young trees: scale-like, subulate to acicular *and* linear to S-curved, bilaterally flattened and longer in young trees and with some species also both kinds in mature trees **4**

2a. Involucral leaves at base of seed cone 6–11 mm long, incurved, enclosing the receptacle and part of the seed(s) ***D. cinctus***

2b. Involucral leaves at base of seed cone 4–7 mm long, more or less straight, enclosing the receptacle only **3**

3a. Leaves 1.6–3 mm long, acicular. Receptacles 4–5 mm long, colouring dark purple; seeds 6–8 mm long ***D. compactus***

3b. Leaves 2–6 mm long, acicular to slightly S-curved. Receptacles 3–4 mm long, not changing colour or perhaps becoming yellowish; seeds 5–6(–7) mm long ***D. expansus***

4a. Pollen cones 20–30 mm long; microsporophylls subulate. Involucral leaves at base of seed cone 6–13 mm long, incurved, enclosing the receptacle and part of the seed(s) ***D. cumingii***

4b. Pollen cones 7–12 mm long; microsporophylls apiculate. Involucral leaves at base of seed cone 1–8 mm long, spreading or incurved, at most only enclosing the receptacle **5**

5a. Pollen cones 7–10 mm long, 1 mm wide. Involucral leaves at base of seed cone 1–2 mm long, leaving the 2–3 mm long receptacle free ***D. vieillardii***

5b. Pollen cones 8–12 mm long, 2–3 mm wide. Involucral leaves at base of seed cone 2–8 mm long, at least in part enclosing the 3–7 mm long receptacle **6**

6a. Involucral leaves at base of seed cone 5–8 mm long, entirely enclosing the blue to purple receptacle ***D. kinabaluensis***

6b. Involucral leaves at base of seed cone 2–5 mm long, partly to nearly entirely enclosing the orange to red receptacle **7**

7a. Involucral leaves at base of seed cone 2–3 mm long, spreading, leaving most of the receptacle free; seeds 3.5–4 mm long, smooth with a notched apex. Largest (foliar) leaves 3–7 mm long ***D. dacrydioides***

7b. Involucral leaves at base of seed cone 3–5 mm long, incurved, enclosing part or nearly all of the receptacle; seeds 4–7 mm long, grooved towards a curved apex. Largest (foliar) leaves (3–)5–12(–17) mm long **8**

8a. Foliar, more or less S-curved, distichously arranged leaves present in saplings and young trees, 5–10 mm long, 0.8–1.1 mm wide. Receptacles 3–4 mm long ***D. steupii***

8b. Foliar, more or less S-curved, distichously arranged leaves present both in young trees and in mature trees, (3–)7–12(–17) mm long, 1–2 mm wide. Receptacles 4–7 mm long ***D. imbricatus***

Dacrycarpus cinctus (Pilg.) de Laub., J. Arnold Arbor. 50: 332. 1969. *Podocarpus cinctus* Pilg., Bot. Jahrb. Syst. 69: 253. 1938; *Bracteocarpus cinctus* (Pilg.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 58. 1998.
Type: Papua New Guinea: Morobe, Búsú River, Mt. Sarawaket, *M. S. Clemens 5261* (holotype B, destroyed; isotypes A, LAE, NY). Fig. 100

Podocarpus dacrydiifolius Wasscher, Blumea 4 (3): 410. 1941; *Bracteocarpus dacrydiifolius* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998.

Etymology

The species epithet (Latin *cinctus* = enclosed or encircled) refers to the seed cones enclosed by involucral leaves.

Vernacular names

sareh (Sulawesi); djariha (and many other names, New Guinea)

Description

Dioecious shrubs or trees to 30 m tall; trunk up to 1 m d.b.h., erect; branches contorted, spreading, crown eventually more or less flattened. Bark exfoliating in small plates or strips, brown weathering grey or blackish. All foliage branches spreading to erect and with leaves of similar kind, acicular and more or less bifacially flattened. Leaves on all shoots spirally arranged, not or rarely somewhat distichous on terminal vegetative shoots in young plants, all spreading slightly and equally around the shoot, acicular (thin and hair-like on seedlings), curved inward, keeled abaxially, 2–6(–10) × 0.4–0.8 mm, with curved, apiculate apex. Leaves of branchlets in crowns of mature trees shorter (2–4 mm) than on younger trees, spreading at ca. 45°, decurrent, curved inward, apiculate, often glaucous. Stomata on all sides (leaves amphistomatic) but on abaxial side restricted to basal part of leaf, in 2 or more rows on adaxial face up to near apex. Pollen cones terminal on short or long shoots, subtended by acicular leaves, nearly globose when immature, at maturity elongating to 8–10 mm long and 2–3 mm wide. Microsporophylls with apiculate apex, ca. 1.5 × 0.6 mm, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with spreading, 2–3 mm long, curved acicular leaves; involucral leaves conspicuously longer, 6–11 mm, enclosing receptacle and part of seed. Ripe receptacle 3–4 mm long, warty, red or purplish tinged. Ripe seeds 1(–2) on a receptacle, subglobose, 4–6 mm long, including the smooth, light or dark red-brown, sometimes glaucous epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Distribution

Malesia: Borneo (Sarawak), Sulawesi, Maluku [Moluccas] (Ceram); Papuasia: New Guinea.

TDWG codes: 42 BOR-SR MOL SUL 43 NWG-IJ NWG-PN

Ecology

Dacrycarpus cinctus occurs from montane rainforest at around 1800 m to alpine low mossy forest or shrubland and tree fern grassland in New Guinea as high as 3600 m a.s.l. In Sulawesi it is reported from lower montane forest at 900 m. In high montane forest it attains tall tree size and is dominant (emergent) or codominant with *Nothofagus, Elaeocarpus*, and the conifers *Papuacedrus papuana* and *Podocarpus* spp. (in New Guinea). Above 3000 m *Cunoniaceae* and *Myrtaceae* become abundant and the forest patches are often interspersed with swampy and peaty tussock grasslands dominated by solitary clumps of *Dacrycarpus* and scattered tree ferns (*Cyathea*) until the last shrubby specimens reach the tree line as solitary shrubs or krummholz trees.

Conservation

IUCN: LC

Uses

Large trees of this species will be valuable timber and have undoubtedly been logged for this purpose. Its wood is probably not distinguished from other members of the family and traded as 'podocarp' wood. Its properties and uses would be similar to those of *D. imbricatus*. In Sarawak and Sulawesi the wood has been traditionally used for the construction of longhouses.

Dacrycarpus compactus (Wassch.) de Laub., J. Arnold Arbor. 50: 336. 1969. *Podocarpus compactus* Wasscher, Blumea 4 (3): 411. 1941; *Bracteocarpus compactus* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 58. 1998. Type: Papua New Guinea: Owen Stanley Range, Mt. Albert Edward, *L. J. Brass 4284* (holotype L).

Etymology

The species epithet refers to the dense and compact foliage of older trees.

Vernacular names

kaipik, umbwa and many other names varying with the languages of native tribes

Description

Dioecious trees to 20 m tall; trunk up to 60 cm d.b.h., erect or contorted; branches irregular and contorted; crown eventually more or less flattened. Bark exfoliating in small plates or strips, dark brown weathering grey; inner bark reddish. All foliage branches spreading to erect; terminal vegetative shoots not distichous in young plants. Leaves on all shoots of similar kind, acicular and more or less bifacially flattened, spirally arranged, imbricate and spreading equally on all sides of the shoot, acicular (thin and hair-like on seedlings), curved inward, strongly keeled abaxially, 1.6–3 × 0.6–1 mm, with acute apex. Leaves of branchlets in crowns of mature trees virtually similar to those of young trees, slightly wider at base, imbricate, short decurrent, curved inward, acute to apiculate, often glaucous. Stomata on all sides (leaves amphistomatic) but on the abaxial side restricted to basal part of leaf, in 2 or more rows on the adaxial face up to near the apex. Pollen cones terminal on short or long shoots, subtended by acicular leaves, nearly globose when immature, at maturity elongating to 8–10 mm long and 2–3 mm wide. Microsporophylls with apiculate apex, 1.5–2 × 0.5 mm, yellow with reddish apex, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with imbricate, 1.6–3 mm long, curved acicular leaves; involucral leaves longer, 5–7 mm, enclosing the receptacle and reaching but not enclosing the seed. Ripe receptacle 4–5 mm long, warty, green turning dark purple. Ripe seeds 1(–2) on a receptacle, subglobose, 6–8 mm long, including the smooth, green to purplish brown epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Taxonomic notes

This species has formerly been known as *Podocarpus papuanus*, a name given to another species by Ridley in 1916 and now a synonym of *Dacrycarpus imbricatus* var. *robustus*. Wasscher named the present species *Podocarpus compacta* (which should have

been the masculine form *compactus*) and it was subsequently placed in the genus *Dacrycarpus* by David de Laubenfels in 1969, where subsequent accounts have all accepted it to belong. The genus name *Bracteocarpus* when proposed by Bobrov & Melikyan included the type of *Dacrycarpus* de Laub. and is therefore an illegitimate name.

Distribution

New Guinea (highlands).
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

Dacrycarpus compactus is a highland species occurring in subalpine shrubberies and on the fringes of alpine tussock grassland dominated by *Deschampsia klossii*. It is common in coniferous high montane forest with *Papuacedrus papuana, Podocarpus* spp., and a few angiosperms and then becomes more abundant and often a dominant emergent tree in mossy low forest and shrubbery fringing peaty wet tussock grasslands. Here the deepest peat is grassland and the conifers *Dacrycarpus* and *Papuacedrus* occupy stony rises and scree slopes where the peat is thinner or absent and drainage better. Isolated trees may occur scattered in the grassland as they are relatively resistant to grass fires once they reached some size. There is a cool, misty climate at these heights that has almost no seasonal changes. The altitudinal range of this species is (2800)3000–4300 m a.s.l.

Conservation

IUCN: LC

Uses

This tree of moderate size produces useful timber of fine quality but its inaccessibility and relative scarcity of straight trees of good size prevent commercial exploitation. The species is not in cultivation for forestry or horticulture.

Dacrycarpus cumingii (Parl.) de Laub., J. Arnold Arbor. 50: 329. 1969. *Podocarpus cumingii* Parl., in Candolle, Prodr. 16 (2): 521. 1868; *Bracteocarpus cumingii* (Parl.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 58. 1998. Type: Philippines: Luzon, Tayabas Prov., *H. Cuming 803* (syntype K).

Etymology

This species was named in honour of the plant collector H. Cuming, who collected the specimens on which the original description was based.

Vernacular names

sangu (Sumatera); igem (Phillipines: Davao, Mindanao) and other local names.

Description

Dioecious trees to 38 m tall; trunk up to 1 m d.b.h., erect, monopodial; crown eventually spreading, dome-shaped. Bark exfoliating in small plates or strips, brown weathering grey. Foliage branches with leaves of two kinds, more or less acicular and flattened. Primary shoots of seedlings slender, of mature trees slender or in exposed crowns short and stiff, terminating in a bud-like cluster of incurved acicular leaves. Leaves on all shoots spirally arranged, subulate or acicular (thin and hair-like on seedlings), curved inward at tip, spreading slightly, keeled abaxially, with curved, apiculate apex. Leaves on 2–6 cm long terminal and deciduous branchlets of seedlings to young trees flattened, distichous, decurrent, linear or slightly s-curved, with parallel smooth margins, 5–14 mm long (shortest at base and apex of branchlet), 0.8–1.3 mm wide, weakly keeled on both surfaces; apex curved forward, apiculate. Leaves of branchlets in crowns of mature trees similar to more acicular, 2–4(–6) × 0.4–0.7 mm, less distichously arranged to spreading on all sides, curved, apiculate. Stomata on both kinds of leaves and on all sides (leaves amphistomatic) in many intermittent rows on flat, larger leaves, in 2 or more rows on each face of acicular leaves. Pollen cones terminal on short shoots, subtended by small acicular leaves,

short when immature, at maturity elongating to 20–30 mm long and 2–3 mm wide. Microsporophylls subulate like leaves, ca. 1.5 × 0.5 mm, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with spreading, 7–13 mm long, curved acicular leaves enclosing receptacle and seed. Ripe receptacle 3–4 mm long, warty, reddish. Ripe seeds 1(–2) on a receptacle, subglobose, 3.5–4.5 mm long, including the smooth, light yellowish brown to blackish brown, sometimes glaucous epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Distribution

Malesia: Borneo (Sarawak), Philippines, N Sumatera (Gunung Leuser N.P.).
TDWG codes: 42 BOR-SR PHI SUM

Ecology

Dacrycarpus cumingii occurs in mossy forest. The climate is cool and wet and fog is shrouding the mountains much of the time. Lowest records are from 1600 m a.s.l. in montane forest, where more commonly *D. imbricatus* would occur and where both species may be associated with *Agathis* spp. and *Sundacarpus amarus*, the highest from 3300 m a.s.l. near the tree line.

Conservation

IUCN: LC

Uses

This species can grow to a tall forest tree and such specimens yield valuable timber, but it is usually smaller and grows at high altitude where timber extraction is more difficult. The uses of its wood in Borneo are assumed to be similar to that of *D. imbricatus* where it is available in low quantities, e.g. construction for local houses, furniture and tool making. In the Philippines where *D. cumingii* is (or was) more common it is an important source of face veneer.

Dacrycarpus dacrydioides (A. Rich.) de Laub., J. Arnold Arbor. 50: 337. 1969. *Podocarpus dacrydioides* A. Rich., in Lesson & Richard, Voy. Astrolabe Bot. [Ess. Fl. Nouv. Zél.] 1: 358. 1832. Type: New Zealand: North Island, *J. S. C. Dumont d'Urville s.n.*, 1827 (holotype? G-DC). Fig. 101, 102, 103

Etymology

The species epithet alludes to a similarity with *Dacrydium*.

Vernacular names

White pine; kahikatea (Maori)

Description

Large dioecious trees to 60 m tall; trunk 1.5–2 m d.b.h., erect, monopodial, old trees often butressed near the base. Bark smooth at first, becoming rough and scaly, exfoliating with large flakes, brown turning grey; inner bark reddish. Crown conical in young trees, becoming domed or spreading in old trees with heavy lower branches. Foliage branches with leaves of three kinds, short acicular, intermediate and longer flattened. Leaves on all branches of seedlings and saplings to 1–2 m tall bilaterally flattened, distichous, decurrent, slightly S-curved, with parallel smooth margins, 3–7 mm long (shortest on primary branches and at base and apex of the terminal branchlets), 0.6–1 mm wide; apex curved forward, apiculate. Intermediate leaves appearing on young but often fertile trees on primary and terminal branches, spirally arranged, not distichous, spreading at ca. 45°, 2–4 mm long. Leaves on primary shoots, fertile shoots, and some terminal shoots of large mature trees spirally arranged, mostly subulate or scale-like, curved inward at the tip, appressed to imbricate, keeled abaxially, 1–2 × 0.4–1 mm, apiculate. Stomata on all kinds of leaves and on all sides (leaves amphistomatic) in several intermittent rows from base to apex. Pollen cones terminal (or paired) on short scale-leaved shoots, at first semi-globose but elongating to 8–10(–12) × 2 mm; microsporophylls triangular, incurved, 1–1.2 × 0.8 mm, apiculate, green, with two light yellow pollen sacs at their

base. Seed cones terminal on short shoots with spreading, 2–3 mm long subulate leaves enclosing the initial structure, subtending the receptacle later. Receptacle 5–7 mm long, swelling to subglobose shape, warty, turning from (green) yellow to orange to red, with only tips of 1–3 bract leaves protruding. Ripe seeds 1 on a receptacle, subglobose, 3.5–4 mm long, including the smooth, lustrous, purple-glaucous epimatium, with a barely visible notched apex.

Distribution

New Zealand.
TDWG codes: 51 NZN NZS

Ecology

This still widespread species used to be a dominant emergent tree in lowland podocarp forests which have largely been destroyed by unlimited logging and forest clearance for agriculture. It is now virtually restricted to forest reserves on steeper terrain at altitudes up to 600 m a.s.l. These are mixed conifer-angiosperm forests with usually dominance of *Agathis australis* (only in the far north of New Zealand), and/or several of the 'podocarps' *Dacrydium cupressinum, Podocarpus totara, P. cunninghamii, Prumnopitys taxifolia, P. ferruginea, Halocarpus bidwillii, Manoao colensoi*, and *Phyllocladus trichomanoides*. Angiosperm trees in these forests are e.g. *Beilschmiedia tarairi, Laurelia novae-zelandiae* (in swampy places), *Metrosideros robusta* (which begins life as an epiphyte), and especially in South Island *Nothofagus* spp. Shrubs and tree ferns (*Cyathea, Dicksonia*) as well as epiphytes of many kinds can be abundant in these moist evergreen forests in a subtropical to warm temperate climate. In swamps in the lowlands *Dacrycarpus dacrydioides* is often dominant in the ecotone between dry land and standing water.

Conservation

IUCN: LC

Uses

Extensively logged with other species and hardly distinguished in the timber trade from other 'podocarp' wood, White pine (now preferably called by its Maori name kahikatea) was an extremely valuable tree due to its potential size and the good qualities of podocarp wood. It was used for carpentry, flooring and panelling in houses, dry cooperage, tool handles, etc. Today this species enjoys near total protection (I experienced from a private landowner first hand that he was "not allowed to touch these trees" but I was free to photograph them) and consequently its wood is no longer traded. In New Zealand it is not cultivated as an ornamental tree (New Zealanders prefer to plant 'British' gardens not native ones) and it would require a mild, moist climate to do so. Its profuse and colourful 'fruit' (only present in female trees) and delicate foliage are certainly attractive, but it is slow growing. It is in cultivation in SW England and Ireland in some of the famous woodland gardens and could certainly be tried elsewhere if given proper growing conditions.

Dacrycarpus expansus de Laub., J. Arnold Arbor. 50: 334. 1969. *Podocarpus expansus* (de Laub.) Whitmore, in Whitmore *et al.* (eds.), Tree Fl. Indonesia, Checkl. Irian Jaya: 234. 1997; *Bracteocarpus expansus* (de Laub.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: Papua New Guinea: Western Highlands, Laiagam Subdistrict, ["Yobobos Grassland"], *R. D. Hoogland & R. Schodde 7463* (holotype L).

Etymology

The species epithet refers to the spreading leaves on foliage branches of adult trees.

Vernacular names

pau or pa'u in the Enga language

Description

Dioecious trees to 25(–30) m tall; trunk up to 60 cm d.b.h., erect or contorted; branches irregular, contorted, crown eventually more or less flattened. Bark exfoliating in coarse plates or strips, dark brown weathering grey; inner bark pink to reddish brown. Foliage branches spreading or sometimes pendulous, with leaves of slightly different kind, juvenile

longer and S-curved leaves gradually disappearing in crowns of older trees. Leaves on primary shoots and fertile shoots spirally arranged, on lateral branchlets often more or less distichous or 4-ranked especially in young plants, acicular (thin and hair-like on seedlings), curved inward, strongly keeled abaxially, 2–6 × 0.5–1 mm, with apiculate apex. Leaves of branchlets in crowns of mature trees similar to those of young trees, subulate-acicular, not distichous or S-curved, and 2–3 mm long, spreading at 30–45°, short decurrent, curved inward, acute to apiculate, often glaucous. Stomata on all sides (leaves amphistomatic) but on the abaxial side restricted to basal part of leaf, in 2 or more rows on the adaxial face up to near apex. Pollen cones terminal on short or long shoots, subtended by acicular leaves, nearly globose when immature, at maturity elongating to 8–10 mm long and 2–3 mm wide. Microsporophylls with long apiculate apex, 1.5–2 × 0.5 mm, yellow with reddish apex, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with imbricate, 2–3 mm long, curved acicular leaves; involucral leaves slightly longer, 4–6 mm, enclosing receptacle only. Ripe receptacle 3–4 mm long, warty, green or olive green (?). Ripe seeds 1(–2) on a receptacle, subglobose, 5–6(–7) mm long, including the smooth, green to purplish brown epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Distribution

New Guinea (mostly Central Highlands of Papua New Guinea).
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

Dacrycarpus expansus occurs in lower montane to high montane forests (ca. 2000 m to 3500 m a.s.l.), often on the margins of tussock grassland with tree ferns (*Cyathea*). It can be mixed with *Papuacedrus papuana* or occur in nearly pure stands. The soil is often water-logged, peaty and acidic.

Conservation

IUCN: LC

Uses

Little is known about the uses of this species; it is assumed to be logged on a small scale for local use mainly, and if traded, would be called 'podocarp' together with species of *Podocarpus* logged in the Central Highlands.

Dacrycarpus imbricatus (Blume) de Laub.,
J. Arnold Arbor. 50: 317. 1969.

Etymology

The species epithet refers to the imbricate (overlapping) leaves on primary shoots.

Vernacular names

Numerous vernacular names are given under four varieties by De Laubenfels (1988) in Flora Malesiana, but this is clearly based on geography, not on the recognition of these varieties by local people. No single vernacular name is in use for the species as a whole, although Pilger (1903) cites two: kimerah and kiputri. The latter names seem to apply to 'podocarps' of Jawa, not to a particular species.

Description

Shrubby to large dioecious trees to 40–50 m tall, up to 2 m d.b.h.; trunk erect, terete; branches of large trees spreading and ascending, forming a broad, open crown. Bark hard, with rough surface, on large trees breaking into thick, slightly elongate plates or exfoliating in short strips, dark brown weathering greyish white, grey or blackish; inner bark pink to reddish brown and slightly fibrous. Foliage branches with leaves of two kinds, short acicular and longer flattened. Leaves on primary shoots, fertile shoots and some terminal shoots of mature trees spirally arranged, subulate or acicular (thin and hair-like on seedlings), curved inward at tip, appressed to imbricate or spreading, keeled abaxially, 1–3(–4) × 0.4–1 mm, apiculate. Leaves on many 1–5(–7) cm long terminal and deciduous branchlets bilaterally flattened, distichous, decurrent, slightly S-curved, with parallel smooth margins, (3–)7–12(–17) mm long (shortest

at base and apex of branchlet), 1–2 mm wide; apex curved forward, apiculate; this type of foliage branchlets often persist in crowns of mature trees. Stomata on both kinds of leaves and on all sides (leaves amphistomatic) in 3–6 intermittent rows on flat, larger leaves, in 1–2 rows on each face of acicular leaves. Pollen cones terminal on short shoots, subtended by small acicular leaves, nearly globose when immature, at maturity elongating to 8–12 mm long and 2–3 mm wide. Microsporophylls with triangular, apiculate apex, ca. 1.2 × 0.8 mm, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with spreading, 3–5 mm long acicular leaves enclosing the initial structure, subtending the receptacle later. Ripe receptacle 4–7 mm long, warty, orange-red or red, with protruding green bract leaves. Ripe seeds 1(–2) on a receptacle, subglobose, 5–7 mm long, including the smooth, glaucous green to red-brown epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Distribution

China: Hainan, Guangxi, NW Yunnan; Indochina; Malesia; Papuasia; SW Pacific: Fiji, Vanuatu.

TDWG codes: 36 CHC-YN CHH CHS-GX 41 CBD LAO MYA THA VIE 42 BOR-BR BOR-KA BOR-SB BOR-SR JAW LSI-BA LSI-ET LSI-LS MLY-PM PHI SUL SUM 43 BIS NWG-IJ NWG-PN 60 FIJ VAN

Ecology

This widespread species is growing in primary and secondary lower montane to upper montane rainforests, common or scattered, codominant or rarely without codominants, it is a canopy tree or an emergent. *Dacrycarpus imbricatus* is common on volcanic or ultramafic soils, and occasionally occurs on sandstone or limestone. It occurs most widely in *Lithocarpus-Castanopsis* mixed forest, often on steeper slopes and on ridges. In W Jawa var. *imbricatus* occurs on Mt. Tjeremai only with *Podocarpus neriifolius* and *Altingia noronhae* between 2400 and 2700 m a.s.l. In Lombok *D. imbricatus* has been found as low as 200 m while in Sulawesi it ascends to ca. 3000 m and in New Guinea to 3720 m. At elevations above ca. 1200 m, i.e. above the dipterocarp rainforests of Malesia, *Lithocarpus* (tropical oaks), *Castanopsis* (chestnuts) and other conifers (*Agathis, Dacrydium, Phyllocladus, Podocarpus*) are the important associated trees; in New Guinea it occurs also with *Nothofagus* and *Phyllocladus hypophyllus*. On ultramafic substrates *Casuarinaceae* (e.g. *Ceuthostoma, Gymnostoma*), *Myrtaceae* (e.g. *Eugenia, Leptospermum, Tristania, Xanthomyrtus*) and the conifer genus *Dacrydium* are the most common associates of *Dacrycarpus imbricatus*. The upper montane forests above ca. 1800 m are rich in epiphytes, especially mosses are very abundant and hang from every branch and these forests are often shrouded in fog for days on end.

Uses

This widespread species is one of the most valuable timber trees in SE Asia. Its wood, known as 'podocarp' or 'melur' (Indonesia) in the timber trade, is there not differentiated from other genera like *Nageia* and *Podocarpus*. *Dacrycarpus imbricatus* produces excellent pulpwood due to its relatively long fibres, but its higher grades are put to more specialized uses such as furniture (especially table tops), cabinet work, and wood carving in Thailand, the Philippines as well as in Fiji, masts for sailing boats, panelling, and veneer, light construction timbers, drawing boards, tea chests, utensils, and much more (ETI/PROSEA, CD-ROM on Timber trees; www.eti.uva.nl). It is used in tropical countries as an ornamental tree in parks and gardens.

3 varieties are recognized:

Dacrycarpus imbricatus (Blume) de Laub. var. ***imbricatus***. *Podocarpus imbricatus* Blume, Enum. Pl. Javae 1: 89. 1827; *Bracteocarpus imbricatus* (Blume) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: Indonesia: Jawa, ["western Java"], *C. L. Blume s.n.* (lectotype L). Fig. 104

Podocarpus kawaii Hayata, Bull. Econ. Indochine 19: 439. 1917; *Bracteocarpus kawaii* (Hayata) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998.

Dacrycarpus imbricatus (Blume) de Laub. var. *patulus* de Laub., J. Arnold Arbor. 50: 320. 1969.

Description

Leaves on primary shoots of mature trees slightly spreading, more or less free, or sometimes imbricate and mostly appressed (shoots appear very slender), spreading only here and there, 1–2(–3) × 0.4–0.6 mm.

Taxonomic notes

According to De Laubenfels var. *patulus* is restricted to Jawa, the Lesser Sunda Islands, and Sulawesi [Flora Malesiana ser. 1, 10 (3): 377, f. 25 (1988)] but collections at K and FHO that seem to belong to this form with slender, inbricate primary leaves have been gathered from Thailand to Vanuatu and Fiji, i.e. through the entire range of the species. The distinction between this form and branchlets with more spreading primary leaves is often gradual and both may well occur in the same tree. Verification of specimens at KEP (Forest Research Institute of Malaysia) and observations in the field in September-October 2008 confirmed this. *Dacrycarpus imbricatus* var. *patulus* does not appear to be truly distinct and is here treated as a synonym of *Dacrycarpus imbricatus* var. *imbricatus*.

Distribution

As for the species.

Conservation

IUCN: LC

Dacrycarpus imbricatus (Blume) de Laub. var. ***curvulus*** (Miq.) de Laub., J. Arnold Arbor. 50: 326. 1969. *Podocarpus cupressinus* R. Br. *ex* G. Benn. var. *curvulus* Miq., Pl. Jungh. 1: 4. 1851. Type not designated (coll. by F. W. Junghuhn in Jawa).

Description

Shrubby trees to 8 m tall; foliage branchlets of mature trees drooping to pendulous, with adult type imbricate scale leaves 1.2–3 × 0.8–1 mm; involucral leaves spreading but apically incurved, not exceeding the receptacle in length.

Distribution

Indonesia: Jawa, N Sumatera.
TDWG codes: 42 JAW SUM

Conservation

IUCN: LC

Dacrycarpus imbricatus (Blume) de Laub. var. ***robustus*** de Laub., J. Arnold Arbor. 50: 323. 1969. Type: Papua New Guinea: Eastern Highlands, Mt. Wilhelm, *L. J. Brass 30568* (holotype A).

Podocarpus papuanus Ridl., Trans. Linn. Soc. London, Bot., ser. 2, 9: 158. 1916; *Bracteocarpus papuanus* (Ridl.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. *Dacrycarpus steupii* de Laub., Kalikasan 7 (2): 127. 1978, *non* de Laub. 1969.

Description

Leaves on primary shoots robust, 2–6 mm long, 0.6–1 mm wide, often nearly all spreading around the shoot, involucral leaves spreading.

Distribution

Malesia: Borneo, Maluku [Moluccas], Philippines; Papuasia: New Guinea.
TDWG codes: 42 BOR-BR BOR-KA BOR-SB BOR-SR MOL PHI 43 NWG-IJ NWG-PN

Conservation

IUCN: LC

Dacrycarpus kinabaluensis (Wassch.) de Laub., J. Arnold Arbor. 50: 330. 1969. *Podocarpus imbricatus* Blume var. *kinabaluensis* Wasscher, Blumea 4 (3): 400. 1941; *Bracteocarpus kinabaluensis* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Fig. 105, 106

Etymology

The species epithet means 'from Kinabalu', the mountain on which it is endemic.

Vernacular names

No common names are recorded for this species.

Description

Dioecious shrubs or small trees to 13 m tall, with up to 30 cm stem diam.; trunk of trees short, often gnarled; crown becoming dense. Bark exfoliating in small plates or strips, brown weathering grey. Foliage branches with leaves of two kinds only on seedlings and saplings, or on trees with adventitious shoots. Leaves on primary shoots spirally arranged, more or less imbricate, subulate or acicular, curved inward or more or less straight, keeled abaxially, 3–6 × 0.7–1 mm, with curved, apiculate apex. Leaves on 2–4(–5) cm long terminal (deciduous) branchlets of seedlings and saplings (or adventitious and shaded shoots) flattened, distichous or nearly 4-ranked, decurrent, linear or slightly S-curved, with parallel smooth margins, 5–10 mm long (shortest at base and apex of branchlet), 0.8–1.3 mm wide, more or less smooth; apex curved forward, apiculate. Leaves on terminal branchlets in crowns of mature trees spirally arranged or sometimes 4-ranked, never distichously arranged, shorter and narrower, curved, apiculate. Stomata on both kinds of leaves and on all sides (leaves amphistomatic) in 2–5 intermittent rows on flat, larger leaves, in 1 grooved row on each face of acicular leaves. Pollen cones terminal on short shoots, subtended by small acicular leaves, nearly globose when immature, at maturity elongating to 8–12 mm long and 2–3 mm wide. Microsporophylls with triangular, apiculate apex, ca. 1.2 × 0.8 mm, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with spreading, 5–8 mm long, incurved acicular leaves enclosing the receptacle only. Ripe receptacle 4–5 mm long, warty, blue or purple. Ripe seeds 1(–2) on a receptacle, subglobose, 5–7 × 5–6 mm long, including the smooth, light yellowish brown to brown, sometimes glaucous epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Distribution

Borneo: Sabah (Mt. Kinabalu).
TDWG codes: 42 BOR-SB

Ecology

Dacrycarpus kinabaluensis is a shrubby tree restricted to the upper montane forest and subalpine dwarf forest on Mt. Kinabalu (4101 m). It occurs on this mountain from ca. 2600 a.s.l. m up to the tree line at ca. 3500 m. *Dacrycarpus imbricatus* occurs to at least 2400 m and possibly higher on this mountain, but is a tree of taller forest. *Dacrycarpus kinabaluensis* is growing predominantly on ultramafic rock but becomes one of the dominant shrubs above 3000 m on granite. It can form dense, nearly pure stands but is commonly associated with other conifers, e.g. *Dacrydium gracile, D. gibbsiae, Phyllocladus hypophyllus* and *Podocarpus brevifolius*. Angiosperm trees are often scarce but heather-like tall shrubs and dwarfed trees are common with *Rhododendron* spp. and *Leptospermum* spp. the most abundant. There is often a thick moss layer on the forest floor, in which orchids and pitcher plants (*Nepenthes* spp.) are common, and epiphytes are abundant on the shrubs and low trees.

Conservation

This species is only known from the higher parts of Mt. Kinabalu and consequently occupies only a small area probably less than 100 km² in extent. On the other hand, being in the centre of one of the better protected National Parks in the whole of SE Asia provides it with a degree of protection, and no decline is known at present. Increased tourism might pose indirect threats to this species, for instance by increasing the incidence of fires in episodes of draught associated with El Niño climatic cycles.
IUCN: LC

Uses

This species occurs within a National Park at high altitude and is not used economically. As far as known it is not in cultivation except perhaps in a few botanic gardens and/or private collections.

Dacrycarpus steupii (Wasscher) de Laub., J. Arnold Arbor. 50: 328. 1969. *Podocarpus steupii* Wasscher, Blumea 4 (3): 405. 1941; *Bracteocarpus steupii* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: Indonesia: Sulawesi, Enrekang, Rantelemo, *F. K. M. Steup NIFS 22857* (holotype L, isotype BO).

Etymology

This species was named after Dutch forester F. K. M. Steup, who collected plants in Sulawesi in the 1930's.

Vernacular names

miejoop, nak, pau and other names are used for this species in New Guinea

Description

Dioecious trees to 36 m tall; trunk up to 1 m d.b.h., erect, monopodial; crown more or less conical. Bark exfoliating in small plates or strips, brown weathering grey. Foliage branches with leaves of two kinds, acicular leaves and flattened leaves. Leaves on primary shoots and fertile shoots spirally arranged, imbricate or spreading, subulate or acicular (thin and hair-like on seedlings), curved inward at tip, keeled abaxially, 2–3(–4) × 0.5–0.8 mm, with curved, apiculate apex. Leaves on 2–5 cm long terminal and deciduous branchlets of seedlings to young trees bilaterally flattened, distichous, decurrent, linear or slightly s-curved, with parallel smooth margins, 5–10 mm long (shortest at base and apex of branchlet), 0.8–1.1 mm wide, weakly keeled on both surfaces; apex curved forward, apiculate. Leaves of terminal branchlets in crowns of mature trees similar to more acicular, shorter (2–6 mm) and narrower, 4-ranked to more commonly spirally arranged, decurrent, curved inward, apiculate. Stomata on both kinds of leaves and on all sides (leaves amphistomatic) in 4–6 intermittent rows in two bands on flat, larger leaves, in 1–2 rows on each face of acicular leaves. Pollen cones terminal on short shoots, subtended by small acicular leaves, nearly globose when immature, at maturity elongating to 8–12 mm long and 2–3 mm wide. Microsporophylls with triangular, apiculate apex, ca. 1.2 × 0.8 mm, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with spreading, 3–5 mm long, curved acicular leaves nearly enclosing the receptacle only. Ripe receptacle 3–4 mm long, warty, reddish. Ripe seeds 1(–2) on a receptacle, subglobose, 4–6 mm long, including the smooth, light yellowish brown to blackish brown, sometimes glaucous epimatium, with a longitudinal grooved crest terminating in a curved protruding apex.

Distribution

Malesia: Borneo [Kalimantan, Balikpapan (extinct?), Kembajan] Sulawesi (Latimodjong Mts., Mt. Roroka Timbu); Papuasia: New Guinea.
TDWG codes: 42 BOR-KA SUL 43 NWG-IJ NWG-PN

Ecology

Dacrycarpus steupii is common in mossy forest and subalpine shrubberies from montane to alpine zones. Depending on the vegetation type it is a shrub or a tall emergent tree; its best growth is in protected gullies in the upper montane forest where trees can grow taller. In peaty, wet tussock grasslands at high altitudes it forms clumps, sometimes without other trees present, or mixed with *Papuacedrus papuana* in New Guinea. The altitudinal range is from 860 m to 3470 m a.s.l.

Conservation

Dacrycarpus steupii has been collected from Gunung Beratus, a mountain near Balikpapan, but it had disappeared there by the early 1980's due to deforestation. It is still present in central Sulawesi and widespread in New Guinea; consequently the global status of this species is still considered outside the threatened categories.
IUCN: NT

Uses

Large trees will be valuable timber and have undoubtedly been logged for this purpose. Its wood is probably not distinguished from other members of the family and traded as 'podocarp' wood. Its properties

and uses would be similar to those of *D. imbricatus* and particularly useful for construction of houses and making of furniture.

Dacrycarpus vieillardii (Parl.) de Laub., J. Arnold Arbor. 50: 326. 1969. *Podocarpus vieillardii* Parl., in Candolle, Prodr. 16 (2): 521. 1868. Type: New Caledonia: Grande Terre, Province Sud, near Poila, *E. Vieillard 1262* (holotype P).

Etymology

The species epithet commemorates the French botanist Eugène Vieillard (1819–1896).

Vernacular names

No vernacular names are recorded for this species.

Description

Shrubby to large trees to 25 m tall (usually much smaller); trunk up to 50 cm d.b.h.; crown open, often candelabra-shaped. Bark exfoliating in short strips, dark brown weathering greyish white. Foliage branches with leaves of two kinds, acicular and longer flattened. Leaves on primary or secondary shoots and fertile shoots spirally arranged, decurrent, subulate-acicular, curved inward at tip, appressed to imbricate or slightly spreading on lateral foliage branches, keeled abaxially, 2–7 × 0.6–1 mm, apiculate. Leaves on many 1–5 cm long terminal and deciduous branchlets of younger trees bilaterally flattened, distichous, decurrent, slightly S-curved, with parallel smooth margins, (3–)7–10(–12) mm long (shortest at base and apex of branchlet), 1–1.2 mm wide; apex curved forward, apiculate; this type of branchlets is replaced on larger trees by those with shorter, less distichous, bilaterally flattened leaves intermediate in size and shape. Stomata on all sides of leaves (leaves amphistomatic) in a few intermittent rows on each face from base to apex; leaves often glaucous. Pollen cones lateral on foliage branchlets on very short shoots, subtended by a few small leaves, short when immature, at maturity elongating to 7–10 mm long and 1 mm wide. Microsporophylls with triangular, apiculate apex, ca. 0.6 × 0.4 mm, each bearing two protruding pollen sacs. Seed cones terminal on short shoots with spreading, 1–2 mm long leaves up to the receptacle. Ripe receptacle 2–3 mm long, warty, green turning purplish, with one protruding green bract leaf. Ripe seeds 1(–2) on a receptacle, subglobose to oval, 5–6 × 4 mm, including the smooth, grey-white or glaucous epimatium, with an obtuse double apex from one of which descends a small ridge on either side.

Distribution

New Caledonia: Grande Terre.
TDWG codes: 60 NWC

Ecology

Dacrycarpus vieillardii is common on and probably restricted to the serpentine ultramafic rocks and lateritic soils derived from these. In moist draws and along river banks it grows to a small tree up to 10 m, only in forest can it attain taller stature. It is tolerant of flooding and thereby avoids competition from most other trees. It has been found from near sea level to about 900 m altitude. In so-called tall 'maquis minier' it is often accompanied by *Casuarinaceae, Myrtaceae* (e.g. *Melaleuca*) and conifers like *Dacrydium araucarioides*; in taller rain forest it can grow with *Agathis lanceolata* and other *Myrtaceae* (*Metrosideros, Weinmannia*).

Conservation

IUCN: LC

Uses

There are few large trees of this species and most individuals occur along streams in ultramafic soil, which dwarves them. Consequently, there is no commercial exploitation of the timber of this species in New Caledonia.

FIGURE 60. *Austrotaxus spicata* tree in New Caledonia (photo M. Gardner)

FIGURE 61. *Callitris canescens* in Western Australia

FIGURE 63. *Callitris macleayana* trees in the Herberton Range, Queensland

FIGURE 62. *Callitris columellaris* in Kings Canyon N.P., Australia

FIGURE 64. *Callitris macleayana* seed cones

FIGURE 65. *Callitris muelleri* in New South Wales, Australia

FIGURE 66. *Callitris muelleri* seed cones

FIGURE 67. *Callitris preissii* at Woodman Point, Western Australia

FIGURE 68. *Callitris rhomboidea* seed cones, Grampian Mts., Victoria, Australia

FIGURE 69. *Callitris roei* in Fitzgerald River N.P., Western Australia

FIGURE 70. *Callitris roei* seed cones and foliage

FIGURE 73. *Calocedrus formosana* foliage and seed cones

FIGURE 74. *Calocedrus macrolepis* foliage and pollen cones →

FIGURE 71. *Calocedrus decurrens* tree in the Sierra Nevada, California, USA

FIGURE 75. ***Calocedrus rupestris*** foliage and pollen cones (photo L. Aveyanov)

FIGURE 72. *Calocedrus decurrens* trunk in the Sierra Nevada

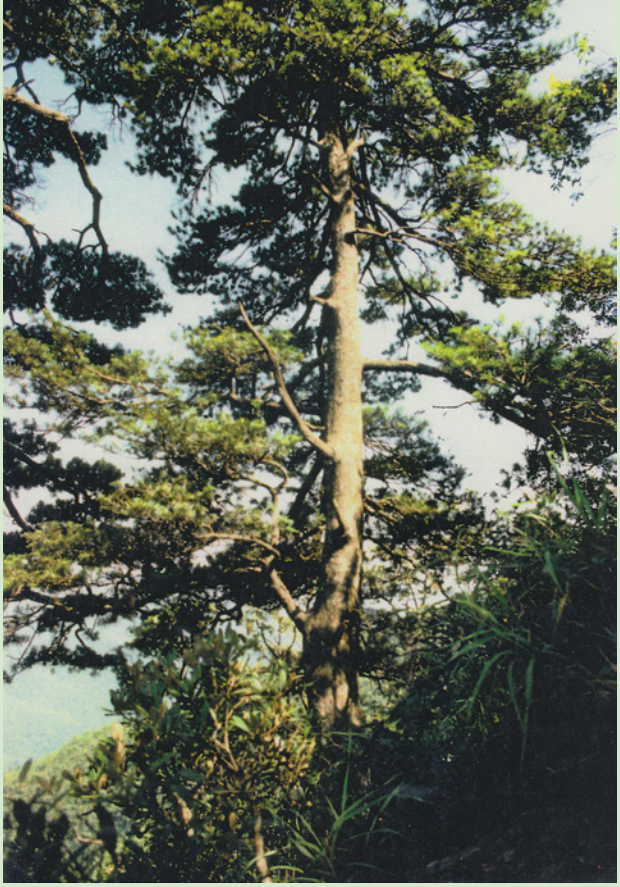


FIGURE 76. *Cathaya argyrophylla* tree in Sichuan (photo H. N imsch)

FIGURE 77. *Cathaya argyrophylla* seed cones (photo S. X. Yu)

FIGURE 78. *Cedrus atlantica* pollen cones

FIGURE 79. *Cedrus deodara* seed cones

FIGURE 80. *Cedrus libani* var. *libani* in the Taurus Mts., Turkey

FIGURE 81. *Cephalotaxus fortunei* var. *fortunei* pollen cones and foliage

FIGURE 83. *Cephalotaxus harringtonii* var. *harringtonii* pollen cones

FIGURE 82. *Cephalotaxus fortunei* var. *fortunei* ripe seeds

FIGURE 84. *Cephalotaxus harringtonii* var. *harringtonii* ripe seeds

FIGURE 87. *Chamaecyparis formosensis* foliage and seed cones

FIGURE 85. *Cephalotaxus mannii* leaves and seeds (photo L. Averyanov)

FIGURE 86. *Chamaecyparis formosensis* and *C. obtusa* in Chilan Shan, Taiwan

FIGURE 88. *Chamaecyparis lawsoniana* pollen cones

FIGURE 89. *Chamaecyparis lawsoniana* seed cones

FIGURE 90. *Chamaecyparis thyoides* var. *thyoides* trunk in North Carolina, USA

FIGURE 91. *Cryptomeria japonica* seed cones

FIGURE 92. *Cunninghamia konishii* foliage

FIGURE 93. *Cunninghamia lanceolata* seed cones

FIGURE 94. *Cupressus arizonica* var. *arizonica* seed cones

FIGURE 95. *Cupressus dupreziana* tree in the Sahara (Tassili n'Ajjer, Algeria)

FIGURE 96. *Cupressus guadalupensis* var. *forbesii* in California, USA

FIGURE 98. *Cupressus macrocarpa* near Monterey, California, USA

FIGURE 97. *Cupressus lusitanica* var. *benthamii* seed cones

FIGURE 99. *Cupressus torulosa* var. *torulosa* seed cones

FIGURE 100. *Dacrycarpus cinctus* foliage and cones (photo T. Utteridge)

FIGURE 101. *Dacrycarpus dacrydioides* tree in North Island, New Zealand

FIGURE 103. *Dacrycarpus dacrydioides* seed cones

FIGURE 102. *Dacrycarpus dacrydioides* trunk

FIGURE 104. *Dacrycarpus imbricatus* var. *imbricatus* flushing foliage

FIGURE 105. *Dacrycarpus kinabaluensis* tree on Mt Kinabalu, Borneo

FIGURE 106. *Dacrycarpus kinabaluensis* seed cones

FIGURE 108. *Dacrydium araucarioides* foliage and pollen cones

FIGURE 107. *Dacrydium araucarioides* in New Caledonia

FIGURE 109. *Dacrydium beccarii* foliage with pollen cones

FIGURE 110. *Dacrydium comosum* canopy at Gunung Ulu Kali

FIGURE 111. *Dacrydium comosum* at Gunung Ulu Kali, Malaysia

FIGURE 112. *Dacrydium comosum* foliage

FIGURE 113. *Dacrydium cupressinum* in North Island, New Zealand

FIGURE 114. *Dacrydium elatum* at Gunung Ledang, Malaysia

FIGURE 116. *Dacrydium gracile* at Bukit Tupai, Mt Kinabalu

FIGURE 117. *Dacrydium guillauminii* in New Caledonia (photo A. Schmidt)

FIGURE 115. *Dacrydium gibbsiae* small tree on Mt Kinabalu, Borneo

FIGURE 118. *Dacrydium xanthandrum* tree in the Crocker Range, Borneo

FIGURE 119. *Dacrydium xanthandrum* trunk in the Crocker Range

FIGURE 120. *Diselma archeri* in Cradle Mountain N.P., Tasmania, Australia

Dacrydium Sol. *ex* G. Forst., Pl. Escul. Ins. Ocean. Austr. Comm. Bot.: 80. 1786. [Fl. Ins. Austr. Prod.: 92. 1786] Type: *Dacrydium cupressinum* Sol. *ex* G. Forst. (*Podocarpaceae*).

Metadacrydium Baum.-Bod., Syst. Fl. Neu-Caledonien 5: 76. 1989. Type: *Metadacrydium araucarioides* (Brongn. & Gris) Baum.-Bod. [*Dacrydium araucarioides* Brongn. & Gris]

Greek: *dakryon* = a tear; referring to drops of resin exuded by the tree.

Description

Dioecious or rarely monoecious evergreen shrubs or trees. Resin in bark and (1 canal) in leaves. Bark hard, with numerous small lenticels, becoming fissured and scaly, exfoliating in plates. Primary branches in pseudo-whorls, numerous or sparse, spreading and assurgent, repeating the same pattern (Rauh's model), or with spreading and/or pendulous foliage branches; latter foliage branches not terminating in distinct buds. Leaves spirally arranged, dimorphic, scale-like and subulate or acicular, usually curved inwards, gradually transitional from juvenile to adult forms, keeled, triangular or quadrangular in cross-section, sometimes dorsiventrally flattened (i.e. wider than thick). Stomata on all sides (leaves amphistomatic). Pollen cones solitary or in groups, terminal or lateral on foliage shoots, axillary on short scaly peduncles or nearly sessile, becoming short cylindrical; microsporophylls peltate, triangular to apiculate, with two basal pollen sacs containing bisaccate pollen. Seed cones terminal on (short) foliage branchlets, small, consisting of several spirally arranged, scale-like or leaf-like (acicular) bracts following smaller scales; fertile bracts with a single more or less inverted ovule on the adaxial side; the whole enlarged, swollen and red when ripe forming a small receptacle with protruding bract tips in most species. Seeds 1–2(–3) per cone, becoming more or less erect and usually standing obliquely from axis of subtending receptacle, protruding from a cup-like epimatium covering its basal part only and ripening to dark lustrous brown or nearly black.

22 species.

Distribution

Continental SE Asia: S China (Hainan); Indochina (excluding Myanmar). Malesia: from Peninsular Malaysia to the D'Entrecasteaux Islands (PNG), but excluding Jawa & Lesser Sunda Islands. SW Pacific: Solomon Islands; New Caledonia; Fiji; New Zealand.

Taxonomic notes

The genus *Dacrydium* is one of the two earliest described genera in the family *Podocarpaceae* (the other is *Podocarpus*) and it has in the past accomodated numerous species, which are at present classified in other, in part segregate, genera, leaving a genus *Dacrydium* with a narrower, more precise circumscription and at present containing 22 species. The segregate genera are, in order of publication date, *Lepidothamnus* (1860), *Acmopyle* (1903), *Falcatifolium* (1969), *Parasitaxus* (1972), *Halocarpus* (1982), *Lagarostrobos* (1982) and, segregated again from *Lagarostrobos, Manoao* (1995). The circumscription of *Dacrydium* has remained open to various interpretations until quite recently (Quinn, 1982), and as a result conifer species that do not properly belong in the genus (even if including its segregates) or not even in *Podocarpaceae*, have been ascribed to it. An informal classification into sections A, B and C by Florin (1931) divided the genus in its wider sense and only the species of his section B are still included in *Dacrydium*. In subsequent accounts, when the genus was circumscribed in a narrower sense, no attempts were made to subdivide it (e.g. De Laubenfels, 1969, 1988; Gaussen, 1974; Quinn, 1982). No phylogenetic analysis of the genus has been published; at best a few species were included in investigations into the phylogeny of the family *Podocarpaceae* at the genus level. There is therefore no sound basis upon which to base a classification of *Dacrydium*. Divisions of the genus based on a pre-selected few morphological characters would, as is explained under *Podocarpus*, most likely be artificial. It is for this reason that this relatively large (in conifer terms) genus must be

treated here in geographical groupings for the sake of constructing identification keys that are manageable and may work in the field. Few species are in cultivation outside their native areas, so this should not create undue problems. Two islands stand out as logical entities for this purpose: New Caledonia and Borneo. The five species in New Caledonia are, as the other conifers there, endemic. Most of the seven species of Borneo are also restricted to the island, but three species are also found elsewhere. These, and the remainder (11 species) are dealt with in the third key.

Key to the species of *Dacrydium* in New Caledonia

Juvenile leaf forms gradually merge into adult leaf forms and the 'extremes' of both types should therefore be taken for comparison with the character states used in this key. Adult leaf forms are in most species shorter than juvenile leaf forms.

1a. Shrubs or dwarfed trees up to 2.5 m (rarely to 4 m) tall. Juvenile and adult leaves similar in size and shape or adult leaves only slightly shorter, the shortest at least 5 × longer than wide **2**

1b. Small or large trees. Juvenile and adult leaves very different in size and shape, the shortest less than 4 × longer than wide **3**

2a. Adult leaves slightly shorter than juvenile leaves, 5–10 mm long (juvenile leaves 10–15 mm long), imbricate but with a free apex, narrowly lanceolate. Seeds 3–4 × 2 mm ***D.* × *suprinii***

2b. Adult leaves equally long as juvenile leaves, (10–)13–15(–17) mm long, spreading but curved forward, acicular. Seeds 4–5 × 2.5 mm ***D. guillauminii***

3a. Adult leaves linear-lanceolate, 0.6–0.8 mm wide; apex pungent. Pollen cones 4–7 mm long, 1.2 mm wide ***D. lycopodioides***

3b. Adult leaves oblong, incurved apically, 1–1.8 mm wide; apex obtuse. Pollen cones 8–18 mm long, 1.5–4 mm wide **4**

4a. Adult leaves imbricate, strongly incurved apically hiding the apex from view. Pollen cones 3–4 mm wide. Seed cones 8–10 mm long, with 1–3 seeds ***D. araucarioides***

4b. Adult leaves spreading 30–45° from shoot; apex incurved but free and visible. Pollen cones 1.5–2 mm wide. Seed cones 2–3 mm long, with a single, rarely 2 seeds ***D. balansae***

Key to the species of *Dacrydium* in Borneo

Juvenile leaf forms gradually merge into adult leaf forms and the 'extremes' of both types should therefore be taken for comparison with the character states used in this key. Adult leaf forms are in most species shorter than juvenile leaf forms.

1a. Adult leaves scale-like, appressed, 1–1.5 mm long ***D. elatum***

1b. Adult leaves acicular, linear or linear-lanceolate, spreading, (1.5–)3–10(–13) mm long **2**

2a. Adult leaves and juvenile leaves similar, acicular, spreading wide to nearly 90°, nearly straight, 5–10 mm long, 0.7–1 mm wide, flattened ***D. ericoides***

2b. Adult leaves and juvenile leaves of different length (adult leaves much shorter); adult leaves spreading forward or in one species wide to 90° **3**

3a. Adult leaves spreading wide to nearly 90°, curved forward or nearly straight. Microsporophylls of pollen cones with a rostrate apex ***D. xanthandrum***

3b. Adult leaves spreading forward more or less close to the shoot, usually curved. Microsporophylls of pollen cones triangular or in one species lanceolate **4**

4a. Adult leaves very slender and soft, 0.3–0.4 mm wide, slightly curved or nearly straight ***D. beccarii***

4b. Adult leaves more or less rigid, (0.4–)0.5–1.2 mm wide, curved at least towards the apex **5**

5a. Adult leaves robust, 0.9–1.2 mm wide, linear or linear-lanceolate. Pollen cones 20–25 × 4.5–7 mm; microsporophylls lanceolate, 4–5 mm long ***D. gibbsiae***

5b. Adult leaves slender, 0.4–0.8 mm wide, acicular or linear. Pollen cones 6–12 × 2 mm; microsporophylls triangular-apiculate, 1–1.5 mm long **6**

6a. Adult leaves linear, nearly as thick as wide, 0.4–0.8 mm wide, keeled sharply on the abaxial

side; apex obtuse or short apiculate. Seed cones terminal on foliage shoots; epimatium covering the basal third of the seed ***D. pectinatum***

6b. Adult leaves acicular, wider than thick (transverse-triangular in cross-section), 0.4–0.5 (–0.7) mm wide, keeled weakly on the abaxial side; apex apiculate. Seed cones lateral on foliage shoots; epimatium covering the basal half of the seed ***D. gracile***

Key to the species of *Dacrydium* in regions outside Borneo and New Caledonia

Juvenile leaf forms gradually merge into adult leaf forms and the 'extremes' of both types should therefore be taken for comparison with the character states used in this key. Adult leaf forms are in most species shorter than juvenile leaf forms.

1a. Adult leaves 1–2(–3) mm long, scale-like or acicular, appressed or spreading forward and incurved, 0.2–0.5(–0.7) mm wide **2**

1b. Adult leaves (1.5–)3–10(–30) mm long, acicular or linear-lanceolate, spreading forward or outward, if incurved mostly longer than 3 mm, 0.3–1.2 mm wide **5**

2a. Adult leaves scale-like, appressed, on slender, cord-like shoots **3**

2b. Adult leaves acicular, spreading forward and incurved, on slender, brush-like shoots **4**

3a. Juvenile leaves 5–12 mm long, 0.4–0.6 mm wide, keeled abaxially; bracts at base of seed cones 3 mm long ***D. novo-guineense***

3b. Juvenile leaves 10–15 mm long, 0.3 mm wide, keeled on 4 sides; bracts at base of seed cones 1 × 1 mm, triangular ***D. elatum***

4a. Adult leaves sharply keeled abaxially; apex obtuse or sometimes acute ***D. nausoriense***

4b. Adult leaves not keeled but transverse-triangular in cross-section; apex acute-pungent to acuminate ***D. leptophyllum***

5a. Juvenile leaves 15–33 mm long, 0.8–1 mm wide; adult leaves (5–)7–25(–30) mm long, 0.5–1.2 mm wide **6**

5b. Juvenile leaves 5–20 mm long, 0.2–0.6(–1) mm wide; adult leaves (1.5–)2–10 mm long, 0.3–1 mm wide **7**

6a. Shrubs or dwarf trees to 6 m tall; adult leaves crowded, spreading and curved forward, 12–25(–30) mm long, 0.6–1.2 mm wide ***D. comosum***

6b. Trees to 35 m tall, sometimes shrubs at highest altitudes; adult leaves spreading at ca. 90°, straight or curved, (5–)7–10(–13) mm long, 0.5–0.8 mm wide ***D. xanthandrum***

7a. Juvenile leaves 5–7 mm long, 1 mm wide, flattened, 0.2–0.3 mm thick; adult leaves 2–4 mm long, 0.8–0.9 mm wide, flattened, 0.2–0.3 mm thick, linear-lanceolate ***D. spathoides***

7b. Juvenile leaves 5–20(–25) mm long, 0.2–0.6 mm wide, not flattened; adult leaves not flattened **8**

8a. Bracts subtending seed cones longer than the leaves immediately below these, 3–8 mm long, completely hiding the cones **9**

8b. Bracts subtending seed cones shorter or equally long as the leaves immediately below these, 1–3 mm long, exposing the cones and/or the epimatium **12**

9a. Juvenile leaves 8–14 mm long, strongly curved; apex apiculate. Pollen cones 8–12 × 1.8–2 mm; microsporophylls triangular ***D. cornwallianum***

9b. Juvenile leaves 10–20 mm long, straight or slightly curved; apex pungent. Pollen cones (7–)10–18 × 2–2.5 mm; microsporophylls apiculate or elongated **10**

10a. Juvenile leaves very slender, 0.2–0.3 mm wide, not keeled abaxially. Microsporophylls of pollen cones short, apiculate; seeds 3.5–4 mm long, lustrous brown ***D. nidulum***

10b. Juvenile leaves 0.4–0.6 mm wide, keeled abaxially. Microsporophylls of pollen cones elongated, with incurved apex; seeds 4–5 mm long, brown or black **11**

11a. Adult leaves partly imbricate, straight with incurved apex, 0.5–0.6 mm wide. Pollen cones 7–9 × 2.5 mm. Bract scales subtending seed cones 3–5 mm long ***D. medium***

11b. Adult leaves free, spreading forward, incurved, 0.3–0.4 mm wide. Pollen cones 10–16 × 2–2.5 mm. Bract scales subtending seed cones 6–8 mm long ***D. magnum***

12a. Juvenile leaves 5–8 mm long, not much longer than adult leaves, keeled on 4 sides; adult leaves 0.8–1 mm wide. Seed cones when fully developed 6–8(–10) mm long, swollen succulent and orange to red; seeds lustrous black
D. cupressinum

12b. Juvenile leaves 10–20(–25) mm long, much longer than adult leaves, keeled abaxially; adult leaves 0.3–0.8 mm wide. Seed cones minute, ca. 3 mm long; seeds lustrous brown **13**

13a. Adult leaves (4–)6–10 mm long, acicular, soft, 0.3–0.4 mm wide. Seeds 1–2(–3) per cone
D. beccarii

13b. Adult leaves (1.5–)3–5(–7) mm long, linear, rigid, 0.4–0.8 mm wide; Only 1 seed per cone
D. pectinatum

Dacrydium araucarioides Brongn. & Gris, Ann. Sci. Nat. Bot., sér. 5, 6: 244. 1866. *Metadacrydium araucarioides* (Brongn. & Gris) Baum.-Bod., Syst. Fl. Neu-Caledonien 5: 76. 1989. Type: New Caledonia: Grande Terre, Province Sud, Canala, ["montagnes au-dessus de Canala"], *E. Vieillard 1277* (lectotype P). Fig. 107, 108

Etymology

The species epithet means 'similar but not equal to *Araucaria*' and refers to the foliage branches and their leaves.

Vernacular names

This species does not have a common name.

Description

Small trees 2–7 m tall; trunk to 15 cm d.b.h., erect, monopodial. Bark smooth becoming rough, with horizontal ridges, breaking into small scales, brown weathering grey; inner bark slightly fibrous, red-brown. Primary branches few, spreading and assurgent, with foliage branches towards the end, forming a candelabra crown but often irregular and open. Juvenile leaves on seedlings and saplings, acicular, straight on seedlings to curved on saplings, 7–12 mm long, 0.7–1 mm wide and thick, keeled on four sides; apex acute to apiculate. The (pen)ultimate branchlets with adult leaves 4–8 mm thick; the leaves spirally arranged, imbricate, spreading from base at <30° and strongly incurved towards apex, oblong, 2–4 (–5) × 1–1.5 mm, keeled from base abaxially, becoming convex towards the obtuse (invisible) apex, lustrous green. Stomata on juvenile leaves on all sides in lines between ribs (leaves amphistomatic), on adult leaves largely confined to the adaxial side but a few near base abaxially. Pollen cones terminal or lateral on very short branchlets, cylindrical, 9–18 × 3–4 mm; microsporophylls similar to adult leaves but smaller and shorter, nearly triangular with incurved apex; pollen sacs not visible due to imbricate microsporophylls. Seed cones terminal, subtended by 3 mm long leaves; bracts elongated to ca. 5 mm, less curved than the leaves, covering the 8–10 mm long cone up to the seed, turning purplish red at maturity; epimatium at base of seed. Seeds single or 2–3 per cone, partly covered by the bracts, ovoid with a slightly constricted apex, 4–4.5 mm long, brown.

Distribution

New Caledonia: Grande Terre, Province Sud.
TDWG codes: 60 NWC

Ecology

This species is restricted in its occurrence to the ultramafic substrates derived from peridotite or serpentine; it is particularly abundant on laterite soils and 'ironstone' ('cuirasse de fer') in the Plaine des Lacs and the surrounding hills. It occurs in low, open woodland on mountain ridges and in tall 'maquis minier' on slopes and plains, from just above sea level to ca. 1000 m altitude. It is accompanied by numerous angiosperms; one of the most characteristic small trees looking very similar from a distance is *Gymnostoma chamaecyparis* (*Casuarinaceae*). Associated conifers are e.g. *Araucaria muelleri, Agathis ovata, Retrophyllum minus*, and *Neocallitropsis pancheri*. This type of vegetation is prone to fires and regeneration of the conifers and other small trees is generally slow due to the extreme poverty of nutrients in the soil.

Conservation

IUCN: LC

Uses

No uses are recorded of this species.

Dacrydium balansae Brongn. & Gris, Bull. Soc. Bot. France 16: 328. 1869. *Metadacrydium balansae* (Brongn. & Gris) Baum.-Bod., Syst. Fl. Neu-Caledonien 5: 76. 1989. Type: New Caledonia: Grande Terre, Province Sud, Bourail, ["au-dessous de Téné près de Bourail"], *B. Balansa 1380* (holotype P).

Etymology

The species epithet commemorates the plant collector Benjamin Balansa (1825–1892), who collected in New Caledonia in the years 1868–1872.

Vernacular names

No vernacular name is known for this species.

Description

Trees 3–12(–20?) m tall; trunk to 30 cm d.b.h., erect, monopodial. Bark becoming rough, with horizontal ridges, breaking into irregular scales, brown weathering grey; inner bark fibrous, red-brown. Primary branches spreading and assurgent, with numerous foliage branches towards end, forming a domed crown but often irregular and open. Juvenile leaves on seedlings and saplings, acicular, straight on seedlings to curved on saplings, 9–13 mm long, 0.7–1 mm wide and thick, keeled on four sides; apex acute to apiculate. Adult leaves spreading 30–45° from shoot and free, length variable on branchlets with shorter leaves often at beginning and end of branchlet, 2–5(–7) × 1–1.8 mm, oblong but widest near base, curved forward, keeled abaxially, flat or concave adaxially; apex incurved, obtuse. Stomata on juvenile leaves on all sides in several intermittent lines (leaves amphistomatic), on adult leaves idem but not extending to apex on the abaxial side. Pollen cones terminal or lateral on very short branchlets, cylindrical, becoming curved when expanded to 8–15 × 1.5–2 mm; microsporophylls similar to adult leaves but smaller and shorter, nearly triangular with incurved apex; pollen sacs not visible due to imbricate microsporophylls. Seed cones terminal, 2–3 mm long, subtended by 2 mm long leaves; bracts elongated to 3.5–4 mm, curved at apex, covering the cone up to the seed, turning purplish red at maturity; epimatium basal to seed. Seeds single or rarely two per cone, obliquely oriented, often partly covered by bracts, ovoid with a slightly constricted apex, 4.5–5 × 3.5 mm, brown.

Distribution

New Caledonia: Grande Terre.
TDWG codes: 60 NWC

Ecology

Dacrydium balansae is a small tree occurring mostly on ultramafic soils derived from serpentine at elevations from near sea level to 800–900 m. Its stature is partly dependent on soil and exposure, with dwarfed trees predominantly on the most metalliferous rocks with very thin soil that support 'maquis minier' vegetation and taller trees occurring infrequently in moist ravines that support taller forest. Here individuals rarely may attain hights near 20 m, but identity of such trees observed lacks evidence from herbarium specimens. It is not uncommon in some localities, but never forms large populations. It is associated with several other conifers (*Agathis ovata, Araucaria* spp., *Dacrydium araucarioides*) and numerous angiosperms.

Conservation

IUCN: LC

Uses

The commonly small stature of this species makes it an unlikely source of timber despite good wood properties; an occasional larger specimen may have been taken for this purpose. It is not known in cultivation.

Dacrydium beccarii Parl., in Candolle, Prodr. 16 (2): 494. 1868. Type: Malaysia: Sarawak, Gunung Pueh (Mt. Poe), *O. Beccari 2385* (lectotype FI). Pl. 13, Fig. 109

Etymology

This species was named after the Italian botanist Odoardo Beccari (1843–1920), who collected the type specimen.

Vernacular names

Many vernacular names are in use for this species, differing from island to island and even locally. Some are: kayu embun (Borneo), ekor kuda (Malaya), netukuria (New Guinea).

Description

Shrubs or trees of medium size, to 25 m tall; trunk to 80 cm d.b.h., much branched eventually developing a broadly spreading dense crown, sometimes more or less flat-topped. Bark scaly; outer bark brown; inner bark finely fibrous, exuding red resin from slash. Foliage of two indistinct types, with juvenile leaves and adult leaves mainly differing in length and width. Juvenile leaves spreading at 30–70° from shoot, acicular, very slender, 15–20(–25) × 0.3–0.6 mm, usually curved forward, keeled abaxially, pungent. Adult leaves densely set, spreading at 30–45° forward, sometimes closer to shoot, acicular, very slender and soft, slightly curved or nearly straight, (4–)6–10 × 0.3–0.4 mm, triangular in cross-section and slightly wider than thick, keeled abaxially, pungent, dark green, flushing light green. Stomata on all sides (leaves amphistomatic), in 1–2 intermittent lines on each face to apex. Pollen cones lateral or terminal on branchlets with adult leaves (sometimes with juvenile leaves), 7–10 × 2.5–3 mm at maturity; microsporophylls triangular, 1 mm wide at base, with extended narrow apex 1 mm long and 0.3 mm wide at base, turning brown; 2 basal reddish pollen sacs. Seed cones terminal on leaved branchlets, subtended by yellowish involucral leaves, 3 mm long, covered with triangular bract scales 1 × 2 mm, slightly swelling and turning red at maturity. Seeds single or 2, rarely 3, obliquely positioned, 3.5–4 mm long, covered for the basal third by the epimatium and turning lustrous dark brown.

Distribution

Malesia: Borneo, Peninsular Malaysia, Maluku [Moluccas], Philippines, Sulawesi, Sumatera; Papuasia: New Britain, New Guinea, Solomon Islands.

TDWG codes: 42 BOR-BR BOR-KA BOR-SB BOR-SR MLY-PM MOL PHI SUL SUM 43 BIS NWG-IJ NWG-PN SOL-SO

Ecology

Dacrydium beccarii is most common in low canopy (to 20 m) mossy forest on leached, podzolic sandy soils (kerangas), where it can dominate the canopy especially on ridges of mountains at altitudes from 500 m to 2500 m a.s.l. It has also been found on karst limestone, granite, and andesite, as well as in wet peaty soil. In exposed locations on mountain summits it becomes an emergent low tree above dense scrub. It is associated with other conifers, such as *Agathis* spp., *Dacrycarpus* spp., *Falcatifolium gruezoi* (e.g. on Mt. Halcon in the Philippines), *Nageia wallichiana*, and sometimes *Sundacarpus amarus*. On mountain ridges it can better compete with the numerous angiosperms in these forests, where these angiosperms remain smaller trees and shrubs.

Conservation

IUCN: LC

Uses

Dacrydium beccarii is locally exploited for timber; the wood is used in building houses and for making drums (New Guinea). The bark is used in some villages in the highlands as an insulation material in the walls of round small houses or huts.

PLATE 13. *Dacrydium beccarii*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Leaf. **4.** Branchlet with juvenile leaves. **5.** Branchlet with leaves and seed cones. **6.** Seed cone with seed.

Dacrydium comosum Corner, Gard. Bull. Straits Settlem. 10: 244, t. 10. 1939. Type: Malaysia: Malaya, Negeri Pahang, Pine Tree Hill, *E. J. H. Corner SFN 33222* (holotype SING). Fig. 110, 111, 112

Etymology

The species epithet means 'bearing a tuft of leaves' (Latin *comosus* = 'with much or long hair').

Vernacular names

No common names have been recorded for this species.

Description

Small trees to 15 m tall, with a single stem to 50 cm d.b.h., on exposed ridges dwarfed and flat-topped. Branches spreading and ascending in candelabra fashion, making an umbrella-shaped crown with crowded, upturned foliage branches at ends of primary branches. Juvenile leaves and adult leaves very similar. Juvenile leaves spreading more perpendicular to branch, acicular, curved forward, very narrowly tapering, to 33 mm long, ca. 1 mm wide at base, keeled abaxially, ending in a pungent apex. Adult leaves densely crowded and covering the shoot completely, spreading forward, acicular, straight or slightly curving outward, 12–25(–30) mm long, 0.6–1.2 mm wide at or just above a slightly widened base, flattened with a sharp abaxial keel, gradually tapering to a pungent apex. Stomata on both sides (leaves amphistomatic) in a few intermittent lines nearly to apex. Pollen cones mostly lateral on foliage branches, subtended by a few short leaves ca. 5 mm long, 8–10 × 3 mm; microsporophylls terminating in a narrow extension, 1.5–2 mm long and 0.5 mm wide at base, with two basal pollen sacs. Seed cones few, terminal on short foliage branchlets, ca. 3 mm long, nearly hidden by leaves, with several lanceolate, coloured bracts and 1(–2) exposed, ovoid, light brown seeds 4–5 mm long covered at base by the epimatium.

Distribution

Peninsular Malaysia (Genting Highlands, Gunung Hulu Kali, Negeri Pahang).
TDWG codes: 42 MLY-PM

Ecology

Dacrydium comosum occurs on exposed mountain ridges as a local dominant in stunted mossy forest on rocky acidic soil or shallow peat; in one area at altitudes between 1170 and 1440 m a.s.l. (the altitudinal range is incompletely known). Occasional individuals may grow in forest below the ridge and attain tree size to reach the canopy.

Conservation

Dacrydium comosum is known from two separate areas and in total from less than five localities within these areas. Corner (*op. cit.*) mentioned four trees from the type locality, but the numbers at other localities are not known. There is a risk of fire threatening these small populations coming from burning and clearing forest at lower elevations. Seed production seems to be low and seedlings are sparse.
IUCN: EN [B1ab (ii–v), B2ab (ii–v)]

Uses

No uses have been recorded of this species.

Dacrydium cornwallianum de Laub., Fl. Malesiana, ser. 1, 10 (3): 366. 1988, ["cornwalliana"]. Type: Indonesia: Papua, Danau Paniai [Wissel] Lakes, Arupa, *C. Versteegh BW 3041* (holotype A, isotype K).

Dacrydium nidulum de Laub. var. *araucarioides* de Laub., J. Arnold Arbor. 50: 293. 1969. Type: Indonesia: Papua, Danau Paniai [Wissel] Lakes, Arupa, *C. Versteegh BW 3041* (holotype L).

Etymology

Although no explanation was given, the species epithet means 'of Cornwall'.

Vernacular names

No vernacular names are known for this species.

Description

Trees to 30 m, monopodial, erect; trunk d.b.h. to 50 cm; crown elongated, dense, often with fastigiate branching. Bark thin and hard, scaly and shedding small flakes, brown, weathering grey; inner bark slightly fibrous and pinkish. Foliage in much branched tufts, spreading or assurgent in mature trees. Leaves on seedlings and juvenile trees acicular, 8–14 mm long, 0.4–0.5 mm wide and 0.2–0.3 mm thick, spreading and strongly curved forward or incurved, keeled abaxially, sharply apiculate. Adult leaves shorter and mostly uniform on branchlets, spirally arranged and decurrent at base, (2–)3–5(–8) mm long, 0.6–0.8 mm wide and 0.3–0.4 mm thick, keeled sharply on the abaxial side, spreading at 30° but strongly curved forward and with an incurved, apiculate apex. Intermediate forms of leaves occur on younger trees. Stomata on all sides (leaves amphistomatic), but extending to apex only on the adaxial side where they are separated by a midvein. Pollen cones terminal or sometimes lateral, 8–12 ×1.8–2 mm; microsporophylls triangular, 1–1.2 × 0.7 mm, incurved, faintly keeled abaxially, obtuse, with two basal pollen sacs. Seed cones terminal, ca. 3 mm long, subtended by short (1.5–2 mm) leaves followed by longer (3–5 mm) cone bracts surrounding the epimatium, becoming swollen and red at base. Seed single, epimatium covering only the basal third or less of the 4–5 mm long, lustrous brown seed.

Taxonomic notes

This taxon was elevated to a species by De Laubenfels in 1988 (*op. cit.*) from *Dacrydium nidulum* var. *araucarioides* de Laub. (1969, *op. cit.*). It appears to have sufficient distinct characters to merit this move, which is here accepted. The author based the two taxa on different type specimens (duplicates) of the same collection taken from a single tree, lodged in different herbaria; he also described *D. cornwallianum* explicitly as a new species, yet cited the earlier published variety as a synonym. The binomial *D. araucarioides* could not be used as it had already been applied to a species from New Caledonia.

Distribution

New Guinea.
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

This species is a dominant in mixed forest, or forms nearly pure stands in swamp forest, and perhaps also in mossy forest, between 1450 and 2300 m altitude. A photograph in Flora Malesiana 1, 10: 366 (1988) shows a dense stand of this tree in the ecotone between montane rainforest and swamp "on black peat".

Conservation

Although apparently rare and only known from a handful of collections and localities, this species occurs in habitat that is far removed from deforestation or other land uses detrimental to the natural vegetation. It may be more common than the few collections known seem to suggest. This species does not appear to occur within protected areas.
IUCN: LC

Uses

The timber of this species may be locally used for construction of traditional houses in the villages of the highland areas in western New Guinea.

Dacrydium cupressinum Sol. *ex* G. Forst., Pl. Escul. Ins. Ocean. Austr. Comm. Bot.: 80. 1786. Type not designated (New Zealand, prob. coll. D. Solander on Cook's first voyage). Fig. 113

Etymology

The species epithet denotes a similarity with cypresses (*Cupressus*).

Vernacular names

Red pine; rimu (Maori)

Description

Large trees to 50(–60) m tall; trunk d.b.h. to 1.5–2 m, erect, usually monopodial, sometimes forked. Bark rough and scaly, peeling in elongated, thick flakes, light brown weathering grey. Young trees pyramidal, crown of mature trees becoming domed, with spreading to ascending first order branches. Foliage branches drooping to pendulous, slender. Juvenile and adult leaves similar in shape but adult leaves shorter, especially on fertile branches. Juvenile leaves on seedlings to saplings and young trees, spreading, straight, soft and pliable, 5–8 mm long, 0.3–0.5 mm wide in seedlings and saplings, becoming stiffer and thicker on larger young trees, keeled on four sides, pungent, green but often turning bronze in winter. Adult leaves 2–3(–4) mm long, 0.8–1 mm wide, decurrent, widest just above base where they spread at 45–60°, straight or slightly curved, triangular in cross-section, acute to acuminate. Leaves amphistomatic, but with most stomata on adaxial side in many lines to apex, on abaxial side a few lines near base (on adult leaves nearly absent on that side). Pollen cones terminal, ovate-oblong, 7–10 mm long, 4 mm wide; microsporophylls with elongated apex, 2–2.5 mm long, green, each with two yellow pollen sacs at base. Seed cones terminal on short, curved branchlets or lateral, 6–8(–10) mm long; bracts short, scarcely protruding when the swollen, orange to red cone is mature. Seeds solitary, obliquely placed, the basal ⅓ covered by a green, later bright red epimatium, seed ovoid, slightly flattened, 4–5 mm long, ripening to lustrous black.

Distribution

New Zealand, distributed widely on all main islands.
TDWG codes: 51 NZN NZS

Ecology

Dacrydium cupressinum is a dominant or codominant emergent in mixed conifer (podocarp) forest or conifer-angiosperm forest at low to middle elevations up to 700 m a.s.l. These forests are (warm) temperate evergreen rain forests with year-round high precipitation and are multi-layered with emergent conifers, a canopy of conifers and/or angiosperms, an understorey of shrubs, tree ferns and palms, and a ground cover of ferns and mosses. In the kauri forest of Northland *D. cupressinum* is a minor component, but in other forest types it is often the most common species, sometimes occurring in nearly pure stands. Very large specimens may be around 1000 years old, but few of these survive today in only remnants of a once extensive native lowland forest cover. Common associated conifer species are *Agathis australis* (restricted to the northern part of the range of *D. cupressinum*), *Podocarpus totara, Prumnopitys ferruginea, P. taxifolia, Dacrycarpus dacrydioides, Manoao colensoi, Phyllocladus trichomanoides* and, less frequently, *Halocarpus kirkii*. Some common angiosperm trees are *Beilschmiedia tarairi* (*Lauraceae*), *Metrosideros* spp. (*Myrtaceae*), *Weinmannia racemosa* (*Cunoniaceae*) and *Quintinia acutifolia* (*Escalloniaceae*), and there are many other genera and species. *Dacrydium cupressinum* is a typical example of a long-lived 'catastrophic regeneration' conifer (Ogden & Stewart in Enright & Hill, eds. 1995).

Conservation

Dacrydium cupressinum is a widespread and common species in New Zealand not considered in danger of extinction at present. However, since nearly all of the primary lowland forests in which it was abundant have been cleared for agriculture, plantation forestry, and urban development within a period of 150 years ending around 1970, this (and other) tree species has undergone a very severe reduction in its area of occupancy (AOO) of at least 70% over "three generations" (even though that reduction has now ceased) and would therefore qualify as Endangered (EN) under IUCN criterion A1. The application of this criterion to New Zealand trees remains controversial, because conservationists in that country take the view that assessments of threat to species should only consider the present and future, not the past.
IUCN: LC

Uses

Rimu or Red pine was, when exploited, the major timber tree in New Zealand as it was ubiquitous throughout the lowlands of the major islands and attained large sizes. The following remark "...wood close grained rather brittle and very durable... next in

estimation to kauri for house building." [Mr Clarke in Alan Cunningham's New Zealand Herbarium, No. 332 (K)] indicates its importance. The wood is reddish brown in colour, often finely figured and very durable and strong. It was used in general construction, for bridges, railway sleepers, fence posts, indoor flooring and panelling, and furniture. The most decoratively figured pieces were reserved for cabinet making. Due to severe depletion of this natural resource, exploitation has been halted and this species is now protected from logging by law. As a slow growing tree it is not considered suitable for plantation forestry and it finds only limited use as an amenity tree in gardens and parks, mainly in New Zealand.

Dacrydium elatum (Roxb.) Wall. *ex* Loudon, Arb. Frut. Brit. 4: 2102. 1838. *Juniperus elata* Roxb., Fl. Ind. 3: 838. 1832. Type: Malaysia: Peninsular Malaysia, Penang Island, Penang Hill, ["native of the Island of Pulo Pinang"], *"Dr. Cantor" s.n.* (holotype K). Fig. 114

Dacrydium pierrei Hickel, Bull. Soc. Dendrol. France 76: 74. 1930. Type: Viet Nam: South Viet Nam, Quan Phu Quoc, *L. Pierre 1396* (lectotype K, designated here).

Etymology

The species epithet *elatum* means 'tall' and refers to the large size some trees can attain.

Vernacular names

kayuru bukit, ru bukit (Malaya); ouk (Borneo); sambinur (?)

Description

Trees of medium to large size, to 40 m tall; trunk to 1 m d.b.h., much branched eventually developing a broadly spreading dense crown, sometimes more or less flat-topped. Bark scaly; outer bark brown to blackish; inner bark pink to red, exuding red resin from slash. Foliage of two types, with juvenile leaves and with adult leaves. Juvenile leaves acicular, on seedlings and saplings very slender, 10–15 × 0.3 mm, shorter and slightly thicker on young trees (especially at base of branchlets), straight or slightly curved forward, spreading at less than 45° from the shoot, keeled on four sides, pungent. Transitional leaves sometimes present, but usually abrupt change to adult leaves. Adult leaves scale-like on slender, cord-like, much branching shoots up to 10 cm long and to 3 mm wide (ultimate branchlets usually 1 mm wide), appressed or rarely free at apex, rhombic to oblong-rhombic, 1–1.5 × 0.3–0.5 mm on ultimate branchlets, larger on leading shoots, keeled abaxially, obtuse or acute with incurved apex. Stomata on all sides (leaves amphistomatic), on juvenile leaves in narrow grooves, on adult leaves in scattered lines, absent on the distal part of the abaxial side, on the adaxial side to apex. Pollen cones terminal on branchlets with adult leaves (sometimes with juvenile leaves), 4–8 × 1.2–1.5 mm at maturity, microsporophylls broad triangular, 1 × 1 mm, acute-apiculate, with two basal reddish pollen sacs, turning brown. Seed cones sometimes among juvenile foliage, but always terminal on branchlets with adult leaves, 3–4 mm long, covered with broadly triangular bract scales 1 × 1 mm, slightly swelling and turning red at maturity. Seeds single, obliquely positioned, 3.5–4.5 mm long, covered only at base by the epimatium and turning lustrous black.

Taxonomic notes

The morphological differences between *Dacrydium pierrei* and *D. elatum* as stated by Hickel (*op. cit.*) and Gaussen (1974) do not exist in the herbarium specimens examined at K from 'Indochina'. Among these are 4 sheets of L. Pierre 1396 specifically mentioned by Hickel for the alledged differences; one of these sheets (Kew barcode K000288637) is here designated as the lectotype of *D. pierrei* Hickel.

Distribution

S China: Guangxi; Indochina: Kampuchea [Cambodia], Lao PDR, Thailand, Viet Nam; Malesia: Borneo (Brunei, Sabah and Sarawak), Philippines, Peninsular Malaysia (including Penang Island), Sumatera (W coast).

TDWG codes: 36 CHS-GX 41 CBD LAO THA VIE 42 BOR-BR BOR-SB BOR-SR PHI MLY-PM SUM

Ecology

Dacrydium elatum occurs in evergreen tropical rainforest from the lowlands up into the mountains at altitudes between 250 m and 2350 m a.s.l. It is often found in wet places such as peat swamp forests intermixed with patches of kerangas forest. In the latter type of vegetation, which occurs on nearly white sandy soil, conifers often dominate in the forest, with *Agathis, Dacrydium* and *Podocarpus* usually present. In more open situations in the border zone between forest and swamp or savannah *D. elatum* is usually growing along streams. It appears to be restricted to acidic soils derived from granite or sandstone, often mixed with organic matter like peat.

Conservation

IUCN: LC

Uses

Dacrydium elatum is probably the main source of 'sempilor' wood in SE Asia, which includes species of *Dacrycarpus, Dacrydium, Falcatifolium* and *Phyllocladus*, between which the timber trade makes no distinction. It is a light and relatively hard wood used in construction, window frames, doors, joinery, furniture, flooring, interior finishing, veneer, and plywood as well as pulp for the paper industry. A volatile oil resembling cedar oil can be distilled from the wood, which is done during the pulping process. This species is cultivated as an ornamental tree, mainly in countries within its natural range.

Dacrydium ericoides de Laub., Fl. Malesiana, ser. 1, 10 (3): 371. 1988. Type: Malaysia: Sarawak, Merurong Plateau, Bukit Skelap, *E. F. Brunig, SFN 8722* (holotype L).

Etymology

The species epithet refers to a supposed similarity with *Ericaceae* (Heather family) or the genus *Erica*.

Vernacular names

sempilor (in the Bintulu dialect, given with the name *D. beccarii* Parl. as the original identification of the type collection)

Description

Trees 10–18 m tall; trunk to 30 cm d.b.h., erect and single-stemmed, branching to form a spreading crown. Bark scaly, brown; inner bark more or less fibrous, reddish. Foliage branches mostly drooping or nearly pendulous, with more or less persistently juvenile type leaves becoming only slightly shorter in the adult form on mature trees. Leaves linear, straight, spreading at almost right angles to shoot except on new growth, 5–10 mm long, 0.7–1 mm wide, 0.2–0.3 mm thick, flattened but becoming slightly concave towards apex, sharply keeled on the abaxial side, with a faint midrib adaxially, narrowing abrubtly at the distal end to an apiculate apex. Stomata in two bands of 6–8 lines on adaxial side from base to apex, only a few near base abaxially (leaves weakly amphistomatic). Pollen cones mostly lateral on foliage branches, subtended by reduced leaves, 7–10 mm long and 2–2.5 mm diam.; microsporophylls triangular, ending in a lanceolate apex ca. 1 mm long, with two basal pollen sacs partly hidden by the base of the microsporophyll. Seed cones mostly below end of foliage branchlets, terminal on very short dwarf shoots with reduced, 2–3 mm long, narrowly triangular leaves; cones 4–5 mm long; cone bracts 3–4 mm long, becoming reddish. Seeds one or two per cone; mature seeds not observed.

Taxonomic notes

De Laubenfels (1988) described this as a new species in his treatment of the conifers in Flora Malesiana, distinguishing it from *D. spathoides* in having longer and straight leaves (as in juvenile plants) even on mature trees. Only the fertile structures (both male and female) have adult type (much reduced) leaves at their base on very short dwarf shoots. The other species in Borneo with juvenile type acicular leaves has curved leaves which are not flat (not wider than

thick) terminating in an acute apex. Only a limited number of herbarium collections are known, now mostly at KEP in Malaysia.

Distribution

Borneo: Sarawak (Mt. Dulit, Bukit Lawi, Bukit Skelap, Gunong Mulu, Gunong Murud).
TDWG codes: 42 BOR-SR

Ecology

This species is locally common in primary mossy forest on exposed mountain ridges between 1000 m and 2200 m a.s.l.

Conservation

This species is only known from five localities, where it is locally common. The type of forest it occurs in and its habitat generally are not prime targets for logging, as the forest quality from that point of view is poor on exposed mountain ridges.
IUCN: LC

Uses

No uses have been recorded of this rare species.

Dacrydium gibbsiae Stapf, J. Linn. Soc., Bot. 42: 192, t. 4. 1914. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N.P., spur above Lobang, *L. S. Gibbs 4162* (holotype K). Fig. 115

Dacrydium beccarii Parl. var. *kinabaluense* Corner, Gard. Bull. Straits Settlem. 10: 244, t. 9. 1939.

Etymology

This species was named after Lilian Suzette Gibbs (1870–1925), who collected and studied the flora of Mt. Kinabalu.

Vernacular names

No vernacular names have been recorded.

Description

Small trees 2–12 m tall, usually monopodial but with low, spreading and assurgent primary branches; foliage branches in dense tufts towards ends of primary branches, forming a flat-topped or domed candelabra crown. Juvenile leaves only on seedlings and saplings, spreading widely or in young trees spreading at 30° forward, covering shoot, 12–18 mm long, 1–1.2 mm wide, straight or slightly curved, keeled abaxially, pungent. Adult leaves robust, directed forward, densely covering shoot, linear to linear-lanceolate, (3–)5–8(–10) mm long, 0.9–1.2 mm wide, sharply keeled abaxially; apex incurved, pungent to apiculate. Stomata mostly on adaxial side in intermittent lines from base to apex on both juvenile and adult leaves, few near base on abaxial side. Pollen cones terminal or on a short lateral branchlet, cylindrical, 20–25 × 4.5–7 mm; microsporophylls lanceolate, 4–5 mm long, 1.5 mm wide at base. Seed cones terminal or often on short lateral branchlets with smaller leaves; bract leaves longer, the upper one subtending the seed nearly equally long as seed and spreading, leaving the seed exposed. Seeds solitary or sometimes in pairs, obliquely positioned, ovoid, 4–5 mm long, covered for basal third by the epimatium, lustrous light brown.

Distribution

Borneo: Sabah (Mt. Kinabalu).
TDWG codes: 42 BOR-SB

Ecology

This species occurs on Mt. Kinabalu from swampy mossy forest at 1500–2000 m a.s.l. to high rocky ridges and slopes up to 3600 m. It is mostly restricted to the serpentine and its ultramafic erosion products where competition from other trees is limited. Below the summit of Mt. Kinabalu it grows as a shrub on granite. The vegetation there is low and more or less open, with other conifers, e.g. *Dacrycarpus imbricatus, Phyllocladus hypophyllus* and *Podocarpus gibbsiae*, and *Myrtaceae*, e.g. *Leptospermum recurvum, Tristaniopsis* spp., *Ericaceae* and various small

oaks (*Quercus*) as codominants. At high altitudes the common ericaceous shrub *Rhododendron ericoides* has an uncanny resemblance to *Dacrydium gibbsiae* until one sees the red tubular flowers. Codominant or common conifers that grow with *D. gibbsiae* at higher altitudes on the mountain are *Phyllocladus hypophyllus, Dacrycarpus kinabaluensis*, and *Podocarpus brevifolius*.

Conservation

Although as far as is known this species is restricted to Mt. Kinabalu, where it is abundant in specific habitats, no decline has been observed. Mount Kinabalu is a National Park which receives many visitors who hike up the mountain, and fire prevention might become an issue if tourism increases. Little is known about the capacity of this species to regenerate after fire.
IUCN: LC

Uses

No uses have been recorded of this species.

Dacrydium gracile de Laub., Fl. Malesiana, ser. 1, 10 (3): 367. 1988, ["*gracilis*"]. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N.P., Silau-Silau trail, *D. J. de Laubenfels P 716* (holotype L). Fig. 116

Etymology

The species epithet refers to the thin, slender (juvenile) leaves.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 40 m tall; trunk to 100 cm d.b.h., usually with a clear bole and with long, tortuous branches, developing a broadly spreading and very open crown, sometimes more or less flat-topped. Bark scaly; outer bark dark brown; inner bark exuding red resin from slash. Foliage of two types, with juvenile leaves and adult leaves markedly differing in length and width. Juvenile leaves remotely set, spreading at 50–90° from shoot, acicular, very slender, 12–20 × 0.3–0.4 mm, curved forward, triangular in cross section, pungent. Adult leaves more densely set, spreading at 30–45° forward, closer to shoot on leading branches, acicular, slightly to strongly curved forward, (3–)4–6(–8) × 0.4–0.5(–0.7) mm, triangular in cross-section and slightly wider than thick, weakly keeled abaxially, apiculate, dark green, flushing light green. Stomata on all sides (leaves amphistomatic), in 1–3 intermittent lines on each face to apex. Pollen cones terminal or lateral on branchlets with adult leaves, 6–7 × 2 mm at maturity; microsporophylls 0.7 mm wide at base, with extended narrow apex 0.6–1 mm long, with two basal pollen sacs, turning brown. Seed cones mostly below ends of foliage branches with adult leaves, terminal on dwarf shoots, subtended by shorter involucral leaves, covered with bracts 2–3 mm long and reaching to base of seed, turning reddish at maturity. Seeds usually single, obliquely positioned, 3–3.5 mm long, covered for the basal half by the epimatium and turning lustrous dark brown to black.

Distribution

Borneo: Sabah (Mt. Kinabalu and vicinity), one locality in Sarawak.
TDWG codes: 42 BOR-SB BOR-SR

Ecology

Dacrydium gracile is a tree occurring scattered in lower montane rainforest, at altitudes between 950 m and 1800 m a.s.l. It is usually associated with the conifers *Agathis borneeensis, Podocarpus laubenfelsii, Sundacarpus amarus, Falcatifolium falciforme, Nageia wallichiana*, and *Dacrycarpus imbricatus* on soils poor in nutrients (kerangas forest); in Sarawak it occurs in low canopy 'heath' forest on sandstone.

Conservation

This species is quite rare and occurs as individual trees in primary forest. Most herbarium collections are from Mt. Kinabalu and vicinity (partly in Mt. Kinabalu National Park) and the disjunct locality in Sarawak (in a different habitat) could indicate that it is more widespread than currently known. With

the present knowledge its area of occupancy (AOO) is certainly less than 20 km² but the total number of mature individuals is unknown.
IUCN: VU (D2)

Uses

No uses have been recorded of this species; it can be assumed to be of value for its timber like other species in the genus that grow into tall forest trees. Its protected status within Mt. Kinabalu National Park makes exploitation at least of these trees unlikely; outside this protected area it may be logged.

Dacrydium guillauminii J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 282. 1949. Type: New Caledonia: Grande Terre, Province Sud, Chûtes de la Madeleine, *J. T. Buchholz 1728* (holotype ILL).
Fig. 117

Etymology

This species is named after the French botanist André Guillaumin (1885–1974).

Vernacular names

No vernacular name has been recorded for this species.

Description

Slender shrubs or dwarf trees to 2.5 m tall; stem thickened at base, often sparsely branched. Bark rough, with horizontal stripes and large lenticels, breaking into small scaly plates, brown weathering blackish grey; inner bark fibrous, red-brown. Branches spreading and ascending, with foliage branches upright and tufted near ends. Leaves permanently of the juvenile type, densely covering branches, acicular, curved forward or sometimes curved near base only, (10–)13–15(–17) × 1 mm, transverse triangular in cross-section, pungent. Stomata in 2–5 intermittent lines on all three sides (higherst number of lines on adaxial side) from base to apex. Pollen cones both terminal and lateral; terminal cones 8–15 mm long and 4 mm wide when expanded; lateral cones at base of a terminal cone and smaller. Microsporophylls 4–5 mm long near base of cone, with a greatly elongated acicular apex, gradually shortening towards cone apex to 1–2 mm; pollen sacs 2, partly hidden by the curved basal part of the microsporophyll. Seed cones terminal on long or short foliage shoots, 8–10 mm long, hidden by leaves. Seeds 1–5 per cone, proximally covered for a third to half by the epimatium and subtended by bracts; bracts long, leaf-like, much exceeding the seed; seeds ovoid-oblong, 4–5 × 2.5 mm, brown, with a constricted apex.

Distribution

New Caledonia (Grand Lac, Lac en Huit, Rivière des Lacs).
TDWG codes: 60 NWC

Ecology

Dacrydium guillauminii is a strictly riparian species growing on the banks and shores of streams and small lakes that are frequently flooded; its seeds germinate in water-logged soil. The Plaine des Lacs is a basin where small rivers and shallow lakes drain ultramafic laterite soils and eroded serpentine hills, and the water after heavy rains is often of a milky colour (one locality is on the aptly named Pernod Creek). This species does not occur above the high water line. The altitudinal range is 150–275 m a.s.l. It is commonly associated with *Retrophyllum minus*, another podocarp restricted to this habitat. Just meters away where the ground rises, the 'maquis minier' vegetation dominates; consequently the niche of this species is (literally) very narrow.

Conservation

The extreme rarity of this species and its very restricted habitat alone put this species at risk of extinction. The 2–3 populations are fragmented due to the very local presence of its habitat; changes in the water regime (e.g. by pollution or diversion of streams caused by mining operations upstream) could destroy these. Although one population is protected in the Chûtes de la Madeleine Botanical Reserve, the others are unprotected and on land under mining concessions (not actively mined at present). The species is very sensitive to fire and numbers of individuals have declined, probably as a result of increased tourism; restoration of habitats

in the reserve is now being undertaken after tourism became better regulated.
IUCN: CR [B1ab(iii)+2ab(iii);C2a(i)]

Uses

There are no recorded uses of this species and (except in a few botanical collections) it is not in cultivation.

Dacrydium leptophyllum (Wasscher) de Laub. *ex* Silba, Phytologia Mem. 7: 27. 1984. *Podocarpus leptophyllus* Wasscher, Blumea 4 (3): 414. 1941; *Dacrycarpus leptophyllus* (Wasscher) Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 20): 150 (*nom. inval.*, Art. 33.4). 1974; *Bracteocarpus leptophyllus* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: Indonesia: Papua, Pegunungan Maoke, Mt. Goliath, *A. C. de Kock 39* (holotype BO).

Etymology

The species epithet (Greek *lepto* = slender, thin, narrow) means 'with slender leaves'.

Vernacular names

No common names are known for this rare species.

Description

Shrubs or trees [habit remained undescribed in the protologue and subsequent treatments and has not been observed by the author] with very slender ultimate foliage branchlets (0.25–0.4 mm diam.), including the leaves 1–2.5 mm diam.. Leaves acicular, spreading from base but abruptly bent forward below the middle parallel to the filiform branchlet or even curved inward, on ultimate branchlets 1–1.5 mm long, 0.2–0.4 mm wide, 0.1 mm thick, subulate, transverse-triangular, sharply keeled abaxially, flat or slightly concave on adaxial side, finely acuminate; leaves on leading (older) branches adpressed, narrowly triangular, 2–3 mm long and 0.6–0.7 mm wide near base, dorsiventrally flattened, weakly keeled on the abaxial side, acute-pungent. Fertile material (pollen cones and seed cones) remaining unobserved.

Taxonomic notes

This species is imperfectly known taxonomically as no fertile material has ever been collected. Originally described as *Podocarpus leptophyllus* by Wasscher (*op. cit.*) and transferred to *Dacrycarpus* by Gaussen, it was finally settled in the genus *Dacrydium* by De Laubenfels, where it undoubtedly belongs. The combination under *Dacrydium* was first validly published by Silba as cited above. Wasscher was uncertain of its placement for want of "flowers and fruits" and suggested it could belong in *Dacrydium*, but he unfortunately chose the wrong genus (which was then treated in a much wider sense than at present). This remains a poorly known species of which few if any specimens other than the type are identified.

Distribution

New Guinea: Papua (Mt. Goliath).
TDWG codes: 43 NWG-IJ

Ecology

Mossy heath forest.

Conservation

Only known from one location on a mountain summit. First described as *Podocarpus leptophyllus* by Wasscher (*op. cit.*), based on a herbarium collection made in 1911 and not recorded from other localities since. Population size unknown, but likely fewer than 1000 mature trees; no evidence of decline, but obviously at some risk if this locality became subject to environmental changes detrimental to this species.
IUCN: VU (D1, 2)

Uses

There are no uses recorded of this species.

Dacrydium lycopodioides Brongn. & Gris, Bull. Soc. Bot. France 16: 329. 1869. Type: New Caledonia: Grande Terre, Province Sud, Mt. Mou, *J. A. I. Pancher s.n.* (holotype P).

Etymology

The species epithet refers to similarity of the foliage branches with *Lycopodium*, a genus of clubmoss common in New Caledonia.

Vernacular names

No vernacular name is known for this species.

Description

Trees to 25 m tall; trunk d.b.h. to 50 cm, erect, in forest forming a clear bole; crown spreading, dense and rounded in old trees. Bark scaly with small flakes, brown, weathering grey; inner bark more or less fibrous and light brown. Foliage in much branched tufts, spreading to erect in mature trees. Leaves on seedlings and juvenile trees acicular, 7–10 mm long, 0.2–0.3 mm wide and thick, spreading at ca. 45° from shoot, slightly curved forward to nearly straight, triangular in cross section, pungent. Adult leaves shorter and gradually changing from juvenile leaves, spirally arranged and spreading at 30–40°, curved forward above base, linear-lanceolate, (2–)3–5(–6) mm long, 0.6–0.8 mm wide just above base and 0.3–0.4 mm thick, keeled sharply on abaxial side, gradually tapering to a pungent apex. Stomata on all sides (leaves amphistomatic), but extending to distal part of leaf only on adaxial side, in a few intermittent rows separated by the keel and by a midrib on the adaxial side. Pollen cones terminal or lateral below a terminal cone, 4–7 × 1.2 mm when mature; microsporophylls narrowly triangular, keeled abaxially, tapering to an acute apex, with two basal pollen sacs. Seed cones terminal, often on dwarfed shoots, 2–3 mm long, subtended by short (1–2 mm) leaves followed by longer (2–3 mm) flattened cone bracts surrounding the basal epimatium, becoming swollen and red at base. Seeds single, covered for only the basal third or less by the epimatium, 3.5–4 mm long, ovoid but slightly flattened, lustrous brown.

Distribution

New Caledonia: Grande Terre, Province Sud.
TDWG codes: 60 NWC

Ecology

Dacrydium lycopodioides is an uncommon tree in montane forest on serpentine, occurring in a few sheltered ravine forests or hollows which have escaped the ravages of fire in the surrounding landscape. These forest pockets are naturally less prone to burn than the drier woodland and 'maquis minier', but are not absolutely safe from forest fires. This species also occurs on moist mountain slopes and ridges (e.g. Mt. Mou) where fires are infrequent. Here its stature becomes more stunted to 5–10 m as it occurs towards the summit area at around 1000–1200 m a.s.l. in association with the conifers *Araucaria humboldtensis, A. laubenfelsii* (emergents), *Falcatifolium taxoides*, and *Prumnopitys ferruginoides* in low forest with numerous angiosperms among which species of the *Myrtaceae* are dominant.

Conservation

This species is known from several herbarium collections made over a period of more than 150 years, some of which are without locality data. The localities recorded are Mt. Mou, Mt. Dzumac, Mt. Nakada, Mt. Humboldt, and a mountain ridge above the Ouinné River; it was most frequently collected from Mt. Mou. This may partly be due to relative ease of access of the latter mountain and it may occur elsewhere in the mountains of the SE part of Grande Terre. It is obviously a relatively rare species, but it is not at risk at present, thanks to the relatively undisturbed mountain ravines in which it occurs.
IUCN: NT

Uses

No commercial or other uses are recorded of this rare species.

Dacrydium magnum de Laub., J. Arnold Arbor. 50: 299. 1969. Type: Indonesia: Maluku, Obi, *G. A. L. de Haan bb 23.806* (holotype L).

Dacrydium beccarii Parl. var. *rudens* de Laub., J. Arnold Arbor. 50: 303. 1969.

Etymology

The species epithet means 'large' and was presumably given for its relatively large pollen cones.

Vernacular names

No common names are recorded for this species.

Description

Trees to 30 m tall; trunk d.b.h. to 60 cm, monopodial, crown compact, densely branched. Bark scaly, reddish brown; inner bark pinkish or reddish. Primary branches spreading and ascending, terminating with dense tufts of upright foliage branches. Juvenile leaves spreading widely, similar to adult leaves but longer, to 20 mm, acicular, slightly curved, triangular in cross section, keeled abaxially, 0.4–0.5 mm wide; apex pungent. Adult leaves slightly spreading but strongly directed forward on shoot and more or less imbricate, short acicular, (2–)3–5(–6) × 0.3–0.4 mm, mostly uniform on a shoot, curved with apex turning back to the shoot (making it possible to strike a finger tip backwards over a foliage branchlet), triangular in cross section, keeled abaxially, apiculate. Stomata on all sides (leaves amphistomatic) but more numerous on the adaxial side, in intermittent lines to apex. Pollen cones terminal on foliage branchlets, 10–16 × 2–2.5 mm. Microsporophylls with elongated and strongly incurved apex and two basal pollen sacs. Seed cones terminal, ca. 3 mm long, subtended by leaves similar in length and shape to adult leaves; the cone bracts longer, 6–8 mm, spreading or curved inward partly covering the seed. Seeds solitary or in pairs, obliquely positioned, covered for basal third by the epimatium, 4–5 mm long, ovoid, brown.

Taxonomic notes

This species is quite similar in its botanical characters to *D. medium*, described by the same author from Malaya. Rather subtle differences in the adult foliage leaves lead however to a different appearance of branchlets; the pollen cones of *D. magnum* are longer and the two species occupy different habitats, leading to greater tree size in *D. magnum*. The fact that the distributions of the two species do not overlap is in the Malesian Archipelago of less significance; disjunct distribution in this genus within species and even varieties is rather commonplace, as it is among other conifers.

Distribution

Malesia: Maluku [Moluccas] (Obi Island); Papuasia: Louisiades Archipelago (Tagula Island), D'Entrecasteaux Islands (Normanby Island); Solomon Islands (Choiseul).
TDWG codes: 42 MOL 43 NWG-PNSOL-SO

Ecology

Dacrydium magnum is a canopy tree in tropical rainforest at altitudes between 60 m and 1200 m a.s.l.; on ridges of mountains it can become the dominant forest tree. On exposed sites it becomes more stunted, but not a low shrub.

Conservation

The conservation status of this species is difficult to assess due to its wide and scattered distribution. It is known from islands west and east of New Guinea but not from New Guinea itself. It is undoubtedly a rare species which may well turn up in collections made in New Guinea already or to be made in future. Due to the possibly wider distribution than presently known, but at the same time the likelihood of exploitation along with other species of *Podocarpaceae* from which loggers will not distinguish it, it is here listed as Near Threatened.
IUCN: NT

Uses

No uses have been recorded for this species.

Dacrydium medium de Laub., Blumea 23 (1): 98. 1976. Type: Malaysia: Peninsular Malaysia, Pahang, Gunung Tahan, *D. J. de Laubenfels P 540* (holotype L).

Dacrydium beccarii Parl. var. *subelatum* Corner, Gard. Bull. Straits Settlem. 10: 243, t. 7. 1939.

Etymology

The species epithet describes it as being intermediate (midway between) two other species.

Vernacular names

sangu (Gajo Lands, Sumatera)

Description

Shrubs or small, often gnarled trees to 4–6 m tall, some trees in forest to 20 m, crown compact, densely branched. Bark scaly, brown. Primary branches spreading and ascending, terminating with dense tufts of upright foliage branches. Juvenile leaves spreading, acicular, similar to adult leaves but longer, 10–20 mm, slightly curved, transverse-triangular in cross section, keeled abaxially, 0.5–0.6 mm wide; apex pungent. Adult leaves spreading slightly, directed forward on shoot and more or less imbricate on leading shoots, acicular, (2–)4–6(–10) × 0.5–0.6 mm, mostly uniform on a shoot, nearly straight with incurved apex, on older plants up to 6 mm long, more strongly curved inward, triangular in cross section, keeled abaxially, apiculate. Stomata on all sides (leaves amphistomatic) but more numerous on adaxial side, in intermittent lines to apex. Pollen cones terminal on foliage branchlets, 7–9 × 2.5 mm; microsporophylls with elongated and strongly incurved apex and two basal pollen sacs. Seed cones mostly terminal, ca. 3 mm long, subtended by shorter leaves to 2 mm long; cone bracts longer, 3–5 mm long, spreading or curved inward partly covering the seed, flattened and turning reddish at maturity. Seeds solitary, obliquely positioned, covered for basal third by the epimatium, 4–5 mm long, ovoid, brown to black.

Distribution

Malesia: Peninsular Malaysia, N Sumatera.
TDWG codes: 42 MLY-PM SUM

Ecology

Dacrydium medium occurs mostly on mountain summits and ridges in low, scrubby vegetation on poor soils that will not support forests. The soils in these places are often very shallow and rocky. The altitudes of these sites vary between 1050 m and 2600 m a.s.l. The conifers are either shrubs themselves or small trees rising above the general vegetation, in which *Myrtaceae* (e.g. *Baeckea* and *Leptospermum*) are most common. More rarely scattered individuals occur in forest below the mountain ridges where they may grow taller to keep their crowns in or above the canopy as they are light demanding.

Conservation

General deforestation and fragmented distribution threaten this species, which is declining especially in unprotected areas.
IUCN: VU [B2ab (ii–v)]

Uses

No uses are recorded of this species.

Dacrydium nausoriense de Laub., J. Arnold Arbor. 50: 287. 1969, ["*nausoriensis*"]. Type: Fiji: Viti Levu, Navosa, Nausori Highlands, 6.5 km SE of Nausori, *D. J. de Laubenfels P 302* (holotype A).

Etymology

The species epithet refers to the Nausori Highlands on the island of Viti Levu from where this species was described.

Vernacular names

yaka, tangitangi (Fijian)

Description

Trees of medium size, to 25 m tall; trunk to 50 cm d.b.h., much branched eventually developing a broadly spreading domed crown. Bark scaly with large flakes; outer bark brown weathering grey; inner bark pink to reddish. Foliage of two types, with juvenile leaves and with adult leaves. Juvenile leaves acicular, on seedlings and saplings very slender, 10–15 × 0.3 mm, shorter and slightly thicker on young trees, straight or slightly curved forward, spreading at more than 45° from shoot, keeled on four sides, pungent. Transitional leaves present on saplings, 3–5 mm long, spreading at ca. 45°. Adult leaves on numerous slender, much branching shoots, decurrent at base, spreading out and forward at ca. 30° from shoot, short acicular, 1–1.5 mm long and 0.3–0.4 mm wide (on leading branches slightly larger), keeled abaxially, obtuse or sometimes acute with incurved apex. Stomata on all sides (leaves amphistomatic), on juvenile leaves in narrow grooves, on adult leaves in a few scattered lines, absent on the distal part of the abaxial side, on the adaxial side to apex. Pollen cones terminal or lateral on branchlets with adult leaves, 4–6 × 1–1.2 mm at maturity, microsporophylls triangular, 1 × 0.7 mm, acute-apiculate, with two basal pollen sacs. Seed cones terminal on long or very short branchlets with adult leaves, ca. 3 mm long, with distal bracts 2 mm long, slightly swelling and turning red at maturity. Seeds solitary, free from leaves, obliquely positioned, covered for basal third by the epimatium, ovoid, 3.5–4 mm long, turning lustrous brown.

Distribution

Fiji (Vanua Levu, Viti Levu).
TDWG codes: 60 FIJ

Ecology

Dacrydium nausoriense is a canopy tree in more or less open montane rainforest (annual rainfall ca. 3000 mm) and fairly common on the plateaux and summits of the Nausori Highlands. It is associated with *Dacrycarpus imbricatus* and *Podocarpus nerifolius* var. *degeneri* and with numerous angiosperm trees and shrubs.

Conservation

This species exists in small stands in remnants of rainforest and is exploited for its timber. Much of this forest is privately owned or on tribal land or both and there are no forest reserves where this species is being protected. It is mostly known from the Nausori Highlands but other localities have been found, one of them on Vanua Levu. Much of the former rainforest which was the habitat of this species has been converted to agriculture or pasture, especially in more densely settled areas. Regeneration is slow and does not appear to be adequate; this podocarp probably needs periodic disturbance by fire to spread from seed, but too frequent fires destroy that opportunity.
IUCN: EN [B2ab (iii)]

Uses

Considered a highly valuable timber tree in Fiji (graded Class I), this species is used in construction and all kinds of carpentry work.

Dacrydium nidulum de Laub., J. Arnold Arbor. 50: 292. 1969. Type: Indonesia: Papua, Jazirah Doberai, Lake Aja-Maroe, W side of lake ["Segior"], *W. Vink & M. Vink BW 15271* (holotype L).

Etymology

The species epithet is derived from Latin *nidus* (= nest) and refers to the 'nesting' of the growing seed cone within its elongated leaf-like bracts.

Vernacular names

yaka (Fijian)

Description

Trees to 30 m tall, monopodial and erect; trunk d.b.h. to 70 cm or rarely more, usually with a clear bole; crown spreading, dense and rounded in old trees. Bark irregularly fissured, scaly, dark brown, weathering grey; inner bark slightly fibrous and red-brown. Foliage in much branched tufts, drooping to spreading in mature trees. Leaves on seedlings and juvenile

trees long acicular, 10–20 mm long, 0.2–0.3 mm wide and thick, spreading widely, slightly curved to nearly straight, triangular in cross section, pungent. Adult leaves much shorter but variable in length between trees and within trees, spirally arranged and decurrent at base, short acicular, (1.5–)3–5(–7) mm long, 0.3–0.7 mm wide and 0.3–0.4 mm thick, keeled sharply on abaxial side, spreading at 30–45°, slightly curved or nearly straight but with an incurved, obtuse to short apiculate apex. Intermediate forms of leaves occur on younger trees. Stomata on all sides (leaves amphistomatic), but extending to apex only on the adaxial side, in several intermittent rows. Pollen cones terminal or lateral, ca. 4 × 2 mm when immature, elongating to 18 mm; microsporophylls triangular, 1.2 × 0.8 mm, keeled abaxially, apiculate, with two basal pollen sacs. Seed cones terminal, 2–3 mm long, subtended by short (1.5–2 mm) leaves, followed by longer (3–5 mm) cone bracts surrounding the epimatium, becoming swollen and red at base. Seeds solitary, covered for only the basal third or less by the epimatium, 3.5–4 mm long, lustrous brown.

Taxonomic notes

This species is very similar to *Dacrydium lycopodioides* of New Caledonia, but differes in having much longer pollen cones and non-flattened bracts, which encase the growing seed cone as if in a nest.

Distribution

Malesia: Maluku [Moluccas] (Halmaheira), Sulawesi; Papuasia: D'Entrecasteaux Islands, Louisiades Archipelago, New Guinea; SW Pacific: Fiji.
TDWG codes: 42 MOL SUL 43 NWG-IJ NWG-PN 60 FIJ

Ecology

Dacrydium nidulum is a canopy tree of mostly lowland tropical rainforest, from 10 m to 750 m above sea level and rarely above 1200 m. It often occurs along rivers or on lake shores and regenerates well in secondary forest after disturbances. It is found on soils over limestone as well as acidic types of rock. In a few locations it has been observed in bogs on peat at higher altitudes to 2300 m a.s.l.

Conservation

IUCN: LC

Uses

In Fiji, where this species (and *D. nausoriense*, not distinguished by loggers) is considered a very valuable timber tree, it is used mainly for construction and carpentry such as furniture making.

Dacrydium novoguineense Gibbs, Contr. Phytogeogr. & Fl. Arfak Mts.: 78. 1917. Type: Indonesia: Papua, Arfak Mts., Koebre Ridge, *L. S. Gibbs 5648* (lectotype BM).

Etymology

The species epithet refers to its occurrence in New Guinea.

Vernacular names

kaowié, kowié, aru, munump (New Guinea, various languages)

Description

Trees of small to large size, to 30 m tall; trunk to 50 cm d.b.h., much branched eventually developing a broadly spreading domed crown, sometimes more or less flat-topped. Bark scaly; outer bark brown to blackish; inner bark reddish, slightly resinous. Foliage of two types, with juvenile leaves and with adult leaves. Juvenile leaves acicular, on seedlings and saplings 5–12 × 0.4–0.6 mm, shorter on young trees (especially at base of branchlets), curved forward, spreading at less than 45° from the shoot, strongly keeled abaxially, pungent. Transitional leaves sometimes present on mature trees, but usually abruptly changing to adult leaves, also present on saplings less than 1 m tall. Adult leaves scale-like on slender, cord-like, much branching shoots 2–7 cm long and 0.8–2.3 mm wide (ultimate branchlets variable in width, thread-like or more robust), appressed, oblong-rhombic, 1.3–2 × 0.3–0.5 mm on ultimate branchlets, slightly larger on leading shoots, rounded or keeled abaxially, obtuse or acute with

incurved apex. Stomata on all sides (leaves amphistomatic), on juvenile leaves in narrow grooves, on adult leaves in scattered lines, mainly on adaxial side. Pollen cones terminal on branchlets with adult leaves (sometimes with transitional leaves), 5–8 × 1.5 mm at maturity; microsporophylls triangular, 1.2 × 1 mm, obtuse or apiculate, with two basal reddish pollen sacs, turning brown. Seed cones terminal on branchlets with adult leaves, 3 mm long, covered with elongated bracts to 3 mm long, turning red at maturity. Seeds solitary, obliquely positioned, covered only at base by the epimatium, 4–5 mm long, turning dark brown.

Distribution

New Guinea, Moluccas, Sulawesi.
TDWG codes: 42 MOL SUL 43 NWG-IJ NWG-PN

Ecology

Dacrydium novo-guineense is very common in New Guinea, where it forms a canopy tree in open forest especially on mountain ridges. In forests at middle altitudes (1300–2200 m) it is an emergent above the general canopy, but higher up on ridges it becomes a small tree among other scrub and tree ferns. It often regenerates abundantly after disturbance by fire, when it can become temporarily dominant. This species is indifferent to soil types and occurs on clay, sand, quartzite and other rock debris as well as on peat. The altitude range of this species is very large, from 50 m to 3000 m according to data from herbarium labels.

Conservation

IUCN: LC

Uses

The timber of this species is used for building and the bark for insulation of the walls of traditional houses in the highlands of New Guinea.

Dacrydium pectinatum de Laub., J. Arnold Arbor. 50: 289. 1969. Type: Malaysia: Sabah, Beaufort District, Sandakan, *D. I. Nicholson SAN 17292* (holotype A).

Dacrydium pectinatum de Laub. var. *robustum* de Laub., J. Arnold Arbor. 50: 291. 1969.

Etymology

The species epithet refers to the spreading (pectinate) arrangement of the foliage leaves.

Vernacular names

malur, melur, sempilor, tjemantan (different parts of Borneo); lokinay (Philippines); lu jun song (Chinese).

Description

Small to medium size trees to 20 m, rarely to 40 m tall; trunk d.b.h. to 1.5 m or rarely more; crown spreading, dense and rounded in old trees. Bark brown, weathering grey, peeling profusely in broad, loose brown strips. Foliage in much branched tufts, drooping to more or less erect on mature trees. Leaves on seedlings and juvenile trees long acicular, 10–20 mm long, 0.2–0.4 mm wide and thick, slightly curved, abaxially keeled, pungent. Adult leaves much shorter but variable in length between trees and within trees, linear, (1.5–)3–5(–7) mm long, 0.4–0.8 mm wide and thick, keeled sharply on abaxial side, spirally arranged and decurrent at base where they are imbricate, spreading at 30–45°, slightly curved or nearly straight but with an incurved, obtuse to short apiculate apex. Intermediate forms of leaves present on younger trees. Stomata on all sides (leaves amphistomatic), but extending to apex only on adaxial side, in several intermittent rows. Pollen cones terminal, ca. 4 × 2 mm when immature, elongating to 12 mm; microsporophylls narrowly triangular, 1.5 × 0.5 mm, keeled abaxially, apiculate, with two basal pollen sacs. Seed cones terminal, subtended by short leaves followed by slightly longer (2–3 mm) cone bracts, becoming swollen and red. Seeds single, covered for only the basal third or less by the epimatium, ovoid, 4–5 × 3 mm, chestnut to lustrous dark brown.

Taxonomic notes

This species resembles the lowland form of *D. nidulum*, but differs from it by its more robust leaves and by the fully exposed mature seed. The length of leaves in mature trees is influenced by environmental conditions, with shorter leaves associated with more adverse environments such as peat bogs.

Distribution

China: Hainan; Malesia: Borneo (including Karimata and Serutu Islands), Philippines, Sumatera: Pulau Bangka and Pulau Belitung.
TDWG codes: 36 CHH 42 BOR-BR BOR-KA BOR-SB BOR-SR PHI SUM

Ecology

Dacrydium pectinatum is a species of lowland to montane rainforests, where it occurs as scattered individual trees at altitudes from near sea level to 1500 m a.s.l.; above 600–800 m trees become scarce. More dense stands or even pure stands of this species are restricted to nutrient-poor soils like shallow, leached sands or to swamps with peat formation above the water table. The forest on nutrient-poor sandy soils are known as kerangas and the poorest sites may only support 'heath forest' dominated by this conifer and *Gymnostoma* (*Casuarinaceae*) which looks in habit like a conifer. In Sabah *D. pectinatum* may occur on ultrabasic soils supporting an open, low vegetation of shrubs and ferns, where trees remain small.

Conservation

Deforestation especially in relation to expanding oil palm plantations poses a serious threat and has fragmented remaining populations.
IUCN: EN [B2ab (iii)]

Uses

No uses have been recorded for this species.

Dacrydium spathoides de Laub., J. Arnold Arbor. 50: 299. 1969. Type: Indonesia: Papua, Pegunungan Maoke, Idenburg River, 18 km SW of Bernhard Camp, *L. J. Brass 12659* (holotype A).

Etymology

The species epithet refers to the shape of the adult leaf resembling a spathe (as in palms) with its concave adaxial side.

Vernacular names

No common names have been recorded for this species.

Description

Trees 25–35 m tall; trunk monopodial, erect, to 50 cm d.b.h. Bark scaly, brown weathering grey; inner bark reddish and exuding red sap. Crown spreading above a clear bole in canopy forest. Juvenile and adult leaves similar, mainly differing in size and with a gradual transition. Juvenile leaves flattened acicular, spreading at ca. 60°, 5–7 mm long, 1 mm wide and 0.2–0.3 mm thick, straight or slightly curved forward at the pungent apex, keeled on abaxial side, slightly concave on adaxial side. Adult leaves linear-lanceolate, spreading at ca. 45°, 2–4 mm long, 0.8–0.9 mm wide and 0.2–0.3 mm thick, straight or slightly curved forward at apiculate apex, keeled abaxially, distinctly concave adaxially. Stomata on both sides (leaves amphistomatic) but more abundant on the adaxial side where lines extend to apex. Pollen cones not observed. Seed cones terminal, often on a small lateral shoot, 2–3 mm long, subtended by reduced leaves less than 2 mm long; cone bracts slightly spreading, straight, up to 3 mm long and 0.5 mm wide, covering the basal epimatium of the seed when mature. Seeds solitary or in pairs, at oblique angle to cone or shoot apex, ovoid, slightly flattened, ca. 4 mm long, brown.

Taxonomic notes

De Laubenfels (1969), when first describing this new species, included collections from Borneo (Sarawak)

in it, but later, in Flora Malesiana (De Laubenfels, 1988) he had concluded that these belong to *Dacrydium ericoides* (*E. F. Brunig SFN 8722*, type). The latter species has longer and slightly wider, straight and distinctly flattened leaves narrowing abruptly to an apiculate apex. Hence *D. spathoides*, as far as is known, is restricted to one locality in New Guinea.

Distribution

New Guinea: Papua (Central Highlands, Idenburg River drainage).
TDWG codes: 43 NWG-IJ

Ecology

Dacrydium spathoides is known from a single locality on the Idenberg River where it forms a canopy tree in moist, mossy montane rain forest at an altitude of 2150–2200 m a.s.l.

Conservation

This species is known from only one locality including its type specimen, but due to poor collecting records from the area nothing can be concluded from this as to rarity, population size etc. The fact that is has been described in 1969 and no subsequent collections were made is due to its obscurity as a species, which is not commonly known to botanists who might visit the area. Rather than maintain it as DD, the Conifer Specialist Group believes this species should be flagged as NT as it is surely very rare and restricted. As a canopy tree in rain forest it may be subject to logging.
IUCN: NT

Uses

The timber of this tree is possibly used for construction (house building), but its very localized occurrence means that no specific data are available.

Dacrydium* ×*suprinii Nimsch, Feddes Repert. 118 (1–2): 52. 2007. Type: New Caledonia: Grande Terre, Province Sud, Chûtes de la Madeleine, 100 m downstream from waterfall, *H. Nimsch 5122* (holotype B).

Etymology

This hybrid species was named after Bernard Suprin, a French resident botanist with intimate knowledge of the New Caledonian flora.

Vernacular names

No common names are known for this species.

Description

Small shrub-like tree 2–4 m tall. Branches in mature plants in pseudo-whorls of a few first order branches only, spreading and ascending to form a candelabra crown with tufts of foliage branches. Leaves have characters intermediate between *D. araucarioides* and *D. guillauminii*; juvenile leaves 10–15 mm long, 0.8–1 mm wide, adult leaves densely arranged, 5–10 mm long, ca. 1 mm wide, rhombic in cross-section, partly imbricate but free at least towards apex, narrowly lanceolate with a wide base, gradually tapering towards the acute-acuminate but non-pungent apex. Stomata few near base on abaxial (lower) face and in two lateral lines from base to apex on the adaxial side. Pollen cones both terminal and lateral, 10–16 mm long and 4–5 mm wide when expanded; lateral cones at base of a terminal cone and smaller. Microsporophylls with a greatly elongated acicular apex 4–5 mm long near base of cone, gradually shortening towards cone apex to 1–2 mm; pollen sacs 2, partly hidden by curved basal part of microsporophyll. Seed cones terminal on long or short foliage shoots, ca. 6 mm long, hidden by leaves. Seeds 1–2 per cone, proximally covered for half or more by the epimatium and subtended by bracts; bracts leaf-like, long, exceeding the seed; seeds ovoid-oblong, 3–4 × 2 mm, with a constricted apex, brown.

Taxonomic notes

Plants with foliage characters intermediate between those of *Dacrydium araucarioides* and *D. guillau-*

minii were first noted in 1994 by Bernard Suprin in the area of the Chûtes de la Madeleine along the Rivière des Lacs. These plants were observed there in subsequent years, but rarely collected. A study by Knopf *et al.* (2007) investigating both macro- and micromorphology concluded that these plants are a fixed hybrid species originating from these two species, with *D. guillauminii* as the putative female parent. Investigations into the DNA of all three taxa would be required to test the hybrid hypothesis, but the morphological evidence, together with its close proximity to the maternal parent, are strongly supportive of it.

Distribution

New Caledonia (Grand Lac, Rivière des Lacs).
TDWG codes: 60 NWC

Ecology

Dacrydium ×*suprinii* is a semi-riparian species growing on the banks and shores of streams and small lakes that are frequently flooded; however, unlike one of its parents, *D. guillauminii*, it may be found on slightly drier ground in the transition to low gallery forest along the river. It is commonly associated with *D. guillauminii*, while the other parent, *D. araucarioides*, occupies higher and drier ground in 'maquis minier' and low gallery forest, a small distance away from the water line.

Conservation

This hybrid taxon is very rare and so far only known from three localities in the drainage of the Rivière des Lacs, within 15 km from each other. Its distribution coincides closely with one of the parent species, *D. guillauminii*, but far fewer individuals appear to exist of the hybrid. The female parent species (*D. guillauminii*) is considered Critically Endangered (CR) on the IUCN Red List. At present, only one of the three localities is within a nature reserve: the Chûtes de la Madeleine Botanical Reserve. This reserve is surrounded by land under mining concessions for nickel; however, no operations are carried out at the present time.
IUCN: NE

Uses

No uses are recorded of this species and it is not known to be in cultivation.

Dacrydium xanthandrum Pilg., Bot. Jahrb. Syst. 69: 252. 1938. Type: Papua New Guinea: Morobe, Ogeramnang, *M. S. Clemens 4504* (lectotype A). Fig. 118, 119

Etymology

The species epithet is a composite word with Greek *xantho-* = yellow and *-andrus* = male; it describes the colour of the pollen cones.

Vernacular names

kerapui (Sabah); arun gunong (Sumatera, Aceh); hinubayan (Philippines)

Description

Trees to 35 m tall, sometimes shrubs; trunk of trees monopodial, to 80 cm d.b.h. Bark scaly and flaking; outer bark dark brown; inner bark red-brown exuding red resin. Branches spreading or assurgent and foliage branches numerous, spreading or drooping, forming a dense, rounded crown. Juvenile leaves and adult leaves very similar; juvenile leaves spreading perpendicular to branch or curved forward from base, to 20 mm long and 0.8–1 mm wide, strongly keeled abaxially, ca. 0.2 mm thick without keel, narrowly acute. Adult leaves short decurrent, crowded but spreading perpendicular to shoot or at least at a wide angle, curving forward or nearly straight, (5–)7–10(–13) mm long, 0.5–0.8 mm wide, slightly flattened with a sharp abaxial keel and a narrow adaxial midrib, distally tapering to a pungent apex. Stomata on both sides (leaves amphistomatic), but in several lines on either side of midrib on adaxial side and only few on abaxial side near base. Pollen cones lateral or terminal on foliage branches, subtended by a few short leaves ca. 2 mm long, 6–13 × 2–2.5 mm; microsporophylls extended into a curved, rostrate apex, 1.5–2 mm long, yellow with two reddish basal pollen sacs. Seed cones few, often below ends of foliage branches, terminal on a dwarf shoot with

small, 2–3 mm long leaves, or when terminal following normal size leaves, with several spreading green bracts. Seeds 1(–2), exposed, covered at the base by the epimatium, ovoid, 4–5 mm long, lustrous brown.

Taxonomic notes

In Flora Malesiana ser. 1, 10 (3): 369–370 (De Laubenfels, 1988) this species has been stated to occur in Peninsular Malaysia ("Malaya") but critical examination of all herbarium specimens involved (FRIM, K, L) has revealed that this was based on erroneous identification: all specimens from the peninsula belong to *D. beccarii*.

Distribution

Malesia: Borneo, Maluku [Moluccas], Philippines, Sulawesi, N Sumatera; Papuasia: New Britain, New Guinea, Solomon Islands, Bougainville.

TDWG codes: 42 BOR-BR BOR-KA BOR-SB BOR-SR MOL PHI SUL SUM 43 BIS NWG-IJ NWG-PN SOL-NO SOL-SO

Ecology

Dacrydium xanthandrum is a widespread and locally common or dominant species, occurring from primary lowland rainforest with scattered individual tall trees to high montane ridges (up to 2700 m) with low mossy forest, where it may dominate. Soils vary from clay to peat but *D. xanthandrum* becomes abundant or dominant only in exposed rocky ridges or in peat over acid rocks (dacite, granite, or sandstone) or nutrient-poor sand. In such localities it is accompanied by various species of *Myrtaceae* and other angiosperm shrubs and small trees.

Conservation

IUCN: LC

Uses

The timber of this species is not distinguished from other species of *Dacrydium* and where large trees occur in the forest, they will probably be logged and traded as 'sempilor' a collective name for several genera and species of *Podocarpaceae*. This wood is valued for construction and furniture making.

Diselma Hook. f., Fl. Tasmania 1 (5): 353. 1857. Type: *Diselma archeri* Hook. f. (*Cupressaceae*).

Microcachrys W. Archer, Hooker's J. Bot. 2: 51. 1850, *non* Hook. f. (1845). Type not designated.

Greek: *di* = two; *selma* = upper deck, seat; referring to the fertile scales in the seed cone.

Description

See the species description.

Distribution

As for the species.

Diselma archeri Hook. f., Fl. Tasmania 1 (5): 353, t. 98. 1857. Type: Australia: Tasmania, Great Western Tiers, Meander Falls, ["summit of the western mountains and Falls of Meander"], *R. C. Gunn [366] s.n.* (lectotype K). Fig. 120

Etymology

This species was named after William Archer (1820–1874), who studied the flora of Tasmania.

Vernacular names

Cheshunt pine

Description

Shrubs, or very small trees 1.5–4 m, occasionally a small tree up to 6 m in shade, rarely prostrate, stem to 30–40 cm diam. but mostly smaller, evergreen, dioecious; trunk monopodial, short, or multistemmed, with sprawling or assurgent branches from a common base, forming extensive bushes. Bark scaly, rough, brown turning grey; inner bark reddish brown. Branches short, rigid, forming a dense crown. Foliage branches numerous, not in a plane, very dense, straight and more or less rigid, short (10–20 mm), tetragonal or occasionally trigonal, ca. 1.5 mm diam., covered with closely appressed leaves, persistent. Leaves opposite-decussate, occasionally in whorls of 3, imbricate, scale-like, rhombic, more or less keeled distally, with entire margins and obtuse apex, 1–2 × 0.6–1.5 mm; stomata in two short whitish bands in lower part of the leaf, eglandular; young leaves on mature branchlets reddish at first, turning green or olive-green. Pollen cones numerous, terminal and solitary on ultimate branchlets, to 3 mm long; microsporophylls 6–8, smaller than leaves, triangular-deltoid, usually 4 fertile, each with 2 abaxial pollen sacs. Seed cones terminal on ultimate branchlets, maturing in one season to small cones 3 × 2 mm, consisting of 2 pairs of decussate cone scales surrounding a central columella; upper scales fertile, 2–3 × 1–1.5 mm, with bract margin visible at the distal end; columella relatively large, resinous-glandular, clavate or ovate-cylindrical, breaking off in old persistent cones. Seeds 2 (or 1) developing on each fertile bract-scale complex, ovoid-flattened, brown; wings 2(–3), marginal, broad, partly surrounding seed.

Taxonomic notes

The foliage and leaf arrangement as well as leaf morphology of *Diselma archeri* very closely resemble those of the sympatric prostrate shrub *Microcachrys tetragona* (*Podocarpaceae*), which are opposite-decussate ("in distichous pairs" according to Hill & Brodribb, 1999), unlike the usually helical arrangement in that family. It may be worthwhile to investigate whether the two taxa really have a homologous phyllotaxis or whether the podocarpaceous conifer has in fact a bijugate phyllotaxis (Tomlinson & Zacharias, 2001) as a deviation from a helical arrangement. It is interesting that the terminal cones of both sexes in *Microcachrys* have their sporophylls in a helical arrangement, while those in *Diselma* are, like their leaf homologues, decussately arranged.

Distribution

W Tasmania, in most highland areas but absent in the NW.
TDWG codes: 50 TAS

Ecology

This shrubby species occurs in subalpine and alpine moorland and boulderfields, sometimes riparian along streams or on shores of lakes and ponds, among perennial herbs and other shrubs ('coniferous heath'), e.g. *Astelia alpina, Pherosphaera hookeriana, Microcachrys tetragona, Podocarpus lawrencei, Richea scoparia, R. pandanifolia, Lomatia* spp., *Orites acicularis, O. revoluta, Helichrysum* spp., *Leptospermum* spp. and larger shrubs or stunted trees, e.g. *Athrotaxis cupressoides, Phyllocladus asplenifolius, Nothofagus gunnii*, and *Eucalyptus coccifera*. The altitudinal range of *Diselma* archeri is from 550 m to 1400 m a.s.l. Soils are acidic, often peaty and water-logged and shallow over igneous rock. Annual precipitation is very high, snow and frost are possible year-round, with snow cover at the highest altitudes lasting several months.

Conservation

This monotypic genus, though endemic to Tasmania, is widely distributed in the highlands, where almost all populations are reserved within the Western Tasmania Wilderness World Heritage Area (WTWWHA). It is not considered threatened, although it is sensitive to fires, which have in historic times increased in frequency in some areas.
IUCN: LC

Uses

This shrub is uncommon in cultivation, but some specialist nurseries grow it for the horticultural trade. It is also grown in botanic gardens. *Diselma archeri* (the vernacular name is rarely used) is a slow growing, more or less erect shrub, depending on what shoots are being used for propagation by cuttings, and very suitable for rock gardens. 'Read Dwarf' is an even slower growing cultivar with light green young foliage from a plant found on Mt. Read in the north of Tasmania.

Falcatifolium de Laub., J. Arnold Arbor. 50: 308. 1969. Type: *Falcatifolium falciforme* (Parl.) de Laub. [*Podocarpus falciformis* Parl.] (*Podocarpaceae*).

Latin: *falcis* = sickle; *folia* = leaf.

Description

Dioecious evergreen shrubs or trees. Resin in bark and leaves. Bark thin, with scattered lenticels, eventually flaking. Branching in monopodial trees in pseudo-whorls, more irregular in shrubs, foliage branches terminating in loose buds formed by narrowly triangular scale leaves. Leaves spirally inserted, dimorphic, more or less appressed scale leaves on leading and fertile shoots, alternating with more or less distichously spreading, bilaterally flattened, obliquely lanceolate-falcate foliage leaves on (lateral) vegetative shoots, latter leaves single-veined, much larger than scale leaves, but variable in size, with stomata on both sides (leaves amphistomatic). Pollen cones on axillary, usually solitary but sometimes clustered, short, scaly shoots (peduncles), cylindrical and catkin-like; microsporophylls small, triangular or acuminate, with two globose pollen sacs containing bisaccate pollen. Seed cones solitary on axillary, scaly dwarf shoots (peduncles), consisting of several spirally arranged bracts; bracts becoming swollen, fleshy and red, forming an irregularly shaped receptacle, with one fertile bract at or near apex bearing an inverted ovule on the adaxial side. Seeds at an oblique angle to axis of receptacle, erect, surrounded at base by a swollen epimatium, ovoid but more or less flattened, with two lateral ridges.

6 species.

Distribution

Malesia: Peninsular Malaysia, Borneo, Sulawesi, Phulippines, Maluku [Moloccas], New Guinea. SW Pacific: New Caledonia.

Key to the species of *Falcatifolium*

The reproductive organs (pollen cones and seed cones) of some species remain not or poorly known; for this reason their use in this key remains tentative and should be treated with some caution. Transitional forms between juvenile and adult leaf forms also exist and one should consult the descriptions before concluding an identification.

1a. Low shrubs. Adult leaves 0.6–1 cm long, 1.8–2 mm wide (only known from one locality in New Guinea) ***F. sleumeri***

1b. Shrubs or (small) trees. Adult leaves normally longer than 1 cm **2**

2a. Juvenile leaves narrowly linear-lanceolate, up to 7 cm long, 1.2–1.5 mm wide. Trees to 20 m tall ***F. angustum***

2b. Juvenile leaves usually shorter than 3 cm, if longer (to 12 cm) then wider than 5 mm. Shrubs or trees to 22 m tall **3**

3a. Juvenile leaves nearly linear, 1–2 cm long, 1.5 mm wide, adult leaves 3–6 mm wide with obtuse or sometimes acute apex. Receptacle when full-grown 20 × 8 mm ***F. taxoides***

3b. Juvenile leaves falcate or linear-lanceolate, 2.5–12 cm long, 3.5–12 mm wide, adult leaves (1.5–)2–9 mm wide with acuminate or pungent apex. Receptacle when full-grown smaller than 12 × 6 mm **4**

4a. Juvenile leaves 10–12 cm long, 10–12 mm wide; adult leaves falcate or S-curved ***F. falciforme***

4b. Juvenile leaves not longer than 7.5 cm and not wider than 7 mm, adult leaves falcate (sometimes at base only), not S-curved **5**

5a. Leaves flushing whitish/yellowish green or glaucous; juvenile leaves only slightly longer than adult leaves, to 3 cm long. Pollen cones 0.5–1.3 cm long ***F. papuanum***

5b. Leaves flushing pinkish or purplish; juvenile leaves markedly longer than adult leaves, to 7.5 cm long (adult leaves to 4 cm long). Pollen cones 5–6 cm long ***F. gruezoi***

Falcatifolium angustum de Laub., J. Arnold Arbor. 50: 312. 1969. Type: Malaysia: Sarawak, Bintulu, Sg. Meluang W.S., *E. F. W. Brunig S8866* (holotype L).

Etymology

The species epithet refers to the narrow leaves.

Vernacular names

No vernacular names are recorded for this species.

Description

Trees to 20 m tall; trunk to 30 cm d.b.h. Bark smooth, becoming rough and scaly, purplish brown, weathering grey. Foliage branchlets terete, glabrous. Juvenile leaves narrowly linear-lanceolate, curved forward, up to 7 cm long and 1.2–1.5 mm wide above a sessile or short petiolate, decurrent base, gradually tapering towards a pungent apex, flattened. Adult leaves shorter, 1.8–3.5 cm long and 1.5–2.5 mm wide, decurrent at base, with nearly parallel sides for most of their length, flattened but keeled on both sides forming an acutely raised midrib, tapering to a pungent apex. Stomata in several lines on both sides from base to apex (leaves amphistomatic). Pollen cones terminal or lateral, axillary to leaves, in a more or less immature state 8 mm long and 2 mm diam. Seed cones not observed.

Taxonomic notes

This species is distinct in its extremely narrow leaves but the cones remain unknown or, in the case of male cones, poorly known. This taxon has been collected from two locations near the coast in Sarawak (NW Borneo) namely Bintulu and Kuching and is undoubtedly rare.

Distribution

Borneo: Sarawak (two locations on coast).
TDWG codes: 42 BOR-SR

Ecology

Falcatifolium angustum occurs in kerangas (forest on podzolised white sands) at 90–240 m altitude near the coast. The two populations occur in open forest with among other trees *Gymnostoma* sp. (*Casuarinaceae*), *Parastemon* sp. (*Chrysobalanaceae*) and *Shorea albida* (*Dipterocarpaceae*).

Conservation

Deforestation in relation to the expansion of oil palm plantations poses a serious threat to this species.
IUCN: EN [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Uses

No uses have been recorded of this rare species.

Falcatifolium falciforme (Parl.) de Laub., J. Arnold Arbor. 50: 309. 1969. *Podocarpus falciformis* Parl., in Candolle, Prodr. 16 (2): 685. Type: Malaysia: Sarawak, Gunung Pueh, (Mt. Poe), *O. Beccari 2437* (lectotype FI). Fig. 121, 122, 123

Falcatifolium usan-apuense de Laub. & Silba, Phytologia 68: 32, 512. 1990.

Etymology

The species epithet (Latin *falcis* = sickle) refers to the falcate leaves.

Vernacular names

ekor sabit (Malay); kayu china (Sabah)

Description

Shrubs or small trees 1.5–12 m tall, occasionally in forest a tall tree to 35–40 m, with an erect, monopodial trunk to 80 cm d.b.h. and a spreading, more or less open crown. Bark smooth, in large trees becoming fissured and scaly, dark brown weathering grey-brown; inner bark slightly fibrous, greyish brown, exuding red resin or sap in slash. Leaves of two types: scale leaves and foliage leaves. Scale leaves on leading shoots and on the base of lateral shoots, more or less appressed, subulate to narrowly lanceolate, 4–6 × 1–2 mm, sometimes transforming into small foliage leaves. Foliage leaves on seedlings and saplings much longer than on mature plants, flushing leaves pinkish to purplish red, turning lustrous green. Juvenile type leaves linear-lanceolate to more often falcate, on seedlings soon becoming large to 10–12 cm long, rapidly widening from a petiole-like base to 10–12 mm well below the middle, gradually tapering

and curved forward to an acuminate apex, midribs on either side a thin, barely raised ridge running from base to apex. Adult shade leaves falcate or more commonly slightly S-curved, 3–7 cm × 5–9 mm, tapering at both ends, midrib not or only slightly raised; apex acuminate. Adult sun-exposed leaves still shorter, variable in size on a branch, (0.6–)2–4 cm × (2–)4–8 mm, shortest ones often more abrubtly tapering at both ends, otherwise of similar shape as shade leaves or sometimes less curved. Stomata in numerous intermittent lines on both sides of leaves from base to apex. Pollen cones solitary or clustered, on axillary or sometimes terminal scaly dwarf shoots, 2–4 cm × 2.5–3.5 mm; microsporophylls terminating in an acuminate apex above two pollen sacs. Seed cones solitary on axillary dwarf shoots with acuminate scale leaves; receptacles 4–6 mm long, swelling to 10–12 mm and becoming succulent and orange or bright red. Mature seed single, ovoid, obliquely attached, 6–7 mm long, slightly flattened with two lateral ridges, green turning purplish black.

Taxonomic notes

De Laubenfels (1988) in his treatment of the species *Falcatifolium falciforme* for Flora Malesiana mentioned a specimen with very small leaves (6 × 2 mm) "in the form of shade leaves" collected on the Usan Apua Plateau of Sarawak in "high kerangas" from a tree said to be 24 m tall. He suggested that this might be a new species, whereupon Silba proceeded to erect a new species *F. usan-apuensis* based on *G. H. Pickels SAR-3925* (holotype in SAR; there is no material in FHO, another herbarium where Pickels deposited specimens) collected on this plateau. Measurements of leaves given by Silba (6–19 × 2.5–4.5 mm) presumably from this specimen are small, but in the lower range of the sun-exposed leaves of the species *F. falciforme* and no evidence other than De Laubenfels' remark is presented that the leaves of the Pickels specimen are shade leaves. A 24 m tall tree would most likely have its foliage in or above the forest canopy and not in the shade of it. The two different kinds of leaves have no truly distinct shapes but merge almost imperceptibly into each other.

Distribution

Borneo (including Lingga Island), Peninsular Malaysia.

TDWG codes: 42 BOR-BR BOR-KA BOR-SB BOR-SR MLY-PM

Ecology

Falcatifolium falciforme is most common on mountain ridges where the forest is more sparse or dwarfed; here it forms shrubs or small trees to 12 m tall. However, its altitudinal range is from 300 m to 2100 m a.s.l. In kerangas (forest on leached podzolic sands) it is an understorey tree or occasionally a canopy tree, with e.g. *Agathis borneensis, Sundacarpus amarus, Nageia wallichiana* and *Dacrycarpus imbricatus* as (co)dominant or emergent conifer trees. Occasionally it is found as a co-dominant or more or less emergent large tree in lowland to sub-montane primary rainforest on more fertile soils; these individuals are scattered and rare and may be associated with episodal disturbance and succession events, which initially led to more abundant conifers, most of which were in a later successional stage replaced by angiosperms.

Conservation

IUCN: NT

Uses

The rather rare large trees of this species will be logged together with other podocarps when growing outside protected areas. Its wood is traded as 'sempilor' together with that of *Dacrydium, Dacrycarpus* and *Phyllocladus*. *Falcatifolium* wood is light and easy to work; it is used in light construction, doors, windows, joinery, furniture, interior finishing, veneers as well as boat masts and crates. The wood is not durable and therefore unsuitable for work that will be exposed to outdoor conditions. It is in cultivation only as specimens in some tropical botanic gardens.

Falcatifolium gruezoi de Laub., Fl. Malesiana, ser. 1, 10 (3): 373. 1988. Type: Philippines: Mindoro, Parabatugan, Mt. Halcon, ["Paitan access, Paitaraan"], *W. M. Gruezo 4052* (holotype L).

Etymology

This species was named after W. M. Gruezo, the collector of the type specimen.

Vernacular names

binaton (Philippines)

Description

Small trees 4–12 m tall, with a monopodial trunk to 25 cm d.b.h. Bark smooth, becoming rough, brown weathering grey-brown. Leaves of two types: scale leaves and foliage leaves. Scale leaves on base of lateral shoots, more or less appressed, subulate to narrowly lanceolate, 3–4 × 1 mm, sometimes transforming into small foliage leaves. Foliage leaves on seedlings and saplings much longer than on mature plants, flushing leaves pinkish to purplish red, turning green. Juvenile type leaves linear-lanceolate to falcate, on seedlings soon becoming large to 7.5 cm long, widening from a petiole-like base to 6–7 mm well below the middle, gradually tapering and curved forward to an acuminate apex; midribs on either side a thin, barely raised ridge running from base to apex. Adult shade leaves falcate, 20–40 × 5–8 mm, tapering at both ends, midrib not or only slightly raised; apex acuminate. Adult sun-exposed leaves much smaller, 8–15(–20) × 2–4(–6) mm, of similar shape as shade leaves, glaucous. Stomata in numerous intermittent lines on both sides of leaves from base to apex. Pollen cones solitary, on axillary or sometimes terminal scaly dwarf shoots, 5–6 cm × 1.5–3 mm; microsporophylls terminating in an acuminate apex above two pollen sacs. Seed cones solitary on axillary dwarf shoots with acuminate scale leaves, receptacle 2 mm long (larger when mature?); mature seed single, ovoid, obliquely attached, 6–7 mm long, slightly flattened with two lateral ridges, dark brown.

Taxonomic notes

This species was described by De Laubenfels based on a sterile collection with small, glaucous leaves from Mt. Halcon in the Philippines and on a description published in the Philippine Journal of Science, Botany Vol. 6: 153–154 (1911) by F. W. Foxworthy under *Dacrydium falciforme*. The latter account refers to a collection by Elmer D. Merrill from Mt. Halcon which had pollen cones ca. 6 cm long and 3 mm diam.; however, a duplicate at K of the cited collection (*Merrill 5744*) is sterile. It is possible that a duplicate specimen in the Philippine National Herbarium (PNH) of this collection has such pollen cones, but I have not seen it. If correct, its long, thread-like pollen cones, rather than the small, glaucous leaves, which are not present on Merrills collection which probably represents shade leaves, would be the most striking character of this species distinguishing it from *F. falciforme* as well as other species.

Distribution

Malesia: Maluku [Moluccas] (Obi), Philippines, Sulawesi.
TDWG codes: 42 MOL PHI SUL

Ecology

Falcatifolium gruezoi occurs in lower montane to montane rainforest. It is commonly associated with other conifers, e.g. *Agathis dammara, Dacrydium* spp., *Nageia wallichiana*, and *Sundacarpus amarus*. Angiosperms are often abundant but not dominant; dominance is usually attained by *Agathis, Nageia*, or *Sundacarpus* on these sites, while *F. gruezoi* grows under canopy of these. On mountain ridges it can compete with angiosperms where these remain smaller trees.

Conservation

IUCN: NT

Uses

This species remains a small tree and is therefore unlikely to be of value for its timber. No other uses are known of it.

Falcatifolium papuanum de Laub., J. Arnold Arbor. 50: 312. 1969. *Dacrydium papuanum* (de Laub.) Whitmore, in Whitmore *et al.* (eds.), Tree Fl. Indonesia, Checkl. Irian Jaya: 233. 1997. Type: Papua New Guinea: Morobe District, Wau Subdistrict, Edie Creek, *D. J. de Laubenfels P 483* (holotype A).

Etymology

The species epithet refers to its distribution in Papua New Guinea.

Vernacular names

mungag, tugi (Papuan languages)

Description

Trees to 22 m tall, with an erect, monopodial trunk to 40 cm d.b.h. and a more or less conical crown in forest. Bark smooth, becoming fissured and scaly on the lower trunk, dark brown weathering grey; inner bark slightly fibrous, red-brown. Leaves of two types: scale leaves and foliage leaves. Scale leaves on leading shoots and on base of lateral shoots, more or less appressed, subulate to narrowly lanceolate, 2–5 × 1–2 mm, sometimes transforming into small foliage leaves. First leaves on seedlings linear, spreading at wide angles, petiolate, 10–15 × 1 mm, later leaves on seedlings and small saplings slightly larger than adult leaves, flushing leaves pale whitish green or yellowish green to glaucous, becoming green with a glaucous underside. Adult shade leaves falcate at base, then more or less straight, 10–22 × 2–4 mm, more or less petiolate at base, tapering slightly in the distal part, more or less coriaceous, midrib not or only slightly raised; apex pungently acuminate. Adult sun-exposed leaves smaller, 8–13 × 1.5–2 mm, narrower than shade leaves and sometimes more curved. Stomata in numerous intermittent lines on both sides of leaves from base to apex. Pollen cones solitary on axillary or sometimes terminal scaly dwarf shoots, 0.5–1.3 cm × 2–2.5 mm; microsporophylls terminating in an acuminate apex above two reddish pollen sacs. Seed cones solitary on axillary dwarf shoots with acuminate scale leaves; receptacles 7–10 mm long, swelling and becoming succulent and bright red; mature seed single, ovoid, obliquely attached, 5–6 mm long, slightly flattened with two lateral ridges, light or dark brown.

Distribution

Papua New Guinea.
TDWG codes: 43 NWG-PN

Ecology

This species is locally common in montane rainforest dominated by *Fagaceae* (*Lithocarpus*), *Nothofagaceae*, *Myrtaceae, Cunoniaceae*, and *Podocarpaceae*. On mountain ridges it can reach the canopy, but in taller forest on moist slopes it is usually a sub-canopy tree, not exceeding 15 m in height. On exposed mountain summits this species is sometimes reduced to dwarf size. The altitude range is from 1300 m to 2300 m a.s.l.

Conservation

Despite logging in areas within the distribution of this species which must have included it (no distinction is being made and timber logs once deprived from foliage can only be assigned to 'podocarp' with confidence), it is thought to grow in enough remote and untouched forest localities to be as yet out of risk of extinction.
IUCN: LC

Uses

The wood of this species provides good timber and is being logged together with species of *Dacrycarpus, Dacrydium* and *Phyllocladus*, between which the timber trade makes no distinction. Its relative rarity and usually small size make it unlikely that it will contribute substantially to that trade. Aside from a few specimens in greenhouses of botanical gardens this species is not in cultivation.

Falcatifolium sleumeri de Laub. & Silba, Phytologia 65: 329. 1988. Type: Indonesia: Papua, Arfak Mts., Mt. Nettoti, *P. van Royen & H. O. Sleumer 8203a* (holotype L).

Etymology

This species was named after Hermann Otto Sleumer (1906–1993), a German botanist who worked at the Rijksherbarium in Leiden.

Vernacular names

No vernacular name is known for this rare species.

Description

Low, more or less flattened or prostrate [?] shrubs 20 cm tall or more [based on a single specimen described to be of that dimension this habit and size remain speculative]. Bark scaly, greyish brown. Branches numerous, spreading to erect, creating a spreading, flattened crown covering the ground for several square meters. Leaves linear-ovate, curved at the shortly petiolate base, falcate or nearly straight, 0.6–1 cm long and 1.8–2 mm wide, midrib raised on the abaxial side; margins slightly revolute, more or less abrubtly tapering to an apiculate apex with a prickly spine 0.2 mm long. Reproductive structures not known.

Taxonomic notes

From Mt. Nettoti at 1920 m a.s.l. in the Bird's Head Peninsula a dwarfed plant was collected with very small leaves 6–10 × 2 mm which are morphologically similar to leaves on trees of *Falcatifolium papuanum*, in particular sun-exposed leaves. The leaves were illustrated with a small photograph in the protologue of *F. papuanum* (De Laubenfels, 1969: 313, fig. 6b) and it was speculated that it might represent a distinct "entity" or even a distinct species (De Laubenfels, 1988: 374). De Laubenfels & Silba (*op. cit.*) proceeded to describe it as a new species, *F. sleumeri*, based on the same specimen already mentioned in the account of 1969 and with no further knowledge or information, e.g. on reproductive structures; that single specimen, *P. van Royen & H. Sleumer 8203a* (holotype L) is apparently sterile.This specimen is perhaps distinct in its decumbent habit (shrub to 20 cm tall) and small leaves, but its reproductive structures remain unknown; therefore its taxonomic status is not certain.

Distribution

New Guinea: Bird's Head Peninsula (Mt. Nettoti).
TDWG codes: 43 NWG-IJ

Ecology

Stated to occur in "dark mossy forest", so presumably a ground covering species under a canopy of trees. The altitude is given as 1920 m above sea level.

Conservation

Known from only one locality and its type specimen, but due to poor collecting records from the area nothing can be concluded from this as to rarity, population size etc. It is described as a prostrate shrub in "dark, mossy forest". The fact that is has been described in 1988 and no subsequent collections were made is undoubtedly due to its very local occurrence. Rather than maintain it as DD the Conifer Specialist Group believes this species should be flagged as NT as it is surely very rare and restricted.
IUCN: NT

Uses

No uses are recorded of this species; if its habit is indeed a prostrate shrub it could be of interest to horticulture, but only in countries with a frost-free climate.

Falcatifolium taxoides (Brongn. & Gris) de Laub., J. Arnold Arbor. 50: 310. 1969. *Dacrydium taxoides* Brongn. & Gris, Ann. Sci. Nat. Bot., sér. 5, 6: 245. 1866. Type: New Caledonia: Grande Terre, Province Nord, Balade, ["montagnes de Balade"], *E. Vieillard 1259 [1855–60]* (lectotype P). Fig. 124

Etymology

The species epithet refers to *Taxus*, presumably from a resemblance of its leaves with those of yew.

Vernacular names

No common names are known for this species.

Description

Shrubs or small trees 2–15 m tall; trunk with max. d.b.h. 25 cm. Bark smooth becoming rough on larger stems, brown weathering grey. Crown usually open and sparse in sub-canopy trees, more dense in trees growing in open vegetation. Leaves of two types: scale leaves and foliage leaves. Scale leaves on leading shoots and on base of lateral shoots, more or less appressed, subulate to narrowly lanceolate, 2–3 × 1 mm, sometimes transforming into small foliage leaves. First leaves on seedlings nearly linear, spreading at wide angles, petiolate, 12–20 × 1.5 mm, strongly keeled abaxially, soon replaced by adult leaves, flushing leaves pink with whitish bloom, becoming bright green on both sides. Adult leaves falcate at base, then more or less straight or curved or ovate-oblong, variable in size on a single branchlet, 0.8–2.5 cm × 3–6 mm, more or less petiolate at base, tapering in the distal part; midrib raised on both sides or inconspicuous; apex obtuse or sometimes acute. Stomata in numerous intermittent lines on both sides of leaves from base to apex. Pollen cones on axillary or sometimes terminal scaly dwarf shoots, often 2–3 together, 1.5–2.5 cm × 1.5–2 mm; microsporophylls terminating in an acuminate apex above two yellow pollen sacs. Seed cones solitary on axillary dwarf shoots with acuminate scale leaves, with 10–12 scales subtended by elongated bracts; cone swelling to an irregularly shaped receptacle ca. 20 × 8 mm and becoming succulent and bright red; mature seed single, ovoid, obliquely attached near apex, 6–7 × 3–4 mm, slightly flattened with two lateral ridges, reddish maturing to dark brown.

Distribution

New Caledonia: throughout Grande Terre.
TDWG codes: 60 NWC

Ecology

Falcatifolium taxoides is common as an understorey tree in montane humid forests from lowland hills in the south of Grande Terre to the summit ridges of the highest mountains on the island at 1400 m or even more. It occurs on ultramafic soil derived from serpentine as well as on acidic metamorphic rock (micaschist). It is associated with *Araucaria montana, A. laubenfelsii, A. humboldtensis*, and *Agathis montana* (on Mt. Panié) as well as angiosperm trees e.g. in the *Meliaceae*. Its most peculiar associate is the parasitic podocarpaceous conifer *Parasitaxus usta*, to which it is the only host. This diminutive shrub or treelet usually attaches to its roots and seems to grow from the litter under *Falcatifolium taxoides*. The large and succulent red receptacles are conspicuous and eaten by birds, who disperse the single seed thereby.

Conservation

IUCN: LC

Uses

This small tree is not exploited for its timber and other uses in New Caledonia are unknown. It is in cultivation only in some collections of botanic gardens; it could grow outside only in subtropical to tropical climates. It has attractive pink flushing leaves and larger pollen cones and red, succulent receptacles than other species and would make an attractive small amenity tree in tropical countries.

Fitzroya Lindl., J. Hort. Soc. London 6: 264. 1851. Type: *Fitzroya cupressoides* (Molina) I. M. Johnst. [*Pinus cupressoides* Molina] (*Cupressaceae*).

Named after Robert FitzRoy (1805–1865), who achieved lasting fame as the captain of HMS Beagle during Charles Darwin's famous voyage.

Description

See the species description.

Distribution

As for the species.

Fitzroya cupressoides (Molina) I. M. Johnst., Contr. Gray Herb., n. s. 70: 91. 1924. *Pinus cupressoides* Molina, Sag. Stor. Nat. Chili: 168. 1782. Type: Chile: Los Lagos, Cordillera de la Costa, 30 km from San Juan de la Costa, *J. L. Morrison 17636* (neotype K). Fig. 125, 126

Etymology

The species epithet means "like a cypress" (*Cupressus*).

Vernacular names

Patagonian cypress; Alerce (Spanish), Lahuán

Description

Trees to 50(–60) m tall, evergreen, dioecious, rarely monoecious; trunk monopodial, straight, buttressed in old individuals and often with root suckers, to 3–5 m diam. above buttress. Bark on trunk thick, with deep fissures, exfoliating in long strips, reddish brown. Branches spreading horizontally or curved down, forming a conical or pyramidal crown. Foliage branches spreading or pendulous, ultimate branchlets 1–4 cm long, more or less terete, densely covered with leaves, persistent. Leaves scale-like, in alternate near-whorls of 3, imbricate, decurrent, with distal part variously (re)curved; apex incurved but free, lanceolate to ovate, 4–6 mm long on younger trees, 2–3 mm long on older trees, 1–2 mm wide, keeled abaxially, adaxially with a midrib; margins entire; apex obtuse; stomata abaxially in a few lines on decurrent base; leaf colour lustrous green to glaucous green, with whitish wax on stomatal zones. Pollen cones predominantly terminal, solitary, cylindrical, 6–8 × 2–3 mm; microsporophylls 15–24, in alternate whorls of 3, imbricate, peltate-ovate with acute apex, keeled abaxially; margins entire, bearing (2–)4–6 small pollen sacs on abaxial side. Seed cones terminal or subterminal, formed by 2–3 whorls of slightly modified scale leaves, followed by 2 alternate whorls of 3 fertile scales, maturing in 1 season to cones with wide spreading scales 10–14 mm diam. Bract-scale complexes thin woody, obovoid-spathulate, largest one ca. 5 × 4 mm, with thickened, wrinkled apical part and subapical, curved umbo of exserting bract apex 1–2 mm long. Columella variably shaped, trigonal to tripartite, ca. 4 mm long, flattened, not woody, resinous-glandular, more or less translucent. Seeds usually only well developed on upper fertile whorl, 3–4 × 2 mm, ovoid-oblong, flattened, with a concave hilum; wings usually 2, sometimes 3, crescent-shaped with undulate margins, ca. 2 mm wide.

Distribution

S Argentina: Chubut, Neuquén, Rio Negro; S Chile: Los Lagos. For the most part, the still existing populations of *Fitzroya cupressoides* are in Chile, now disjunct in the coastal Cordillera, some in the Central Valley, and others in the Andes, where they cross the border into Argentina.
TDWG codes: 85 AGS-CB AGS-NE AGS-RN CLS-LL

Ecology

A dominant or emergent tree usually forming more or less large stands ('alerzales') scattered in the Valdivian evergreen rainforest. Understorey tree species are e.g. *Podocarpus nubigenus, P. salignus, Prumnopitys andina, Saxegothaea conspicua, Pilgerodendron uviferum, Nothofagus betuloides, N. dombeyi, N. nitida, N. obliqua, Drimys winteri*, and *Laurelia philippiana*. There are various forest types with shifting dominance of these associates on altitudinal gradients and on soil types, with e.g. a very wet,

acidic woodland bog type at middle to high (–1200 m) elevation dominated by *Pilgerodendron* and *Fitzroya* and a shrublayer of the conifer *Lepidothamnus fonkii* in carpets of *Sphagnum*. Another forest type occurs between 800–1200 m on better drained volcanic soils with dominance of *Nothofagus betuloides* and emergent *Fitzroya*; it is there dependent on episodal disturbance in the absence of which *Nothofagus* would prevent its regeneration. *Fitzroya cupressoides* is one of the longest living trees in the world, with record ages counted between 3500 and 4000 years. The soils on which *Fitzroya* occurs are usually poorly drained and water-logged, or incipient soils on volcanic ash deposits, at lower elevations sandy or loamy soils predominate, often with a very high organic content and a low pH (4.0–5.1) in the upper layer. Mean annual precipitation ranges from 2000–6000 mm, mostly as winter rains, with snow at the higher elevations.

Conservation

The range of *Fitzroya cupressoides* has historically been reduced greatly by centuries of logging, probably aggravated by recurring fires both natural and man-made. It has largely disappeared from the lowland areas N of Puerto Montt, where it was once extensive and abundant (Golte, 1996). It is not doing well in many of the remaining, mostly upland and very wet stands, and large tracts of land merely have standing dead snags with little or no natural regeneration. Exploitation has been on a devastating scale with no intent of sustainability until 1976, when logging of living trees was banned by the Chilean government and the species was declared a National Monument. Fires continue to kill trees, which can then be logged and the land converted to pasture. Since 1973 the species is listed on CITES Appendix I which prohibits all export. Although it is afforded protection in both Argentina and Chile in National Parks, most populations occur on private property. The most notable private property where important populations of *Fitzroya* are protected is The Pumalin Park in southern Chile which was set up in 1991 to help protect 300,000 ha of pristine rainforest, making the largest private park in the world. In the late 1990s, studies carried out into the genetic variability of *Fitzroya* using DNA markers have helped guide researchers from the Forestry Faculty of the Universidad Austral de Chile in establishing an important restoration programme in the Central Depression.

IUCN: EN (A2cd)

Uses

This species has been extensively used for building timber and especially shingles for roofing. Its extremely rot resistant wood is so durable, that shingles on roofs 130–150 years old are still perfectly sound (Golte, 1996). In 1973 logging was still going on and sawmills were well stocked and busy, but exploitation has declined sharply since about 1980, with export no longer legally possible (an illegal shipment of wood was intercepted in the UK and given to the Royal Botanic Gardens, Kew, who built an education centre from it at its garden Wakehurst Place in Sussex, England). This conifer was introduced to cultivation by William Lobb in 1847 (possibly based on his brother's collection) and it remains an uncommon tree mostly confined to dendrological collections. Recently renewed seed collecting has replenished the original introduction, which appeared to have been propagated from cuttings; new plants have been distributed in the UK largely as *ex situ* conservation stock by the International Conifer Conservation Programme of the Royal Botanic Garden at Edinburgh, Scotland. As a CITES Appendix I listed species its commercial distribution will remain restricted and plants can only be sold if they originate from legal stock in cultivation outside Chile and Argentina.

Fokienia A. Henry & H. H. Thomas, Gard. Chron., ser. 3, 49: 67. 1911. Type: *Fokienia hodginsii* (Dunn) A. Henry & H. H. Thomas [*Cupressus hodginsii* Dunn] (*Cupressaceae*).

Fokien is an earlier European spelling for Fujian, a province of China.

Description

See the species description.

Distribution

As for the species.

Fokienia hodginsii (Dunn) A. Henry & H. H. Thomas, Gard. Chron., ser. 3, 49: 66–68, f. 32–35. 1911. *Cupressus hodginsii* Dunn, J. Linn. Soc., Bot. 38: 367. 1908; *Chamaecyparis hodginsii* (Dunn) Rushforth, J. Biol. (Viet Nam) 29 (3): 38. 2007. Type: China: Fujian, Min Jiang, Nanping, ["Yenping"], *A. E. N. Hodgins HK 3505* (holotype K). Pl. 14, Fig. 127

Etymology

The species epithet is after A. E. N. Hodgins, who collected it in 1905.

Vernacular names

Fujian Cypress; fu jian bai (Chinese)

Description

Trees to 30 m tall, evergreen, monoecious; trunk monopodial, to 1 m d.b.h. Bark on trunk nearly smooth, becoming irregularly fissured and flaking, purplish brown. Branches long, spreading or down-curved, self-pruning lower down the trunk, forming a broadly pyramidal, in old trees rounded and dense crown. Foliage branches spreading in flattened sprays (plagiotropic), ultimate branchlets pinnately arranged, forming frond-like sprays, but in older trees of irregular and shorter length forming flat, rounded sprays, deciduous. Leaves decussate, imbricate, decurrent, scale-like, strongly dimorphic on flattened ultimate branchlets but increasingly less so on older (whip) shoots, becoming long decurrent to 15 mm, with facials usually smaller and/or narrower than the laterals, green or glaucous green. Facial leaves appressed, obtuse, variable in size from 2–7 × 1–2 mm on ultimate branchlets; stomata in two bands separated by a midrib. Lateral leaves longer than facials or nearly equal in length, bilaterally flattened, variable, 4–10 × 2–3(–4) mm on ultimate branchlets; apex incurved, free to appressed, acute to obtuse; stomata in a single whitish band, eglandular. Pollen cones terminal, 4–5 × 1.5–2 mm, initially subglobose but elongating when maturing, with 10–12 decussate, broadly ovate-acute microsporophylls each bearing 3 small, abaxial pollen sacs. Seed cones terminal, maturing in the second year, caducous, to 15–25 × 12–22 mm, subglobose, brown. Bract-scale complexes (10–)12–16, decussate, spreading at maturity, to 10 × 16 mm (uppermost 2–4 much smaller and sterile), cuneate-peltate, flattened, woody, with irregular margins, distally with a central depression and a small mucronate umbo (bract tip), dull brown, with striated anterior part, orange- to reddish brown with whitish seed marks. Seeds 20–30 per cone, 4–5 mm long, ovoid and 3–4 ridged, with acute apex and truncate base (hilum), brown, wings 2, very unequal in size and shape; larger wing ca. 6 × 5 mm, smaller one ca. 1.5 mm, or a mere strip near the seed apex.

Taxonomic notes

Some authors have placed this species either in *Cupressus* or (recently) in *Chamaecyparis* based on comparisons of (some) gross-morphological characters. Detailed analyses of the ontogeny of the seed cones (Jagel, 2001; Farjon, 2005a) and phylogenetic analyses based on morphology (Farjon, 2005a) as well as DNA sequence data (Gadek & Quinn, 1993) have demonstrated that *Fokienia hodginsii* represents an evolutionary lineage separate from these two genera and therefore merits recognition at the rank of genus. Similarities observed, especially in the foliage and in later (mature) phases of cone development, are likely to be the result of convergent evolution.

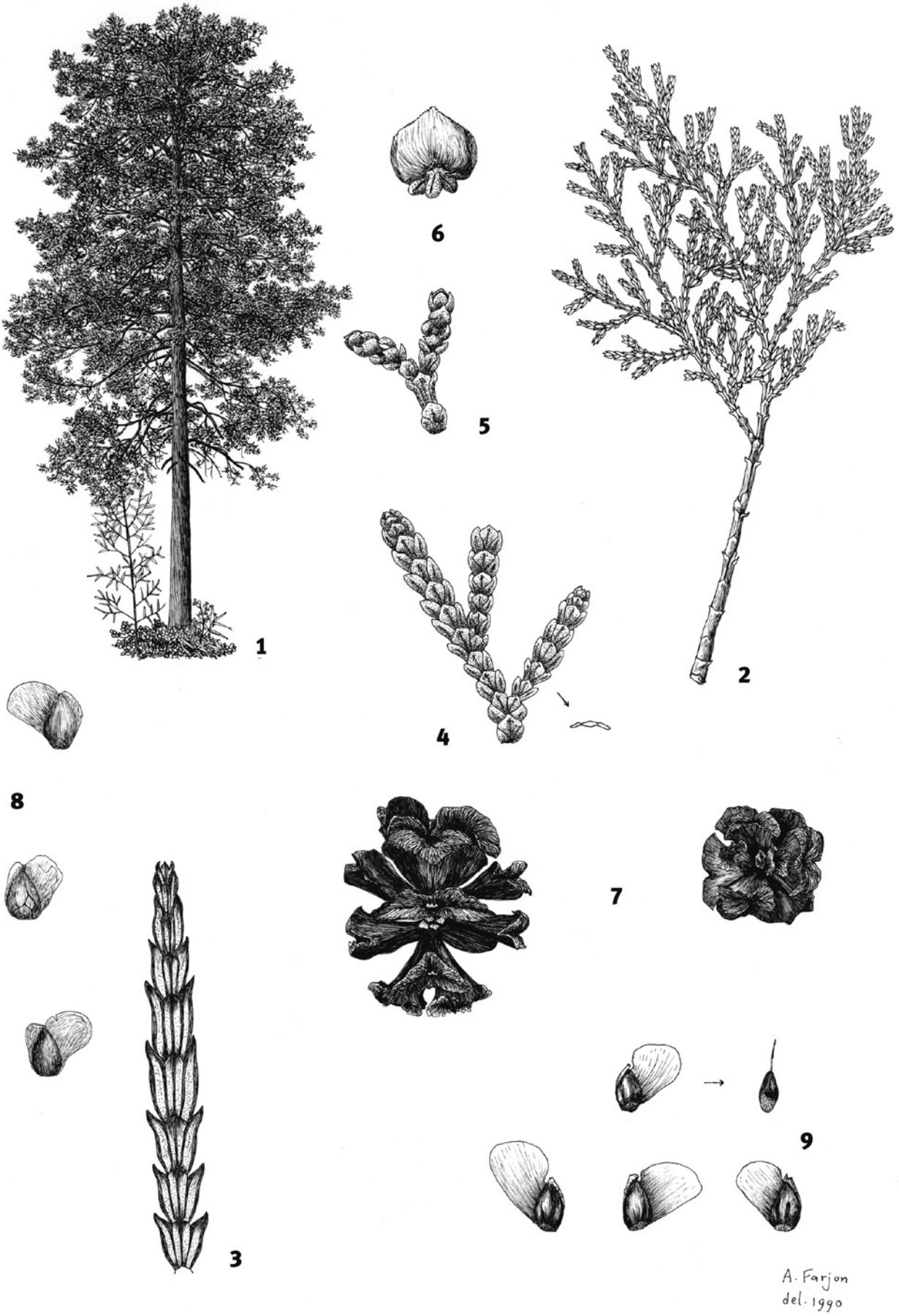


PLATE 14. *Fokienia hodginsii.* **1.** Habit of tree. **2.** Branch with foliage. **3.** Branchlet with juvenile leaves (lower side). **4.** Branchlet with adult leaves. **5.** Pollen cones. **6.** Microsporophyll with pollen sacs. **7.** Seed cones. **8, 9.** Seeds.

Distribution

China: Chongqing, Fujian, N Guangdong, Guangxi, Guizhou, S Hunan, W Jiangxi, SE Sichuan, SE Yunnan, S Zhejiang; N Lao PDR; Viet Nam.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-SC CHC-YN CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JX CHS-ZJ 41 LAO VIE

Ecology

This conifer is usually a minor constituent of subtropical to warm temperate evergreen (mixed) mesophytic forest, which in undisturbed state is dominated by numerous angiosperm trees e.g. *Castanopsis* spp., *Quercus* spp., *Lithocarpus* spp., *Nyssa sinensis, Pasania* spp., *Schima argentea, S. superba*, and a few other conifers e.g. *Cephalotaxus fortunei* and *Nothotsuga longibracteata*. With continued disturbance conifers like *Cunninghamia lanceolata* and especially *Pinus massoniana* or *P. densata* become more abundant and eventually dominate. The altitudinal range of *Fokienia hodginsii* is from 350 m to 2100 m a.s.l. Soils are acidic (pH 5–6) yellow or brown loamy sands over sandstone, shales, granite, or rhyolite and well drained. Mean annual precipitation is 1200 mm or more.

Conservation

Mature trees are selectively logged in Viet Nam and Lao PDR, even from forest reserves in remote areas using helicopters and possibly beyond sustainability, because the dark red timber is considered very valuable (roughly estimated at US$ 2500/m^3). The situation in China is possibly similar in many areas where mature forests are shrinking under population pressures. However, the species is very widely distributed and regeneration has been observed in most populations. Continued logging at current or increased rates may cause scarcity of large trees in the near future and the logging ban in China, if effective, does not apply to other countries.
IUCN: VU [A2acd; B2ab (ii–v)]

Uses

The wood of this species, like other cupressaceous trees in eastern Asia, is much valued for construction. In most areas where it occurs, wild growing trees are logged; its slow growth makes it a tree difficult to exploit economically in plantation forestry. In southern China and in Viet Nam the rot resistant and even-grained wood is prized for doors, window frames, and carved panels, as well as furniture. In remote regions pit-sawn timbers are often transported off the mountains by manpower to fetch high prizes with carpenters in the towns. This conifer is cultivated in cemeteries and parks in China, but rare elsewhere despite its relative hardiness and suitability in parts of the world with similar climates such as New Zealand, Atlantic SW Europe, northern California and Oregon and southern Japan.

Glyptostrobus Endl., Syn. Conif.: 69. 1847. Type: *Glyptostrobus pensilis* (Staunton *ex* D. Don) K. Koch [*Thuja pensilis* Staunton *ex* D. Don] (*Cupressaceae*).

Greek: *glypto-* = cut into; *strobus* = cone; referring to the margins of the seed cone scales.

Description

See the species description.

Distribution

As for the species.

Glyptostrobus pensilis (Staunton *ex* D. Don) K. Koch, Dendrol. 2 (2): 191. 1873. *Thuja pensilis* Staunton *ex* D. Don, in Lambert, Descr. Pinus, ed. 2, 2: 115. 1828. Type: China: Guangdong, ["Province of Guangton"], *G. L. Staunton s.n.* (holotype BM). Fig. 128

Etymology

The etymology of the species epithet is unclear, perhaps it derives from Latin *penicillatus* = pencil-shaped [the branchlets].

Vernacular names

Chinese Swamp Cypress, Chinese Water Fir; shui song (Chinese)

Description

Trees to 15(–25) m tall (one planted tree in China is 39 m tall), semi-evergreen, monoecious; trunk markedly buttressed at base especially when growing in watery substrate, to 1.2–1.5 m d.b.h. Bark on trunk thin with long, irregular strips, whitish brown or grey-brown. Branches long, slender, spreading horizontally or curved down in old trees, foliage in distinct tufts at ends of branches, forming a pyramidal or more rounded, open crown. Foliage branches alternate, spreading at less than 45 degrees, variable in length, dimorphic, 'long' shoots persistent, slender and flexible, 'short' shoots from terminal or dormant lateral buds, deciduous, all covered with leaves. Leaves alternate to helically arranged, of three types, all green with white stomatal dots. Scale leaves on 'long' shoots decurrent, imbricate, 1.5–3 × 0.5–0.8 mm, lanceolate, convex or keeled abaxially; apex incurved but free, obtuse. Needle-like leaves on 'short' shoots of two types, helically arranged, decurrent, and either more or less distichous, linear, 15–30 × 1.5–3 mm, bilaterally flattened, with entire margins, acute, or more commonly in ranks of 3 or nearly radially spreading, subulate, 4–10 × 0.4–0.6 mm, abaxially keeled and adaxially grooved. Stomata on all leaves types on both sides, but more on adaxial side. Pollen cones terminal, solitary, 3–5 mm long, subglobose to ellipsoid, with 15–20 helically arranged, imbricate, ovate-convex microsporophylls bearing (2–)4–6(–9) abaxial, small pollen sacs. Seed cones terminal, solitary on determinate branchlets, subtended by a few short, broad, keeled leaves grading into bract-scale complexes, maturing in two seasons; mature cones pyriform to obovate, 14–25 × 10–15 mm, with 20–25 helically arranged, imbricate woody scales, maturing brown. Bract-scale complexes increasing in size to 13 × 6.5 mm, obovate-oblong, cuneate proximally, rounded distally, connate but parting slightly at maturity, with 4–8(–11) subapical tooth-like lobes ca. 1 mm long (often worn off) along distal margin and a (sub)central, acute bract apex 2–3 × 2–3 mm; abaxial surface grooved or rough; adaxial surface with two unequal, deep seed cavities. Ovules 2 in axil of a fertile bract, erect, in well developed cones maturing to 20–30 seeds; seeds elliptic, 5–7 × 3–4 mm, slightly flattened, often grooved, brown, with a single proximal, oblong and thin wing of 4–7 × 2–4 mm.

Taxonomic notes

In many descriptive works on conifers, the name *Glyptostrobus lineatus* (Poir.) Druce has been applied to this taxon. That combination by Druce, published in 1916, was based on *Thuja lineata* Poir., a species newly described in Supplement Vol. 5 of Lamarck's famous Encyclopédie methodique (Botanique) in 1817. This description was based on a cultivated plant in the garden of "Monsieur Noisette" undoubt-

edly in France. Needless to say, this plant cannot be traced and there is no specimen in the Paris Herbarium (P) that can be linked to it. The description fits *Taxodium distichum* var. *imbricatum* and not *Glyptostrobus pensilis* and while the former had been introduced to Europe and taken into cultivation for more than two hundred years in 1817, the latter has been introduced first in England "about a hundred years ago, but rarely endured our climate... and seems to be unknown in the living state on the continent" (Henry & McIntyre, 1926). The plant in Mr Noisette's garden could not have been a specimen of *Glyptostrobus*.

Distribution

SE China: Fujian, Guangdong; possibly still natural in SE Yunnan; extinct in the wild in N Viet Nam. This species has also been found in S Viet Nam (Gaussen, 1967; Hiep & Vidal, 1996). The collections there cited from Dac Lac: Buon Uik and Krong Buc are said to have been found at ca. 500–700 m a.s.l. and to come from trees growing in "swampy forest or in basaltic terrain."; its indigenous status in S Viet Nam has recently been verified ecologically (Hiep *et al.*, 2004). Gaussen (1967) wrote that it was already found in 1955 "dans les marécages de B. Vit à 60 km au NE de Ban Mêthuôt, province de Darlac". Several localities in China that are situated near streams at altitudes from 300 to 1000 m a.s.l. away from the coastal plain may well have natural populations, too, but this needs to be veryfied. Recently, it was also discovered on the Nakai Plateau in Khammouan Province, Lao PDR, where is now known from 5–6 tiny sub-populations (Thomas & Le Page, 2011).
TDWG codes: 36 CHS-FJ CHS-GD 41 LAO VIE

Ecology

On river floodplains and in deltas, always near or in water, where it develops a buttressed base and occasionally pneumatophores; also extensively planted along rivers and canals. A heliophilous species, intolerant of competition and usually growing in pure stands or solitary along streams. It is restricted to the subtropical to tropical coastal lowlands, but avoids saline and alkaloid soils or water. A probably indigenous occurrence in Viet Nam along a marshy small river at greater altitude (around 700 m) could mean that it also occurs along inland waters. This species was widespread in the Tertiary and may well have occurred more widely along upland streams.

Conservation

The present natural distribution of this species in China is possibly restricted to several isolated localities along upland streams in three or four provinces of SE China. However, it has been widely planted along water courses in lowland S China for a very long time and it may now be impossible to distinguish between regional introductions and original occurrence, as many trees are found in ancient cultivated landscapes. In N Viet Nam it formerly occurred along the Hong (Red) River but no natural stands are to be found there at present. Habitat change due to intensive agriculture is the main cause of its decline. In S Viet Nam two small populations are probably indigenous and its status there is CR.
IUCN: CR [C2a(i)]

Uses

The rather soft, yellowish wood is like most cupressaceous wood decay resistant and finds uses in China ranging from furniture to building of bridges. The wood of the roots is very light and due to its buoyancy it is used in China to make life-saving rings. This species is widely cultivated in southern China and planted along rivers and canals as well as in parks; except for the latter localities mostly to harvest the timber followed by replanting. This conifer is a truly semi-aquatic tree requiring permanent water logged soil to thrive; planting it in rather than adjacent to a pond enhances its chances of survival. It can easily survive mild frosts in this habitat. It can be grafted onto rootstock of *Taxodium*, another conifer that grows well standing in water (but equally outside it). Its autumnal foliage colour is a deeper reddish than that of *Taxodium* and it retains its leaves longer.

Halocarpus Quinn, Austral. J. Bot. 30 (3): 317. 1982. Type: *Halocarpus bidwillii* (Hook. f. *ex* Kirk) Quinn [*Dacrydium bidwillii* Hook. f. *ex* Kirk] (*Podocarpaceae*).

Greek: *halos* = the sea; *karpos* = fruit.

Description

Dioecious, evergreen shrubs or trees. Resin ducts (1) in leaves; resin in bark and leaves. Bark thin, hard, with or without lenticels, becoming scaly and exfoliating in thin flakes. Branching variable, in shrubs often layering, irregular and ascending in trees. Terminal buds on shoots with juvenile leaves only. Leaves spirally inserted, dimorphic, radially spreading lanceolate-linear or linear leaves alternating with appressed, rhombic scale leaves, amphistomatic. Pollen cones solitary or with 2–3 together at apex of scale-leaved branchlets, small, with a few spirally arranged, reddish microsporophylls and two globose, yellow pollen sacs containing bisaccate pollen. Seed cones solitary at apex of scale-leaved branchlets, consisting of a few slightly enlarged, spreading bracts continuing from and similar to the scale leaves and distinguished by a reddish colour from normal leaves; one or more fertile with 1 inverted ovule on the adaxial side. Seeds 1–5 per cone, becoming erect, at base surrounded by the swollen epimatium forming a white or yellow collar; seed mostly protruding, more or less ovoid but flattened, with two lateral ridges, striated, maturing to lustrous black.

3 species.

Distribution

New Zealand.

Key to the species of *Halocarpus*

1a. Prostrate to erect shrubs, sometimes a dwarfed tree to 4 m tall. Juvenile leaves on seedlings and young plants. Swollen epimatium at the base of the seed white ***H. bidwillii***

1b. Erect shrubs or trees to 25 m tall. Juvenile leaves on seedlings, shrubs and trees. Swollen epimatium at the base of the seed yellow or orange **2**

2a. Erect, dense shrubs or small trees to 10 m tall. Juvenile leaves (5–)8–18 mm long, 1–1.5 mm wide. Branchlets with adult scale leaves 2–3 mm thick, angular ***H. biformis***

2b. Trees to 25 m tall. Juvenile leaves 20–45 mm long, 2–4 mm wide. Branchlets with adult scale leaves 1.5–3 mm thick, nearly terete ***H. kirkii***

Halocarpus bidwillii (Hook. f. *ex* Kirk) Quinn, Austral. J. Bot. 30 (3): 317. 1982. *Dacrydium bidwillii* Hook. f. *ex* Kirk, Trans. New Zealand Inst. 10: 388. 1878. Type: New Zealand: South Island, Nelson, *J. C. Bidwill 130* (lectotype K, sheet 1, here designated). Fig. 129, 130

Etymology

The species epithet commemorates John Carne Bidwill (1815–1853) an early collector of plants in New Zealand.

Vernacular names

Bog pine, Mountain pine, Tarwood

Description

Prostrate shrubs, densely branched erect shrubs, or sometimes a dwarfed tree to 4 m tall and 35 cm stem diam., commonly forming extensive thickets by layering. Bark becoming rough, hard and greying with age. Leaves of two distinct types: juvenile and adult. Juvenile leaves on seedlings and young plants, spreading radially, linear, (3–)5–10 mm long, 0.8–1.4 mm wide, convex adaxially, concave abaxially, with a midrib on that side; apex obtuse. Adult leaves abruptly appearing above juvenile leaves, scale-like, arranged in high spirals, on ultimate branchlets seemingly decussate, completely clasping the branchlets (including leaves 1.5–2 mm thick), rhombic in appearance, 1.5 × 1.2 mm (larger on thicker branches), weakly keeled and obtuse. Stomata of

juvenile leaves on both sides (leaves amphistomatic) but in more conspicuous bands on either side of the midrib on the adaxial side, on adult leaves scattered to just below apex. Pollen cones often numerous, terminal on branchlets with adult leaves, 3–5 mm long, slightly wider than branchlet; microsporophylls similar to scale leaves, yellow with 2–4 red pollen sacs. Seed cones subterminal and erect on branchlets with adult leaves, solitary, consisting of 4–5 leaf-like, slightly swollen bracts; one or sometimes two bracts fertile; epimatium aril-like, swollen and fleshy with irregular but clefted upper margin, white, subtending and partially enclosing seed; seed 3–4 mm long, striated and crested, ripening from green to black.

Taxonomic notes

Brian P. J. Molloy annotated a specimen (sheet 1, a) at K collected by J. C. Bidwill under his number 130 as lectotype and specimens with number 131 as "lectoparatype" of *Dacrydium bidwillii* Kirk in September 1991. Lectotypification is only effected when published, and this had not happened; in order to establish Molloy's choice (but extend it to all four branchlets on herbarium sheet 1) *J. C. Bidwill 130* on sheet 1 at K (specimens a-d which are a single gathering from a single tree) is here designated as the lectotype of *Dacrydium bidwillii* Kirk. *Bidwill 130* (e-f) and *131* on sheet 2 at K were annotated by Molloy as "lectoparatypes" and represent the residue of original material at K after this choice; they are syntypes which no longer have a type status for purposes of nomenclature after a lectotype has been chosen and published.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZS

Ecology

Halocarpus bidwillii can form extensive thickets by layering on open, stony ground or in boggy grassland. In the northern parts of its range it is a montane to subalpine shrub occurring between 600 and 1500 m a.s.l. but in the far south on Stewart Island it comes down to near sea level. It can be associated with *H. biformis, Podocarpus nivalis, Phyllocladus trichomanoides* var. *alpinus, Gaultheria depressa*, and *Cassinia vauvilliersii* in the central part of North Island in similar open habitats, or with podocarp trees like *Prumnopitys taxifolia, P. ferruginea* and *Manoao colensoi* in open coniferous forest at lower altitudes further south.

Conservation

IUCN: LC

Uses

This attractive conifer shrub remains exceedingly rare in cultivation. In New Zealand there is a lively gardening tradition but New Zealand gardens are very much Europe (read: England) orientated, with the native flora largely neglected. In England a few plants exist in arboreta, where it proves perfectly hardy. It is a conifer shrub "worthy of more widespread trial" as Keith Rushforth noted 20 years ago in his book Conifers (Rushforth, 1987). Nothing much seems to have happened and a reason for this is perhaps that the horticultural trade is not interested in 'new' species, but in new shapes and colour 'effects' which are more easily achieved working with the well known species already in the trade.

Halocarpus biformis (Hook.) Quinn, Austral. J. Bot. 30 (3): 318. 1982. *Podocarpus biformis* Hook., Icon. Pl., n.s., 2: t. 544. 1843; *Dacrydium biforme* (Hook.) Pilg., in Engler, Pflanzenr. IV.5 [18]: 45. 1903. Type: New Zealand: South Island, Southland, Dusky Sound, *A. Menzies s.n.* (lectotype K). Fig. 131

Etymology

The species epithet refers to the two distinct leaf types often encountered even on mature trees.

Vernacular names

Yellow pine, Pink pine, Alpine tarwood

Description

Densely branched erect shrubs, or sometimes a small tree to 10 m tall and 60 cm d.b.h., with a rounded or flat-topped crown. Bark becoming rough, hard, scaly and greying with age. Leaves of two distinct types: juvenile and adult. Juvenile leaves on seedlings to mature plants, spreading radially, linear, (5–)8–18 mm long, 1–1.5 mm wide, adaxially flat, abaxially with slightly revolute margins and a midrib; apex obtuse or apiculate. Adult leaves abruptly appearing above juvenile leaves (or branchlets reverting to juvenile leaves), scale-like, spirally arranged, completely clasping branchlets (including leaves 2–3 mm thick and angular), rhombic in appearance, 1.5 × 1.2 mm (larger on thicker branches), strongly keeled and obtuse. Stomata of juvenile leaves on both sides (leaves amphistomatic) but in more conspicuous bands on either side of midrib on adaxial side, on adult leaves conspicuous, scattered to just below apex. Pollen cones often numerous, solitary or 2–3 together, terminal on branchlets with adult leaves, 3–4 mm long, slightly wider than branchlet; microsporophylls similar to scale leaves, reddish, turning black, with 2–3 yellow pollen sacs. Seed cones subterminal and erect on branchlets having adult leaves tinged with red below the cones, solitary, consisting of 4–5 leaf-like, slightly swollen bracts; one or sometimes several bracts fertile; epimatium aril-like, swollen and fleshy with irregular but clefted upper margin, yellow, subtending and partially enclosing seed; seed 2.5–3 mm long, striated and crested, ripening from green to black.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Halocarpus biformis occurs more often in forested habitats than *H. bidwillii*, but in boggy terrain in the central volcanic plateau of North Island the two may occur together. The altitudinal range of this species is between 550 m to 1400 m a.s.l. As a small tree in forest it usually remains below the canopy of other trees. In open terrain it forms dense, rounded shrubs to 2 m tall, surrounded by sedges and grasses (e.g. *Deschampsia gracillima*) indicating acid soil and water logging. Here it can be associated with the conifers *H. bidwillii, Podocarpus nivalis*, and *Phyllocladus trichomanoides* var. *alpinus*, as well as with *Cassinia vauvilliersii, Dracophyllum, Olearia colensoi*, and in forest edges *Nothofagus solandri* var. *cliffortioides*.

Conservation

IUCN: LC

Uses

The pink-coloured wood with a pleasant, sweet fragrance is dense, fine-grained and extremely durable. It is therefore suitable for outdoor applications of carpentry like garden furniture, but its generally small size and often shrubby habit ensured that, even in the past when natural forest was much more widespread than now, it was not a very common commodity. It was used for railway sleepers, fence posts and some outdoor building applications. State protection of what is left of native trees prohibits felling and so there is no commercial use of its wood at present. It is not in cultivation outside a few botanic gardens and arboreta.

Halocarpus kirkii (F. Muell. *ex* Parl.) Quinn, Austral. J. Bot. 30 (3): 318. 1982. *Dacrydium kirkii* F. Muell. *ex* Parl., in Candolle, Prodr. 16 (2): 495. 1868. Type: New Zealand: ["Great Barrier Land(?)"],*T. Kirk 81* (holotype not located, isotype K).

Etymology

This species was named after the New Zealand botanist Thomas Kirk (1828–1898), who studied the forest flora of that country.

Vernacular names

monoao, manoao (Maori)

Description

Trees to 25 m tall; trunk to 1 m d.b.h., short with large, ascending branches forming a rounded or flat-topped crown. Bark smooth with horizontal lenticels on young trees, becoming hard, scaly and weathering grey, with exfoliating flakes covered in small pustules exposing reddish brown bark. Leaves of two distinct types: juvenile and adult. Juvenile leaves on seedlings to trees up to 10 m tall, spreading radially, linear, 20–45 mm long, 2–4 mm wide, petiolate and twisted at base, flat adaxially, with slightly revolute margins abaxially, with a faint midrib on either side; apex obtuse. Adult leaves abruptly appearing above juvenile leaves or on separate branches, scale-like, arranged in high spirals and on ultimate branchlets seemingly decussate, completely clasping branchlets (including leaves 1.5–3 mm thick and nearly terete), rhombic in appearance, 1.2–1.5 × 1.5 mm (larger on thicker branches), strongly keeled and obtuse. Stomata of juvenile leaves on both sides (leaves amphistomatic) but more densely in bands on either side of midrib on adaxial side, on adult leaves conspicuous, scattered to just below apex. Pollen cones often numerous, solitary or 2–3 together, terminal on branchlets with adult leaves, 3–4 mm long, slightly wider than branchlet; microsporophylls similar to scale leaves, green turning yellow, with 4–6 reddish pollen sacs. Seed cones subterminal and erect on branchlets with adult leaves tinged with red below cones, solitary, consisting of 4–5 leaf-like, slightly swollen bracts; one or sometimes two or three bracts fertile; epimatium aril-like, swollen and fleshy with irregular but clefted upper margin, orange, subtending and partially enclosing a seed; seed 3–4 mm long, striated and crested, ripening from green to black.

Distribution

New Zealand: North Island (between Hokianga and Te Paki Coastal Park, on Great Barrier Island and in the Coromandel Peninsula).
TDWG codes: 51 NZN

Ecology

Halocarpus kirkii is an uncommon forest tree occuring in lowland subtropical mixed evergreen forest to a maximum altitude of ca. 700 m. In the Waitakere Ranges near Auckland the kauris (*Agathis australis*) form emergent trees, with *Dacrycarpus dacrydioides, Dacrydium cupressinum, Podocarpus cunninghamii, Prumnopitys ferruginea*, and ocasionally *Halocarpus kirkii* together with various angiosperms making up the main canopy below them. Tall tree ferns (*Cyathea, Dicksonia*) often are abundant and can reach the canopy as well. These are rainforests with abundant epiphytes in the larger trees and numerous smaller trees and shrubs in the understorey.

Conservation

This is the only species in the genus to attain large tree size and consequently it has been subject to overexploitation, with many of the forests in which it occurred now gone. It has a limited natural distribution and populations are now fewer and more scattered than before logging began in the 19th century. The reduction that occurred is difficult to estimate, but is likely to have been in excess of 50% from its original area of occupancy (AOO), while podocarp wood was being logged preferentially where forests were not removed altogether. The decline has slowed and ceased in the second half of the twentieth century. It is considered a relatively uncommon tree even in forest reserves that have not or only lightly been logged. Regeneration is probably dependent on episodal disturbance of the forest canopy and may seem poor over shorter time intervals.
IUCN: VU A1 (a, c, d)

Uses

Monoao is a podocarp with fine grained wood suitable for construction timber, a use to which it was put in former times when it was still relatively abundant around Auckland and in Northland. It is now protected from logging and most trees occur in forest reserves. This species is not recorded in cultivation, but may be present in a few botanic gardens. According to Grimshaw & Bayton (2009: 388) there may be only one plant growing in the northern hemisphere: at Tregrehan in Cornwall, England.

Juniperus L., Sp. Pl. 2: 1038. 1753. Type: *Juniperus communis* L. (*Cupressaceae*).

Sabina Mill., Gard. Dict., Abridg. Ed. 4, vol. 3. 1754. Type: *Sabina vulgaris* Antoine [*Juniperus sabina* L.]; *Arceuthos* Antoine & Kotschy, Oesterr. Bot. Wochenbl. 4 (31): 249. 1854. Type: *Arceuthos drupacea* (Labill.) Antoine & Kotschy [*Juniperus drupacea* Labill.]; *Sabinella* Nakai, Chôsen Sanrin Kaihô 165: 14. 1938. Type: *Sabinella phoenicea* (L.) Nakai [*Juniperus phoenicea* L.].

Juniperus is the classical Latin name for junipers.

Description

Decumbent or erect shrubs or trees, evergreen, monoecious or dioecious. Resin cavities in leaves. Bark fissured, fibrous and stringy, exfoliating in long strips, or sometimes tesselated, hard and exfoliating in small flakes. Branches decumbent, erect, spreading or pendulous; foliage branches usually irregularly disposed, sometimes forming more or less flattened sprays. Leaves scale-like or acicular (the latter to 25 × 4 mm), decurrent or articulate, decussate or ternate (both leaf shapes and the two types of phyllotaxis can occur on the same plant, but these have either decurrent or articulate leaf bases), scale leaves glandular or eglandular, leaf margins entire or minutely denticulate; apex obtuse or acute-pungent, amphistomatic or epistomatic. Pollen cones terminal or axillary, with terminal cones solitary and axillary cones on dwarf shoots or sessile, 2–3 per ternate acicular leaf whorl, subglobose to ovoid, 2–7 mm long; microsporophylls 6–18, decussate or ternate, with 2–6 abaxial pollen sacs. Seed cones terminal on axillary (dwarf) shoots, 4–30 mm, globose, semiglobose or ovoid, indehiscent, hard dry or soft succulent with a smooth or sometimes rugose, often glaucous or pruinose surface. Bract-scale complexes in 1–4 decussate or ternate whorls, entirely fused (in one species partly fused), often with visible sutures and minute exserted bract apices on the surface. Seeds 1–8 per cone, in one species fused to a single 'stone', often with resin vesicles and ridges but without wings. Cotyledons 2 (in a few species 3–6); juvenile leaves on seedlings or also on young to mature plants, together with scale leaves or exclusively.

53 species.

Distribution

Europe, Africa, Macaronesia, Asia, North America, Central America, West Indies.

Taxonomic notes

In my Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a), reference was made to the work of R. P. Adams and collaborators, who have used biochemical data, among other data, to delimit the species in the genus *Juniperus*. I was critical of some of the species proposed on the basis of chemical compounds found in the terpines extracted from leaf samples. Since that critical review, the stream of papers by Adams *et al.* proposing new taxa, or recombinations of existing names, has increased dramatically. DNA sequencing is now providing additional data, often interpreted in a way that result in what are termed "cryptic" species: morphologically indistinguishable, but species nevertheless because the samples appear to represent distinct lineages in a phylogenetic (cladistic) analysis of the data. In the context of this Handbook, it is impossible to enter into a discourse about the various species concepts scientists advocate or denounce (for an overview see Stuessy, 2009 and for an entertaining debate on this issue see Wheeler & Meier, 2000). However, it seems to me safe to say that inferences about the delimitation of species when based on the 'phylogeny' of DNA sequence data from (necessarily) limited sampling are at best controversial. It appears that we are confronted with the controversial enforcement of phylogenetic monophyly (= holophyly) used here to identify species. Are species merely genealogical lineages? Are species populations of interbreeding individuals, separate in that function from other populations and thereby accumulating different and eventually distinct characters? Are species just 'kinds', conjured up by us? "Cryptic" species sensu Adams *et al.* may seem to follow the first option with some evidence for accumulating genetic differences. It is likely that they reflect ongoing evolution. Cryptic species certainly do present a problem in the practicalities of how to recognize them. They are not endorsed in this Handbook.

Synopsis

The currently accepted classifications appear to agree on a division of the genus in two sections: sect. *Juniperus* (syn. *Oxycedrus*) and sect. *Sabina* (but sometimes three, with *J. drupacea* removed from sect. *Juniperus*), but to differ in its further subdivisions dependent on the character(s) chosen to separate these. In the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a), I presented some evidence indicating that these (sub)divisions may be 'artificial', i.e. not based on or reflecting natural groups resulting from evolution. None of the chracters used to separate these sections or subsections are consistent throughout and another choice of characters would probably give another set of groups. A comprehensive phylogenetic analysis of the genus is at this time of writing still wanting ("in progress", Adams *et al.*, but see remarks above). A classification of the genus *Juniperus* should be based on inferred phylogeny as much as possible, but recognizing evolutionarily significant character changes as well. We are still some distance in time away from a robust phylogeny of distinct species which can inform a classification that is both informative and useful.

Key to the informal groups

The leaves referred to in the keys below (and with few exceptions in the descriptions) are those found on (sub)ultimate foliage branchlets of mature plants. Different shapes and sizes occur both on juvenile plants and on so-called whip shoots, the faster growing leading shoots; leaves are generally larger on older (lower order) branches, as they may continue to grow for a while with those branches. Plants in cultivation, even if true species, often tend to retain juvenile leaf types longer, especially those grown in a more humid climate than that of their natural range, or indeed in greenhouses. Such plants, especially when sterile, are often difficult to identify and these keys are not tuned to them, but to the species as they are found in nature.

1a. Leaves in mature plants all acicular (needle-like, if sometimes short), in alternating whorls of three **2**

1b. Leaves all scale-like, or at least some branchlets with scale leaves in mature plants, decussate or on some branchlets in whorls of three **Group 3 *('Sabina')***

2a. Leaves articulate at middle. Seed cones (sub) globose, with more than one seed (or seeds fused to one 'stone') **Group 1 *('Oxycedrus')***

2b. Leaves decurrent at base. Seed cones ovoid-globose to ovoid, usually with a single seed **Group 2 *('Squamata')***

Key to the species of Group 1

1a. Seed cones larger than 15 mm, hard, with well marked scales in whorls of three; seeds fused to a single 'stone'. Pollen cones in clusters with whorls of small leaves. Habit a tree ***J. drupacea***

1b. Seed cones smaller than 15 mm, or when larger (up to 23 mm), scales invisible or only marked as sutures; seeds free. Pollen cones solitary. Habit a shrub or tree **2**

2a. Leaves without a midrib on the adaxial side, stomata in a single band **3**

2b. Leaves with a midrib on the adaxial side, separating the stomata in two bands **4**

3a. Stomatal band wider than the green margins of leaves ***J. communis***

3b. Stomatal band narrower than the green margins of leaves, often hidden in a narrow groove ***J. rigida***

4a. Leaves usually obtuse. A species from Japanese islands in the Pacific ***J. taxifolia***

4b. Leaves usually acute or pungent, if obtuse, very short (4–10 mm), boat-shaped **5**

5a. Branchlets pendulous (except in shrubs at high altitude). Habit usually a tree. A species from China (including Taiwan) ***J. formosana***

5b. Branchlets spreading or sometimes pendulous. Habit a shrub (rarely a tree) **6**

6a. Leaves very short (4–10 mm), boat-shaped. A species from the Azores ***J. brevifolia***

6b. Leaves at least 8 mm long, usually longer than 10 mm **7**

7a. Leaves short or long (8–23 mm), widest near the middle. A species from Madeira and the Canary Islands ***J. cedrus***

7b. Leaves mostly 10–20 mm long, widest near the base. A species from the Mediterranean and the Middle East ***J. oxycedrus***

Key to the species of Group 2

1a. Branchlets drooping or pendulous. A large shrub or tree ***J. recurva***
1b. Branchlets spreading. A decumbent or erect shrub, occasionally a small tree **2**
2a. Leaves small (2–5 mm), not more than five times longer than wide, imbricate, usually appressed; apex incurved ***J. pingii***
2b. Leaves more than five times longer than wide, spreading at a narrow angle to patent; apex straight **3**
3a. Seeds usually 2–3 per cone, rarely a single seed ***J. procumbens***
3b. Invariably a single seed per cone ***J. squamata***

Key to the subgroups of Group 3 and *J. phoenicea*

1a. Margins of scale leaves entire. Seed cones dark blue-black, lustrous, succulent, containing a single large seed (very rarely a second, smaller seed) **Group 3a**
1b. Character states not in this combination **2**
2a. Margins of scale leaves minutely denticulate (× 20!). Seed cones lighter coloured, often glaucous, succulent or dry, containing 1–2 seeds (commonly only one seed) **Group 3b**
2b. Margins of scale leaves entire. Seed cones < 10 mm diam., succulent, usually containing two or more seeds (rarely only one) **Group 3c**
2c. Seed cones dry, containing more than two seeds, often glaucous or pruinose, rarely succulent and red or purplish black **3**
3a. Margins of leaves minutely denticulate (× 20!) **4**
3b. Margins of leaves entire **Group 3e**
4a. Seed cones dry when fully mature, usually glaucous **Group 3d**
4b. Seed cones succulent, reddish or purplish black, containing 3–8 seeds ***J. phoenicea***

Key to the species of Group 3a (Asian)

1a. Seed cones when mature < 10 mm long, globose or ovoid **2**
1b. Seed cones when mature usually > 10 mm long, ovoid, rarely globose **3**
2a. Ultimate branchlets slender, subterete, 0.8–1.2 mm wide ***J. convallium***
2b. Ultimate branchlets coarser, quadrangular, 1.0–1.7 mm wide ***J. saltuaria***
3a. Foliage branches drooping or pendulous **4**
3b. Foliage branches spreading **5**
4a. Foliage branches often with scale leaves as well as acicular leaves, both types bearing male or female cones ***J. przewalskii***
4b. Foliage branches with scale leaves only ***J. komarovii***
5a. Ultimate branchlets subterete, rarely quadrangular **6**
5b. Ultimate branchlets mostly quadrangular (except branchlets with leaves in whorls of three). A species of the Himalayas ***J. indica***
6a. Habit usually a monopodial tree, a shrub only under adverse ecological conditions. Leaves sometimes in whorls of three. A species of the Tibetan Plateau **51. *J. tibetica***
6b. Habit a decumbent or erect shrub, rarely a small tree. Adult scale leaves all opposite-decussate. A species of Central Asia ***J. pseudosabina***

Key to the species of Group 3b (American)

1a. Ultimate branchlets usually > 1.5 mm thick; leaves mostly in whorls of three, less often opposite-decussate **2**
1b. Ultimate branchlets < 1.5 mm thick; leaves mostly opposite-decussate, less often in whorls of three **6**
2a. Habit a shrub, rarely a tree **3**
2b. Habit a monopodial tree, rarely a shrub ***J. occidentalis***
3a. Ultimate branchlets thick, 2–2.5 mm diam., terete. Seed cones large, 10–18 mm ***J. californica***
3b. Ultimate branchlets < 2 mm thick. Seed cones smaller, 4–13 mm **4**

4a. Seed cones dry, 7–13 mm. Habit sometimes a small, sturdy tree ***J. osteosperma***
4b. Seed cones succulent when mature. Habit always a shrub **5**
5a. Seeds usually single in a cone. Shrub not coppicing (sprouting from the base) ***J. monosperma***
5b. Seeds 1–2 per cone. Shrub readily coppicing ***J. pinchotii***
6a. Seed cones small, 4–7 mm, dry when mature **7**
6b. Seed cones slightly larger, 5–9 mm, succulent when mature **8**
7a. Bark becoming tesselated on lower stem of mature small trees or large shrubs ***J. angosturana***
7b. Bark becoming stringy, exfoliating in strips ***J. comitana***
8a. Seed cones maturing to dark blue ***J. ashei***
8b. Seed cones maturing to pinkish or orange-red, sometimes purplish blue **9**
9a. Glands of leaves small, rounded, flat and about half as long as the decurrent leaf base ***J. arizonica***
9b. Glands of leaves large, rounded to oblong, flat or slightly raised and as long as the decurrent leaf base ***J. coahuilensis***

Key to the species of Group 3c (North American, Caribbean, Eurasian)

1a. Foliage branchlets commonly with scale leaves and/or acicular leaves on mature plants (some varieties of species have only one type of leaf) **2**
1b. Foliage branchlets of mature plants exclusively with scale leaves **3**
2a. Decumbent shrub. Foliage rarely with acicular leaves (but more commonly in one part of the range); seeds 1–3(–5) per cone ***J. sabina***
2b. (Decumbent) shrub or usually a large tree. Foliage mostly with a mixture of scale leaves and acicular leaves; seeds 2–4(–5) per cone ***J. chinensis***
3a. Seed cones often wider than tall, bilobed to nearly reniform, with two diverging seeds **4**
3b. Seed cones all ovoid-globose to globose, with converging seeds ***J. virginiana***
4a. Scale leaves on ultimate branchlets decussate or in whorls of three, length/width ratio ≥ 3:1 ***J. bermudiana***
4b. Scale leaves on ultimate branchlets all decussate, length/width ratio < 3:1 **5**
5a. Apices of scale leaves mostly mucronate or acute **6**
5b. Apices of scale leaves mostly obtuse **7**
6a. Apices of scale leaves mucronate or acute-acuminate. A species of the Caribbean ***J. gracilior***
6b. Apices of scale leaves acute or sometimes more or less obtuse. A species of W North America ***J. scopulorum***
7a. Scale leaves more or less gibbous, gland often inconspicuous. A species of the Caribbean ***J. barbadensis***
7b. Scale leaves more flattened, gland always conspicuous. A species of Mexico ***J. blancoi***

Key to the species of Group 3d (Mexican, Arizona to W Texas)

1a. Bark on (the lower part of) the trunk of trees tesselated or fissured, hard ***J. deppeana***
1b. Bark on the trunk of trees fibrous, exfoliating in long strips, soft **2**
2a. Habit a monopodial tree **3**
2b. Habit a shrub, rarely a small tree **4**
3a. Foliage branches spreading. Seed cones 5–7.5 mm, brown (variously glaucous) ***J. jaliscana***
3b. Foliage branches drooping to pendulous. Seed cones 8.5–15 mm or larger, light brown (strongly glaucous) ***J. flaccida***
4a. Seed cones light brown to reddish brown, dull, with 1–3, rarely 4 seeds per cone **5**
4b. Seed cones usually purplish red or purplish black, lustrous, with 2–9 seeds per cone ***J. monticola***
5a. Leaves on ultimate branchlets small, nearly as wide as long, 0.8–1.2 × 0.8–1 mm, glands inconspicuous ***J. durangensis***
5b. Leaves on ultimate branchlets larger, longer than wide, 1.2–1.5 × 1–1.2 mm, glands conspicuous but not with resin drops ***J. saltillensis***

Key to the species of Group 3e (American, African, Eurasian)

1a. All leaves on ultimate branchlets appressed, small and scale-like. Seed cones globose, 6–12(–14) mm. A tree of Eurasia ***J. excelsa***
1b. Characters not in this combination **2**
2a. Habit a prostrate or decumbent shrub. A species of boreal North America ***J. horizontalis***
2b. Habit a (small or large) tree, rarely a shrub under adverse conditions… **3**
3a. Seed cones usually broader than long, often more or less reniform or bilobed, in such cones only two seeds present with diverging apices **4**
3b. Seed cones globose or subglobose, with (2–)3–6(–8) seeds per cone with converging apices **5**
4a. Foliage with only acicular leaves (juvenile phase) but capable of bearing male or female cones. A species of the Caribbean ***J. saxicola***
4b. Foliage normally with scale leaves only ***J. semiglobosa***
5a. Scale leaves on foliage branchlets often with spreading, free apex ***J. foetidissima***
5b. Scale leaves on foliage branchlets all appressed **6**
6a. Ultimate branchlets very slender, 0.6–1 mm wide. Seed cones small, 3–7 mm diam. ***J. procera***
6b. Ultimate branchlets thicker, 1–1.4 mm wide. Seed cones usually larger, 6–10 mm diam **7**
7a. Mature seed cones brown, often glaucous. A species of Central America ***J. standleyi***
7b. Mature seed cones blackish blue or purplish black, not glaucous ***J. thurifera***

Juniperus angosturana R. P. Adams, Biochem. Syst. Ecol. 22 (7): 704. 1994. *Juniperus monosperma* (Engelm.) Sarg. var. *gracilis* Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 111. 1946. Type: Mexico: San Luis Potosí, Hacienda de Angostura, 4 km W of Angostura, *C. G. Pringle 3771* (holotype MEXU lost, isotype K).

Etymology

The specific name refers to Hacienda de Angostura in San Luis Potosí, Mexico, where the type specimen was collected.

Vernacular names

Slender one-seed juniper

Description

Small trees or shrubs to 3–8(–10) m tall, dioecious; trunk to 40–50 cm diam. Bark on trunk 1–2 cm thick, fissured, usually tesselated, or with longer exfoliating plates; inner bark light brown or cinnamon; outer bark weathering grey. Branches thick, large, spreading and assurgent, tortuous, foliage spreading or drooping, forming an irregular, spreading or more or less dome-shaped crown. Foliage branches iregularly disposed, lax and slender, ultimate branchlets 4–20 mm long, straight or curved, 1–1.3 mm wide, quadrangular to terete (depending on phyllotaxis. Leaves decussate (mostly on ultimate branchlets) or in alternating whorls of 3, imbricate, appressed, or with a few reflexed leaf apices on older branchlets, oblong-rhombic or oblong-ovate on ultimate branchlets, 1–1.5 × 0.7 mm, obtuse or acute; upper margins minutely hyaline-serrulate (esp. of smaller leaves); stomata few abaxially, near base, partially hidden by margins of lower leaves, adaxially in two bands from base to apex, separated by a narrow midrib, most leaves of ultimate branchlets eglandular, some leaves with an oblong, inactive gland, leaf colour yellowish green or light green. Pollen cones terminal, solitary, ovoid-oblong, 2.5–3 mm long, terete; microsporophylls 10–12, decussate, peltate; margins hyaline-denticulate; apex acuminate, bearing 3–4 abaxial pollen sacs. Seed cones numerous, terminal on very short, lateral branches with only 6–8 decussate scale leaves, maturing in one year, globose or subglobose to ovoid, 4–6 × 3–5 mm, purplish blue, then pinkish with glaucous bloom, drying brown. Bract-scale complexes 4(–6), decussate, sometimes ternate, entirely fused with barely exserted bract tips, smooth (rugose *in sicco*), soft pulpy, slightly resinous. Seeds 1(–2), ovoid to subglobose (when solitary), 3–5 × 2.5–4 mm, with shallow grooves; apex more or less acute, lustrous (light) brown, with a tan hilum at base.

Distribution

Mexico: Coahuila, Hidalgo, Nuevo León, Queretaro, San Luis Potosí, Tamaulipas (Sierra Madre Oriental).
TDWG codes: 79 MXE-CO MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA

Ecology

In open shrubland or in Pinyon-Juniper woodland, associated with *Pinus cembroides, Juniperus flaccida* and sclerophyllous shrubs; on rocky slopes and along intermittent streams. Also found in open pine forest with *P. montezumae*.

Conservation

Increasing pressures from grazing livestock are the main threat to this species.
IUCN: VU [B2ab (iii, v)]

Uses

No uses have been recorded of this species.

Juniperus arizonica (R. P. Adams) R. P. Adams, Phytologia 88 (3): 306. 2006. *Juniperus coahuilensis* (Martínez) Gaussen *ex* R. P. Adams var. *arizonica* R. P. Adams, Biochem. Syst. Ecol. 22 (7): 708. 1994. Type: USA: Arizona, Yavapai Co., Camp Verde, *R. P. Adams 2132* (holotype BAYLU).

Etymology

The species epithet refers to the State of Arizona, where the type specimen was collected.

Vernacular names

No vernacular name has been given to this species; an obvious choice would be Arizona juniper.

Description

Large shrub to 5 m, or small tree to 10 m, dioecious, rarely monoecious; multistemmed or with a short trunk and a maximal diam. of 50 cm. Bark of thick branches and trunk fibrous, exfoliating in strips, weathering ash-grey. Branches numerous, long, ascending from base or spreading, often curved, those of higher orders ascending or spreading, forming a broad, rounded or more irregular and open crown. Foliage branches numerous, irregularly disposed but not pendulous, ultimate branchlets spreading 30–70 degrees, slender and stiff, up to 15 mm long, 1–1.5 mm thick, (weakly) quadrangular in cross section, covered with scale leaves, persistent. Leaves decussate on all ultimate branchlets, decussate or in alternate whorls of 3 on older branchlets, imbricate, scale-like, 1.2–1.7(–1.8) × 0.7–1.2 mm on lateral branchlets, decurrent, rhombic or ovoid-rhombic; apex appressed or rarely free, obtuse to acute; margins minutely denticulate; stomata on abaxial side limited to two small spots near leaf base, on adaxial surface in two tapering bands; glands central on small scale leaves, below the free apex on longer whip shoot leaves, more or less conspicuous, small, rounded, flat, half as long as the decurrent part of the leaf; exudate sometimes present; leaf colour yellowish green or light green. Pollen cones numerous, terminal, solitary, ellipsoid or ovoid-oblong, 3–4 × 2–2.5 mm, yellowish maturing to light brown; microsporophylls 8–10, decussate, peltate, acute, with minutely denticulate upper margins and with 3–4 abaxial pollen sacs. Seed cones terminal on straight, very short branchlets, maturing in one season attaining variable colours from pinkish(–red) or orange(–red) to purplish blue, usually glaucous, (sub-)globose or sometimes broad ovoid, 5–7 mm diam. (if ovoid to 9 mm long), internally soft pulpy, succulent, yellowish to orange-brown. Bract-scale complexes 4(–6), entirely fused, decussate, bract apices minutely exserted or hidden; surface smooth, rugose when dry. Seeds 1(–2) per cone, ovoid-globose, 3–5(–6) × 3–4(–5) mm, base rounded; apex acutish, shallowly grooved and ridged on sides, not or slightly resinous, chestnut brown, with a large, lighter lobed hilum proximally (the seeds in some trees appear to protrude distally from the cone = 'gymnocarpous' cones).

Taxonomic notes

This taxon, formerly recognized as a variety under *Juniperus coahuilensis* (see e.g. Adams, 2004, Farjon, 2005a), has been found in a recent phylogenetic analysis based on DNA sequence data of one-seeded, serrate-leaf junipers of the SW USA and northern Mexico to be quite unrelated to that species. It appears to be forming a clade with *J. occidentalis* and *J. osteosperma*, whereas *J. coahuilensis* is nearer *J. monosperma* and *J. pinchotii*. Therefore, Adams elevated it to species rank, which on the given evidence seems to be convincing and is here followed.

Its morphology is, however, most similar to that of *J. coahuilensis* and the two may not be so easy to separate in the field, as the only reported consistent difference is in the size of the leaf glands.

Distribution

SW USA: Arizona, SW New Mexico; Mexico: NE Sonora.
TDWG codes: 76 ARI 77 NWM 79 MXN-SO

Ecology

In *Bouteloua* grassland and on adjacent rocky slopes. It has a capacity to coppice, considered 'weedy' in some areas by sheepmen and cattlemen. In Arizona it occurs with *Juniperus osteosperma* in some localities; other associated species are sometimes *Opuntia* spp. or *Yucca* spp., but commonly its only associates are grasses. Altitudinal range 980–1600(–2200) m a.s.l.

Conservation

IUCN: LC

Uses

No uses have been recorded of this species.

Juniperus ashei J. T. Buchholz, Bot. Gaz. (Crawfordsville) 90 (3): 329. 1930.

Etymology

The species epithet commemorates William W. Ashe, who made the first botanical collections of it.

Vernacular names

Ashe juniper, Mountain cedar, Ozark white cedar, Rock cedar, Post cedar, Mexican juniper

Description

Large shrubs or small trees 6–10(–15) m, dioecious; with a short trunk 1–3 m tall and a diam. of 30–50(–120) cm, or branching at base. Bark of of thick branches and trunk exfoliating in strips, brown weathering grey. Branches long, spreading to ascending or nearly erect, forming a sympodial, broad, rounded and dense or more irregular and open crown. Foliage branches numerous, irregularly disposed but not pendulous, ultimate branchlets spreading to erect, stiff, 5–10(–20) × 0.9–1.3 mm, mostly 4-sided in cross section, covered with closely appressed leaves, persistent. Leaves decussate, or occasionally in alternate whorls of 3 on whip shoots, (slightly) imbricate, scale-like, 1–2 × 0.8–1.2 mm on lateral branchlets, decurrent, rhombic, often keeled, acute; margins minutely denticulate; stomata on the abaxial side limited to decurrent leaf base, on the adaxial surface in two bands; glands obscure or conspicuous on whip shoot leaves, hemispheric or oval to elongate, raised; exudate absent; leaf colour light to dark green. Pollen cones numerous, terminal, solitary, subglobose to ovoid, 2–4 × 2 mm; microsporophylls 6–10, decussate, peltate with minutely erose-denticulate or entire margins and with 3–4(–5) abaxial, large pollen sacs. Seed cones terminal on straight short branchlets, maturing to dark blue within 1 year, globose to broadly ovoid, (5–)6–9 mm, succulent and resinous. Bract-scale complexes entirely fused, 4–6, decussate, indiscernible in mature cones; surface smooth, rugose when dry, lustrous or very glaucous (in some populations brownish). Seeds 1(–2, rarely 3) per cone, broad ovoid, 4–6 × 3–4.5 mm, not flattened, smooth or vaguely grooved, lustrous yellowish brown to chestnut brown, with a lighter hilum proximally.

Distribution

Central USA: Arkansas, Missouri (Ozark Mts.), Oklahoma, Texas (Edwards Plateau, W Texas); Mexico: N Coahuila.
TDWG codes: 74 MSO OKL 77 TEX 78 ARK 79 MXE-CO

Ecology

This species occurs in open grassland and shrubland, sometimes associated with *Juniperus pinchotii, Pinus remota*, and *Quercus* spp.; in sandy or rocky soil on plains, on bluffs and ridges, on hillsides or along stream beds in sandy or rocky soil, commonly over limestone. The altitudinal range is (150–)600–1550 m

a.s.l. The climate is continental, with warm summers and cold winters, drier with hotter summers in the south of its range.

Uses

In the past the wood was used by cattle ranchers for fenceposts, but metal has displaced it. The wood is now mainly used to produce 'cedarwood oil' through steam distillation. This species is not known to be in cultivation, but it may be present in a few botanic gardens.

2 varieties are recognized:

Juniperus ashei J. T. Buchholz var. ***ashei***. *Sabina ashei* (J. T. Buchholz) A. V. Bobrov & Melikyan, Komarovia 4: 81. 2006. Type not designated.

Description

Glands on whip shoots hemispheric. Seed cones 7–9 mm diam.; seeds mostly 1 per cone, rarely 2.

Distribution

Central USA: Arkansas, Missouri (Ozark Mts.), Oklahoma, Texas (Edwards Plateau).
TDWG codes: 74 MSO OKL 77 TEX 78 ARK

Conservation

IUCN: LC

Juniperus ashei J. T. Buchholz var. ***ovata*** R. P. Adams, Phytologia 89 (1): 17. 2007. Type: USA: Texas, Crockett Co., 5 km W of Ozona, *R. P. Adams 7463* (holotype BAYLU).

Description

Glands on whip shoots oval to elongate. Seed cones (5–)6(–8) mm diam.; seeds more often 2 instead of 1 per cone.

Distribution

USA: W Texas; Mexico: extreme N Coahuila.
TDWG codes: 77 TEX 79 MXE-CO

Conservation

IUCN: NT

Juniperus barbadensis L., Sp. Pl. 2: 1039. 1753.

Etymology

The species epithet refers to the island of Barbados.

Vernacular names

West Indies juniper; Barbados cedar (var. *barbadensis*), Red cedar; Cèdre (French) (var. *lucayana*)

Description

Shrubs or trees to 10–12 m tall; trunk to 40 cm diam., dioecious. Bark on tree trunks thin, stringy, exfoliating in long strips or thin plates, becoming grey-brown. Branches spreading horizontally or ascending, in shrubs ascending or erect, forming initially pyramidal, then open and irregular crowns in trees. Foliage branchlets numerous, irregularly disposed or sometimes more or less distichous and gradually shorter, variable in length from 5–30(–60) mm, slender or very slender, 0.8–1.2 mm diam., subterete to quadrangular in branchlets with scale leaves, persistent. Leaves decussate, decurrent, scale-like on mature plants and branches, imbricate, appressed but slightly diverging, on ultimate branchlets 1–1.5 mm long, rhombic to rhombic-lanceolate; margins entire; apex obtuse to acute or mucronate, abaxially with a more or less conspicuous rounded to elliptic gland, green or greyish green; stomata few at base abaxially, in one or two concave fields adaxially. Pollen cones terminal, oblong, 2.5–3 × 1.5 mm, more or less quadrangular; microsporophylls 12–16, decussate, broad peltate, with rounded and entire upper margin, abaxially bearing 2–3 globose pollen sacs. Seed cones terminal on erect, short ultimate branchlets, maturing in one season, becoming irregularly globose or broad pyriform to nearly reniform, 4–5 × 6–7(–8) mm, usually soft pulpy, resinous, pruinose-blue or blackish blue. Bract-scale complexes 4, decussate, entirely fused, sutures or bract tips invisible. Seeds (1–)2–3(–4) per cone, ovoid-globose (if more than two in a cone flattened on one side), 2–3 mm, light yellowish brown.

Distribution

Bahamas, Cuba, Haiti, Jamaica, Windward Islands.
TDWG codes: 81 BAH CUB HAI-HA JAM WIN-SL

Ecology

In shrubland and in 'pine barrens' or pine savannas, in the latter associated with *Pinus caribaea* var. *bahamemsis, P. tropicalis*, in upland hills with *P. caribaea* var. *caribaea* or *P. occidentalis*, also scattered on rocky cliffs and escarpments in nutrient poor sand or rocks, commonly over limestone or karst. In the pine savannas fires are very frequent. Its altitudinal range is from 8 m to 1600 m a.s.l. The climate is tropical, with a mean annual temperature above 20° Celsius and annual precipitation ca. 1000–1800 mm with a prolonged dry season.

2 varieties are recognized:

Juniperus barbadensis L. var. ***barbadensis***. Type: Barbados: locality unknown, [if collected from Barbados, it is extinct there], *leg. ign. LINN 1198.1* (lectotype LINN).

Description

Ultimate branchlets slender, 1.0–1.2 mm diam. Leaves imbricate, slightly spreading, forming 4 regular rows of nearly free leaf tips along the branchlets; apex obtuse or acute; glands inconspicuous or conspicuous.

Distribution

Windward Islands: St. Lucia (Petit Piton); extinct on Barbados.
TDWG codes: 81 WIN-SL

Ecology

In its only remaining habitat restricted to limestone cliffs near the summit of a mountain, with other shrubs.

Conservation

The population that apparently once existed on Barbados disappeared probably in the early part of the 18th century, the location having been converted to sugar cane plantations. Recently this variety has been found on the 'Petit Piton' summit on St. Lucia at ca. 730 m a.s.l., where Adams (1989) found ca. 25 trees, all within 30 m of the rocky summit, where they seem to have escaped attention from goats as well as people. Despite the possibility of its occurrence on other nearby islands, nothing has been found there to date, and this appears to be the only extant population of this variety.
IUCN: CR (D)

Juniperus barbadensis L. var. ***lucayana*** (Britton) R. P. Adams, Phytologia 78: 145. 1995. *Juniperus lucayana* Britton, N. Amer. Trees: 121. 1908.
Type: Bahamas: New Providence, Southwest Bay, *N. L. Britton & L. J. K. Brace 497* (holotype NY).

Description

Ultimate branchlets very slender, 0.8–1.0 mm diam. Leaves imbricate, appressed or slightly spreading, less markedly in 4 rows; apex obtuse to acute or mucronate; glands conspicuous.

Distribution

Bahamas, Cuba (Sierra de Nipe, Cienfuegos, Las Villas, Isla de la Juventud, Haiti, Jamaica.
TDWG codes: 81 BAH CUB HAI-HA JAM

Conservation

This, the more widespread form of *J. barbadensis*, is nevertheless severely restricted in most of its range and threatened by habitat changes. Small stands of 5–30 trees are the usual situation in the Bahamas and in Jamaica (Adams, 1989) and some are also threatened by cutting as the wood is used in souvenir carving. In Cuba, larger populations exist in the Sierra de Nipe and in swampy areas on Isla de la Juventud

[Isla de Pinos], but an accurate assessment of this taxon in Cuba has not been undertaken to date. At least some stands in Cuba are in less accessible locations, providing for the time being some measure of protection.
IUCN: VU [C2a (i)]

Uses

The wood is locally used for the carving of souvenirs.

Juniperus bermudiana L., Sp. Pl. 2: 1039. 1753. Type: Netherlands: (cultivated), *leg. ign. [ex herb. D. van Royen] 901.130–394* (neotype L).

Etymology

The species epithet refers to its origin, the island of Bermuda, where it is endemic.

Vernacular names

Bermuda cedar, Bermuda red cedar, Bermuda juniper

Description

Trees to 10–12 m tall, with monopodial, erect trunk to 60 cm diam., dioecious. Bark on tree trunks thin, exfoliating in strips, red-brown becoming grey-brown. Branches spreading horizontally or ascending, long, forming initially pyramidal, then open and irregular, spreading or flat-topped crowns. Foliage branchlets numerous, disposed at angles of 25–35 degrees, ultimate branchlets variable in length from 10–40 mm, lax, 1.3–1.6 mm diam., quadrangular or sometimes subterete, persistent. Leaves on ultimate branchlets decussate, occasionally in alternating whorls of 3, decurrent, imbricate, appressed but slightly diverging, overlapping a third to half of the next leaves, on ultimate branchlets scale-like, 1.5–2.5 × 1–1.5 mm, ovate-rhombic to rhombic-lanceolate; margins entire; apex obtuse to acute-mucronate; leaves abaxially with a conspicuous elliptic to linear gland, green; stomata few at base abaxially, in two concave fields adaxially. Pollen cones terminal on ultimate branchlets, oblong-cylindrical, 4–6 × 2–3 mm, more or less quadrangular; microsporophylls 12–16, decussate, peltate; upper margin rounded and entire-hyaline, abaxially bearing 4–6 flattened, tightly packed pollen sacs. Seed cones terminal on erect, short ultimate branchlets, maturing in one season, becoming irregularly globose or broad pyriform to nearly reniform, 4–6 × 5–8 mm, usually soft pulpy, resinous, pruinose-blue or dark purplish blue. Bract-scale complexes 6, decussate, rarely in 2 whorls, entirely fused, sutures invisible, a few minute bract tips protruding. Seeds 1–2(–3) per cone, ovoid-globose, 2–3 mm, more or less keeled, lustrous brown.

Distribution

Bermuda.
TDWG codes: 81 BER

Ecology

Relict trees occur on eroded limestone rocks with pockets or fissures filled with sandy soil, or on hills with skeletal, sandy soil, from near sea level to 50 m a.s.l.

Conservation

In the late 1940's populations became heavily infested with two accidentally introduced species of 'scale' insects, of which the Juniper Scale (*Carulapsis minima*) outcompeted the other species and became lethal to 99% of the then existing junipers. Introduced and naturalized trees and shrubs (*Citharexylum spinosum, Eugenia uniflora, Pimenta officinalis*, and *Schinus terebinthefolius*) have largely replaced the died stands of Bermuda cedar. Some trees survived, possibly due to some resistance to the insects, but regeneration is largely unsuccessful. Where regeneration has occurred, young trees may have developed some resistance but this needs confirmation. Introduction of pest-resistant *Juniperus virginiana* could pose a threat to the genetic integrity of still existing trees of *J. bermudiana*. Ongoing urbanisation has left little natural habitat on the island but some nature reserves have been established.
IUCN: CR (A2a, c, e)

Uses

When Bermuda cedar was still abundant the reddish, durable and sometimes beautifully figured

wood was used in shipbuilding and especially cabinet making. Cabinets made of its wood are highly valued and treated as heirlooms in Bermuda. This species has been taken into cultivation from the late 17th century but only survives in countries with very mild winters, such as southern Europe, Ireland, California and Florida.

Juniperus blancoi Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 73. 1946.

Etymology

This species was named after Cenobio E. Blanco, who collected the type specimen.

Vernacular names

Blanco juniper; táscate (Spanish)

Description

Small (shrubby) trees 8–10(–15) m, or sometimes a small shrub, dioecious; (short) trunk with a maximal diam. of 50 cm. Bark on larger trunks longitudinally fissured, rough, exfoliating in thin, elongated strips or more compact, brown weathering grey-brown. Branches spreading, or ascending in young trees, often contorted, forming a pyramidal crown in young trees, to a broad, rounded or more irregular crown in old trees. Foliage branches numerous, irregularly disposed, spreading to subpendulous, ultimate branchlets spreading or drooping, lax, slender, 4–25 mm long, 0.8–1.2 mm thick, more or less quadrangular in cross section, covered with scale leaves, persistent. Leaves decussate, imbricate, scale-like, 1.3–2 × 0.7–1 mm on lateral branchlets, decurrent, oblong-rhombic; apex appressed or just free, obtuse or apiculate; margins (hyaline-)entire; stomata on abaxial side limited to leaf base, on adaxial surface in two tapering bands; glands conspicuous, large, elliptical or oblong, slightly depressed, usually inactive; leaf colour yellowish green to grey-green. Pollen cones numerous, terminal, solitary, ovoid or subglobose, 2–3 × 1.5–2 mm; microsporophylls 6–8, decussate, peltate, with entire or hyaline-erose upper margins and obtuse or mucronate apex; 3–4 abaxial pollen sacs. Seed cones terminal on straight or curved, 3–6 mm long branchlets, maturing to purplish red, dark blue or tan with glaucous bloom in 1–2 years, subglobose to reniform or bilobed, 5–7 × 5–9 mm (often wider than long), internally soft pulpy. Bract-scale complexes 4–6, entirely fused, decussate, mostly indiscernible in mature cones; bract apices minutely exserted; surface smooth, rugose when dry, usually glaucous. Seeds 1–2(–5) per cone, with apices often diverging, irregularly ovoid-triangular or curved at apex, sometimes concavo-convex, 3–5 × 2–4 mm, grooved and ridged on sides, with small resin pits near base, light brown, with a large darker hilum proximally.

Distribution

Mexico: Chihuahua, Sonora, Durango, México, Michoacán.
TDWG codes: 79 MXC-ME MXE-CU MXE-DU MXN-SO MXS-MI

Ecology

The ecology of this species has not been assessed due to a paucity of specimen data. It is believed to occur in the drier types of pine woodland with *Pinus cembroides*.

Uses

No uses have been recorded of this species.

3 varieties are recognized:

Juniperus blancoi Martínez var. ***blancoi***. Type: Mexico: Durango, El Salto Mun., El Salto, Arroyo de Peñuelas, *M. Martínez & C. E. Blanco 10527* (holotype MEXU).

Description

Small trees. Leaves on ultimate branchlets oblong-rhombic or rhombic, obtuse, appressed. Mature seed cones tan or blue, with glaucous bloom.

Distribution

Mexico: Durango (El Salto, San Ramón), México (Carmona, Villa Victoria), Michoacán.
TDWG codes: 79 MXC-ME MXE-DU MXS-MI

Conservation

This taxon is only known from less than six locations, but in some of these it is locally common and no particular threats seem to be imposed on it.
IUCN: VU [B2ab (iii)]

Juniperus blancoi Martínez var. ***huehuentensis*** R. P. Adams, Biochem. Syst. Ecol. 34: 207. 2006. Type: Mexico: Durango, Cerro Huehuento, summit S of Huachichiles, *S. Gonzáles et al. 6832* (holotype CIIDIR).

Description

Shrubs 0.5–1.5 m tall, 2–4 m wide. Most seed cones situated on the underside of branches.

Distribution

Mexico, Durango (Sierra Madre Occidental, summit area of Cerro Huehuento).
TDWG codes: 79 MXE-DU

Ecology

This is a subalpine shrubby form of *J. blancoi* presently only known from one mountain summit area at 3150–3270 m a.s.l., where it grows together with *J. deppeana* var. *robusta* in nearly bare rock and scree.

Conservation

IUCN: VU [B2ab (iii)]

Juniperus blancoi Martínez var. ***mucronata*** (R. P. Adams) Farjon, Monogr. *Cupressaceae* & *Sciadopitys*: 249. 2005. *Juniperus mucronata* R. P. Adams, Biochem. Syst. Ecol. 28 (1): 158. 2000. Type: Mexico: Sonora, Maicoba River, 19 km W of Maicoba, along Mex. Hwy. 16 at km 307, *R. P. Adams 8704* (holotype SRCG).

Description

Small trees. Leaves on ultimate branchlets rhombic or ovoid-rhombic, apiculate; apex just free. Mature seed cones purplish red or blue, with glaucous bloom.

Distribution

Mexico: Chihuahua, Sonora.
TDWG codes: 79 MXE-CU MXN-SO

Conservation

This taxon was only known from two collections made by Robert P. Adams, on 20 December 1998 only a few km separate from each other. It is likely that this variety occurs more abundantly in this area of northern Mexico, and a search of the herbaria has now resulted in two further specimens. They are located in the drainage of the Rio de Bavispe in NE Sonora, already collected in the 1940s.
IUCN: VU [B2ab (iii)]

Juniperus brevifolia (Seub.) Antoine, Cupress.-Gatt.: 16, t. 20–22. 1857. Type: Macaronesia: Azores, Flores, [the specimen at P is recorded as from Faial], *C. F. Hochstetter 124* (holotype not located, isotypes K, P).

Etymology

The species epithet means "with short leaves".

Vernacular names

Azores juniper, Cedro (Portugese)

Description

Spreading or tall shrubs to small trees, to 6 m, dioecious; trunk diam. to 50 cm, low branching. Bark on large trunks with long, soft strips, from reddish brown to grey-brown. Branches numerous, spreading, assurgent or ascending. Foliage dense and stiff, with numerous spreading, 'jointed' ultimate branchlets, persistent, forming a shrubby, irregular crown (prostrate at high altitudes). Leaves in alternating whorls of 3, rarely 4, non-decurrent, spreading 45–90 degrees at nodes 1.5–3(–5) mm apart, rigid, jointed to leaf part adnate with shoot, lanceolate to narrowly ovate ('boat-shaped'), 4–10 × 1–3 mm, usually

broadest near the curved, slightly thickened base; margins entire; abaxial face keeled; leaf colour green to dark green; apex obtuse-acuminate or acute-pungent; epistomatic, with stomata in two conspicuous bands with whitish cuticular wax separated by a midrib, bordered by green margins broader than the midrib. Pollen cones solitary, 1–2 per leaf whorl, subglobose to ovoid-oblong, 3–5 × 2–4 mm; microsporophylls 10–14, in alternating whorls of 3, peltate, with erose-denticulate margins and acute apex, bearing 3–4 abaxial pollen sacs near lower margin. Seed cones maturing in 2 years; mature cones globose, 6–9 mm diam., with 1(–2) whorls of 3 completely fused bract-scale complexes, only the upper whorl fully developed, 3 sutures visible on distal part of cone, bract tip hidden or very small, tissue soft pulpy, juicy in most cones; immature cones green, hard; mature cones dark red-brown, often slightly glaucous. Seeds 1–3 per cone, (angular-)ovoid, 5–6 × 3–4 mm, light brown with obtuse apex.

Distribution

Azores.
TDWG codes: 21 AZO

Ecology

The habitat of this species has apparently been altered greatly since the arrival of man and his domestic animals on the islands in the 16th century. It is a constituent of the Macaronesian evergreen forest of which only scattered remnants remain. Important species in this forest type in the Azores are *Laurus azorica, Persea indica, Myrica faya, Erica azorica, Frangula azorica, Ilex perado* subsp. *azorica*, and shrubs such as *Bencomia, Pericallis* and *Phyllis*. Well developed forest occurs often on newly formed lava flows. *Juniperus brevifolia* is now more often found in secondary heathland. The altitudinal range of *J. brevifolia* is from near sea level to 1300 m, commonly from 240–800 m a.s.l. The prevailing SW winds ('westerlies') set the conditions for a moist but mild climate with abundant rain and fog.

Conservation

Forest destruction and fragmentation of remnants of natural vegetation have all but eliminated large trees of *Juniperus brevifolia*. Forest remnants are now very restricted and scattered. Afforestation with exotic trees, e.g. *Cryptomeria* and *Eucalyptus*, is widespread and causes (irreversible?) habitat changes unsuitable to native trees. Invasive herbs and shrubs, e.g. *Hedychium gardnerianum* and *Hydrangea macrophylla*, spread over semi-natural vegetation and ubiquitous grazing of domestic animals cause further habitat degradation. Today *Juniperus brevifolia* is only known as a (straggling) shrub, but remains of old trunks on some islands indicate its former extent and condition.
IUCN: VU [A2 (a, c, e); B2ab(ii, iii)]

Uses

This shrubby juniper is rare in cultivation; it would be suitable for gardens in areas with mild winters. Its endangered status in the Azores merits wider use in cultivation especially in connection with *ex situ* conservation programmes.

Juniperus californica Carrière, Rev. Hort., sér. 4, 3: 352. 1854. Type: Illustration in Rev. Hort., sér. 4, 3: 353, f. 21. 1854 (lectotype). Fig. 132, 133

Juniperus californica Carrière f. *lutheyana* J. T. Howell & Twisselm., Four Seasons 2 (4): 16. 1968.

Etymology

The species epithet denotes its origin, the US State of California.

Vernacular names

California Juniper; Huata, Cedro (Spanish)

Description

Large shrubs to 5–7(–10) m, dioecious, sometimes monoecious; with a short trunk to 1 m tall and a diam. of 30–40 cm, but more often multistemmed. Bark of thick branches and trunk exfoliating in strips, weathering grey. Branches numerous, long, ascending or nearly erect, forming a broad, rounded and dense or more irregular and open crown. Foliage branches numerous, irregularly disposed but not pendulous,

ultimate branchlets spreading to erect, very stout and stiff, up to 40 mm long, 2–2.5 mm thick, subterete or rarely weakly 4-sided in cross section, covered with closely appressed leaves, persistent. Leaves in alternate whorls of 3, rarely opposite-decussate, imbricate, scale-like, 1.5–3 × 1.5–2.5 mm on lateral branchlets, decurrent, rhombic to ovoid-rhombic, gibbous, acutish; margins minutely denticulate; stomata on the abaxial side limited to decurrent leaf base, on adaxial surface in two tapering bands; glands conspicuous, oval or oblong, slightly depressed, exudate sometimes present; leaf colour yellowish green or light green. Pollen cones numerous, terminal, solitary, subglobose to ovoid-oblong, 3.5–6.5 × 2–3 mm; microsporophylls (10–)12–15(–18), in alternating whorls of 3, peltate, with minutely erose-denticulate or entire margins and with 3–5 abaxial pollen sacs. Seed cones often numerous on whole plant, terminal on straight short branchlets, maturing to purplish brown with whitish pruinose bloom in second season, globose to ovoid, 10–18 × 7–11 mm, relatively dry-fibrous, slightly resinous. Bract-scale complexes entirely fused, 6, in 2 alternating whorls of 3, partly discernible in mature cones, bract apices exserted, subterminal, causing slight rises in scale tissue, surface smooth, rugose when dry, often very glaucous. Seeds 1(–2, rarely 3) per cone, broadly triangular-ovoid, 5–8(–9) × 4–7 mm, with flattened base and acutish apex, grooved or pitted on sides, lustrous yellowish brown to chestnut brown, with a large, lighter 3-lobed hilum proximally.

Distribution

USA: W Arizona, California, S Nevada; Mexico: Baja California Norte (including Cedros Island and Guadalupe Island).
TDWG codes: 76 ARI CAL NEV 79 MXI-GU MXN-BC

Ecology

This species is adapted to one of the driest habitats in which *Juniperus* can still survive well. It is locally common in desert scrubland of the Colorado, Mohave and Sonoran Deserts ('Upper Sonoran Desert scrub') but extends into chaparral and open *Pinus attenuata* or *P. sabiniana* woodland in somewhat more mesic sites, which often occur nearer the Pacific coast. The altitudinal range is 70–1500 m a.s.l. In (semi-)desert vegetation its common associates are *Yucca brevifolia, Y. schidigera, Agave deserti*, and *Opuntia* spp., with *Larrea divaricata* subsp. *tridentata* in the lower, hotter basins and *Seriphidium tridentatum* (*Artimisia tridentata*) and *Chrysothamnus nauseosus* in cooler uplands. In Pine-Juniper woodlands *Quercus* spp., *Ceanothus leucodermis* and *Arctostaphylos glauca* are commonly growing with it. This juniper can occur on barren serpentine or among granite boulders but is not found in rock crevices, as it needs (coarse) alluvial material to spread its roots. In much of its range there is a long, dry summer period and rains occur only in winter, in some interior desert valleys rain is erratic and the junipers may be associated with deeper water sources in alluvial fans.

Conservation

A widespread species not in danger of extinction. It is possibly extinct on Guadalupe Island.
IUCN: LC

Uses

No commercial uses have been recorded; it could make an attractive ornamental shrub in hot, dry climate and is occasionally used in garden landscaping and for bonsai training in California, USA. In the past, the wood was used for fence posts, but these are now all of metal.

Juniperus cedrus Webb & Berthel., Hist. Nat. Iles Canaries 3 (2), Phytogr. Canar. 3 (89): 277. 1847. Type: Macaronesia: Canary Islands, ["Ins. Can."], *P. B. Webb s.n.* (holotype not located, isotype K).

Juniperus oxycedrus L. subsp. *maderensis* Menezes, Bull. Acad. Int. Geogr. Bot. 18: xii. 1908; *Juniperus cedrus* Webb & Berthel. subsp. *maderensis* (Menezes) Rivas Mart. *et al.*, Itinera Geobot. 15 (2): 703. 2002.

Etymology

The species epithet is the classical name for the wood of cypresses and/or junipers.

Vernacular names

Canary Islands juniper

Description

Trees to 20–25 m tall (most surviving plants smaller and shrubby), dioecious; usually monopodial, often low branching. Bark on trunks with long, soft strips, grey-brown. Branches long, spreading, assurgent or ascending. Foliage usually sparse, with spreading or pendulous, 'jointed' ultimate branchlets, persistent, forming an open, irregular and broad crown (young trees more pyramidal). Leaves in alternating whorls of 3, rarely 4, non-decurrent, spreading 30–60(–90) degrees at nodes 3–8(–10) mm apart, rigid, jointed to leaf part adnate with greenish yellow or glaucous shoot, linear-lanceolate to narrowly ovate ('boat-shaped'), (4–)8–23 × 1–2.3 mm, straight, usually broadest near middle; margins entire; abaxial face (weakly) keeled or grooved, green to dark green; apex acuminate or acute-pungent; epistomatic, stomata in two conspicuous bands separated by a midrib, bordered by green margins broader than midrib. Pollen cones solitary, 1–2 per leaf whorl, subglobose to ovoid-oblong, 3–6 × 2–5 mm, orange-brown; microsporophylls 10–14, in alternating whorls of 3, peltate, with erose-denticulate margins, bearing 3–4 abaxial pollen sacs near lower margin. Seed cones axillary on short (1–2 mm) dwarf shoots with whorls of minute scale leaves, maturing in 2 years; mature cones globose, 8–14 mm diam., with 1(–2) whorls of 3 completely fused bract-scale complexes and only the upper whorl fully developed, 3 sutures visible on distal part of cone; bract tip hidden or very small; tissue soft pulpy, more or less resinous; immature cones green, hard, mature cones orange-brown. Seeds 1–3 per cone, ± ovoid, 5–10 × 4–6 mm.

Taxonomic notes

The variation found in the size and shape of the leaves of this species is considerable, from narrow (ca. 1 mm) and long (23 mm), pungent to broad (2.2 mm) and short (8 mm), obtuse. As in *J. oxycedrus*, to which it is somewhat more distantly related, length and acuteness of the leaves generally decrease with increasing age of the trees and probably with increasing exposure to light and weather. Specimens seen from Madeira have usually short leaves, but these are straight, not curved, as is common in specimens from the Azores (*J. brevifolia*).

Distribution

Canary Islands (Tenerife, La Palma, Gran Canaria, Gomera), Madeira.
TDWG codes: 21 CNY MDR

Ecology

Originally this species would have been a constituent of the Macaronesian evergreen forest, but as this vegetation type, and particularly the more open, drier variant in which *Juniperus cedrus* had its optimum, has been altered or has disappeared altogether, it is now confined to steep rocky places at altitudes ranging from 450 m to 2400 m a.s.l. Here regeneration can succeed, but a forest with junipers and other trees will not easily develop.

Conservation

This species is now restricted to inaccessible places both in the Canary Islands and Madeira. According to David Bramwell, Director of the Botanic Garden in Las Palmas, there are probably not more than 100 mature trees remaining in the wild (on Gran Canaria less than 6, numbers on Las Palmas are unknown). Grazing by goats prevents successful regeneration and it is hardly possible to speak of viable populations in most places.
IUCN: EN [B2ab (ii, iii, v); C2a (i)]

Uses

When Canary Island juniper was still abundant its wood was highly sought after due to its durability; it was used for fence posts and for furniture making. This species is rare in cultivation and ought to be tried more (perhaps not in countries with relatively few hot, sunny days in summer). It grows on Tenerife at altitudes where frost and snow are not uncommon, but solar radiation is intense. *Ex situ* conservation is urgently needed to build up stock for future replanting and horticulture could have an important role to play in this effort.

Juniperus chinensis L., Mant. Pl. 1: 127. 1767.

Etymology

The species epithet means "from China".

Vernacular names

Chinese juniper; yuan bai (Chinese); ibuki, byakushin, ibuki-byakushin, kamakura-byakushin (Japanese); Kong Nam Tsong (Korean)

Description

Decumbent, sometimes ascending or erect shrubs, or a tall trees to 20–25 m with a monopodial, erect trunk to 1 m diam., dioecious or rarely monoecious. Bark on tree trunks fissured, exfoliating in long, fibrous, thin strips, becoming darker grey-brown. Branches spreading horizontally or ascending, in shrubs spreading, ascending or erect, spreading or subpendulous in trees, forming dense matting crowns in decumbent shrubs to initially pyramidal, then open and irregular crowns in trees. Foliage branchlets numerous, spreading, assurgent or erect in shrubs, spreading to pendulous in trees, slender, 1–1.5 mm diam., subterete to quadrangular in branchlets with scale leaves, persistent. Leaves decussate or in alternating whorls of 3, short decurrent, of two types: needle-like and scale-like. Needle-like leaves mostly ternate, linear-subulate,(4–)6–10(–12) × 0.5–0.7 mm, pungent, adaxially canaliculate, epistomatic, with two narrow bands of stomata. Scale leaves increasingly dominant with age of plant in most varieties, always decussate, imbricate, closely appressed, on ultimate branchlets 1.5–3 × 1 mm, ovate-rhombic to rhombic-lanceolate, abaxially with a conspicuous central, elliptic gland, green or glaucous green; margins entire; apex obtuse to acute; stomata few at base abaxially, in two concave fields separated by a narrow midrib adaxially. Pollen cones terminal on ultimate branchlets with scale-like or acicular leaves, ovoid-oblong, 4–6 × 2–3 mm; microsporophylls 12–18, decussate, peltate-cordate, convex, upper margin entire, abaxially bearing 3–4 ovoid-oblong pollen sacs. Seed cones terminal on erect, short shoots 3–10 mm long with small scale leaves, maturing in second season to (irregularly) globose or broad pyriform, 4–10 mm, usually dry pulpy, resinous, light brown, red-brown or glaucous cones. Bract-scale complexes (4–)6(–8), decussate, occasionally ternate, usually the lower pair infertile, entirely fused, sutures of upper scales partly visible as a curved ridge terminating in a minute bract tip. Seeds (1–)2–4(–5) per cone, ovoid-flattened, 3–7 × 2–6 mm, with small resin pits and longitudinal, shallow grooves, light yellowish brown.

Taxonomic notes

Juniperus chinensis is one of the most variable species in the genus. Its polymorphy has been the cause of an almost inextricable synonymy, especially so because horticulturists have described taxa at various ranks from variations observed in cultivation which should have been treated as cultivars.

Distribution

Myanmar [Burma], China, Japan, Korea, Russian Far East, Taiwan.

TDWG codes: 31 KHA KUR PRM SAK 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHI-NM CHI-NX CHM-HJ CHM-JL CHM-LN CHN-BJ CHN-GS CHN-HB CHN-SA CHN-SD CHN-SX CHN-TJ CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HK CHS-HN CHS-JS CHS-JX CHS-ZJ CHT 38 JAP-HK JAP-HN JAP-KY JAP-SH KOR-NK KOR-SK TAI 41 MYA

Ecology

In a few localities this widespread species forms groves of tall trees (e.g. in S Gansu), or it is mixed with pines and deciduous angiosperms at canopy level. It is much more common, under conditions largely determined by man's agricultural practices, in secondary vegetation, on open, rocky slopes. The altitudinal range is (100–)1400–2400(–2700) m a.s.l. Widespread planting and subsequent establishment in areas where it was not originally native have made it difficult to establish its original habitat and types of vegetation. While now predominantly montane, it may have been part of lowland forests in the past (Wang, 1961). High montane varieties *J. chinensis* var. *sargentii* and var. *tsukusiensis* occur on rocky outcrops and amongst boulders and have attained a decumbent habit.

Uses

Juniperus chinensis is (with *Platycladus orientalis*) one of the two most commonly planted cupressaceous trees in traditional Chinese gardens, such as around temples and in the extensive grounds of the Forbidden City in Beijing. These grounds are now virtual reserves for large specimen trees, which have all but disappeared from the countryside. Its wood is highly valued for furniture making and joinery and is hard and durable. In horticulture, *J. chinensis* has been the source of many cultivars and (as *J. sphaerica* Lindl.) one parent of a purported hybrid (of garden origin) with *J. sabina*, for which Van Melle (1946) proposed the name *J.* ×*media*, a later homonym of *J. media* V. D. Dmitriev (1938) = *J. semiglobosa*. A proposal to conserve van Melle's name failed and the cultivars thought to derive from this hybrid origin are now to be listed under *J.* ×*pfitzeriana* based on a selection made by the Späth Nursery in Berlin, Germany in the 1890's (Pfitzer Junipers). A study using RAPDs (Le Duc, Adams & Zhong, 1999) supports the notion of a hybrid origin with parents *J. chinensis* and *J. sabina* of the Pfitzer cultivars, for which the correct botanical name is *Juniperus* ×*pfitzeriana* (Späth) Schmidt ['Pfitzer Group']. This species is also of major importance in bonsai and penjing culture.

3 varieties are recognized:

Juniperus chinensis L. var. ***chinensis***. Type: Sweden: [cultivated in Uppsala Bot. Garden, Sweden], *leg. ign. LINN 1198.3* (lectotype LINN).

Sabina vulgaris Antoine var. *erectopatens* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 86. 1975; *Juniperus sabina* L. var. *erectopatens* (W. C. Cheng & L. K. Fu) Y. F. Yu & L. K. Fu, Novon 7 (4): 444. 1998; *Juniperus erectopatens* (W. C. Cheng & L. K. Fu) R. P. Adams, Biochem. Syst. Ecol. 27 (7): 723. 1999.

Description

Erect shrubs to trees. Leaves of two kinds, needle-like and scale-like, present on a single plant; needle-like leaves mostly in whorls of 3, rarely decussate, 6–12 mm long; scale leaves decussate. Pollen and seed cones only on ultimate branchlets with scale leaves.

Distribution

Myanmar [Burma]; China; Japan; Korea; Taiwan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHI-NM CHN-BJ CHN-GS CHN-HB CHN-SA CHN-SD CHN-SX CHN-TJ CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HK CHS-HN CHS-JS CHS-JX CHS-ZJ 38 JAP-HK JAP-HN JAP-KY JAP-SH KOR-NK KOR-SK TAI 41 MYA

Conservation

IUCN: LC

Juniperus chinensis L. var. ***sargentii*** A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 6: 1432. 1912. *Juniperus sargentii* (A. Henry) Takeda *ex* Nakai, Bot. Mag. (Tokyo) 44: 511. 1930. Type: Japan: Hokkaido, Kitami Prov., Rebun-jima, *M. Furuse 9385* (neotype K). Fig. 134

Vernacular names

yan bai (Chinese); Miyama-byakushin (Japanese)

Description

Decumbent shrubs, forming broad, dense mats. Branches ascending, whip shoots assurgent, later prostrate and rooting. Leaves all needle-like only on seedlings and young plants, gradually replaced by scale leaves on mature plants (but sometimes still present on coning branches), all decussate, the acicular leaves 3–7 mm long.

Distribution

China: Jilin, Heilongjiang; Japan, Russian Far East.
TDWG codes: 31 KHA KUR PRM SAK 36 CHM-HJ CHM-JL 38 JAP-HK JAP-HN JAP-KY JAP-SH

Ecology

This variety is a constituent of high montane to subalpine scrubland and meadows, although in the far

north of its range (Sakhalin Island) it occurs at much lower altitude.

Conservation

IUCN: LC

Uses

This dwarfed form of the species has obvious horticultural merits and is cultivated in many countries and several cultivars exist of it. It was introduced to the Arnold Arboretum around 1892 by the first Director, Charles S. Sargent.

Juniperus chinensis L. var. ***tsukusiensis*** (Masam.) Masam., J. Soc. Trop. Agric. Formosa 2: 152. 1930 [& in 3: 20. 1931]. *Juniperus tsukusiensis* Masam., Bot. Mag. (Tokyo) 44: 50. 1930. Type: Japan: Kyushu, Yakushima, *G. Masamune s.n.* (holotype not designated, syntype TI).

Vernacular names

qing shui yuan bai (Chinese)

Description

Decumbent or low shrubs to 80–100 cm, often prostrate or creeping over rocks. Foliage very dense, ultimate branchlets 8–25 mm long, slender, ca. 1 mm thick, quadrangular in cross-section, lax but not drooping. Leaves on most shrubs of two types, needle-like and scale-like, or only scale leaves; acicular leaves in whorls of 3, 4–8 mm long; scale leaves 1–1.3 × 1 mm, triangular rhombic or gibbous, obtuse or slightly apiculate. Gland central, small, ovoid, conspicuous but inactive. Seed cones small 4–5 mm diam., red-brown to purplish brown, with some glaucous bloom.

Distribution

China?, Taiwan (Chingshui Cliffs), S Japan (Yakushima).
TDWG codes: 38 JAP-KY TAI

Ecology

This variety has been found in a few localities in high mountains as a procumbent shrub but little else is know about its ecology. In Taiwan it is found on steep cliffs high above the Pacific Ocean, where its stems spread over bare rock.

Conservation

Known from Yakushima and three localities in the central mountains of Taiwan, this taxon is undoubtedly rare, but we do not know its entire distribution (it may have been overlooked as most collections in Taiwan are relatively recent) to make a reliable evaluation of its conservation status.
IUCN: DD

Juniperus coahuilensis (Martínez) Gaussen *ex* R. P. Adams, Phytologia 74: 413. 1993. *Juniperus erythrocarpa* Cory var. *coahuilensis* Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 114. 1946. Type: Mexico: Coahuila, Sierra de los Hechiceros, Cañon de La Madera, *I. M. Johnston & C. H. Mueller 1290* (holotype MEXU).

Etymology

The species epithet refers to the Mexican State of Coahuila.

Vernacular names

No common names are recorded for this species.

Description

Large shrub to 5 m, or small tree to 10 m, dioecious, rarely monoecious; multistemmed or with a short trunk and a maximal diam. of 50 cm. Bark of thick branches and trunk fibrous, exfoliating in strips, weathering ash-grey. Branches numerous, long, ascending from base or spreading, often curved, forming a broad, rounded or more irregular and open crown. Foliage branches numerous, irregularly disposed but not pendulous, ultimate

branchlets spreading 30–70 degrees, slender and stiff, up to 15 mm long, 1–1.5 mm thick, (weakly) quadrangular in cross section, covered with scale leaves, persistent. Leaves decussate on all ultimate branchlets, decussate or in alternate whorls of 3 on older branchlets, imbricate, scale-like, 1.2–1.7(–1.8) × 0.7–1.2 mm on lateral branchlets, decurrent, rhombic or ovoid-rhombic; apex appressed or rarely free, obtuse to acute; margins minutely denticulate; stomata on abaxial side limited to two small spots near leaf base, on adaxial surface in two tapering bands; glands central on small scale leaves, more or less conspicuous, large, rounded to oblong, flat or slightly raised, exudate often present; leaf colour yellowish green or light green. Pollen cones numerous, terminal, solitary, ellipsoid or ovoid-oblong, 3–4 × 2–2.5 mm; microsporophylls 8–10, decussate, peltate, acute, with minutely denticulate upper margins and bearing 3–4 abaxial pollen sacs. Seed cones terminal, maturing in one season attaining variable colours from pinkish(–red) or orange(–red) to purplish blue, usually glaucous, (sub-)globose or sometimes broad ovoid, 5–7 mm diam. (if ovoid to 9 mm long), internally soft pulpy, succulent, yellowish to orange-brown. Bract-scale complexes 4(–6), entirely fused, decussate; bract apices minutely exserted or hidden; surface smooth, rugose when dry. Seeds 1(–2) per cone, ovoid-globose, 3–5(–6) × 3–4(–5) mm, with rounded base and acutish apex, shallowly grooved and ridged on sides, not or slightly resinous, chestnut brown, with a large, lighter lobed hilum proximally.

Distribution

Mexico: Chihuahua, Coahuila, Durango, Nayarit, Tamaulipas, Zacatecas; USA: SW Texas.

TDWG codes: 77 TEX 79 MXE-CO MXE-CU MXE-DU MXE-TA MXE-ZA MXS-NA

Ecology

This species occurs in the high desert (1200–2000 m a.s.l.) *Bouteloua* grasslands and adjacent rocky areas. It is unusual, for *Juniperus*, in that it occurs in these seemingly undisturbed grasslands. In Mexico, the populations may occur in canyons or on alluvial fans and, of course, it is found in rocky areas adjacent to grasslands, often in association with *Opuntia* spp. or *Yucca* spp. It is unusual in that *J. coahuilensis* sprouts from the stump when cut or burned. This feature has probably allowed it to remain in the grasslands in spite of periodic grass fires that kill all other juniper species [R. P. Adams, pers. comm.]. It is considered to be 'weedy' in some areas by sheepmen and cattlemen.

Conservation

IUCN: LC

Juniperus comitana Martínez, Anales Inst. Biol. Univ. Nac. México 15 (1): 12. 1944. Type: Mexico: Chiapas, Comitán de Domínguez, 12 km S of Comitán, *M. Martínez 6700* (holotype MEXU).

Etymology

The species epithet refers to the town of Comitán in Chiapas, Mexico.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 8–10 m, presumably dioecious; trunk monopodial, erect or forked and twisted, usually branching well above base, up to 60–80 cm d.b.h. Bark on trunk 5–10 mm thick, fibrous, lacerated, exfoliating in long strips exposing purplish inner bark; outer bark red-brown to grey-brown. Branches long, spreading or ascending, foliage forming in mature trees a broad, rounded or irregular crown. Foliage branches numerous, forming lax, dense foliage tufts, irregularly disposed, ultimate branchlets of irregular length from 4–20(–25) mm, very slender, 0.7–1 mm diam., more or less quadrangular in cross-section to more terete on older branchlets which become rough with free leaf apices, persistent. Leaves on ultimate and lower lateral branchlets decussate,

but occasionally on slower growing sections of older branchlets in alternating whorls of 3, closely appressed, on ultimate branchlets ovoid-rhombic or rhombic-triangular, 1–1.4 × 0.7–1 mm; margins hyaline and minutely erose to serrulate; apex acuminate or sometimes obtuse; stomata few abaxially near base along margins, abundant adaxially from base to apex; glands small, usually inactive; leaf colour light green. Pollen cones terminal, solitary, oblong, 4–6 mm long; microsporophylls 10–12, decussate, peltate, with minutely hyaline-denticulate upper margins, bearing (3–)4 abaxial pollen sacs. Seed cones numerous, terminal, solitary on very short lateral branchlets, maturing in one year to purplish brown cones with a glaucous bloom; mature cones subglobose, 5–7 mm diam. Bract-scale complexes 4, decussate, lower pair smaller than upper pair meeting at cone apex, completely fused, with smooth external surface, lustrous when ripe; 2 decussate pairs of bract tips visible, but these less than 1 mm long, in ripe cones sometimes submerged; internal tissue soft pulpy, resinous. Seeds usually 1 per cone, ovoid, 4–5(–6) × 3.5–4 mm.

Distribution

Mexico: Chiapas; Guatemala.
TDWG codes: 79 MXT-CI 80 GUA

Ecology

Juniperus comitana is found on dry, rocky slopes or in canyons with shrub or open woodland cover, growing with e.g. *Acacia* and *Ficus* in forest pasture on dolomite and other rock types with thin soil. The altitudinal range is from 1300 m to 1800 m a.s.l.

Conservation

This species is threatened by deforestation and overexploitation of forest resources as an indirect result of a rapidly growing human population with an almost exclusively rural economy. Especially the junipers that occur in pine-oak forests, although not specifically targeted, have decreased with that forest type both in Chiapas and in Guatemala. The situation in Guatemala has been described by Islebe (1993) with some emphasis on the situation in the Guatemalan Sierra de los Cuchumatánes where both *J. comitana* and *J. standley* still occur.
IUCN: EN [B2ab (ii, iii, v)]

Uses

The wood of this juniper is used locally by the Amerindian population for firewood and also for fence posts.

Juniperus communis L., Sp. Pl. 2: 1040. 1753.

Etymology

The species epithet means "common"; Linnaeus knew it in abundance from Sweden.

Vernacular names

Common juniper; Genévrier commun (French); Gemeine Wacholder (German); Mozhzhevel'nik obyknovennyy (Russian)

Description

Decumbent, spreading or large shrubs to small trees, to 12 m tall, dioecious, rarely monoecious; multistemmed or occasionally monopodial (trunk to 2–2.5 m tall, diam. to 50 cm), low branching. Bark on large trunks becoming fissured, with thin strips, grey-brown. Branches numerous, decumbent, spreading, ascending or erect. Foliage usually dense and stiff, but sometimes more open and lax to subpendulous, with numerous 'jointed' ultimate branchlets, persistent, forming a very variable crown (habit) largely influenced by site conditions. Leaves in alternating whorls of 3, rarely 4, non-decurrent, spreading 30–90 degrees at nodes 2–15 mm apart, rigid, slightly thickened at base, jointed to leaf part adnate with shoot, (narrowly) linear to broadly lanceolate ('boat-shaped'), 4–25 × 0.8–2.4 mm, straight or curved-falcate; abaxial face keeled or with a faint midrib, green, sometimes glaucous green; adaxial margins narrow or broad relative to the single stomatal band, entire; apex obtuse to acuminate or pungent; stomata in a conspicuous band bordered by green margins. Pollen cones axillary

to leaves, solitary, 1–3 per leaf whorl, subglobose to ellipsoid-oblong, 3–5 mm long; microsporophylls 9–12, in alternating whorls of 3, triangular-peltate, with erose-denticulate margins and acute apex, bearing 3–6 abaxial pollen sacs near lower margin. Seed cones axillary on very short (1 mm) dwarf shoots with whorls of minute scale leaves, maturing in 18 months; mature cones globose or broadly ovoid, 4–13 mm diam., with 1(–2) whorls of 3 completely fused bract-scale complexes, only the upper whorl fully developed, sutures not visible, bract tip hidden or very small; tissue soft pulpy, juicy in most cones; mature cones from purplish red to black-brown, often with dark glaucous-blue bloom. Seeds 1–3 per cone, (tri)angular, oblong, (3–)4–5 × 2–3 mm, light brown with shallow pits and acute apex.

Taxonomic notes

Juniperus communis is a polymorphic species. In almost all cases infraspecific taxa that have been described are either largely sympatric or merge into each other morphologically where they meet. Habit (growth form) is largely dependent on habitat factors, foremost of which is climate (temperature, precipitation, duration of snow cover) and if not supported by other characters it is unlikely to indicate distinct taxa. The recognition of a two-ranked hierarchy of infraspecific taxa is especially inappropriate in this species where within-population variation can be of the same order (measuring morphology) as that between recognized infraspecific taxa.

Distribution

Temperate Eurasia, North Africa, North America N of Mexico. *Juniperus communis* is the most widely distributed conifer species in the world, with a circumpolar distribution extending from ca. 70° N in Alaska, Scandinavia, and Siberia to ca. 28° N in the Himalaya.

TDWG codes: 10 DEN FIN FOR GRB ICE IRE NOR SWE 11 AUT-AU AUT-LI BGM-BE BGM-LU CZE-CZ CZE-SK GER HUN NET POL SWI 12 BAL COR FRA-CI FRA-FR POR SAR SPA-AN SPA-GI SPA-SP 13 ALB BUL GRC ITA-IT KRI ROM SIC-SI TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 BLR BLT-ES BLT-KA BLT-LA BLT-LI KRY RUC RUE RUN RUS RUW UKR-MO UKR-UK 20 ALG MOR 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KAM KHA KUR MAG PRM SAK 32 KAZ KGZ TKM TZK UZB 33 NCS TCS 34 AFG CYP EAI IRN IRQ LBS-LB LBS-SY TUR 36 CHI-NM CHM CHX 37 MON 38 JAP-HK JAP-HN KOR-NK KOR-SK 40 NEP PAK WHM-HP WHM-JK WHM-UT 70 ASK GNL NUN NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 73 COL IDA MNT ORE WAS WYO 74 ILL IOW KAN MIN MSO NDA NEB OKL SDA WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 76 ARI CAL NEV UTA 77 NWM 78 GEO KTY NCA SCA TEN VRG

Ecology

This most widespread of all conifer species occurs in a very wide range of habitats, from lowland bogs and coastal sands to high alpine meadows, moraines, and scree slopes. A limited number of geographical varieties is here recognized, some are ecologically more restricted than the species as a whole, but there is considerable overlap. More detailed information is given under these varieties.

Uses

The Common juniper is widely used as an ornamental in parks and gardens, especially the decumbent varieties, and numerous cultivars have been derived from it. The cones ('berries') are used in cooking and in the preparation of alcoholic distilled beverages. *Juniperus communis* var. *communis* has been used for a considerable time in European horticulture, where especially the fastigiate habit of some NW European plants is popular, and a number of cultivars have been obtained by selection. *Juniperus communis* var. *saxatilis*, being a prostrate shrub, is a useful plant in horticulture, where it is usually known as *J. communis* var. *montana* or var. *nana*, or under a number of cultivar names (= vegetatively propagated clones) selected for dwarfed growth, branching habit, foliage colour, etc.

5 varieties are recognized:

Juniperus communis L. var. ***communis***. Type: Europe, Alps?, *leg. ign. HSC s.n.* (lectotype BM). Fig. 135

Description

Shrubs or small trees to 10–12 m with variable habit, often conical-pyramidal but also spreading, rounded, dense or open, or a tree with short trunk 2–2.5 m tall and a pyramidal, rarely flat-topped crown. Leaves spreading at nodes (2–)5–10(–15) mm apart and at wide or right angle to shoot, (4–)7–20(–25) × 0.7–1.5 mm, linear, straight, tapering above the middle to a pungent tip. Leaf length variable between individual plants as well as on single plants, usually more than twice as long as mature cones. Seed cones globose or broadly ovoid, (4–)5–7(–8) mm, black-brown, with blue bloom, or purplish black. Seeds 3 per cone.

Distribution

Europe, North Africa, Caucasus, Siberia to Russian Far East, Western Asia, Central Asia.
TDWG codes: 10 DEN FIN FOR GRB ICE IRE NOR SWE 11 AUT-AU AUT-LI BGM-BE BGM-LU CZE-CZ CZE-SK GER HUN NET POL SWI 12 BAL COR FRA-CI FRA-FR POR SAR SPA-AN SPA-SP 13 ALB BUL GRC ITA-IT ITA-SM KRI ROM SIC-SI TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 BLR BLT-ES BLT-KA BLT-LA BLT-LI KRY RUC RUE RUN RUS RUW UKR-MO UKR-UK 20 ALG 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU PRM SAK 33 NCS TCS 34 AFG CYP EAI IRN IRQ LBS-LB LBS-SY TUR 37 MON

Ecology

This, the 'typical' variety, is largely a pioneer woodland species, occupying natural rock outcrops and other places with skeletal soil and abundant sunlight in woodland and light forest, both broad-leaf and coniferous forest (especially *Pinus sylvestris-Betula* spp.-*Quercus* spp.), in which it can obtain local dominance after disturbances (non-fire). It is also prevalent in the ecotone between open woodland and grassland on poor sandy soils and on stabilised inland sand dunes. It occurs often with *Calluna vulgaris, Erica* spp., *Vaccinium* spp., *Arbutus* sp., *Cytisus scoparius, Ulex* sp., *Salix* spp., and the above mentioned tree genera, in Russia also in grass steppes. The altitude ranges from 5 m to 2400 m a.s.l. It seems very indifferent to soil type and occurs in dry sand, chalk downs, and loose (dolomitic) scree, as well as in acidic peat, with low or fluctuating ground water levels.

Conservation

IUCN: LC

Juniperus communis L. var. ***depressa*** Pursh, Fl. Amer. Sept. 2: 646. 1814. *Juniperus depressa* (Pursh) Raf., Med. Fl. 2: 13. 1830; *Juniperus communis* L. subsp. *depressa* (Pursh) Franco, Bol. Soc. Brot., ser. 2, 36: 117. 1962. Type not designated.

Vernacular names

Dwarf juniper, Prostrate juniper

Description

Decumbent or spreading shrubs to 1.5 m, rarely a large shrub or small tree to 10 m, not forming a conical or pyramidal crown; branchlets ascending at tips. Leaves at nodes 3–6(–10) mm apart, spreading at angles of 30–70 degrees, often ascending or more or less erect, at internodes of c. 5 mm, curved at base (sometimes straight), linear, (5–)10–20 × 1–1.7 mm; stomatal band from as wide as each green margin to nearly twice as wide. Seed cones 6–9 mm, globose. Seeds 3 per cone.

Distribution

North America, from Alaska to Newfoundland, S to Arizona and South Carolina.
TDWG codes: 70 ASK NUN NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 73 COL IDA MNT ORE WAS WYO 74 ILL IOW KAN MIN MSO NDA NEB OKL SDA WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 76 ARI CAL NEV UTA 77 NWM 78 GEO KTY NCA SCA TEN VRG

Ecology

In a wide range of habitats from sea shores to (sub) alpine meadows and rocky ridges. Mostly associated with coniferous woodland and forest, but usually occupying localities or topography less suitable for tree growth, or in open woodland on thin or poor sandy soil or dolomite. Associated e.g. with *Pinus banksiana, P. ponderosa, P. flexilis, Abies balsamea, A. lasiocarpa, Picea engelmannii, P. glauca*, and *Populus tremuloides* in lowland to subalpine forests, with shrubs and herbs in coastal or inland sand dunes, in (sub)alpine meadows, or in peat bogs. The altitudinal range is from 5 m to 3800 m a.s.l. It is indifferent to soil types, with pH from very acid to neutral or mildly alkaline and with low or fluctuating water tables.

Conservation

IUCN: LC

Juniperus communis L. var. ***megistocarpa*** Fernald & H. St. John Type: Canada: Quebec, Madeleine Islands, Alright Island, Narrows, *M. L. Fernald & B. H. Long 6729* (holotype GH).

Description

Decumbent shrubs, often creeping over rock or sand. Leaves at nodes 2–5 mm apart, ascending, short and wide, 4–12 × 1.6–2.4 mm, more or less boat-shaped or broad-linear, acuminate-pungent, with broad stomatal band slightly wider than one of the broad green margins. Seed cones often as large or larger than leaves, 9–13 mm, soft pulpy, blackish blue or glaucous blue. Seeds 3 per cone.

Distribution

E. Canada: Newfoundland, Nova Scotia (Sable Island), Quebec (Île de la Madeleine).
TDWG codes: 72 NFL-NE NFL-SP NSC QUE

Ecology

In *Empetrum* heath and open vegetation on sand dunes and on serpentine and magnesian limestone barrens, commonly in the ecotone between open vegetation and coniferous forest with *Abies balsamea* or *Picea rubens*.

Conservation

IUCN: LC

Juniperus communis L. var. ***nipponica*** (Maxim.) E. H. Wilson, [Conifers & Taxads Japan] Publ. Arnold Arbor. 8: 81. 1916. *Juniperus nipponica* Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 12: 230. 1868; *Juniperus rigida* Siebold & Zucc. subsp. *nipponica* (Maxim.) Franco, Bol. Soc. Brot., ser. 2, 36: 119. 1962. Type: Japan: Honshu, Iwate Pref., ["Prov. Nambu, in alpibus altioribus"], *Tschonoski (Chônosuka Sugawa) [ex herb. C. J. Maximowicz s.n.]* (holotype LE).

Vernacular names

Miama-nezu (Japanese)

Description

Decumbent or spreading shrubs 0.5–1.5 m tall with spreading branches. Leaves spreading at nodes 3–5 mm apart, ascending, acicular, 7–10 × 0.8–1 mm, usually distinctly curved (falcate), triquetrous; adaxial face sulcate; stomatal band narrow, nearly hidden from view; apex pungent. Seed cones globose or ovoid-globose, 4–6(–7) mm, brown-pruinose to blue-black. Seeds 1–3 per cone.

Distribution

Japan: Hokkaido, N Honshu.
TDWG codes: 38 JAP-HK

Ecology

Insufficiently known. The known altitudinal range is 230–650 m a.s.l.

Conservation

IUCN: LC

Juniperus communis L. var. ***saxatilis*** Pall., Fl. Rossica 1 (2): 12. 1789. Type: Illustration in Pallas, Fl. Rossica 1 (2): 12, t. 54. 1789 (lectotype). Fig. 136

Juniperus sibirica Burgsd., Anleit. Sich. Erzieh. Holzart. 2: 124. 1787.
Juniperus communis L. var. *montana* Aiton, Hort. Kew. 3: 414. 1789; *Juniperus montana* (Aiton) Lindl. & Gordon, J. Hort. Soc. London 5: 200. 1850.
Juniperus pygmaea K. Koch, Linnaea 22: 302. 1849; *Juniperus communis* L. subsp. *pygmaea* (K. Koch) Imkhan., Novosti Sist. Vyssh. Rast. 27: 10. 1990.
Juniperus communis L. var. *charlottensis* R. P. Adams, Phytologia 90 (2): 187. 2008.

Vernacular names

Mountain juniper; Zwergwacholder (German); Ginepro nano (Italian); Genévrier nain (French); xian bei ci bai (Chinese)

Description

Decumbent or spreading shrubs with spreading branches. Leaves at nodes 2–4 mm apart, spreading or ascending, often almost imbricate, straight or curved, 4–10 × 1–2 mm, flattened-concave, keeled abaxially; apex acuminate-pungent; stomatal band wider than green margins. Seed cones ovoid-globose 4–7(–10) mm, brown-pruinose, blue or blue-black. Seeds 1–3 per cone.

Taxonomic notes

The correct name of this taxon under *Juniperus communis* has not been agreed upon in the horticultural and taxonomic literature, where the epithets '*alpina*', '*montana*', '*nana*' and '*saxatilis*' are all to be found in use for what is evidently the same plant. All four and *J. sibirica* Burgsd. have been used at specific rank as well, and some in addition at subspecific rank, while the nomenclature has been further confused by the adoption of various combinations of these epithets. Adams (*op. cit.*) recently considered that this taxon does not occur in Japan, Sakhalin and Kamchatka (all treated as var. *nipponica*), and that the shrubs of this species on the coast of NW North America should be recognized as yet another variety, *J. communis* var. *charlottensis*. Morphologically, at least, these plants are all very similar.

Distribution

Europe, Caucasus, Siberia, Central Asia, W Asia, Jammu-Kashmir, Himachal Pradesh, Uttar Pradesh, Nepal, Pakistan, NE & NW China, Japan, Korea, Russian Far East, W North America, Greenland.
TDWG codes: 10 ICE FIN FOR GRB IRE NOR SWE 11 AUT-AU AUT-LI CZE-CZ CZE-SK GER POL SWI 12 COR FRA-FR POR SPA-AN SPA-SP 13 ALB BUL GRC ITA-IT KRI ROM SIC-SI TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 RUE RUN UKR-MO UKR-UK 20 MOR 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KAM KHA KUR MAG PRM SAK 32 KAZ KGZ TKM TZK UZB 33 NCS TCS 34 AFG CYP EAI IRN IRQ LBS-LB TUR 36 CHI-NM CHM CHX 37 MON 38 JAP-HK KOR-NK KOR-SK 40 NEP PAK WHM-HP WHM-JK WHM-UT 70 ASK GNL 71 BRC 73 ORE WAS 76 CAL

Ecology

Widely distributed in montane to (sub)alpine vegetation types of high mountains in Eurasia and western North America; also in the Asian high steppes. The altitudinal range is great: from 5 m to 4050 m a.s.l. In the Alps forming dominant vegetation cover over usually siliceous scree and rock outcrops in sunny, relatively dry, early snow-free expositions at (sub)alpine altitudes; also abundant in *Pinus mugo* thickets and as undergrowth in montane, open *Larix* and *Pinus* forests, in Central Asia also with *Picea schrenkiana* and *Abies sibirica*, or with *Betula* sp., elsewhere (e.g. Caucasus, Himalaya, Rocky Mountains) with other species of *Abies, Picea* or *Pinus*. Also on lake shores and in peat bogs in mountains, associated with typical holarctic plants e.g. *Vaccinium, Arctostaphylos, Cotoneaster, Rosa, Artemisia* (the latter especially in Asian mountains and steppes), and grasses. Mostly on acidic soils but in dry places also on limestone.

Conservation

IUCN: LC

Juniperus convallium Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 62. 1914.

Etymology

The species epithet probably derives from Latin *convallis* = 'deep, enclosed valley', and if so, is referring to its habitat.

Vernacular names

mi zhi yuan bai (Chinese)

Description

Small to medium size trees (rarely shrubs) to 20 m, dioecious or monoecious; trunk multistemmed or monopodial, up to 50 cm d.b.h. Bark on larger stems exfoliating in longitudinal strips, grey-brown. Branches spreading or ascending, foliage branches very dense, short, stiff and speading, or longer and more or less lax, forming a dense, rounded crown. Foliage branchlets ultimately slender, subterete or weakly quadrangular, 0.8–1.2 mm wide, covered with closely appressed leaves, persistent. Leaves on mature plants scale-like, decussate (sometimes ternate), imbricate, decurrent, 1.5–2 × 0.8–1 mm, rhombic, keeled near apex or not, obtuse; epistomatic, stomata in a proximally divided band; leaves abaxially glandular (in one variety often inconspicuous); gland concave or convex, yellowish or darker than the light green or greyish green leaf. Pollen cones numerous, solitary, terminal on short branchlets, globose to subglobose, 2–3 mm; microsporophylls decussate, 6–8, peltate-triangular, with obtuse apex, bearing 2–3 abaxial pollen sacs near the lower margin. Seed cones terminal on short, curved or erect branchlets, maturing in the second season to subglobose or ovoid-conical, 5–8(–10) × 5–6 mm, light reddish brown to purplish black or glaucous cones. Bract-scale complexes 4–6, decussate, entirely fused, sometimes sutures faintly visible near apex of cone; bract tip usually hidden or barely visible; scale tissue dry pulpy or more succulent. Seeds 1 per cone, subglobose (onion-shaped) or globose-conical to ovoid-conical, sometimes slightly flattened, 3–5 mm diam., shallowly grooved or bifacially ridged, with small resin pits near base.

Distribution

China: S Gansu, SE Qinghai, W Sichuan, E Xizang [Tibet], NW Yunnan.
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHQ CHT

Ecology

In high montane to subalpine coniferous forest, juniper woodland, occasionally in the ecotone to alpine steppe, at high altitudes often on S-SW facing slopes or on sun-warmed rock outcrops, both of limestone and granitic rock. The altitudinal range is 2200–4430 m a.s.l. Associated with *Abies, Picea* (these genera predominantly on N-NE facing, moister and cooler slopes), *Juniperus saltuaria, J. tibetica (*which usually reaches higher altitudes), *Quercus aquifolioides, Seriphidium* (*Artemisia*), *Caragana*, and *Rosa*; woodlands are often degraded to scrub-pasture. In the dryer valleys beyond the direct monsoon influence the lower limit of annual rainfall (mostly summer) is ca. 300 mm at 3600–3800 m. Low winter temperatures, to which this species is more sensitive than *J. tibetica*, cause it to remain below the latter in many areas, but there are mixed stands especially on S-SW exposed slopes where *J. convallium* can occur at higher altitudes.

Uses

Not known, probably for firewood in areas with few trees.

2 varieties are recognized:

Juniperus convallium Rehd. & E. H. Wilson var. ***convallium***. Type: China: Sichuan, NW Sichuan, (loc. not indicated), *Wilson 3010* (holotype A).

Description

Leaves conspicuously glandular, not keeled near apex. Seed cones subglobose to ovoid-conical, 6–8 (–10) × 5–6 mm. Seeds 4–5 mm diam., subglobose to globose-conical or ovoid-conical.

Distribution

China: S Gansu, SE Qinghai, W Sichuan, E Xizang [Tibet], NW Yunnan.
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHQ CHT

Conservation

IUCN: LC

Juniperus convallium Rehd. & E. H. Wilson var. ***microsperma*** (W. C. Cheng & L. K. Fu) Silba, Phytologia Mem. 7: 33. 1984. *Sabina convallium* (Rehd. & E. H. Wilson) W. C. Cheng & L. K. Fu var. *microsperma* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 86. 1975; *Sabina microsperma* (W. C. Cheng & L. K. Fu) W. C. Cheng & L. K. Fu, Fl. Xizangica 1: 390. 1983; *Juniperus microsperma* (W. C. Cheng & L. K. Fu) R. P. Adams, Biochem. Syst. Ecol. 28: 540. 2000. Type: China: Xizang (Tibet), Mekong River, Qamdo, ["Chang Du"], *leg. ign.* ["*(First) Exped. to Xizang (Tibet)*"] *10019* (holotype PE).

Vernacular names

xiao zi yuan bai (Chinese)

Description

Leaves often inconspicuously glandular, keeled near apex. Seed cones ovoid, 5–7 × 5 mm. Seeds 4 × 3 mm, slightly flattened-ovoid.

Distribution

China: W Sichuan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHT

Conservation

The distribution of this form seems to be more limited than that of the species as a whole, but its extent remains insufficiently known, in part due to problems with identification.
IUCN: DD

Juniperus deppeana Steud., Nomencl. Bot., ed. 2, 1: 835. 1840.

Etymology

This species was named after Ferdinand Deppe (1794–1861) who collected plants in Mexico with Christian Julius Wilhelm Schiede in 1828–29.

Vernacular names

Alligator Juniper, Checkerbark Juniper; Cedro, Cedro chino, Táscate, Táscate blanco (Spanish); Tláscal (Aztec)

Description

Arborescent shrubs or trees to 12–15(–25) m, dioecious; monopodial; trunk very short or longer, to 1.2(–2) m diam. Bark on trunks 1–5 cm thick (occasionally to 20 cm at base), hard, scaly, breaking up into tesselated patterns or longitudinal fissures and reticulating ridges, slowly exfoliating with small flakes or long strips; inner bark red-brown or dark brown; outer bark (ash-)grey. Branches long, spreading or assurgent, forming a broad, rounded or pyramidal crown. Foliage branchlets ultimately slender, stiff or more or less flaccid, up to 25 mm long, quadrangular or subterete, (0.8)1–1.4 mm wide, covered with imbricate (gibbous) leaves, persistent. Leaves on mature plants scale-like, on ultimate branchlets decussate, imbricate, decurrent with appressed apex, 1.0–2.5 × 0.6–1.2 mm, ovate-rhombic, convex or keeled; margins hyaline and minutely denticulate; abaxial stomata in 2 conspicuous bands, adaxial stomata in two concave fields; leaves abaxially glandular or eglandular; gland in central depression, elliptic or rounded, active with resin exudate or inactive; leaf colour yellowish green to light green. Pollen cones numerous, solitary, terminal on branchlets, oblong to cylindrical, 4–6 × 1.6–2.1 mm; microsporophylls 12–16, decussate, peltate, with obtuse or nearly acute apex, bearing 3–5 abaxial angular pollen sacs. Seed cones terminal on very short, erect lateral branchlets, maturing in the second season to (sub)globose or broadly ovoid, 7–15 mm diam., light or red-brown, usually glaucous or pruinose cones. Bract-scale complexes 4 or 6(–8), decussate or in whorls

of 3 (or 2 whorls + 2 opposite), entirely fused; bract tips often conspicuous, up to 1 mm, on a small transverse ridge or elevation; scale tissue dry and fibrous, with hardening outer layer. Seeds (1–)2–4(–6) per cone (usually 3), ovoid, more or less curved or flattened, often unequal in size, up to 8 × 5 mm, lustrous brown towards apex, with resinous pits and adhering scale tissue towards base.

Distribution

SW USA: Arizona, New Mexico, W Texas; Mexico.
TDWG codes: 76 ARI 77 NWM TEX 79 MXC-PU MXE-CO MXE-CU MXE-DU MXE-HI MXE-ZA MXG-VC MXN-SO MXS-OA

Ecology

In grassland, scrubland or (grazed) Pinyon-Juniper woodland and open pine forests, with e.g. *Opuntia, Agave, Cactaceae, Yucca*, and *Solanum papita* in open habitats; with *Pinus cembroides, P. leiophylla, P. teocote, Juniperus flaccida*, and *Quercus* spp. in scrubland, woodland and forest; in semi-arid mountains and the more arid intermountain zone on dry, rocky slopes or in valleys and flats with sandy soils, on limestone, volcanic deposits or other types of rock. The altitudinal range for the species is from 750 m to 2750 m a.s.l.

Uses

The wood may be used locally for small scale building and fence posts for farms, but is not exploited commercially. Larger trees have been felled for their durable timber especially in parts of Mexico. In horticulture Alligator juniper is suitable as an ornamental tree in regions with hot, dry summers and can withstand winter frost well. A few cultivars are known and the species shows considerable variation within its natural range, which could lead to further selections if the effort was made. In Mexico I have seen it (planted?) as a boundary tree between fields in the state of Puebla, together with *Agave americana*.

5 varieties are recognized:

Juniperus deppeana Steud. var. ***deppeana***. Type: Mexico: Veracruz, Perote, Cofre de Perote, (Volcán Nauhcampatepetl), *C. J. W. Schiede s.n.* (lectotype MO). Fig. 137, 138

Description

Trees to 15 m. Bark tesselated on trunk and large branches. Foliage branchlets ultimately quadrangular. Leaves mostly eglandular but usually glandular on penultimate branchlets, with obtuse or acute apex. Seed cones 7–12 mm diam., rarely ovoid and then up to 15 mm long, reddish brown, often glaucous but not nearly white-pruinose.

Distribution

SW USA: Arizona, New Mexico, W Texas; Mexico.
TDWG codes: 76 ARI 77 NWM TEX 79 MXC-PU MXE-CO MXE-CU MXE-HI MXE-ZA MXG-VC MXS-OA MXN-SO

Conservation

IUCN: LC

Juniperus deppeana Steud. var. ***pachyphlaea*** (Torr.) Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 53. 1946. Type: USA: New Mexico, Valencia Co., Zuni Mts., *J. M. Bigelow s.n.* (holotype NY).

Description

Arborescent shrubs or small trees to 10 m. Bark tesselated on trunk. Leaves on ultimate branchlets small, 1–1.8 mm long and often as wide, always glandular; glands often with white drying resinous exudate, keeled towards the obtuse or acute apex. Seed cones as in var. *deppeana*.

Distribution

USA: Arizona, New Mexico, W Texas; Mexico: Sonora.
TDWG codes: 76 ARI 77 NWM TEX 79 MXN-SO

Conservation

IUCN: LC

Juniperus deppeana Steud. var. ***robusta*** Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 47. 1946. Type: Mexico: Durango, Pueblo Nuevo, Pino Gordo, *C. E. Blanco A 502* (holotype MEXU).

Juniperus patoniana Martínez, Anales Inst. Biol. Univ. Nac. México 27: 62. 1946; *Juniperus deppeana* Steud. var. *patoniana* (Martínez) Zanoni, Phytologia 38: 438. 1978.

Description

Trees to 20–25 m; bark usually tesselated only near base of trunk, breaking in large segments to 5 cm, further upwards fissured, sometimes with reticulate ridges, scaly, exfoliating with longitudinal strips. Leaves eglandular or with inconspicuous gland; apex obtuse or acute. Seed cones globose, large, 10–15 mm diam., glaucous.

Distribution

Mexico: Chihuahua, Durango, Sonora, Zacatecas.
TDWG codes: 79 MXE-CU MXE-DU MXE-ZA MXN-SO

Ecology

Predominantly in pine-oak woodland or pine forest, with *Pinus cembroides, Quercus* spp., *Arctostaphylos, Commelina, Dahlia, Geranium, Sedum* and other herbs; in mountains on rocky soil from 1000 m to 2700 m a.s.l.

Conservation

The total area in which this variety is known is more limited than that for the species. It appears that this form is more often involved in changes in land use leading to situations where scattered trees may be preserved as shade trees but chances of natural regeneration seem greatly reduced.
IUCN: VU (B1+2b)

Juniperus deppeana Steud. var. ***sperryi*** Correll, Wrightia 3: 188. 1966. Type: USA: Texas, Jeff Davis Co., Davis Mts., ca. 13 km from Sproul Ranch HQ, *O. E. Sperry T 870* (holotype GH).

Description

Arborescent shrubs or small trees. Bark fissured from base of trunk upwards, shaggy, slowly exfoliating with long strips. Foliage branches drooping, ultimate branchlets more or less flaccid and pendulous. Leaves with inconspicuous, but sometimes active gland.

Distribution

USA, W Texas, described from two trees in the Davis Mountains and a collection made in 1931 in the Guadalupe Mountains. One known locality in Sonora, Mexico. Other scattered trees probably exist in canyons of the semiarid mountains in the region. Adams (2011) gives additional localities in Arizona and New Mexico.
TDWG codes: 76 ARI 77 NWM TEX 79 MXN-SO

Ecology

Scattered trees on slopes of canyons in semi-arid mountains. One tree grows in grass and scrub on rocky soil (scree) with no other trees in the vicinity. The known altitudinal range is 1800–2000 m.

Conservation

Only known from a few scattered, mature or old trees with no signs of regeneration.
IUCN: CR (D)

Juniperus deppeana Steud. var. ***zacatecensis*** Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 57. 1946. *Juniperus deppeana* Steud. f. *zacatensis* (Martínez) R. P. Adams, Phytologia 88 (3): 229. 2006. Type: Mexico: Zacatecas, Sombrerete, 10 km E of Sombrerete, *M. Martínez A 503* (holotype MEXU).

Description

Arborescent shrubs or small trees to 5–6 m, branching from near the ground, branches assurgent,

forming an irregular, wide crown. Bark on trunk tesselated or more or less fissured, scaly, exfoliating with irregularly shaped flakes. Branchlets slender, 1–1.3 mm diam., subterete, rarely quadrangular. Leaves ovate with acuminate or mucronate apex, glandular. Seed cones globose, 10–15 mm diam., light brown, strongly whitish pruinose.

Distribution

Mexico: Durango, W Zacatecas.
TDWG codes: 79 MXE-DU MXE-ZA

Conservation

Only known from a limited area within which it is uncommon and in which a decline is inferred from deforestation.
IUCN: EN (B1+2b)

Juniperus drupacea Labill., Icon. Pl. Syriae 2: 4, t. 8. 1791. *Arceuthos drupacea* (Labill.) Antoine & Kotschy, Oesterr. Bot. Wochenbl. 4 (31): 249. 1854. Type: Turkey: Hatay, Jebel Akra, ["Habitat in monte Cassio quem Arabi vocant djebel lacara"], *J. J. H. de la Labillardière s.n.* (holotype G-DEL?, isotypes FI, K). Pl. 15

Etymology

The species epithet means 'with stone fruits' and refers to the hard seed within.

Vernacular names

Syrian juniper; andys (Syria); Andız ardıcı, Enek (Turkish)

Description

Trees usually 10–15(–23 in Greece, -40 in Turkey) m tall, sometimes a shrub, dioecious or rarely monoecious; trunk to 1–1.2 m diam. Bark on trunk with long, fibrous strips, brown turning grey. Branches numerous, long, spreading or assurging, the lower ones more or less pendulous. Foliage usually dense, with short, spreading, 'jointed' ultimate branchlets, persistent, forming a dense, pyramidal or conical, in older trees rounded crown. Leaves in alternating whorls of 3, articulate-decurrent, spreading 60–90 degrees at nodes 3–5(–10) mm apart, rigid, jointed to leaf part adnate with shoot, ovate-lanceolate, but shortest foliage leaves narrowly ovate ('boat-shaped'), (4–)10–20(–24) × 2–4 mm, straight; margins entire; apex acute-pungent; epistomatic, stomata in two conspicuous broad bands, separated by a midrib, bordered by green margins wider than the midrib; abaxial face prominently keeled or ridged, green to dark green. Pollen cones axillary to slightly modified leaves of 2–3 consequtive whorls on ultimate branchlets, 2–3 per leaf whorl, often appearing clustered, subglobose to ovoid, 4–7 × 4–5 mm; microsporophylls in (3–)5–6 alternating whorls of 3, subpeltate (leaf-like), with entire margins and acuminate apex, bearing 4–6(–9) abaxial ellipsoid pollen sacs in 2 rows near the lower margin. Seed cones axillary on 5–10 mm long dwarf shoots with whorls of small (2–4 mm) triangular leaves, maturing in 2 years; mature cones ovoid-globose, 15–30 × 12–24 mm, with 2–3(–4) alternating, imbricate whorls of 3 mostly fused bract-scale complexes, (2–)3 whorls fully developed (middle scales largest), ovate-mucronate, thick, with prominent margins, becoming hard semi-woody, more or less resinous, surface rugose, light to dark brown, often glaucous or pruinose. Seeds usually 3 per cone, more or less triangular, often with small resin vescicles on outer surface, fused for ⅔-¾ proximally into an ovoid-globose yellowish brown 'stone' 10–18 × 7–15 mm, connate distally.

Taxonomic notes

This species was known in pre-Linnaean times to botanists as *Juniperus major* on account of its large cones and tree size and botanical travellers reported it from the Turkish mountains as early as 1547; despite this Linnaeus (1753) appears to have overlooked it. De Labillardière encountered it in N Syria near the Turkish border on Mt. Cassius (Djebel Akra, now in Turkey) in 1788. Its very large cones which clearly show the outline of the bract-scale complexes and contain partly fused, large seeds have been seen as sufficiently distinct to erect a new genus *Arceuthos* for it. More commonly, this species has been assigned to its own section *Caryocedrus* since Endlicher (1847), although Gaussen (1968) used

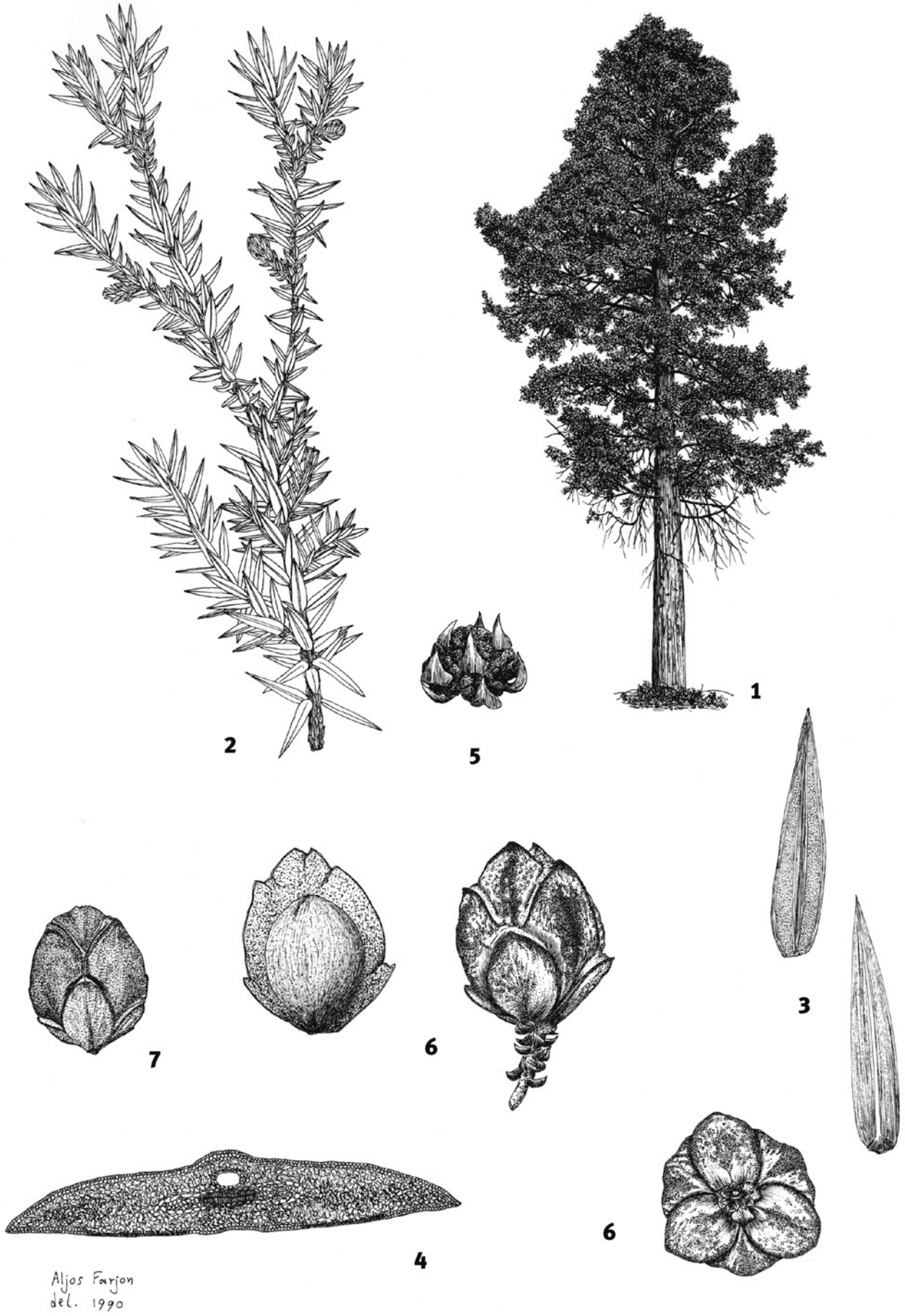


PLATE 15. Juniperus drupacea. **1.** Habit of tree. **2.** Branch with foliage. **3.** Leaves. **4.** Cross-section of leaf. **5.** Pollen cone. **6, 7.** Seed cones (with cross-section showing fused seeds).

subgenus *Caryocedrus* for it. The partly fused seeds stressed by Endlicher as a diagnostic character of this section (= *J. drupacea*), as well as the cone itself, require a careful ontogenetic study for which unfortunately no material was available. What is clear is that the ovules originate independently in the axils of the fertile whorl of 3 bracts, so that fusion is a secondary character state. Some similarities with large cones of *J. oxycedrus* subsp. *macrocarpa* (in which the 3 seeds remain free but lie closely appressed so as to determine each other's shape during growth) suggest that these differences are relative rather than absolute.

Distribution

Greece, Turkey (mountains along Mediterranean coast), Syria, Lebanon, Israel.
TDWG codes: 13 GRC 34 LBS-LB LBS-SY PAL-IS TUR

Ecology

Juniperus drupacea occurs in mixed (low) montane conifer forest and woodland with *Pinus brutia, P. nigra, Abies cephalonica, A. cilicica, Cedrus libani, Juniperus excelsa, J. foetidissima, J. oxycedrus, Quercus coccifera, Q. ilex*, and more rarely with *Fagus orientalis*. Forest degradation has changed the vegetation in some areas to maquis in which the junipers have regenerated or spread. It occupies, with other junipers, the rockier, more shallow soils, often on calcareous but also on granitic rock. The altitudinal range is from 600 m to 1800 m a.s.l. The climate is Mediterranean, with winter rain, sometimes snow, and dry, hot summers.

Conservation

This species is rare in Greece, Lebanon and Israel, where it is probably Vulnerable (Greece) or even Endangered (Israel); however in Turkey and Syria it is still more widespread and locally common. Boratynski & Browicz (1983) gave an account of the populations in Greece, all in the Parnon Massif in the Peloponnisos. While some stands represent degraded fir forest (*Abies cephalonica*) or have been converted to pasture, others appear to be natural or semi-natural. They suggested protective status for at least one of the major stands in Greece.
IUCN: LC

Uses

The wood of large trees is valuable as timber with decay resistant properties but it is not extensively used for this purpose. In Turkey, the local population harvest the fleshy cones, which have a high content of sugars, for consumption as a kind of marmelade or dried fruit. Its habit in cultivation tends to remain columnar for many years and its large leaves with conspicuous stomatal bands are also ornamental. Yet its use in gardens is limited despite good growth rates and tolerance to frost; this omission deserves to be rectified as it is probably a better species for horticulture than the more common *J. oxycedrus* (in southern Europe and regions with equivalent climate).

Juniperus durangensis Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 94. 1946. Type: Mexico: Durango, El Salto, Puerto de Santo Domingo, *M. Martínez 7015* (holotype MEXU).

Etymology

The species epithet refers to the State of Durango in Mexico.

Vernacular names

Durango juniper; táscate (Spanish)

Description

Shrubs or small trees to 6 m, presumably dioecious; trunk forked at base or branching low, or erect and curved or contorted, to 30–40 cm diam. Bark becoming fibrous, 5–10 mm thick, exfoliating in long, thin strips, light brown weathering grey. Branches thick, contorted, spreading and assurgent, foliage dense, forming an irregular and open crown with wide spreading branches. Foliage branches numerous, rigid, forming dense tufts, ultimate branchlets short, rigid, spreading in all directions,

straight or towards ends of foliage branches downcurved, 4–10(–18) mm long, 1.2–1.5 mm diam., more or less quadrangular in cross-section, leading ultimate branchlets to 2 mm diam. Leaves decussate on ultimate lateral branchlets, in alternating whorls of 3 on lower branchlets, imbricate, on ultimate branchlets appressed, broadly ovoid-rhombic, 0.8–1.2 × 0.8–1 mm, often nearly as wide as long, gibbous; margins thick, minutely denticulate; apex obtuse, leaves on older branchlets broad rhombic, acute; stomata few on lower margin abaxially and scattered stomata from base to apex adaxially; gland central, small, oval-oblong to linear, inactive; leaf colour dark green, new foliage often yellowish green. Pollen cones terminal, solitary, subglobose or ovoid, 2.5–3 × 2 mm; microsporophylls 10–12, decussate, peltate, as broad as long, with hyaline-denticulate margins, obtuse, bearing 2–3 abaxial, relatively large pollen sacs. Seed cones numerous, terminal on curved or straight, 2–3 mm long branchlets; mature cones subglobose to nearly reniform, often wider than long, 4–6 × 5–7 mm, irregular, more or less bilobed if with 2 seeds, smooth (rugose *in sicco*), orange-brown or reddish brown, often glaucous to pruinose. Bract-scale complexes 4, decussate, upper pair larger than lower pair, bract tips exserted, 0.5 mm, triangular and more or less curved; tissue soft pulpy, succulent or sometimes dry. Seeds 1–3(–4) per cone, variable but mostly angular-ovoid, 3–4.5 × 2–3 mm, curved or not, ridged and/or shallowly pitted, hilum a third to half of seed, resinous or not, seed coat light brown or reddish brown, but hilum lighter and usually turning yellowish brown.

Distribution

Mexico: Aguascalientes, Chihuahua, Durango, Jalisco, Sonora, Zacatecas.
TDWG codes: 79 MXE-AG MXE-CU MXE-DU MXE-ZA MXN-SO MXS-JA

Ecology

Martínez (*op. cit.*) described the habitat of this species as very poor, dry, rocky soil, and presented some photographs of trees that are apparently growing in a deforested landscape, which probably had been covered with pine-oak woodland. On two labels of herbarium collections examined, a habitat consisting of (cleared) oak-juniper woodland was mentioned, with *Juniperus deppeana* var. *robusta* also present. According to Adams (2011) it is found on rhyolite rocks and in openings of pine-oak forests, and his book shows similar habitat photographs. This habitat is confirmed on the labels of several herbarium collections kept in ARIZ (Tucson, Arizona). These collections were made at altitudes of 1500–2700 m a.s.l.

Conservation

Although it is known from a wide range in N Mexico, only a limited number of verified collections have been made and it is apparently not common. Often, these collections were made in 'clearings' of pine-oak forest or woodland, some of these appear to be natural rocky areas with few trees. A more detailed survey of specimens has now established its approximate extent of occurrence and probable conservation status. It does not seem to be threatened at present.
IUCN: LC

Uses

No specific uses have been recorded of this species; it presumably serves both as firewood and for fence-posts locally.

Juniperus excelsa M.-Bieb., Tabl. Prov. Mer. Casp.: 204. 1798. [Beschr. Länd. Terek & Kur, Bot. Anhang: 204. 1800.]

Etymology

The species epithet means 'high' and perhaps refers to the considerable size of this species compared to the shrubby species known from central and western Europe.

Vernacular names

Greek juniper, Grecian juniper, Crimean juniper, Turkestan juniper (subsp. *polycarpos*); Ardıç, Boylu ardıç (Turkish); Dedali-gwia (Iran); Parmiro alañ (Central Asia, subsp. *polycarpos*)

Description

Trees (rarely shrubs) to 20–25 m, monoecious or more commonly dioecious; monopodial; trunk up to 2.5 m d.b.h., or a (decumbent) multistemmed shrub. Bark on trunks exfoliating in longitudinal fibrous strips, reddish brown weathering grey-brown. Branches spreading or ascending, foliage branches very dense, short, stiff and spreading, or longer and more or less lax, forming a dense, rounded or irregular, sometimes sympodial crown. Foliage branchlets ultimately subterete or weakly quadrangular, 0.7–1.3 mm wide, covered with closely appressed leaves, persistent. Leaves on mature plants normally scale-like, decussate, imbricate, decurrent, 0.6–1.6 × 0.4–0.9 mm, ovate-rhombic, obtuse; margins entire; stomata in 2 inconspicuous lines on each side mostly near base; leaves abaxially glandular; gland central, large and conspicuous, elliptic or nearly circular, often with exudate; leaf colour yellowish green to dull light green. Pollen cones numerous, solitary, terminal on short branchlets, globose to subglobose, 3–4 × 2–3 mm; microsporophylls 8–10, decussate, peltate, with rounded entire margins, bearing 3–4 abaxial pollen sacs. Seed cones terminal on short, erect branchlets, maturing in the second season and becoming (sub)globose, 6–12(–14) mm diam., pinkish brown, blue or purplish blue, usually glaucous or pruinose. Bract-scale complexes 4–6(–8), decussate, entirely fused, sometimes sutures faintly visible near apex of cone, bract tip small, ca. 0.5 mm, on a small ridge, scale tissue dry pulpy or rarely more succulent, resinous. Seeds (2–)3–6(–8) per cone, subovoid-conical, more or less flattened or curved, 4–6 × 3–4 mm, yellowish- to reddish brown, with lighter hilum at base.

Distribution

SE Europe: Albania, Bulgaria, Greece, Macedonia; E Europe: Ukraine: Krym [Crimea]; Caucasus: Armenia, Azerbaijan, Gruzija, Severo-Osetiya, Russia(?); Central Asia: Kazakhstan, Kirgyzstan, Tadzhikistan, Turkmenistan, Uzbekistan; W Asia: Afghanistan, Cyprus, Iran, Lebanon, Syria, Turkey; Arabian Peninsula: Oman; S. Asia: NW India, Pakistan.

TDWG codes: 13 ALB BUL GRC YUG-MA 14 KRY 32 KAZ KGZ TKM TZK UZB 33 NCS-SO TCS-AR TCS-AZ TCS-GR 34 AFG CYP IRN LBS-LB IRQ LBS-SY TUR 35 OMA 40 PAK WHM-JK

Ecology

In shrubland (Mediterranean), deciduous woodland and coniferous forest, in the interior eastern parts of its range also in montane *Seriphidium maritimum* (*Artemisia maritima*) steppes and on alpine scree or moraines. The altitudinal range is (100–)500–3000(–3950) m a.s.l. It is most common on dry slopes of calcareous hills and mountains in the Mediterranean climate parts of its range, but occurs also on siliceous rock in the continental interior, more often near intermittent groundwater sources. In Central Asia, it is restricted to the more western parts of the numerous mountain ranges, where it forms, with some other species, (*J. semiglobosa, J. pseudosabina, J. sabina*) extensive juniper forest or woodland ('Archa forest') on all but the N-facing slopes (where e.g. *Picea schrenkiana* dominates, a conifer that is more abundant and not restricted to N-facing slopes farther east). In contrast to North America, this juniper forest is not mixed with pines (*Pinus* spp.) and angiosperms are uncommon in it. Several species of *Juniperus*, including low shrubs, therefore determine the structure of these forests or woodlands in large areas, often from the valley bottom to the tree line.

Uses

The wood of *J. excelsa* is durable and hard and, in parts of Turkey at least, sufficiently common to be utilized. However, trees grow slowly and take two centuries or more to attain any harvestable size, so its exploitation for timber is or would not be sustainable if it occurred on a commercial scale. In many parts of SW Asia it also serves as firewood, especially for people who live (temporarily) in the mountains. The wood of large trees is used for carpentry and furniture. Foliage is sold and burnt as incense. Greek juniper is uncommon in horticulture and only a few cultivars have been selected; the one best known in Britain is a columnar form with glaucous and more juvenile type foliage properly named 'Stricta' but also known under several varietal names. Forms with pendulous foliage and with dwarf growth have

also been named and are used more often in central and southern Europe.

2 subspecies are recognized:

Juniperus excelsa M.-Bieb. subsp. ***excelsa***. Type: Ukraine: Crimea, Krymskiye Gory, *P. S. Pallas, [ex herb. Pallas] s.n.* (lectotype LE).

Description

Trees to 20–25 m; ultimate branchlets slender, 0.7–1 mm diam., weakly quadrangular or subterete, often in regularly disposed sprays, more or less lax. Seed cones 6–14 mm diam., mostly darker hues, glaucous or pruinose. Seeds 3–6(–8) per cone.

Distribution

SE Europe: Albania, Bulgaria, Greece, Macedonia; E Europe: Ukraine: Krym [Crimea]; Caucasus: Armenia, Azerbaijan, Gruzija, Severo-Osetiya; W Asia: Cyprus, Iran (Elburz Mts.), Iraq, Lebanon, Syria, Turkey; Central Asia: Turkmenistan (Kopet Mts.).

TDWG codes: 13 ALB BUL GRC YUG-MA 14 KRY 32 TKM 33 NCS-SO TCS-AR TCS-AZ TCS-GR 34 CYP IRN IRQ LBS-LB LBS-SY TUR

Ecology

This subspecies occurs in shrubland (Mediterranean), woodland and pine forest on dry hillsides and rocky mountain slopes at altitudes from 100 m to 2000(–2700) m a.s.l. It is associated with *Pinus brutia, P. nigra, Cedrus libani, Abies cephalonica, A. cilicica, A. nordmanniana, Juniperus foetidissima, J. oxycedrus, Quercus* spp., *Pistacio lentiscus, Berberis, Acer obtusifolium*, etc. It grows most often on limestone and also on igneous rocks, but not in acidic soil. The climate is Mediterranean, with winter rain and dry, hot summers, grading eastward into more continental conditions, where *J. excelsa* subsp. *polycarpos* predominates.

Conservation

IUCN: LC

Juniperus excelsa M.-Bieb. subsp. ***polycarpos*** (K. Koch) Takht., Fl. Yerev.: 53. 1972. *Juniperus polycarpos* K. Koch, Linnaea 22: 303. 1849; *Juniperus excelsa* M.-Bieb. var. *polycarpos* (K. Koch) Silba, Phytologia Mem. 7: 34. 1984. Type: Turkey: Gümüshane, Anadolu Daglari, Taltaban, *P. E. E. Sintenis 5520* (neotype L). Pl. 16

Juniperus macropoda Boiss., Fl. Orient. 5: 709. 1884. *Juniperus seravschanica* Kom., Bot. Zurn. (Moscow & Leningrad) 17: 481. 1932; *Juniperus polycarpos* K. Koch var. *seravschanica* (Kom.) Kitam., [Fl. Pl. W. Pakist. Afghan.: 7. 1964] Add. & Corr. Fl. Afghan.: 68. 1966; *Juniperus excelsa* M.-Bieb. subsp. *seravschanica* (Kom.) Imkhan., Bot. Zurn. 75 (3): 407. 1990. *Juniperus turcomanica* B. Fedtsch., in Fedtschenko *et al.*, Fl. Turkmenii 1: 14. 1932; *Juniperus excelsa* M.-Bieb. subsp. *turcomanica* (B. Fedtsch.) Imkhan., Bot. Zurn. 75 (3): 408. 1990; *Juniperus polycarpos* K. Koch var. *turcomanica* (B. Fedtsch.) R. P. Adams, Phytologia 86 (2): 50. 2004.
Juniperus polycarpos K. Koch var. *pendula* Mulk., Dokl. A. N. Armen. S.S.R. 45 (2): 86. 1967; *Juniperus excelsa* M.-Bieb. subsp. *polycarpos* (K. Koch) Takht. var. *pendula* (Mulk.) Imkhan., Bot. Zurn. 75 (3): 407. 1990.

Description

Trees to 20 m, rarely (decumbent) shrubs; ultimate branchlets thicker (1–1.3 mm diam.), subterete, rigid, spreading in all directions. Seed cones 8–12(–14) mm diam., pinkish brown to purplish blue, usually pruinose. Seeds (2–)3–4(–6) per cone.

Distribution

Central Asia: Kazakhstan, Kirgyzstan, Tadjikistan, Turkmenistan, Uzbekistan; Caucasus: Armenia, Azerbaijan, Russia (?); W Asia: Afghanistan, Iran, E Turkey; Arabian Peninsula: Oman; S Asia: Pakistan, NW India (Kashmir).

TDWG codes: 32 KAZ KGZ TKM TZK UZB 33 TCS-AR TCS-AZ TCS-GR 34 AFG IRN TUR 35 OMA 40 PAK WHM-JK

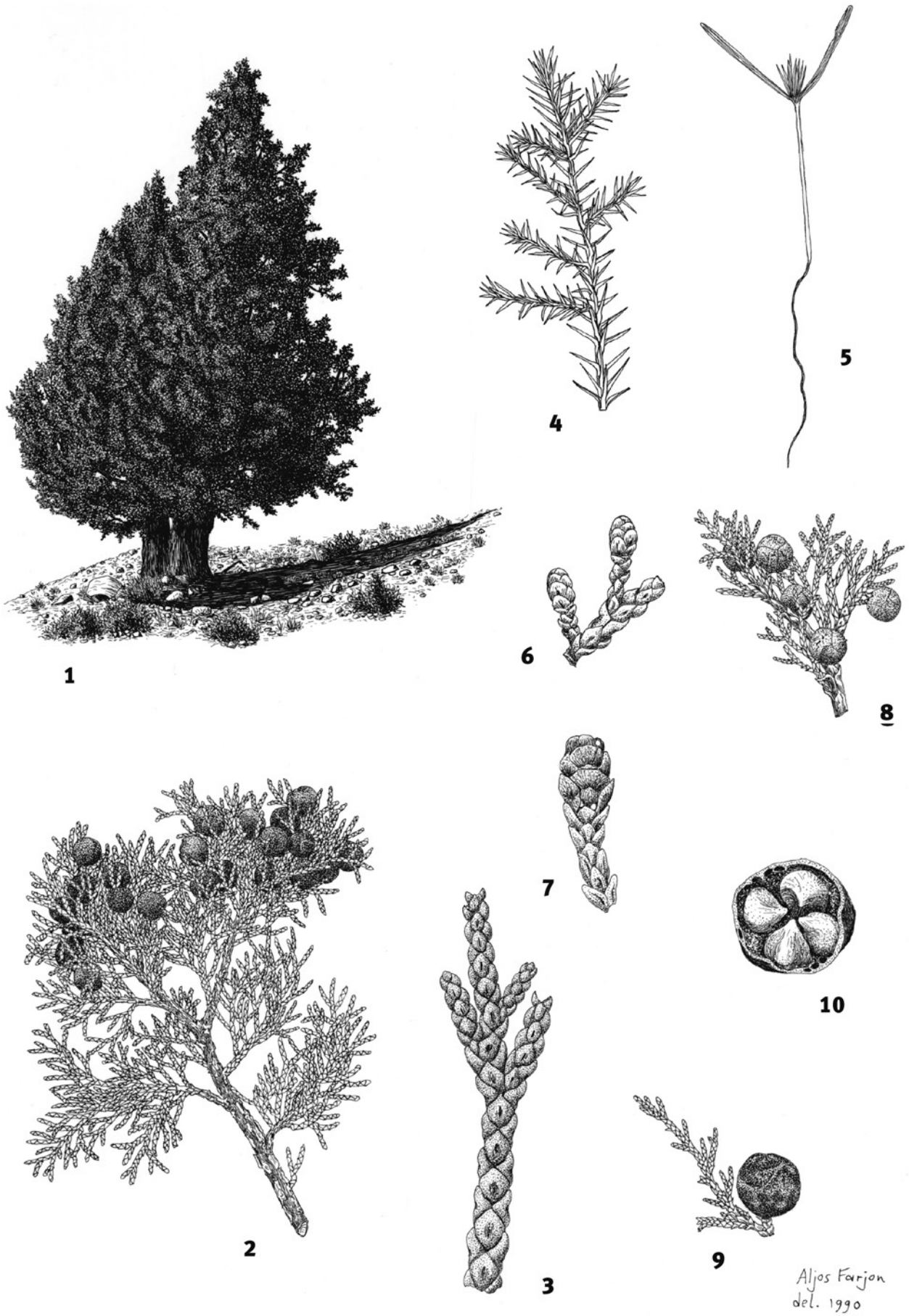


PLATE 16. Juniperus excelsa subsp. polycarpos. **1.** Habit of tree. **2.** Branch with foliage and seed cones. **3.** Branchlet with adult leaves. **4.** Branchlet with juvenile leaves. **5.** Seedling. **6, 7.** Pollen cones. **8.** Branchlet with seed cones. **9.** Seed cone. **10.** Opened seed cone with seeds.

Ecology

The continental subspecies occupies a range of habitats from montane (mixed) coniferous forest to upper montane steppes dominated by *Seriphidium maritimum* (*Artemisa maritima*). Its altitudinal range is (550–)1000–3300(–3950) m a.s.l. In coniferous forest it can be associated with *Pinus gerardiana, P. wallichiana, Cedrus deodara* or *Abies pindrow*, in broad-leaved forest or woodland with *Carpinus* sp., *Juglans nigra, Malus sieversii, Crataegus* sp., *Prunus* sp., *Sorbus* sp. and shrubs e.g. *Dodonaea* and *Sageretia*. At its highest altitudes in Afghanistan and Pakistan it forms very open stands on bare scree or glacial moraines with decumbent *Juniperus squamata*. It is found on calcareous as well as siliceous rocks, usually in shallow, stony soils, but sometimes in loess or loam, and on dry slopes or near intermittent streams.

Conservation

IUCN: LC

Juniperus flaccida Schltdl., Linnaea 12: 495. 1838.

Etymology

The species epithet (Latin *flaccidus* = soft, weak, withered) refers to the pendulous foliage branchlets.

Vernacular names

Drooping Juniper, Weeping Juniper, Mexican Drooping Juniper; Cedro liso, Enebro, Tascate (Spanish); Tláscal (Aztec)

Description

Small trees (rarely shrubs) to 10–15 m, dioecious; trunk very short to 3 m, to 50–80 cm diam. Bark on trunks ca. 10 mm thick, fissured, scaly, exfoliating in fibrous strips, brown weathering grey-brown. Branches long, spreading or ascending, foliage branches long and lax, spreading to pendulous, commonly in more or less flattened sprays, forming a sympodial, broad, rounded crown. Foliage branchlets ultimately slender, flaccid, subterete, 1–1.2 mm wide, covered with imbricate leaves, persistent. Leaves on mature plants scale-like, decussate, imbricate, decurrent with free to spreading apex, 2–4 × 0.7–1 mm, broad lanceolate to rhombic, acute to acuminate-pungent; gland abaxially in central depression, elliptic or oblong; margins nearly entire-hyaline or minutely denticulate; leaf colour yellowish green to light green; stomata abaxially in 2 inconspicuous lines near the base, adaxially in two bands barely separated by a midrib. Pollen cones numerous, solitary, terminal on short branchlets, ovoid-oblong, 3–5 × 1.5–2 mm, often elongated at pollen dispersal; microsporophylls 10–16, decussate, peltate-acuminate, with hyaline-erose margins, bearing 2–4 abaxial pollen sacs. Seed cones terminal on very short, erect lateral branchlets, maturing in the second season to (sub)globose, 8.5–16 (in one var. up to 20, in another down to 6) mm diam., light brown, usually glaucous or pruinose cones. Bract-scale complexes 6, decussate, entirely fused, sutures often visible on entire cone forming a polygonal pattern; bract tip usually conspicuous, triangular, ca. 1 mm, on a small transverse ridge; scale tissue dry pulpy. Seeds (4–)6–8(–12) per cone, angular-conical, more or less flattened, 3–4 mm long, reddish brown, with lighter hilum at base.

Distribution

SW USA: W Texas (Big Bend National Park); Mexico: Chihuahua, Coahuila, Durango, Guerrero, Hidalgo, Jalisco, México, México D.F., Michoacan, Morelos, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, Sonora, Tamaulipas, Tlascala, Veracruz, Zacatecas.

TDWG codes: 77 TEX 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-SO MXS-GR MXS-JA MXS-MI MXS-OA

Ecology

Juniperus flaccida occurs in montane Pinyon-Juniper woodland, pine-oak forest and woodland,

and oak woodland, with *Pinus cembroides, Pinus* spp., *Juniperus deppeana, J. saltillensis, Quercus* spp., *Fraxinus, Arbutus*, mimosoid legumes, *Yucca* spp., etc., on limestone or other rocks including siliceous (granitic) rocks. The altitudinal range is from 800 m to 2600 m a.s.l.

Uses

No uses have been recorded for this species; the wood may locally serve for fuel or be used for fence posts.

3 varieties are recognized:

Juniperus flaccida Schltdl. var. ***flaccida***. Type: Mexico: Hidalgo, Regla, *C. A. Ehrenberg 8* (lectotype MO). Fig. 139

Description

Foliage spreading to pendulous, not in more or less flattened, distichously branching sprays, green. Leaves with nearly entire-hyaline margins, acuminate-pungent. Seed cones 8.5–15 mm diam., with more than 3 and up to 12 (usually 6–8) seeds.

Distribution

SW USA: W Texas (Big Bend National Park); Mexico: Chihuahua, Coahuila, Durango, Guerrero, Hidalgo, Jalisco, México, México D.F., Michoacan, Morelos, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, Sonora, Tamaulipas, Tlascala, Veracruz, Zacatecas.
TDWG codes: *77* TEX *79* MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-SO MXS-GR MXS-JA MXS-MI MXS-OA

Conservation

IUCN: LC

Juniperus flaccida Schltdl. var. ***martinezii*** (Pérez de la Rosa) Silba, Phytologia 58: 367. 1985. *Juniperus martinezii* Pérez de la Rosa, Phytologia 57: 81. 1985. Type: Mexico: Jalisco, Sierra Cuatralba, El Cuarento, 4 km E of village, *J. A. Pérez de la Rosa 661* (holotype IBUG).

Description

Leaves with hyaline, (minutely) denticulate margins, acuminate-pungent, glaucous green. Seed cones small, 6–8 mm diam., with only 1–3 seeds.

Distribution

Mexico: Aguascalientes, Guanajuato, Jalisco, Veracruz, San Luis Potosí (?).
TDWG codes: *79* MXE-AG MXE-GU MXG-VC MXS-JA

Conservation

Only known from a limited number of locations in which forest cover is decreasing overall, this variety could be at some risk of extinction.
IUCN: VU [B2ab (ii, iii, v)]

Juniperus flaccida Schltdl. var. ***poblana*** Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 31. 1946. *Juniperus poblana* (Martínez) R. P. Adams, Phytologia 88 (3): 239. 2006. Type: Mexico: Puebla, Amozoc de Mota, 1 km NW of town, *M. Martínez A 507* (holotype MEXU).

Description

Foliage in more or less distichously branched, slightly flattened sprays; leaves acute. Seed cones large, up to 20 mm diam., with conspicuous sutures of bract-scale complexes (polygonal markings).

Taxonomic notes

In a recent paper, Adams *et al.* (2006) concluded that this variety is distinct based on molecular data (DNA sequence data and RAPDs) and should be

recognized as a species. Only one sample of this taxon was included in the analysis and its phylogenetic relationship remained unresolved although it seemed distant from *J. flaccida* var. *flaccida* and var. *martinezii*.

Distribution

Mexico: Guerrero, Jalisco, Michoacan, Oaxaca, Puebla, Zacatecas.

TDWG codes: 79 MXC-PU MXS-GR MXS-JA MXS-MI MXS-OA

Conservation

This variety may be in decline due to land clearing.
IUCN: NT

Juniperus foetidissima Willd., Sp. Pl. 4 (2): 853. 1806. Type: Turkey: locality unknown ["habitat in Armenia"], *J. P. de Tournefort B-W 18547* (holotype B-W).

Etymology

The species epithet means 'stinking extremely' and refers to the odour of crushed foliage.

Vernacular names

Stinking juniper; Selwı aghatch, Ardyoch, Selwı ardıç (Turkey); Twia, Malokedra Mamaligwia (Greece & Macedonia)

Description

Trees (rarely shrubs) to 25(–42) m, monoecious or dioecious; trunk up to 3.5(–4.6) m d.b.h., or a (decumbent) multistemmed shrub. Bark on larger stems exfoliating in longitudinal fibrous strips, weathering grey-brown. Branches spreading or ascending, foliage branches short, stiff and spreading, forming a dense, broad pyramidal to eventually rounded or irregular crown. Foliage branchlets ultimately subterete or weakly quadrangular, 1.2–2 mm wide, covered with appressed or apically spreading leaves, persistent. Leaves on mature plants eventually scale-like, decussate, imbricate, decurrent, 2–3 × 1–1.5 mm, ovate-rhombic, more or less acute; margins entire; stomata in 2 inconspicuous lines on each side mostly near the base; scale leaves abaxially glandular, with central, inconspicuous gland; leaf colour yellowish green to lustrous green. Intermediate leaf shapes, as well as juvenile-type leaves after coppicing, usually present in mature trees but diminishing in older trees. Foliage with a 'foetid' odour when crushed. Pollen cones numerous, solitary, terminal on short branchlets, subglobose to ovoid-globose, 2–3.5 mm long; microsporophylls 8–12, decussate, peltate, with rounded entire or erose margins, bearing 3–4 abaxial pollen sacs. Seed cones terminal on 3–4 mm long, erect branchlets, maturing in the second season to become (sub)globose, 5–13 mm diam., dark blue or blackish blue, usually glaucous or pruinose. Bract-scale complexes 6, decussate, entirely fused, sometimes sutures visible, bract tip small, ca. 0.5 mm, on a small ridge, smooth or more or less rugose *in sicco*; scale tissue dry pulpy or rarely more succulent, resinous. Seeds 1–2(–3) per cone, if more than one, connate, often partly fused, ovoid-globose or more or less flattened on one side or hemispherical, 5–7 mm diam., pale brown.

Distribution

SE Europe: Albania, Greece, Macedonia; E Europe: Ukraine: Krym [Crimea]; Caucasus: Armenia, Azerbaijan, Gruziya, Krasnodar, Stavropol; W Asia: Cyprus, NW Iran, Lebanon, Turkey; Central Asia: Turkmenistan.
TDWG codes: 13 ALB GRC YUG-MA 14 KRY 32 TKM 33 NCS-KR NCS-ST TCS-AR TCS-AZ TCS-GR 34 CYP IRN LBS-LB TUR

Ecology

In (Mediteranean) scrubland, *Juniperus-Quercus* scrub, open pine forest and other coniferous forest, with *Pinus brutia, P. nigra, Juniperus excelsa, J. drupacea, J. oxycedrus, Cedrus libani, Abies cephalonica, A. cilicica, A. nordmanniana, Quercus ilex, Pistacia lentiscus*, etc. Often on limestone crags or rocky slopes, or on serpentine or other base-rich rock, in shallow soils. The altitudinal range is from 600 m to 2000 m a.s.l. The climate is Mediterranean with transitions to more continental interior regions where winters are drier and colder.

Conservation

This widespread species is not threatened with extinction. Some exceptionally large and old trees, e.g. in southern Turkey, Mersin, Kadincik Deresi, are protected.
IUCN: LC

Uses

Large trees have been utilised in the past for the making of durables like furniture, but its commercial use is now limited. In some areas firewood may still be extracted from this species. It is uncommon in cultivation, perhaps due to the unpleasant smell of the foliage, although this is not as extreme as its species name implies and will usually only be noticed when fresh leaves are crushed.

Juniperus formosana Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25 (19): 209. 1908. Type: Taiwan: Nantou, Chia-i Pref., Yu-Shan, ["Mt. Morrison"], *T. Kawakami & U. Mori 2039* (lectotype TI).

Juniperus mairei Lemée & Lév., Monde Pl. 2 (16): 20. 1914; *Juniperus formosana* Hayata var. *mairei* (Lemée & Lév.) R. P. Adams & C. F. Hsieh, Biochem. Syst. Ecol. 30: 239. 2002.

Etymology

The species epithet indicates the island of Taiwan (formerly Formosa), from where it was first described; see also Latin *formosus* = handsome or well formed.

Vernacular names

Formosan juniper, Prickly cypress; ci bai (Chinese)

Description

Shrub or tree to 15(–25) m, dioecious; often 2–3-stemmed or low branching. Bark on trunks with long, thin strips, grey-brown. Branches spreading or ascending. Foliage dense or more open, mostly with pendulous, 'jointed' ultimate branchlets, but spreading and rigid at high-altitude, persistent, forming a pyramidal to conical crown, or a dense shrub at high altitude. Leaves in alternating whorls of 3, non-decurrent, spreading 30–60(–90) degrees at nodes 3–10 mm apart, rigid, jointed to leaf part adnate with triangular shoot, linear-lanceolate, (4–)10–20(–30) × (1–)1.1–2.1 mm, straight or slightly curved, usually broadest near the middle; abaxial face (weakly) keeled, lustrous green or dark green; margins entire; apex acuminate or acute-pungent; epistomatic, stomata in two conspicuous bands separated by a midrib, bordered by green or glaucous green margins as wide as midrib. Pollen cones axillary, solitary, 1–2 per leaf whorl, subglobose to ovoid, 4–6 × 3–4 mm; microsporophylls 9–12, in alternating whorls of 3, peltate, with hyaline margins and acuminate apex, bearing 4–6 abaxial pollen sacs near lower margin. Seed cones axillary on short (1–2 mm) dwarf shoots with whorls of minute scale leaves, maturing in 1 year; mature cones (sub)globose, 6–9 mm diam., with 2 whorls of 3 completely fused bract-scale complexes, only upper whorl fully developed, with 3 sutures visible on distal part of cone; bract tip hidden or very small; tissue dry pulpy, occasionally more succulent; mature cones orange-brown or light brown, sometimes dark purple, slightly pruinose. Seeds 2–3 per cone, subglobose to (angular-)ovoid, 4–5 × 3–3.5 mm, light brown, with 3–4 basal resin pits and obtuse apex.

Distribution

China: S Anhui, Chongqing, W Fujian, E Gansu, Guizhou, W Hubei, S Hunan, S Jiangsu, Jiangxi, NE Qinghai, S Shaanxi, Sichuan, S Xizang [Tibet], Yunnan, Zhejiang; Taiwan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SX CHQ CHS-AH CHS-FJ CHS-HN CHS-JS CHS-JX CHS-ZJ CHT 38 TAI

Ecology

In coniferous forest, secondary coniferous woodland, and (subalpine) grassland, at high altitudes predominantly on S-SW facing slopes with shrubs and grasses, also in open areas of deciduous broad-leaved forest on dry, rocky soils. The altitudinal range is from 400 m to 3830 m a.s.l. and increases from E to W. This species is associated with *Pinus* spp. *Picea*

spp., *Abies* spp., *Tsuga* spp., *Juniperus squamata, Rhododendron* spp., numerous angiosperm trees and shrubs, and with grasses. It occurs on all types of rock, from limestone and shale to granite.

Conservation

IUCN: LC

Uses

Formosan juniper is in cultivation and usually grows into a columnar habit when planted in gardens and parks. It is more commonly in use as an ornamental in China and Japan than in Europe and the USA, probably because of the availability of similar forms or cultivars of *J. communis* there.

Juniperus gamboana Martínez, Anales Inst. Biol. Univ. Nac. México 15 (1): 7. 1944. *Juniperus deppeana* Steud. var. *gamboana* (Martínez) R. P. Adams, Phytologia 88 (3): 229. 2006. Type: Mexico: Chiapas, Teopisca, [protologue: "inter Rancho Mitzitón et Comitán"; photo caption: "Belén"], *M. Martínez 6701* (holotype MEXU).

Etymology

This species was named after Rafael P. Gamboa, at the time Governor of the State of Chiapas, Mexico.

Vernacular names

Gamboa juniper; cedro, táscate (Spanish); tzotzil ni' (Mexico)

Description

Shrubs or small trees to 8–12 m, monoecious or dioecious; trunk very short or straight, to 50–90 cm diam. Bark on trunks fissured, 10–15 mm thick and hard, forming longitudinal plates, lower part of trunk often with quadrangular plates, weathering grey. Branches spreading or ascending, forming a broadly conical or pyramidal crown, in old trees becoming irregular and spreading. Foliage branches spreading or drooping, ultimate branchlets spreading at 30–50°, variable in length from 4–20 mm, 1–1.2(–1.4) mm thick, quadrangular to terete, persistent. Leaves on ultimate branchlets decussate, on older branchlets often in alternate whorls of 3, or a mixture of these arrangements, all scale-like, imbricate, appressed, broadly rhombic, (1.3)1.5–2 × 0.7–1 mm (on older branchlets to 2.5 mm long), gibbous or keeled towards the acute-mucronate apex; margins minutely denticulate; apex more or less free esp. on whip shoots with acuminate leaves; stomata few near abaxial base, in two narrow converging bands adaxially; glands in a central abaxial groove, not producing a resin drop (inactive); leaf colour light yellowish green. Pollen cones terminal, solitary, oblong, to 6 × 2 mm; microsporophylls 10–12, decussate, subpeltate, with mucronate apex, bearing 3–4 abaxial pollen sacs. Seed cones terminal, maturing in one year to globose, subglobose or irregular shapes (4–)6–8(–9) mm diam., ripening to pinkish or reddish brown, sometimes glaucous. Bract-scale complexes 4, decussate, entirely fused and invisible in mature cone, hard, dry and resinous; bract tip minute but visible. Seeds 1(–2) per cone, broadly ovoid or ovoid-conical, 6–7 × 5–6 mm, slightly flattened, with deep grooves and resinous pits, yellowish brown, ochraceous or light chestnut-brown.

Taxonomic notes

This species was recently found to be closely related to *Jupiperus deppeana* in an analysis of DNA sequence data (Adams & Schwarzbach, 2006) and therefore interpreted as a variety of that species. While it shares some characters, like the checkered bark (not present in all varieties of *J. deppeana*), it also has some distinct ones. The analysis presented is far from convincing, with largely unresolved relationships among the varieties of *J. deppeana*, but high statistical support for a clade with *J. gamboana* and *J. deppeana* var. *robusta*. If *J. gamboana* were indeed most closely related to *J. deppeana* var *robusta*, the geographical distribution of these two taxa would be hard to explain, as they are separated by populations of *J. deppeana* var. *deppeana*. A better resolved cladogram based on a wider sampling of data is needed to justify this new taxonomy and *J. gamboana* is therefore here maintained as a distinct species.

Distribution

Mexico: Chiapas; Guatemala: Huehuetenango.
TDWG codes: 79 MXT-CI 80 GUA

Ecology

This species occurs in the understorey of, or mixed with other trees in *Quercus-Pinus-Juniperus* forests, bearing many epiphytes indicating frequent fog conditions, on often rocky soil types; also in open pine forest, e.g. with *Pinus oocarpa*, where *J. gamboana* attains greatest size. The known altitudinal range is 1820–2200 m a.s.l.

Conservation

Due to its very limited range (most collections known are from Chiapas, Mexico) in an area which suffers rapid deforestation, the species is likely to have suffered a significant reduction in its area of occupancy (AOO) as well as its overall numbers of mature trees. The situation in Guatemala with this species is poorly known.
IUCN: EN [B2ab (ii, iii, v)]

Juniperus gracilior Pilg., in Urban, Symb. Antill. 7: 481. 1913.

Etymology

The epithet (Latin *gracilis* = slender) means 'comparatively slender'.

Vernacular names

Sabina, Cèdre (Spanish/French)

Description

Shrubs or trees to 10–15 m with monopodial, erect trunk to 40 cm diam., dioecious. Bark on tree trunks thin, exfoliating in strips or thin plates, becoming grey-brown. Branches spreading horizontally or ascending, of higher order spreading or drooping in trees, forming dense irregular or rounded crowns. Foliage branchlets numerous, irregularly disposed at angles between 25–45 degrees, mostly shorter than 20 mm, slender or thicker in one variety, 0.9–1.5 mm diam., more or less quadrangular in ultimate branchlets, persistent. Leaves decussate, decurrent, scale-like, imbricate, with free apex on ultimate branchlets, 1.5–2 × 0.6–1 mm, rhombic to rhombic-lanceolate; margins entire, hyaline; apex obtuse, mucronate or acute-acuminate; stomata few at base abaxially, in one concave field adaxially; abaxial gland more or less conspicuous in basal to central part of leaf, rounded to oval; leaf colour green. Pollen cones terminal on ultimate branchlets, subglobose, very small ca. 2 mm; microsporophylls 6–8, decussate, peltate, with rounded and hyaline upper margin, abaxially bearing 2–3(–4) globose pollen sacs. Seed cones terminal on straight, short ultimate branchlets, maturing in one season, becoming globose (with a single seed) or broad pyriform to nearly reniform, 4–5(–6) mm wide, usually soft pulpy, resinous, reddish brown with glaucous-blue bloom. Bract-scale complexes 4, decussate, the lower pair small and sterile, entirely fused; sutures or bract tips invisible. Seeds 1–2 per cone, ovoid-globose, 2–3 mm diam., light brown.

Distribution

Hispaniola (Dominican Republic and Haiti), very localized in relict populations.
TDWG codes: 81 DOM HAI-HA

Ecology

The three varieties each occur in very limited localities in the humid montane forest zone from 1200 m to 2550 m a.s.l.; their habitat is characterized by a scattering of *Manacla* palms and abundant epihytes. The forest cover has been destroyed in most localities and secondary vegetation predominates, often dominated by the fern *Pteridium aquilinum*. In most localities the junipers are present with only solitary individuals. The species is mainly found on acid forest soil, but *J. gracilior* var. *urbaniana* occupies two very limited areas: on Pic la Selle between 2300–2550 m and in the Sierra de Baoruco at 2100 m a.s.l., both on limestone.

Uses

No current uses have been recorded for this species; its durable wood was in demand locally in the past.

3 varieties are recognized:

Juniperus gracilior Pilg. var. ***gracilior***. Type: Dominican Republic: Cordillera Central, Sierra de la Constanza, Las Cañitas, *M. Fuentes & D. Goodwin 1939* (lectotype NY).

Description

Trees. Ultimate branchlets drooping or pendulous, spreading at 25–30 degrees, slender, 0.9–1.1 mm diam., more or less quadrangular. Leaves distinctly longer than wide, obtuse or acute-acuminate, gland central.

Distribution

Hispaniola: Dominican Republic (La Vega Prov., near and 14 km W of Constanza; Azua Prov., Valle del Yaque).
TDWG codes: 81 DOM

Conservation

Encroachment of human habitation and the concomitant loss of habitat have reduced the three subpopulations known of this species considerably. Even at its greatest historically known extent it would not have occupied more than a few km² (AOO less than 10 km²) and its population is severely fragmented. It is now known from only three localities, in each of which fewer individuals survive.
IUCN: EN [B2ab (ii–v)]

Juniperus gracilior Pilg. var. ***ekmanii*** (Florin) R. P. Adams, Phytologia 78: 144. 1995. *Juniperus ekmanii* Florin, Ark. Bot. 25-A (5): 14. 1934. Type: Haiti: Ouest, Massif de la Selle, Badaud, ["Badeau"], *E. L. Ekman 3140* (holotype S).

Description

Trees. Ultimate branchlets spreading at 30–45 degrees, slender, 0.9–1.0 mm diam., more or less quadrangular. Leaves slightly longer than broad; apex acuminate or mucronate; gland conspicuous, near base.

Distribution

Hispaniola: Haiti, Massif de la Selle (Morne la Selle, Morne la Visite?); Dominican Republic (Sierra Baoruco).
TDWG codes: 81 DOM HAI-HA

Conservation

This variety is now limited to two or perhaps three localities, where very few trees remain.
IUCN: CR (D)

Juniperus gracilior Pilg. var. ***urbaniana*** (Pilg. & Ekman) R. P. Adams, Phytologia 78: 144. 1995. *Juniperus urbaniana* Pilg. & Ekman, Ark. Bot. 20-A (15): 9. 1926; *Juniperus barbadensis* L. var. *urbaniana* (Pilg. & Ekman) Silba, Phytologia 56: 341. 1984; *Juniperus barbadensis* L. subsp. *urbaniana* (Pilg. & Ekman) Borhidi, Acta Bot. Acad. Sci. Hungarica 37 (1–4): 90. 1992. Type: Haiti: Ouest, Massif de la Selle, Morne de la Selle, near the summit, *E. L. Ekman 3157* (holotype S).

Description

Decumbent or low shrubs. Ultimate branchlets spreading, curved, rigid, thick, 1.3–1.5 mm diam., distinctly quadrangular. Leaves nearly as wide as long, mucronate; glands often inconspicuous, near base.

Distribution

Hispaniola: Haiti, Massif de la Selle (Pic la Selle); Dominican Republic (Sierra de Baoruco).
TDWG codes: 81 DOM HAI-HA

Conservation

Restricted to two small localities, from a small range that has probably been reduced due to increased pressure from man-made fires and possibly overgrazing.
IUCN: EN (B1)

Juniperus horizontalis Moench, Methodus: 699. 1794. Type: Canada: Nova Scotia, Halifax, ["prope Halifax"], *M. Hultgren s.n.* (neotype BM).

Juniperus horizontalis Moench subsp. *hamptonensis* Silba, J. Int. Conifer Preserv. Soc. 11 (1): 28 (–29, 32). 2004.
Juniperus horizontalis Moench subsp. *neopangaea* Silba, J. Int. Conifer Preserv. Soc. 11 (1): 28 (31). 2004.

Etymology

The species epithet refers to the growth habit close to the ground.

Vernacular names

Creeping juniper, Waukegan juniper, American savin, Shrubby red cedar; Savignier, Sevigné (French)

Description

Prostrate or decumbent shrubs to 1 m, usually lower and rarely taller, spreading with rooting branches over soil and rock, dioecious or rarely monoecious; stem to ca. 5 cm diam. Bark on thicker branches and stems in thin flakes or wide strips, weathering grey-brown. Branches creeping, spreading or whip shoots assurgent, higher order branches ascending or spreading against the ground or rocks. Foliage branches 3–15 cm long, often arranged upright along a prostrate, rooting branch, or prostrate also, ultimate branchlets densely crowded, curved, twisted or nearly straight, of irregular length, more or less quadrangular in cross-section, with appressed scale leaves 1–1.5 mm wide. Leaves decussate, sometimes in parts in irregular whorls of 3, imbricate, small scale leaves appressed, scale leaves on ultimate branchlets rhombic, 1.5–2.2 × 1–1.2 mm; margins entire; apex acute or acuminate, transitional leaves common, lanceolate to acicular, distal part or only the acuminate to pungent apex free, 3–6 mm long, leaves on whip shoots long decurrent, to 10–13 × 2 mm; apex caudate-pungent; abaxial stomata in 1–2 bands near base, adaxial stomata scattered from base to apex; glands conspicuous but inactive, on small scale leaves elliptic, on longer leaves linear, leaf colour green, turning reddish purple in winter. Pollen cones numerous, terminal, solitary, subglobose to ovoid, 1.5–3 × 1–2 mm, yellowish green turning yellowish brown; microsporophylls (10–)12, decussate, imbricate, peltate, with hyaline, entire or slightly erose margins and obtuse apex, bearing 3–5 abaxial pollen sacs. Seed cones terminal on short, usually curved ultimate branchlets, maturing in two years to irregular, then (sub)globose cones (3–)5–8 mm diam., pinkish turning brownish blue or blackish blue. Bract-scale complexes 6, decussate, rarely two whorls of 3, completely fused at maturity but retaining partly visible scale and bract margins, outer surface smooth, usually pruinose; cone tissue soft pulpy and resinous. Seeds (2–)3–4 per cone, more or less ovoid, often slightly curved, 3–4(–4.5) × 2–3 mm, with shallow grooves, resinous; apex obtuse, brown, with a light hilum a third of seed length.

Taxonomic notes

John Silba (*op. cit.*) described two new subspecies from a small area on Long Island, NY which are mainly based on habit that appears to differ from the normal prostrate or decumbent forms in growing more upright (to 2 m) or with an "oval" or "bonsai" appearance. Some of the latter plants had very small (3 mm) seed cones. The typical form was also found in the area but said to be uncommon. Other species in the area are *J. communis* and *J. virginiana*. Such growth forms, while unusual, are unlikely to be true taxa and, at the periphery of the southeastern range of *J. horizontalis*, could have involved introgression

from *J. virginiana* (see taxonomic notes under the latter species).

Distribution

Boreal and Subarctic North America, from Alaska (disjunct) to Newfoundland, more scattered further south in the USA.

TDWG codes: 70 ASK NUN NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NSC NFL-NE ONT PEI QUE 73 MNT WYO 74 ILL IOW MIN MSO NEB NDA SDA WIS 75 MAI MAS MIC NWY VER 78 VRG

Ecology

This species occurs in a variety of habitats, usually on more or less open ground; on sandy beaches and in sand dunes, on dry rocky slopes and outcrops, limestone ridges, in dry 'barrens', in grassland (prairies), open bogs or 'muskeg' (*Picea mariana* / *Pinus banksiana* bog-woodland), or heathland (e.g. *Empetrum nigrum*), or on stream banks, often forming wide patches. The altitudinal range is from 10 m to 1160 m a.s.l.

Conservation

IUCN: LC

Uses

Creeping juniper is a desirable species for horticulture in cool temperate to cold regions, since 1830 known in cultivation in England. There are now numerous garden forms (cultivars) known, selected both in Europe and North America and widely used in gardens and parks. It makes an excellent ground cover on sandy soils and in rockeries. Many forms that originated in cultivation have in the past been given botanical latinized names but since they are not taxa but cultivars these names should be changed to cultivar names written in inverted commas (or preceded by 'cv.'), capitalized and in roman type; e.g. *Juniperus horizontalis* var. *viridis* Grootendorst becomes *J. horizontalis* 'Viridis'. All such names were excluded from my Monograph of Cupressaceae and Sciadopitys (Farjon, 2005a) which only includes taxa (ranked entities classifying variation that occurs in nature).

Juniperus indica Bertol., Misc. Bot. 23: 16, t. 1. 1862.

Etymology

The species epithet denotes the country of origin, i.e. India, from where it was first described.

Vernacular names

Black juniper, Wallich's juniper; dian zang fang zhi bai (Chinese)

Description

(Decumbent) shrubs, rarely small trees to 15(–20) m tall, dioecious; multistemmed or monopodial; trunk up to 1.2 m d.b.h. Bark on larger stems exfoliating in sheets or longitudinal strips, weathering dull brown. Branches ascending or spreading, foliage branches dense, short, stiff and spreading or erect, forming a dense, broad pyramidal to eventually rounded or irregular crown. Foliage branchlets ultimately stout, quadrangular, sometimes more or less terete, 1.2–1.5 mm wide, covered with appressed or sometimes spreading leaves, persistent. Leaves on mature plants eventually scale-like, decussate, sometimes 3-whorled, imbricate, decurrent, 1.2–2 × 1–1.2 mm, triangular-rhombic, obtuse; margins entire; scale leaves amphistomatic, stomata in 2 inconspicuous lines on each side mostly near base; glands central in a groove, elliptic or oblong, sometimes absent; leaf colour green or slightly glaucous green. Pollen cones numerous, solitary, terminal on short branchlets, subglobose to ovoid-globose, 2–3 mm long; microsporophylls 6–8, decussate, peltate-cordate, with rounded entire hyaline margins, bearing 2–3 abaxial pollen sacs. Seed cones terminal on short erect branchlets, maturing in the second season to subglobose or ovoid, (4.5–)5–13 × 4–8 mm, lustrous blue-black or brownish black, soft cones. Bract-scale complexes 3–6, decussate or (2×) 3-whorled, entirely fused, sometimes incompletely covering the seed; bract tip subapical, small, ca. 0.5 mm; surface smooth; scale tissue succulent, resinous. Seeds single, ovoid, laterally compressed or more or less flattened, 5–6 × 4 mm, shallowly grooved, pale yellowish brown.

Distribution

Himalaya, E into high mountains of China. Bhutan; China: W Sichuan, S Xizang [Tibet], NW Yunnan; India: Himachal Pradesh, Uttar Pradesh, Kashmir; Nepal; N Pakistan; Sikkim.
TDWG codes: 36 CHC-SC CHC-YN CHT 40 EHM-BH EHM-DJ EHM-SI NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

From upper montane coniferous forest and woodland in pure stands, or with e.g. *Abies, Pinus, Cupressus torulosa*, or in *Betula utilis* subalpine woodland, to alpine heath and grassland and into the bare moraines and scree of the niveous zone. The altitudinal range is from 3600 m to 4800 m a.s.l. As an understorey shrub or tree in coniferous forest it is often accompanied by *J. squamata, Rhododendron* spp., *Rosa*, and *Cotoneaster*. Above the tree line it can form juniper-rhododendron thickets, grow in *Kobresia-Stipa* turf with dwarfed alpine shrubs (e.g. *Rhododendron, Salix, Juniperus squamata*), or occur scattered on moraines and consolidated scree slopes of granite or gneiss or other metamorphic acidic rock, at the highest altitudes exclusively on S-facing slopes. The climate is high montane to alpine with a pronounced monsoon phase delivering heavy precipitation (much as snow) from May to October.

Uses

Black juniper is probably rare in cultivation under either *J. wallichiana* or *J. pseudosabina*; the first being a synonym of *J. indica* and the latter a closely related species from Central Asia. The recently discovered variety *J. indica* var. *caespitosa* is a decumbent form suitable as ground cover in rock gardens, but not yet in cultivation. The growth habit of *J. indica* var. *indica* is erect, but varies from shrub to small tree. Both forms are commendable for horticulture, but slow growing. In the Himalayas, where Black juniper is common and widespread, its wood is used for fuel and branches and foliage are burned as incense in Buddhist temples.

2 varieties are recognized:

Juniperus indica Bertol. var. ***indica***. Type: Illustration in Bertoloni, Misc. Bot. 23: 16, t. 1. 1862 (lectotype).

Juniperus wallichiana Hook. f. & Thomson *ex* E. Brandis, Forest Fl. N.W. & Central India: 537. 1874.

Description

Erect shrubs to small trees to 15(–20) m tall. Foliage branches spreading or more or less erect, dense with short branchlets. Seed cones when mature mostly (broadly) ovoid, 8–13 × 5–8 mm, blue-black or brownish black.

Distribution

As the species.

Conservation

IUCN: LC

Juniperus indica Bertol. var. ***caespitosa*** Farjon, Monogr. *Cupressaceae & Sciadopitys*: 313. 2005. Type: Nepal: Dhaulagiri Himal, Dolpo, Mugu Karnali, S of Mugu, *S. Miehe 99–03001* (holotype K).

Description

Decumbent or ascending shrubs 50–100 cm tall. Foliage branches (nearly) erect, very dense with short branchlets. Seed cones when mature (sub) globose to broadly ovoid, (4.5–)5–8 × 4–6.5 mm, blue-black.

Distribution

Nepal, S Xizang [Tibet], Bhutan; probably elsewhere and as yet incompletely known.
TDWG codes: 36 CHT 40 EHM-BH NEP

Ecology

This is a decumbent form that is generally associated with tree line habitat and above, but in some localities it has been found growing amongst both the tall,

erect form of the species and within the uppermost belt of subalpine forest dominated by *Abies* and *Larix*.

Conservation

IUCN: LC

Juniperus jaliscana Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 69. 1946. Type: Mexico: Jalisco, Talpa de Allende, Cumbre Blanca, *M. Martínez & A. Q. Gonzalez 7002* (holotype MEXU).

Etymology

The species epithet refers to the State of Jalisco in Mexico.

Vernacular names

Jalisco juniper; cedro, enebro (Spanish)

Description

Small trees to 10 m tall, dioecious or monoecious; trunk erect, more or less straight. Bark on trunk fibrous, soft, exfoliating in long thin strips, orange-brown to reddish brown, weathering grey. Branches ascending or spreading, in younger trees nearly erect, forming a conical crown, later a rounded crown. Foliage branches numerous, dense, slender and lax, ultimate branchlets more or less curved, of unequal length up to 15 mm, thin, 1.1–1.3 mm wide, more or less quadrangular in cross-section. Leaves all scale-like, decussate, not or slightly imbricate, persistent on 3–4 orders of branching, on ultimate branchlets ovoid-oblong, 1–1.5 × 0.7–0.8 mm (growing to 4–5 mm long and 2–2.5 mm wide with a caudate, acute apex on older lower order branchlets), slightly incurved; margins minutely or remotely denticulate to nearly entire; apex free, acute-acuminate; amphistomatic, nearly all stomata adaxially; glands central, linear or oblong, inactive; leaf colour grey-green. Pollen cones terminal, not seen. Seed cones terminal, solitary on short, curved branchlets, maturing to subglobose, irregular cones of 5–7.5 mm diam., brown, variously glaucous. Bract-scale complexes 6, decussate, with protruding, recurved bract tips up to 1 mm long, pulpy tissue hardening when drying and shrinking. Seeds 5–8(–10) per cone, of unequal size, the largest 4 × 2.5 mm, narrowly ovoid, more or less acute on both ends, light brown, with yellow resin drops at chalazal end, micropylar protusion sometimes persistent.

Distribution

Mexico: S Durango, NW Jalisco, only known from two localities.
TDWG codes: 79 MXE-DU MXS-JA

Ecology

The ecology of this species is not well known. Some specimens have been collected in goat pasture, with the grasses frequently burned, on steep, weathered granitic slopes, i.e. disturbed secondary vegetation. The altitudinal range is reported to be from 430 m to 2670(?) m. The divergent altitudes of the two localities are remarkable; whereby it must be stated that the high altitude was reported for the locality that has not been identified.

Conservation

This species is only known from two localities, one of which, mentioned by Martínez (*op. cit.*) as the place in Durango where C. E. Blanco collected it, has not been found back recently, nor traced on the map. *Juniperus jaliscana* occurs in grazed secondary vegetation as well as in woods (at the higher altitude in Durango). It is listed as Endangered even though it is likely that a thorough exploration of the relevant regions would turn out more individuals or even populations.
IUCN: EN [B2ab (ii, iii, v)]

Juniperus komarovii Florin, Acta Horti Gothob. 3: 3. 1927. Type: China: Sichuan, N Sichuan, Sangarmai, ["Sankar-vou-mâ"], *H. Smith 4402* (holotype GB).

Etymology

The species epithet commemorates the Russian Botanist Vladimir L. Komarov (1869–1945), compiler of the multi-volume Flora of the U.S.S.R.

Vernacular names

ta zhi yuan bai (Chinese)

Description

Trees to 20 m, monoecious; trunk up to 1.2 m d.b.h. Bark on trunk stringy, exfoliating in longitudinal strips, light brown or greyish brown. Branches spreading from trunk, foliage branches drooping to pendulous, branchlet systems often tapering with distal branchlets successively shorter. Foliage branchlets straight or slightly curved, ultimate branchlets terete or quadrangular, stout, 1.2–1.5 mm diam., covered with green scale leaves, persistent. Leaves mostly decussate, triangular-ovate, 1.5–3.5 × 1–1.5 mm; margins entire; apex acute or sometimes obtuse; stomata restricted to concave distal part of scale leaves; abaxial gland often inconspicuous, in lower part of leaf or near the base, orbicular to oblong, convex; leaf colour green. Pollen cones solitary and terminal on ultimate branchlets, globose to ovoid, 2–3 mm long; microsporophylls (6–)8–10, decussate, peltate, with rounded margin, bearing 2–3 abaxial pollen sacs near lower margin. Seed cones terminal, initially (sub)erect on short branchlets, becoming pendulous with growing branchlets, maturing in two seasons, turning from (brownish) green to bluish- or purplish black when ripe, ovoid (in green cones with acute apex), 8–10(–12) × 6–8(–9) mm, smooth, lustrous in ripe, blackish cones or slightly glaucous. Bract-scale complexes 6, decussate; sutures visible at least until maturity; bract tips small, acute, protruding near apex. Scale tissue soft pulpy, resinous. One seed per cone, ovoid or ellipsoid with acute base and apex, more or less with two opposite ridges, irregularly grooved, 7–10 mm long, light brown, with darker resin pits near base and 1–2 pits near middle.

Distribution

China: S Gansu, SE Qinghai, NW Sichuan.
TDWG codes: 36 CHC-SC CHN-GS CHQ

Ecology

This species has been found in deep gorges and on rocky or grass-covered slopes in the semi-arid mountains and plateaus of S Gansu, SE Qinghai and NW Sichuan, where it is associated with few other trees and mainly restricted to S-facing slopes. The altitudinal range is from 2110 m to 4000 m a.s.l. N-facing slopes are covered with spruce forest (*Picea asperata*).

Conservation

IUCN: NT

Uses

No uses have been recorded for this species, but its wood and foliage may be used locally for firewood and incense burning. In cultivation it is only known in a few arboreta and these are recent introductions.

Juniperus monosperma (Engelm.) Sarg., Silva N. Amer. 10: 89. 1896. *Juniperus occidentalis* Hook. var. *monosperma* Engelm., Trans. St. Louis Acad. Sci. 3: 590. 1878. Type: USA: Colorado, Fremont Co., Canon City, *G. Engelmann s.n.* (lectotype MO). Pl. 17

Etymology

The species epithet means 'with a single seed', but this species is not strictly monospermous, as are some others.

Vernacular names

One-seed juniper, Cherrystone juniper, West Texas juniper; Sabina (Spanish)

Description

Large shrubs to 6 m, dioecious, rarely monoecious; multistemmed or rarely with a short trunk and a maximal diam. of 30 cm. Bark of thick branches and trunk fibrous, exfoliating in strips, weathering ash-grey. Branches numerous, ascending from base or nearly erect, often curved, those of higher orders ascending or spreading, forming a broad, rounded or more irregular and open crown. Foliage branches numerous, irregularly disposed but not pendulous, ultimate branchlets spreading to erect, slender and stiff, up to 15 mm long, 1.2–1.9 mm thick, subterete or weakly quadrangular in cross section, covered with

scale leaves, persistent. Leaves in alternate whorls of 3, less often decussate on ultimate branchlets, imbricate, scale-like, 1–2(–3) × 0.6–1.5 mm on lateral branchlets, decurrent, rhombic to broadly rhombic; apex appressed or sometimes free, acute/acuminate; margins minutely denticulate; stomata on abaxial side limited to decurrent leaf base, on adaxial surface in two tapering bands; glands more or less conspicuous, large, elliptical, slightly depressed, exudate often present; leaf colour yellowish green or light green. Pollen cones numerous, terminal, solitary, ellipsoid or ovoid-oblong, 3–4 × 2–2.5 mm; microsporophylls 8–10, decussate, peltate, acute, with minutely denticulate upper margins and 3–4 abaxial pollen sacs. Seed cones terminal on straight, very short branchlets, maturing to purplish orange or reddish brown with glaucous or blue bloom in one season, subglobose to ovoid-globose, 5–8 mm diam., internally soft pulpy, succulent, yellowish to orange. Bract-scale complexes 4–6, entirely fused, decussate, bract apices prominently exserted, surface smooth, rugose when dry, glaucous. Seeds 1(–2) per cone, broadly ovoid, 4–6 × 3–4 mm, base truncate; apex acutish, shallowly grooved and ridged on sides, not resinous, light yellowish brown to chestnut brown, with a large, lighter lobed hilum.

Distribution

USA: Arizona, S Colorado, S Nevada, New Mexico, W Oklahoma, NW Texas; Mexico: Chihuahua (?).
TDWG codes: 73 COL 74 OKL 76 ARI NEV 77 NWM TEX 79 MXE-CU

Ecology

In Pinyon-Juniper woodland, with *Pinus edulis, Juniperus osteosperma, J. scopulorum*, and in grassland with *Opuntia* spp., *Yucca* spp. on dry, rocky soils of intermountain basins, or on rock outcrops, buttes and mesas of limestone, sandstone or igneous rock. The altitudinal range is from 970 m to 2200 m a.s.l. The climate is continental semi-arid, with summer rainfall mainly arriving with erratic and local storms from the Gulf of Mexico.

Conservation

IUCN: LC

Uses

The wood is useful as firewood and for fence posts. The fibrous bark was woven into mats and cloth by Native Americans (Apache, Comanche, Ute). One-seed juniper is of no particular interest to horticulturists probably because of its growth habit, often not 'knowing' whether it wants to be a shrub or a tree.

Juniperus monticola Martínez, Anales Inst. Biol. Univ. Nac. México 17 (1): 79. 1946. Type: Mexico: Hidalgo, Mineral del Monte, Rancho del Guajolote, *C. A. Ehrenberg s.n.* (isotype MO).

Juniperus monticola Martínez var. *monticola* f. *compacta* Martínez, Bol. Soc. Bot. México 7: 19. 1948; *Juniperus compacta* (Martínez) R. P. Adams, Phytologia 89 (3): 368. 2007.

Etymology

The Latin species epithet means 'mountain-dwelling'.

Vernacular names

Mexican juniper; Sabina, Savino (Spanish); Tláscal (Aztec)

Description

Decumbent shrubs to small trees 6–10 m, dioecious; trunk prostrate and tortuous to erect, usually forked near base or branching low, to 60 cm diam. Bark on larger trunks becoming fibrous, to ca. 1 cm thick, exfoliating in long strips. Branches spreading or ascending to nearly erect; forming a variable crown from decumbent to broadly rounded and dense. Foliage branches often in tapering tufts, ultimate branchlets numerous, straight or curved, (3–)5–20(–22) mm long, quadrangular in cross section, often thick on plants from above ca. 3000 m (1-2–1.7 mm), other localities 1.2–1.4 mm diam., persistent. Leaves decussate, imbricate, closely appressed, appearing in four rows, or in some plants more irregularly oriented and less closely appessed, on ultimate branchlets broadly rhombic, 0.8–1.4 × 1–1.2 mm, distinctly keeled; margins minutely hyaline-erose to serrulate; apex obtuse;

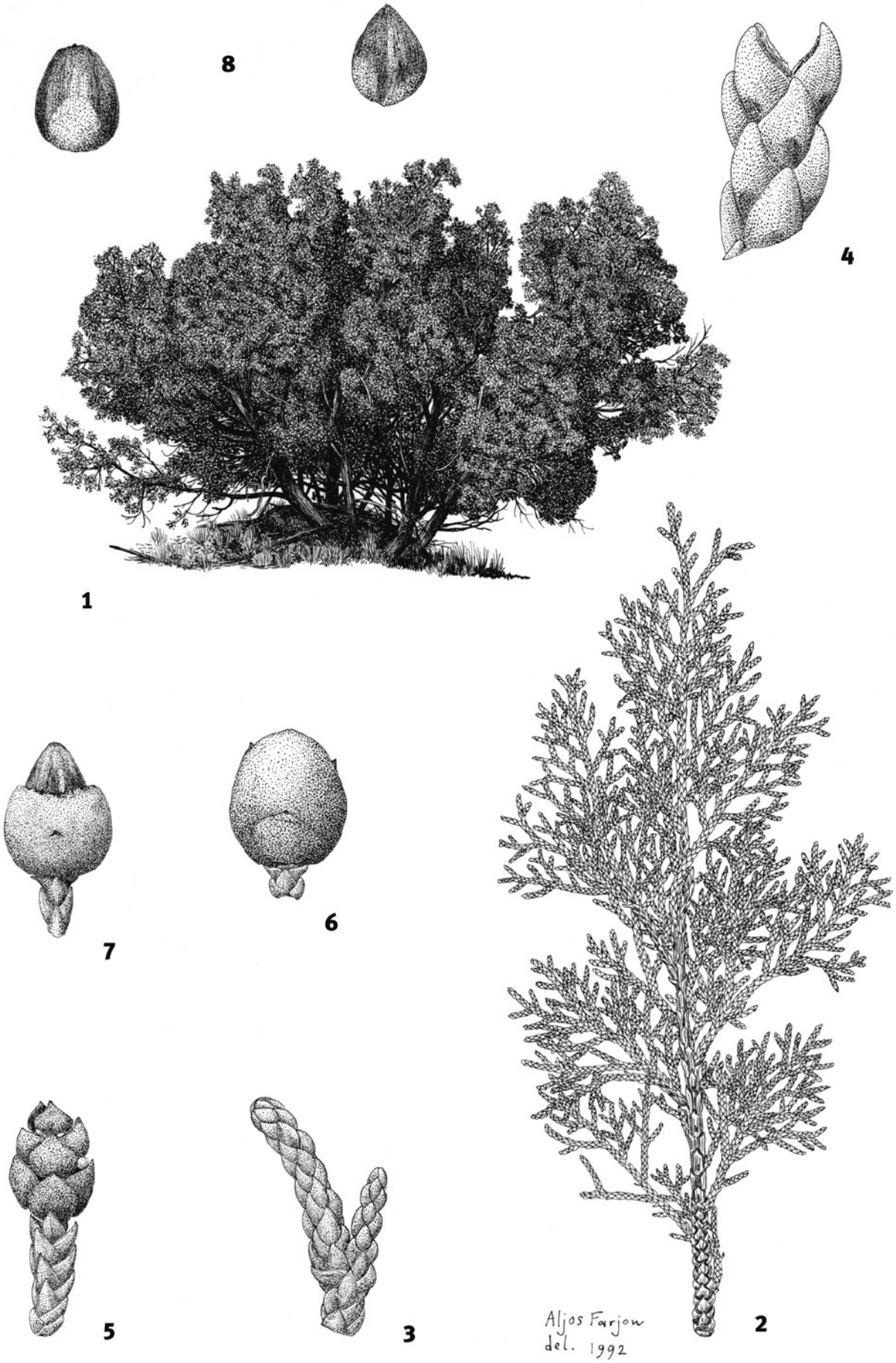


PLATE 17. Juniperus monosperma. **1.** Habit of shrub. **2.** Branch with foliage. **3.** Branchlet with leaves. **4.** Leaves with gland. **5.** Pollen cone. **6, 7.** Seed cones, one opened to show seed. **8.** Seeds.

few stomata abaxially on lower margin, stomata scattered adaxially, covered by thick cuticular wax; glands central, elliptic or nearly linear, or absent on many smallest leaves; leaf colour light to dark green or glaucous green. Pollen cones terminal, solitary, oblong, 3–4 × 2–2.5 mm, more or less quadrangular in cross section; microsporophylls 10–12, decussate, peltate, often keeled, bearing 3–4 abaxial pollen sacs. Seed cones terminal on very short branchlets; mature cones globose or subglobose, 6–9(–10) mm diam., lustrous, purplish black or purplish red, sometimes dull orange-brown, usually with a glaucous bloom. Bract-scale complexes 6, completely fused, forming a soft pulpy, succulent, resinous cone with smooth surface and minutely exserted (lower) bract tips. Seeds (2–)3–7(–9) per cone, angular ovoid, irregular but more or less flattened, 3–5 × 2–3 mm, small relative to cone size, with a small light hilum at or near base, grooved or pitted proximally, with resin in pits, lustrous (dark) chestnut-brown.

Taxonomic notes

Recently, Adams (*op. cit.*) raised *Juniperus monticola* var. *monticola* f. *compacta* to the rank of species: *J. compacta* (Martínez) R. P. Adams, based on analysis of DNA sequence data and biochemistry. No morphological characters seem to separate *J. monticola* from *J. compacta* other than the habit mentioned by Martínez in his original description. Whilst it may be so that these biochemical differences exist (and even could turn out to be consistent with wider sampling), it remains to be demonstrated that it is taxonomically informative to base species concepts on such data, creating, as Adams admits, "cryptic species".

Distribution

Mexico: Guerrero, Hidalgo, Jalisco, México, México D.F., Michoacan, Nuevo León, Puebla, Veracruz; Guatemala: Huehuetenango.
TDWG codes: 79 MXC-DF MXC-ME MXC-PU MXE-NL MXE-SL MXG-VC MXS-JA MXS-MI MXS-GR 80 GUA

Ecology

The large shrub to small tree form of this species is occasionally found in Pinyon-Juniper woodland, or in other open pine forest; it has also been reported from "*Ficus religiosa* forest", with an understorey of *Ribes, Rosa* and *Rubus* (herbarium collection *Zanoni 2718*, Mexico, Federal District, 2895 m). The decumbent shrub form is common at or above the tree line (usually with *Pinus hartwegii*) on ridges of basalt or consolidated scree, with grasses e.g. *Calamagrostis* and *Festuca*, shrubs such as *Ribes*, and some alpine herbs, or on rocks and cliffs to the limit of vegetation on Mexico's highest volcanoes. The altitudinal range of the species is 2000–4270 m a.s.l. Despite high precipitation on these mountains, the environment is decidedly xeric due to the porosity of volcanic substrates, but snowmelt may provide a relatively reliable, slow-release moisture source in spring and early summer.

Conservation

IUCN: LC

Uses

This species is not in cultivation, but the decumbent alpine form would probably be suitable for rock gardens and withstand low winter temperatures.

Juniperus occidentalis Hook., Fl. Bor. Amer. 2 (10): 166. 1838.

Etymology

The Latin species eithet means 'from the west'.

Vernacular names

Western juniper, Sierra juniper (var. *australis*)

Description

Trees 10–15(–20) m tall, to 1.5–2.5 m diam., monoecious or dioecious; trunk monopodial or with several massive stems low above the ground. Bark on trunk fissured, fibrous, exfoliating in long strips, orange-brown to (reddish) brown. Branches thick, ascending or spreading, often curved or contorted, the foliage branches forming dense rounded tufts at ends of heavy main branches, forming a pyramidal crown in young trees, becoming rounded and irregular in old trees. Foliage branchlets numerous, stout, sub-

terete to quadrangular, ultimate branchlets to 5 cm long, (1.2–)1.5–2 mm thick, covered with scale leaves, persistent. Leaves in alternate whorls of 3, less often decussate on ultimate branchlets, closely appressed, scale-like, 2–3 × 2 mm on ultimate branchlets, ovoid-rhombic; margins minutely denticulate, acute or obtuse; stomata abaxially near base and in two tapering bands adaxially; glands conspicuous, central, oval, often active with white-drying resinous exudate; leaf colour dark green. Pollen cones numerous, terminal on short ultimate branchlets, subglobose to ovoid-oblong, 3–5 × 2–3 mm; microsporophylls (10–)12–16(–18), mostly decussate, peltate, bearing 3 abaxial pollen sacs near lower margin. Seed cones terminal on ultimate branchlets, growing in two seasons from purplish red to blue or purple with a glaucous bloom, subglobose to ellipsoid, (6–)7–9(–10) × (5–)6–8 mm, fleshy or pulpy, more or less resinous, eventually dry. Bract-scale complexes (4–)6, decussate or in two alternate whorls of 3, entirely fused, smooth, rugose when dry, with small triangular bract apices protruding. Seeds 1–2 per cone, ovoid or semi-ovoid, 5–6(–7) × 4–5 mm, with shallow grooves and resinous pits, yellowish brown.

Distribution

W USA: California, W Idaho, Nevada, Oregon, Washington.
TDWG codes: 73 IDA ORE WAS 76 CAL NEV

Ecology

In the northern part of its range (var. *occidentalis*) Western juniper is often forming single species stands, or it is associated with *Pinus ponderosa*. Here it is most frequently found on flood plains, terraces, and grassy plateaux and uplands. In E Oregon it is also spreading onto abandoned agricultural fields and rangeland, partly as a result of a decreasing frequency of wildfires. In the Sierra Nevada (var. *australis*) it can grow with *Pinus jeffreyi, P. albicaulis, P. monticola, P. contorta, Abies magnifica, Calocedrus decurrens*, and *Tsuga mertensiana*. The most common understorey shrub in its entire range is *Seriphidium tridentatum* (*Artemisia tridentata*); in the north also *Chrysothamnus* spp., *Purshia tridentata, Ribes cereum*, in the south *Arctostaphylos* spp., *Ceanothus* sp., and several others. The altitudinal range is 200–1200 m a.s.l. (var. *occidentalis*) and 1980–3100 m a.s.l. (var. *australis*). In coniferous forest it usually occurs where rock outcrops cause shallow soils, at higher altitudes in the Sierras it can usually be found among granite boulders or even in crevices on bare granite domes. In the north it grows on xeric soils, often derived from volcanic rock, or from non-calcareous sediment. The climate ranges from semi-arid in the rain shadow of the Cascades (15–45 cm p/a) in the north to mesic in the Sierras, with precipitation mostly in the form of winter snow.

Uses

The wood of this juniper is still used locally for firewood, fence poles, corrals, etc. Its very durable wood is also used for special purposes such as furniture, interior panelling and decorative applications. Horticultural use is rare, but the species has value for landscaping of disturbed sites. There are a few cultivars known, one of these has conspicuously silvery glaucous foliage and is called 'Sierra Silver' and, at least for a time, retains the columnar or pyramidal habit of younger plants.

2 varieties are recognized:

Juniperus occidentalis Hook. var. ***occidentalis***. Type: USA: Washington, Columbia River, ["Common on the higher parts of the Columbia, at the base of the Rocky Mountains"], *D. Douglas s.n.* (holotype K).

Description

Trees mostly monoecious ("submonoecious"); bark "brownish". Scale leaves decussate or in whorls of 3. Cotyledons 2–4 in embryos, usually 2 in seedlings.

Distribution

W USA: N California, W Idaho, NW Nevada, Oregon, S Washington.
TDWG codes: 73 IDA ORE WAS 76 CAL NEV

Conservation

Of conservation concern, mostly for other reasons than species survival in the strict sense, are the very ancient specimen trees of both recognized varieties

which occur in the Cascades and especially in the Sierra Nevada (var. *australis*). Many of these trees, possibly several thousand years old but difficult to date with accuracy, are on protected public lands, where cutting trees and grazing livestock are either prohibited or strictly regulated. They are of great aesthetic and scientific value.
IUCN: LC

Juniperus occidentalis Hook. var. ***australis*** (Vasek) P. Lebreton & N. H. Holmgren, Intermountain Fl. 1: 239. 1972. *Juniperus occidentalis* Hook. subsp. *australis* Vasek, Brittonia 18: 352. 1966; *Juniperus grandis* R. P. Adams, Phytologia 88 (3): 306. 2006. Type: USA: California, San Bernardino Co., San Bernardino Mts., along Polique Canyon Road to Holcomb Valley, *F. C. Vasek 610929–38* (holotype RSA). Fig. 140

Description

Trees mostly dioecious, occasionally monoecious; bark orange-brown or reddish brown. Scale leaves mostly in whorls of 3. Cotyledons 2–4 in embryos, 2–4 in seedlings.

Distribution

W USA: California, extreme W Nevada.
TDWG codes: 76 CAL NEV

Conservation

IUCN: LC

Juniperus osteosperma (Torr.) Little, Leafl. W. Bot. 5: 125. 1948. *Juniperus tetragona* Schltdl. var. *osteosperma* Torr., Pacif. Railr. Rep. 4 (5) [no. 4]: 141. 1857; *Juniperus californica* Carrière subsp. *osteosperma* (Torr.) E. Murray, Kalmia 12: 21. 1982. Type: USA: Arizona, Coconino Co., Bill Williams Mt., *J. M. Bigelow s.n.* (lectotype NY).

Etymology

The species epithet means 'with bony seed', presumably referring to the hardness of the seeds.

Vernacular names

Utah juniper, Bigberry juniper; Sabina morena (Spanish)

Description

Arborescent shrubs or small trees 3–6(–12) m tall, monoecious or rarely dioecious; trunk to 1 m diam. near base, with several stems low above ground. Bark on trunk scaly, fibrous, exfoliating in long strips, (reddish) brown weathering grey. Branches thick, spreading and ascending, often curved or contorted, the foliage branches forming tufts at ends of main branches; crown becoming rounded and irregular in old trees. Foliage branchlets numerous, thick, subterete or sometimes quadrangular, ultimate branchlets to 3 cm long, 2–2.5 mm thick, covered with scale leaves, persistent. Leaves in alternate whorls of 3, sometimes decussate on ultimate branchlets, closely appressed, scale-like, 1.5–3.5 × 1–2.5 mm on ultimate branchlets, ovoid-rhombic to rhombic; margins minutely denticulate, acute or obtuse; abaxially a few stomata near base and in two tapering bands adaxially; glands inconspicuous, central, usually inactive; leaf colour green with whitish wax. Pollen cones numerous, terminal on short ultimate branchlets, subglobose to ovoid, 3–4.5 × 2–2.5 mm; microsporophylls (10–)12–16, mostly decussate, peltate, bearing 3–4 abaxial pollen sacs near lower margin. Seed cones terminal on short branchlets, growing in two seasons from blue-green or purplish to light brown with a glaucous white bloom, subglobose to ovoid-ellipsoid, 7–13(–15) × 6–12 mm, pulpy or fibrous, more or less resinous, maturing dry and hard. Bract-scale complexes 4–6, usually decussate or sometimes (in part) in whorls of 3, entirely fused, smooth, slightly rugose when dry, with triangular bract apices protruding from crescent ridges. Seeds 1–2 per cone, subglobose or broadly ovoid, 4–10 × 4–9 mm, with shallow grooves and resinous pits and a large proximal hilum, light brown.

Taxonomic notes

Genetic research (DNA) undertaken recently (Terry *et al*., 2000) has produced evidence for introgression of *J. occidentalis* into *J. osteosperma*; this is possibly

linked with the recent spread of the former species into the west of the range of *J. osteosperma*.

Distribution

W USA: Arizona, E California, Colorado, S Idaho, S Montana, Nevada, W New Mexico, Utah, Wyoming.
TDWG codes: 73 COL IDA MNT WYO 76 ARI CAL NEV UTA 77 NWM

Ecology

This species is a codominant in the widespread Pinyon-Juniper woodland of the Intermountain Region of the American West, with *Pinus edulis, P. monophylla* (in the SW of its range), *P. cembroides* (in the S of its range), *Juniperus scopulorum, J. occidentalis* (in the W of its range), *Seriphidium tridentatum* (*Artemisia tridentata*), *Chrysothamnus* spp., *Quercus gambelii*, and *Ephedra viridis*, or in pure stands at the lower altitudinal limits of the community. The altitudinal range is 460–2700 m a.s.l. *Juniperus osteosperma* is abundant on rocky or gravelly alluvial fans and hillsides, as well as on bare sandstone or shale where it finds crevices in the rock to grow in. It is one of the most drought resistant junipers in North America.

Conservation

IUCN: LC

Uses

In many arid places on the Colorado Plateau and elsewhere in its extensive range, this species of juniper is the most important small tree providing important habitat for wildlife. Its use for firewood is now incidental and its contorted habit when growing older precludes most other uses of its wood. In regions with dry and hot summers it could be used in gardens; it is very hardy as it occurs naturally in continental climate and at high altitudes.

Juniperus oxycedrus L., Sp. Pl. 2: 1038. 1753.

Etymology

The species epithet is a combination of the Greek '*oxy*' (from *oxus* = sharp) and *cedrus*, the classical (Latin) word for fragrant conifer wood.

Vernacular names

Prickly juniper; Oxycèdre, Genévrier cade, Genévrier epineux (French); Cade, Enebro de bajas rochas (Spanish); Katran ardıcı (Turkish)

Description

Shrubs or small trees to 10(–15) m tall, dioecious; multistemmed or monopodial to 50–100 cm diam., low branching, sometimes prostrate with ascending stems. Bark on trunks with long, soft strips, brown turning grey. Branches numerous, spreading or ascending. Foliage usually dense, with short, spreading or sometimes longer, subpendulous, 'jointed' ultimate branchlets, persistent, forming a dense, irregular and broad, sometimes pyramidal or conical crown. Leaves in alternating whorls of 3, non-decurrent, spreading 60–90 degrees at nodes 3–5(–10) mm apart, rigid, jointed to leaf part adnate with shoot, subulate to linear-acicular, sometimes narrowly ovate ('boat-shaped') or narrowed towards base as well as apex, (4–)10–20(–25) × 1.1–3 mm, straight; margins entire; apex from more or less acute to acute-pungent; epistomatic, stomata in two conspicuous whitish bands separated by a midrib, bordered by green margins as wide as midrib, abaxial face (weakly) keeled or ridged, green to dark green. Pollen cones axillary, solitary, 2–3 per leaf whorl, subglobose to ovoid, 3–4 × 2–3 mm, yellowish, turning brown; microsporophylls 8–12, in alternating whorls of 3, peltate, with entire margins and acuminate apex, bearing 4–6 abaxial pollen sacs. Seed cones axillary on short (1–2 mm) dwarf shoots with whorls of minute scale leaves, maturing in 2 years. Mature cones globose or ovoid-globose, 8–20(–23) mm long, with 1(–2) whorls of 3 completely fused bract-scale complexes, only the upper whorl fully developed, with 3 sutures conspicuous on distal half of cone; bract tip hidden or very small; surface smooth or rugose; tissue dry pulpy, more or less resinous; immature cones

green, hard; mature cones orange-brown to purplish brown, sometimes glaucous or pruinose. Seeds 2–3 per cone, triangular-ovoid, often slightly flattened, 5–12 × 4–8 mm, brown.

Distribution

Mediterranean Region, around the Black Sea and Middle East: Albania, Algeria, Bosnia-Herzegovina, Bulgaria, Caucasus, Croatia, Cyprus, France, Greece, Iran (Azerbajian), Irac, Israel, Italy, Jordan, Lebanon, Libya, Macedonia, Malta, Morocco, Portugal, Romania, Serbia, Spain, Syria, Transkaukasus, Tunisia, Turkey, Ukraine: Krym [Crimea].

TDWG codes: 12 BAL COR FRA-FR FRA-MO POR SAR SPA-AN SPA-GI SPA-SP 13 ALB BUL GRC ITA-IT ITA-SM ITA-VC KRI ROM SIC-MA SIC-SI TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 KRY 20 ALG LBY MOR-MO MOR-SP TUN 33 NCS TCS 34 CYP EAI IRN IRQ LBS-LB LBS-SY PAL-IS PAL-JO TUR

Ecology

A common shrub in Mediterranean sclerophyll scrubland (maquis, garrigue); also in dry woodland with *Pinus* spp., *Carpinus betulus, Quercus ilex* and other oaks, *Quercus-Lentiscus* scrub, as well as in montane and wetter forest with *Cedrus libani, Pinus nigra, Juniperus foetidissima*, and *J. excelsa*. The altitudinal range is 1–2200 m a.s.l. It occurs on dry, stony slopes in thin soils over all kinds of rock from calcareous to siliceous and serpentine, but uncommonly on sand dunes; in pastures at higher altitudes it is usually a sign of overgrazing. It is largely restricted to regions with a Mediterranean climate, but in the Balkans and the Iberian Peninsula it may occur in more continental conditions. The subspecies *badia* and *oxycedrus* are tolerant of frost, unlike the subspecies *macrocarpa* and *transtagana*. The latter two are largely restricted to coastal dunes or old, vegetated beaches on sand, where they occur in open pine woods (*Pinus halepensis, P. brutia, P. pinea*) as well as in scrub (garrigue, maquis) or associated with coastal grasses.

Uses

Prickly juniper is suitable for cultivation as an ornamental in southern Europe where a number of cultivars, especially with more pendulous foliage, are commonly planted in gardens and parks. Essential oils are extracted from the branches and leaves, especially in France and Turkey. This 'oil of cade' is used for medicinal puposes.

4 subspecies and 1 variety are recognized:

Juniperus oxycedrus L. subsp. ***oxycedrus***.Type: Spain: ["Habitat in Hispania, G. Narbonensi"], *Herb. Burser XXV: 67* (lectotype UPS).

Juniperus oxycedrus L. var. *oxycedrus* f. *parvifolia* Novák, Preslia 4: 53. 1926; *Juniperus oxycedrus* L. var. *parvifolia* (Novák) Jovan., in Saric (ed.), Fl. Serbia 1: 218. 1992.
Juniperus oxycedrus L. var. *fastigiata* Jovan., in Saric (ed.), Fl. Serbia 1: 413. 1992.
Juniperus deltoides R. P. Adams, Phytologia 86 (2): 47. 2004.

Description

Shrubs, or small trees to 8 m, with spreading or ascending branches; foliage branchlets variable but ultimate branchlets not subpendulous. Leaves 6–25 × 1.1–2 mm, spreading at 60–90 degrees from shoot. Seed cones globose, 6–13 mm diam., maturing to orange- or reddish brown, rarely more or less glaucous.

Distribution

as for the species.

Conservation

IUCN: LC

Juniperus oxycedrus L. subsp. ***oxycedrus*** var. ***spilinanus*** Yaltirik, Eliçin & Terzioglu, Turkish J. Bot. 31 (1): 38. 2007. Type: Turkey: W Anatolia, Manisa, Spildagi N.P., *F. Yaltirik et al. 13371*, 28 May 1995 (holotype KATO).

Description

Dioecious, prostrate shrubs up to 0.5–0.6 m tall. Leaves lanceolate, patent, green, with two glaucous

bands adaxially (upperside), 6–10 × 1–1.5 mm, acuminate-mucronate. Seed cone when ripe globose, to 10 mm diam., reddish brown. Seeds usually 3 per cone, free within the pulpy cone tissue.

Distribution

Turkey, W Anatolia (Spildagi National Park).
TDWG codes: 34 TUR

Ecology

This prostrate variety has been found in forest clearings among *Pinus brutia* and *Pinus nigra* subsp. *pallasiana*, growing on rocky slopes at 800–1400 m a.s.l.

Conservation

IUCN: NE

Juniperus oxycedrus L. subsp. ***badia*** (H. Gay) Debeaux, Fl. Kabylie: 412. 1894. *Juniperus oxycedrus* L. var. *badia* H. Gay, Assoc. Franç. Avancem. Sci. Compt. Rend. 1889: 501. 1889. Type: Algeria: 20 km S of Medea ["l'oxycèdre des Haouaras"], *H. Gay s.n.*, 17 June 1888 (holotype G?).

Description

Pyramidal shrubs or trees to 15 m tall; branches spreading, ultimate branchlets subpendulous. Leaves linear-acicular, or 'boat-shaped' in shortest leaves, (8–)12–20 × 1.2–2 mm, acuminate or acute-pungent (short and subobtuse leaves often occur on male plants). Seed cones globose, 10–13 mm diam., yellowish brown and more or less glaucous when growing, purplish brown at maturity.

Distribution

N Algeria; also reported from E Portugal and central Spain.
TDWG codes: 12 POR SPA-SP 20 ALG

Conservation

IUCN: LC

Juniperus oxycedrus L. subsp. ***macrocarpa*** (Sibth. & Sm.) Ball, J. Linn. Soc. London, Bot. 16: 670. 1878. *Juniperus macrocarpa* Sibth. & Sm., Fl. Graeca Prodr. 2: 263. 1816. Type: Greece: [locality not stated], *J. Sibthorp s.n.* (lectotype OXF). Fig. 141

Description

Shrubs or small trees with spreading branches, foliage branches short, thick and rigid. Leaves spreading at nearly right angles from shoot, subulate, 2–3 mm wide at base, very rigid. Pollen cones 4 × 3 mm when closed. Seed cones (12–)15–23 mm long, ovoid-globose or globose, smooth or rugose, with scale margins often prominent, turning from orange or yellowish to brown or purplish brown to purplish red, pruinose when ripe.

Distribution

Mediterranean and Black Sea coasts: Albania, Algeria, Bosnia-Herzegovina, Bulgaria, Croatia, France, Greece, Italy, Malta, Morocco, Spain, Turkey, Ukraine: Krym [Crimea].
TDWG codes: 12 BAL COR FRA-FR SAR SPA-SP 13 ALB BUL GRC ITA-IT KRI SIC-MA SIC-SI TUE YUG-BH YUG-CR 20 ALG LBY MOR-MO MOR-SP 34 EAI TUR

Conservation

IUCN: LC

Juniperus oxycedrus L. subsp. ***transtagana*** Franco, Fedde's Repert. Sp. Nov. Regni Veg. 68 (3): 166. 1963. *Juniperus oxycedrus* L. var. *transtagana* (Franco) Silba, Phytologia Mem. 7: 35. 1984. Type: Portugal: Ribatejo, Portela de Sacavem, Alcochete, ["in arenosis trans Tagum pr. Alcochete"], *A. X. Pereira Coutinho s.n.* (holotype LISU).

Juniperus navicularis Gand., Bull. Soc. Bot. Prance 57: 55. 1910.

Description

Shrubs to 2 m with fastigiate branching; foliage branchlets spreading. Leaves spreading at 70–90

degrees from shoot, (4–)6–12 × 1.1.5 mm, 'boat shaped' (but on whip shoots longer and linear-acicular), subobtuse to acute (pungent on whip shoots). Pollen cones 2–3 mm long, ovoid. Seed cones subglobose to ovoid, 7–10 mm long, yellowish or reddish but not glaucous or pruinose when growing, red when ripe.

Distribution

SW Portugal, adjacent part of Spain.
TDWG codes: 12 POR SPA-SP

Conservation

IUCN: NT

Juniperus phoenicea L., Sp. Pl. 2: 1040. 1753.

Etymology

The species epithet refers to Phoenicia, the classical name for the famous sea-faring nation on the North African coast (now part of Tunisia).

Vernacular names

Phoenician juniper; Genévrier rouge (French); Arâr (Morocco); Fınıke ardıcı (Turkish)

Description

Arborescent shrubs or small trees to 8–12 m tall, monoecious or rarely dioecious; trunk to 1 m diam. near base, monopodial or with several stems low above ground. Bark on trunk and larger branches scaly, exfoliating in long strips, weathering grey. Branches spreading and assurgent, often curved, the foliage branches forming tufts at ends of main branches; crown more or less conical in young trees, becoming rounded and irregular in old trees. Foliage branchlets numerous, patent or spreading with a narrower angle, slender, quadrangular, ultimate branchlets 1–1.5 mm diam., covered with gibbous scale leaves, persistent. Leaves decussate, sometimes in alternate whorls of 3, closely appressed, scale-like, 0.5–1(–2) × 0.5–0.7 mm on (pen)ultimate branchlets, broadly rhombic, gibbous; margins entire or minutely denticulate; apex obtuse, sometimes acutish; stomata in two small groups abaxially near base, adaxially in two narrow bands; glands conspicuous, sometimes inconspicuous, central, oval to linear, usually active; leaf colour lustrous light green or greyish green. Pollen cones numerous, terminal on short ultimate branchlets, ovoid or short cylindrical, 2–4 mm long; microsporophylls 6–16, decussate or sometimes ternate, peltate, with minutely denticulate margins, bearing 3–5 abaxial pollen sacs. Seed cones terminal on short branchlets, growing in two seasons to ochraceous, red-brown or purplish black, sometimes pruinose, (sub)globose to ovoid, (5–)7–12(–14) mm diam., soft pulpy or fibrous, maturing soft succulent. Bract-scale complexes 4–6(–9), decussate or ternate, entirely fused, smooth, lustrous or slightly rugose when dry, with triangular bract apices protruding from transverse ridges (sutures). Seeds 3–8 per cone, relatively small, unequal to 4 mm long, triangular or flattened.

Distribution

Macaronesia: Canary Is., Madeira Is.; Mediterranean Region: Albania, Algeria, Andorra, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, Egypt (Sinai), France, Greece, Italy, Jordan, Lebanon, Libya, Macedonia, Morocco, Portugal, Romania, Spain, Tunisia, Turkey; Saudi Arabia (along Red Sea).
TDWG codes: 12 BAL COR FRA-FR FRA-MO POR SAR SPA-GI SPA-SP 13 ALB GRC ITA-IT KRI SIC-SI TUE YUG-BH YUG-CR 20 ALG LBY MOR-MO MOR-SP TUN 21 CNY MDR 34 CYP EAI LBS-LB LBS-SY PAL-JO SIN TUR 35 SAU

Ecology

In garrigue, maquis, or evergreen microphyllous woodland on dry, stony ground, limestone outcrops, or sand dunes at altitudes between 1 m and 2400 m a.s.l. This species is commonly associated with *Pinus halepensis, P. brutia, Quercus ilex, Pistacea lentiscus, Cistus* spp., *Olea europaea, Lavandula* spp., *Artemisia herba-alba*, and numerous other genera. There is a predominance of limestone, but granitic rock, sandstone, serpentine, volcanic rock, as well as sand dunes are also mentioned as substrates. Soils are

usually rocky or skeletal and it can grow well from crevices in bedrock. The climate is Mediterranean, with dry and hot summers.

Uses

This species is rarely taken into cultivation in Mediterranean countries and only a few cultivars have been named of it. The wood is used in Algeria and Tunisia for construction, fence posts and firewood; in most other areas where it occurs it is of little economic value. The reddish and more or less succulent cones ('berries') can be used in cooking and alcoholic beverages. The subspecies *turbinata* forms a dense, prostrate shrub suitable in rock gardens and as a ground cover in regions where it is not likely to be in danger of damage by frost.

2 subspecies are recognized:

Juniperus phoenicea L. subsp. ***phoenicea***. *Juniperus phoenicea* L. subsp. *eu-mediterranea* P. Lebreton & S. Thivend, Naturalia Monspel., Bot. 47: 8. 1981 (*nom. illeg.*, Art. 26). Type: [locality unknown ("Habitat in Europa australi, Monspeli")], *Herb. Burser XXV: 61* (lectotype UPS). Fig. 142, 143

Juniperus canariensis Guyot & Mathou, Trav. Lab. Forest. Toulouse T. 1 (3, 20): 7. 1942; *Juniperus turbinata* Guss. subsp. *canariensis* (Guyot & Mathou) Rivas-Martínez *et al.*, Itinera Geobot. 7: 511. 1993.

Description

Leaves small, gibbous, obtuse. Seed cones (sub)globose, (5–)7–13 mm diam., smooth, lustrous, greenish or purplish green maturing to red-brown or purplish black.

Distribution

as for the species.

Conservation

IUCN: LC

Juniperus phoenicea L. subsp. ***turbinata*** (Guss.) Nyman, Consp. Fl. Europ. 3: 676. 1881. *Juniperus turbinata* Guss., Fl. Sicula Syn. 2: 634. 1844.
Type: ["In arenosis, vel rupestribus maritimis: Montallegro; Secciara (Gasparr.)"], *G. Gasparrini s.n.* (FI?, PAV).

Description

Leaves more elongate than in subsp. *phoenicea*, acutish. Seed cones subglobose to ovoid, 12–14 × 9–11 mm, rugose, ochraceous or yellowish brown when full grown.

Distribution

Mediterranean: France (Corse and mainland coast), Greece, Italy (Sardinia, Sicily), Morocco, Portugal (Algarve, Estremadura), Spain (Baleares and mainland coast), Tunisia.
TDWG codes: 12 BAL COR FRA-FR POR SAR SPA-SP 13 GRC SIC-SI 20 MOR-MO TUN

Ecology

This subspecies is restricted to littoral maritime habitats, on rocks or sand dunes.

Conservation

IUCN: LC

Juniperus pinchotii Sudw., Forestry & Irrig. 11: 204. 1905. *Juniperus monosperma* (Engelm.) Sarg. var. *pinchotii* (Sudw.) Melle, Phytologia 4: 29. 1952. Type: USA: Texas, SW Texas, Palo Duro Canyon ["Palodura Canyon"], *G. L. Clothier s.n.* (holotype US).

Juniperus erythrocarpa Cory, Rhodora 38: 186. 1936; *Juniperus pinchotii* Sudw. var. *erythrocarpa* (Cory) Silba, Phytologia Mem. 7: 35. 1984.
Juniperus texensis Melle, Phytologia 4: 26. 1952.

Etymology

This species was named after Gifford Pinchot, Chief Forester under US President Theodore Rooseveldt and an early conservationist.

Vernacular names

Pinchot juniper, Redberry juniper

Description

Large shrubs to 6 m, dioecious, rarely monoecious; multistemmed or rarely with a short trunk and a maximal diam. of 20 cm, readily regenerating from burnt or cut stumps (coppicing). Bark of thick branches and stems thin, slowly exfoliating in scales and strips; inner bark cinnamon; outer bark weathering ash-grey. Branches numerous, ascending from base or nearly erect, often curved, forming a broad, rounded or more irregular and open crown. Foliage branches numerous, irregularly disposed but not pendulous, ultimate branchlets slender and stiff, up to 25 mm long, 1.1–1.8 mm thick, subterete or weakly quadrangular in cross section, covered with scale leaves, persistent. Leaves in alternate whorls of 3, or decussate on ultimate branchlets, imbricate, scale-like, 1–2(–3) × 0.5–1.5 mm on lateral branchlets, decurrent, rhombic to broadly rhombic; margins minutely denticulate; apex appressed or sometimes free, acute/acuminate; stomata on abaxial side limited to decurrent leaf base, on adaxial surface in two tapering bands; glands more or less conspicuous, large, circular to elliptical, exudate often present; leaf colour yellowish green or light green. Pollen cones terminal, solitary, ellipsoid or ovoid-oblong, 3–4 × 2–2.5 mm; microsporophylls 8–10, decussate, peltate, acute, upper margins minutely denticulate, with 3–4 abaxial pollen sacs. Seed cones terminal on straight, very short branchlets, maturing to reddish brown or copper-brown in 1–2 seasons, subglobose to globose, (5–)6–8(–10) mm diam., internally soft pulpy, succulent. Bract-scale complexes 4–6, entirely fused, decussate, with upper pairs indiscernible in mature cones; bract apices (prominently) exserted; surface smooth, rugose when dry, glaucous. Seeds 1–2 per cone, broadly ovoid to pyriform, 4–6 × 3–4.5 mm; base truncate; apex acutish, smooth or shallowly grooved and ridged on sides or with two opposite ridges, with resin in the grooves or pits, light yellowish brown to chestnut brown, with a large, lighter bilobed hilum.

Distribution

USA: New Mexico, Oklahoma, Texas; Mexico: Coahuila, Nuevo León.
TDWG codes: 74 OKL 77 NWM TEX 79 MXE-CO MXE-NL

Ecology

Juniperus pinchotii occurs in (semidesert) grassland ("*Bouteloua* grasslands") and in Pinyon-Juniper woodland with *Pinus cembroides*, locally *P. pinceana* or *P. nelsonii, Juniperus* spp., *Quercus* spp., *Opuntia* spp., and *Yucca* spp.; on escarpments or plateaus of limestone or volcanic rock, or along sandy washes and on river terraces in sandy or gravely soil. The altitudinal range is 600–2100 m a.s.l. The climate is warm to cool temperate, with long dry spells and mostly summer rain coming as scattered storms.

Conservation

IUCN: LC

Uses

No uses have been recorded of this shrubby juniper. It is rare in cultivation and would require open spaces with much of sunshine, while it can withstand occasional frost well.

Juniperus pingii W. C. Cheng, Bull. Soc. Hist. Nat. Toulouse 79: 76. 1944.

Etymology

This species was named after Prof. C. Ping, founder of the Biological Laboratory of the Science Society of China.

Vernacular names

Ping's juniper; chui zhi xiang bai, xiang bai (var. *wilsonii*) (Chinese)

Description

Procumbent or erect shrubs to (small) trees, monoecious, to 10 m but reputedly attaining 30 m. Bark on large stems fissured, exfoliating in long strips, weathering grey-brown. Branches spreading or ascending, very dense in procumbent shrubs, forming a spreading or rounded crown. Foliage branches short, patent, drooping or downcurved, or pendulous, ultimate branchlets in shrubs 10–30 mm long, in trees with pendulous branchlets much longer, stout or slender, subterete to more or less 6-angled, sometimes quadrangular, covered with imbricate scale leaves. Leaves in alternate whorls of 3, rarely decussate, imbricate, decurrent at base, appressed with incurved apices or sometimes curved but free, lanceolate (naviculate) to broadly subulate, free portion broadest below middle section, incurved, (2–)3–5(–7) × 1–1.5 mm, concavo-convex; abaxial surface distinctly keeled or ridged, especially towards the apex, smooth, glaucous green; adaxial surface with two whitish bands proximally separated by a flat or slightly raised midrib; margins entire; apex acuminate to pungent; epistomatic, stomata in two converging bands. Pollen cones axillary on very short dwarfed shoots, solitary, globose, 3–4 mm diam.; microsporophylls 6–9, ternate, rarely decussate, more or less cordate, obtuse or cuspidate, bearing 2–3 abaxial globose pollen sacs. Seed cones axillary on very short dwarfed shoots, growing to globose or ovoid cones (5–)6–9 × 5–6 mm in two seasons, ripening to lustrous purplish black or bluish black. Bract-scale complexes 3, rarely 4, entirely fused, not discernible in soft succulent-pulpy mature cones except for the presence of 3(–4) subapical minute bract tips. Seeds ovoid-globose, 5–6 × 4 mm, with several shallow, resinous grooves or pits towards base.

Distribution

China: Gansu (Min Shan), Hubei (Daba Shan), S Qinghai, Shaanxi (Qin Ling Mts.), W Sichuan, NW Yunnan, Xizang [Tibet].
TDWG codes: 36 CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHQ CHT

Ecology

This species occurs from subalpine coniferous forests with *Abies, Larix, Picea* and *Pinus* to beyond the tree line in alpine meadows and high steppes to near the line of perennial snow or glaciers, at altitudes between 2650 m and 4850 m a.s.l.

Uses

The subalpine to alpine decumbent shrub forms are excellent plants for cultivation in cool temperate to cold climate regions. A few clones are in cultivation in the West but are rare; these are commonly *J. pingii* var. *wilsonii*. The tree form (var. *pingii*) is occasionally seen in cultivation in China; in Europe some introductions are likely to masquerade under the names *J. recurva* and/or *J. squamata* which are actually this species. Several selected cultivars are in the horticultural trade.

4 varieties are recognized:

Juniperus pingii W. C. Cheng var. ***pingii***. Type: Illustration in Y. de Ferré, Bull. Soc. Hist. Nat. Toulouse 79: 75. 1944 (lectotype).

Description

Arborescent shrubs to trees possibly to 30 m tall. Foliage branches drooping or pendulous; ultimate branchlets usually 6-angled, or subterete, slender; leaves nearly straight on young trees, later curved.

Distribution

China: W Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHT

Conservation

The tree form is apparently quite rare, but its remoteness has until the present been a safeguard against threats from human interference. Evidence of negative impact from increased grazing has been observed in some areas, which is likely causing decline of the population.
IUCN: VU [B2ab (ii, iii)]

Juniperus pingii W. C. Cheng var. ***chengii*** (L. K. Fu & Y. F. Yu) Farjon, Monogr. *Cupressaceae & Sciadopitys*: 344. 2005. *Juniperus chengii* L. K. Fu & Y. F. Yu, Novon 7 (4): 443. 1998. Type: China: Yunnan, NW Yunnan, Zhongdian, (mountains near Zhongdian), *T. T. Yü 10960* (holotype PE).

Description

Small trees 3–9 m tall. Foliage branchlets slender, 2–3 mm thick, quadrangular to 6-angled, mostly curved. Leaves decussate or in whorls of three, imbricate, scale-like or nearly so, 1.5–2.5 mm long and ca. 1 mm wide on ultimate branchlets (up to 5 mm long on older leafy branchlets), thick, more or less keeled, incurved, with acuminate apex or obtuse.

Distribution

China: NW Yunnan (imperfectly known from the type collection near Zhongdian only).
TDWG codes: 36 CHC-YN

Conservation

The distribution of this form seems to be much more limited than that of the species as a whole, but its extent remains insufficiently known. It was described as a small tree; the most common and widespread variety, *J. pingii* var. *wilsonii* (Rehd.) Silba is a low shrub.
IUCN: DD

Juniperus pingii W. C. Cheng var. ***miehei*** Farjon, Monogr. *Cupressaceae & Sciadopitys*: 346. 2005. Type: China: Xizang (Tibet), Zangbo River, Upper Zangbo basin, S of Saga, along road to Gyirong, *G. Miehe & S. Miehe 9532–01* (holotype K).

Description

Procumbent shrubs with very dense, short foliage. Ultimate branchlets predominantly quadrangular, with decussate, short leaves. Seed cones globose, 5–7 mm diam.

Distribution

China: Xizang [Tibet], known only from a locality in the upper Zangbo River basin.
TDWG codes: 36 CHT

Ecology

Found in juniper dwarf scrub patches in very open alpine steppe on the Tibetan Plateau at 4850 m a.s.l. in the rain/snow shadow of the main crest of the Himalayas.

Conservation

IUCN: DD

Juniperus pingii W. C. Cheng var. ***wilsonii*** (Rehd.) Silba, Phytologia Mem. 7: 36. 1984. *Juniperus squamata* Buch.-Ham. *ex* D. Don f. *wilsonii* Rehd., J. Arnold Arbor. 1: 191. 1920. Type: China: Sichuan, W Sichuan, *E. H. Wilson 985* (lectotype E).

Description

Juniperus pingii W. C. Cheng var. *carinata* Y. F. Yu & L. K. Fu, Novon 7: 443. 1998; *Juniperus carinata* (Y. F. Yu & L. K. Fu) R. P. Adams, Biochem. Syst. Ecol. 28: 541. 2000.

Procumbent to erect shrubs or arborescent shrubs to 6 m tall. Foliage branches not pendulous, usually curved, stout, subterete or prominently 6-angled. Leaves appressed or sometimes curved but free, slightly to strongly incurved.

Taxonomic notes

The distinction between *Juniperus pingii* var. *wilsonii* and *Juniperus squamata* has been a contentious subject for some time. Rehder (*op. cit.*) originally described this taxon as only a form of *J. squamata*, but it was treated as a variety of *J. squamata* in subsequent arboricultural and floristic literature, and as a cultivar name under *J. squamata* in the fourth edition of Dallimore' & Jackson's Handbook of Coniferae and Ginkgo (4th ed., 1966). It was transferred to *Sabina pingii* var. *wilsonii* in FRPS 7 (Cheng

& Fu, 1978); this became *Juniperus pingii* var. *wilsonii* in Flora of China 4 (1999) and again *Sabina pingii* var. *wilsonii* in Higher Plants of China 3 (Fu *et al*., 2000). Its morphological differences with *J. squamata* are mainly in the leaves, which are more similar to those of *J. recurva*. In high altitude subalpine meadows (4000–4300 m) of Baima Shan, NW Yunnan *J. pingii* var. *wilsonii* and *J. squamata* grow together, sometimes accompanied by a form that could be a hybrid of the two (pers. obs., September 2000). Otherwise the two taxa are distinct in this area.

Distribution

China: S Gansu, NW Hubei, S Qinghai, S Shaanxi, Sichuan, NW Yunnan, Xizang [Tibet].
TDWG codes: 36 CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHQ CHT

Ecology

A high altitude variety commonly replacing subalpine coniferous forest or woodland above the tree line, forming thickets or patchy mats of decumbent juniper among scree, rocks, or in alpine grassland or steppe. The altitudinal range is 2650–4800 m a.s.l.

Conservation

IUCN: LC

Juniperus procera Hochst. *ex* Endl., Syn. Conif.: 26. 1847. Type: Ethiopia: Gonder Prov., Amhara, Adda Mariam, near Enschedcap ["ad ecclesiam Adda Mariam prope Enschedcap"], *G. H. W. Schimper 537* (lectotype L).

Etymology

The species epithet means slender or tall.

Vernacular names

African pencil cedar, African juniper, East African cedar, Cedar; Arâr (Arabian); Birbirssa, Tedh (Ethiopia); Deyib (Somalia); there are many local names used in Kenya and Tanzania.

Description

Trees to 30–40 m tall, monoecious or dioecious; trunk to 1.5–2 m d.b.h. Bark on larger stems fissured, exfoliating in long, narrow, fibrous strips, (pale) brown weathering grey-brown. Branches long, spreading or ascending, foliage branches drooping or pendulous, lax, forming a pyramidal crown in young trees, but later broader, rounded and finally flat-topped or open and irregular in old trees. Foliage branchlets ultimately slender, (weakly) quadrangular, 0.6–1 mm wide, covered with closely appressed leaves, persistent. Leaves on mature plants scale-like, decussate, imbricate, decurrent, on ultimate branchlets 0.5–1 × 0.4–0.6 mm, triangular-rhombic, acute; margins entire; stomata in 2 inconspicuous lines on each side mostly near base; leaves abaxially glandular; gland central, conspicuous, elliptic or nearly linear; leaf colour yellowish green or light green. Pollen cones numerous, solitary, terminal on short branchlets, subglobose to ovoid, 3–5 × 2–3 mm; microsporophylls 10–12, decussate, peltate, with minutely denticulate margins, bearing 2–3 abaxial pollen sacs near lower margin. Seed cones terminal on short, erect branchlets, maturing in the second season to (sub)globose, 3–7 mm diam., brown, blue or purplish black, usually glaucous or pruinose. Bract-scale complexes 4(–6), decussate, entirely fused, bract tip small, ca. 0.3 mm, scale tissue dry pulpy. Seeds (1–)2–3(–4) per cone, angular-ovoid, more or less flattened on one side, 4–5 × 3–3.5 mm, yellowish brown, with lighter hilum at base.

Distribution

NE, E & S Tropical Africa: Congo Republic, Djibouti, Eritrea, Ethiopia, Kenya, Malawi, Somalia, Sudan (near Red Sea), Tanzania, Uganda, NE Zimbabwe; Arabian Peninsula: Saudi Arabia (Asir Range), Yemen.
TDWG codes: 23 ZAI 24 DJI ERI ETH SOM SUD 25 KEN TAN UGA 26 MLW ZIM 35 SAU YEM-NY

Ecology

This species is forming evergreen Afromontane forest (also locally invading onto savanna where fires

permit), either with pure stands of *Juniperus procera*, or mixed coniferous, with *Afrocarpus gracilior, Podocarpus milanjianus*, or conifer-mixed angiosperm, with *Olea chrysophylla, O. hochstetterii, Faurea saligna, Dombeya mastersii, Olinia rochetiana, Ilex mitis, Vepris nobilis* and numerous smaller trees and shrubs, e.g. *Agarista salicifolia, Catha edulis, Buddleja* spp., *Cadia purpurea, Cussonia spicata, Dodonaea* sp., *Erica arborea, Euclea schimperi, Faurea* sp., *Maytenus* spp., *Nuxia congesta*, and *Olea* spp. Pure stands are usually evidence of establishment after forest disturbance in the past. *Juniperus procera* occurs on mountain slopes, summits, on escarpments and outcrops and in forested ravines in sand, loam or clay over various rock types, e.g. basalt, volcanic ash and cinders, granite, limestone, or metamorphic rock. The altitudinal range is 1370–3000 m a.s.l. The climate is tropical montane, with a prolonged dry season.

Conservation

This species has been logged in many areas, but it is still too common to be threatened with extinction. Depletion of old growth forest groves of this species threatens to occur in Kenya and Ethiopia and from this ecological point of view there is certainly a conservation issue regarding the only juniper in subsaharan Africa.
IUCN: LC

Uses

The larger trees of this species are prized for timber, having good, workable and decay-resistant wood. It is used for fence posts and shingles on roofs, for construction, furniture, cabinet making, and the manufacture of pencils. It is grown in plantations in Africa and India, but only on a limited scale; in horticulture it is mostly confined to public parks in Ethiopia and Kenya, including cemeteries. Outside Africa it is only planted in a few botanic gardens; under glass in temperate climate regions or outside in warmer countries.

Juniperus procumbens (Siebold *ex* Endl.) Miq., in Siebold & Zuccarini, Fl. Japon. 2: 59, t. 127, f. 3. 1870. *Juniperus chinensis* L. var. *procumbens* Siebold *ex* Endl., Syn. Conif.: 21. 1847. Type: Japan: locality unknown ["Japonia"], *P. F. von Siebold s.n.* (lectotype K).

Etymology

The species epithet means 'laying down' and refers to the growth habit.

Vernacular names

Creeping juniper; hai-byakushin, sonare (Japanese)

Description

Decumbent shrub to 50 cm tall, creeping with long, prostrate stems to 5 cm diam., monoecious, sometimes dioecious. Bark thin, scaly, exfoliating with thin, elongated flakes or strips, brown. Branches spreading, whip shoots ascending, covering rocks or soil. Foliage branches short, stiff, spreading in a forward direction from main stems, young shoots (leaves) glaucous, smaller branchlets spreading at 30–50 degrees from axis, covered with forward-oriented leaves, persistent. Leaves in alternate whorls of 3, decurrent, with free part spreading at a narrow angle, on (pen)ultimate branchlets acicular, rarely partly scale-like, convex with a median groove extending two third of leaf length abaxially, 4–10 mm long, ca. 1 mm wide near base, concave with a raised midrib adaxially, gradually tapering to an acuminate-pungent apex; stomata adaxially in two merging bands bordered by green leaf margins, abaxially on short decurrent leaves in two lateral spots near the base, in long decurrent leaves in two lateral grooves; leaf colour glaucous green or bluish green with white stomatal areas. Pollen cones terminal, solitary on dwarfed axillary shoots, subglobose, 3–4 mm diam.; microsporophylls 9–12, ternate, with entire, hyaline margins and obtuse apex, bearing 3 abaxial pollen sacs. Seed cones terminal, solitary on dwarfed axillary shoots, growing irregularly ovoid but usually subglobose when fully mature, 7–9 mm diam., purplish blue or blackish blue. Bract-scale complexes 3, whorled, of equal size; bract tips barely excerted below the apex of the cone; outer surface

smooth or rugose, inner tissue soft pulpy. Seeds (1–)2–3 per cone, ovoid-globose, 3–5 mm long, more or less flattened except when single, light brown.

Distribution

Japan: Kyushu, Nansei-Shoto [Ryukyu Islands] (Okinawa Group, Sakishima Group).
TDWG codes: 38 JAP-KY NNS OGA

Ecology

The ecology of this species is poorly known. It occurs at high altitudes near or on island mountain summits [Ohwi, Fl. Japan: 118 (1965) has it on "seashores [of] Kyushu" but this is *J. rigida* subsp. *conferta*], where it forms decumbent mats over rocks.

Conservation

IUCN: LC

Uses

This species is popular in gardens as a ground covering evergreen conifer shrub and a limited number of cultivars are in the trade. It is used more often in Japan than in Europe, although it is not uncommon there. Unlike some other species with a similar growth habit, Creeping juniper 'faithfully' follows the contours of rock gardens without erecting itself or massing in one spot. It is therefore very effective in such gardens, especially in traditional oriental gardens.

Juniperus przewalskii Kom., Bot. Mater. Gerb. Glavn. Bot. Sada RSFSR 5: 28. 1924. Type: China: Gansu, Qilian Shan, Daban Shan, ["jugum a fluv. Tetung versus in regione alpina sol. humido, 13.000 ft. alt."], *N. M. Przewalski 318* (lectotype LE).

Etymology

This species name commemorates the Polish soldier, traveller and naturalist Nikolai M. Przewalski (1839–1888), who explored Central Asia and (greater) Mongolia.

Vernacular names

Przewalski juniper; qi lian yuan bai (Chinese)

Description

Trees, rarely shrubs, to 15(–20) m, monoecious; trunk up to 1 m d.b.h. Bark on larger stems exfoliating in longitudinal strips, weathering whitish grey or grey-brown. Branches spreading, smaller branches drooping to subpendulous, forming a broadly rounded or irregular crown. Foliage branchlets slightly curved or drooping to pendulous, quadrangular or subterete, 1.2–1.5 mm wide if covered with appressed scale leaves, often with transitional leaves or juvenile leaves, appearing 'ragged', persistent. Leaves on mature plants scale-like as well as acicular (scale leaves predominant on old trees), decussate, or 3-whorled, imbricate, decurrent, scale leaves on ultimate branchlets 1.5–2.5(–3) × 1–1.5 mm, triangular-rhombic, with free apex, acute, transitional and juvenile leaves with spreading parts 4–8(–10) × 1.5–1.7 mm; margins entire, pungent; scale leaves weakly amphistomatic, juvenile and transitional leaves epistomatic; stomata in two bands separated by an inconspicuous midrib; scale leaves abaxially glandular; gland near base, elliptic to orbicular, convex; leaf colour green or glaucous green. Pollen cones solitary, terminal on short branchlets, subglobose to ovoid-globose, 2–3 mm long; microsporophylls 6–8(–10), decussate, peltate-cordate, with entire hyaline margins, bearing 2–3 abaxial pollen sacs near lower margin. Seed cones terminal on short erect branchlets, maturing in the second season to become ovoid, (8–)10–13 × 9–10 mm, lustrous blue-black or purplish black, slightly pruinose and soft. Bract-scale complexes 6, decussate or (2×) 3-whorled, entirely fused; bract tips usually hidden or minute; surface smooth; scale tissue succulent, resinous. Seeds 1(–2) per cone, ovoid-globose, laterally compressed or slightly flattened, (7–)8–12 × (6–)7–10 mm, shallowly or deeply grooved, with resin pits, light brown.

Distribution

China: SW Gansu, E Qinghai, NW Sichuan (upper tributaries of the Huang He).
TDWG codes: 36 CHC-SC CHN-GS CHQ

Ecology

Juniperus przewalskii occurs in the ecotone between subalpine forest to alpine meadows or steppe, as well as in *Juniper-Picea crassifolia* woodland, on steep, usually S-facing, calcareous slopes, with ground cover of grasses (e.g. *Stipa splendens*), shrubs (e.g. *Salix* sp.) or perennial herbs (e.g. *Polygonum viviparum*), on dry or moist substrates. The altitude ranges between (1900)2250 m and 4000(4500) m a.s.l. The climate is cold temperate with substantial periods of snow cover in winter.

Conservation

The relatively restricted distribution and its occurrence in a region where forest cover is scattered and limited to suitable slopes make it potentially vulnerable to logging and/or deforestation resulting from increased human pressure on these resources. As yet, however, there is no immediate concern regarding this species.
IUCN: LC

Uses

No uses have been recorded, but this species is likely to be used for firewood as it is one of the few trees that exists in some parts of its range.

Juniperus pseudosabina Fisch. & C. A. Mey., Index Sem. Hort. Petrop. 8 (1841): 24, 65. 1842. Type: Kazakhstan: Dzhungarskiy Alatau, Tarbagatay Mts., *A. G. von Schrenk s.n.* (lectotype K). Fig. 144, 145

Juniperus turkestanica Kom., Bot. Mater. Gerb. Glavn. Bot. Sada RSFSR 5: 26. 1924; *Juniperus pseudosabina* Fisch. & C. A. Mey. var. *turkestanica* (Kom.) Silba, Phytologia Mem. 7: 36. 1984.

Etymology

The species epithet means 'similar but not equal to (*J.*) *sabina*', a species that occurs in the same region.

Vernacular names

Xinjiang juniper; xin jiang fang zhi bai, ka shi fang zhi bai, kun lun fang zhi bai (Chinese); no local (Kyrgiz) names have been recorded.

Description

(Decumbent) shrubs or small trees to 8–10 m, dioecious, sometimes monoecious; multistemmed or monopodial, with a short trunk up to 1 m d.b.h. Bark on larger stems shaggy, exfoliating in short strips remaining partly attached, weathering grey-brown. Branches ascending, assurgent or spreading, smaller branches numerous, short, stiff and spreading, forming a dense, spreading or irregular crown. Foliage branchlets thick, quadrangular, sometimes more or less terete, 1.5–2 mm wide, covered with appressed or sometimes apically free leaves, persistent. Leaves on mature plants normally scale-like, decussate, imbricate, decurrent, 1.3–2 × 1–1.2 mm, triangular-rhombic, gibbous, obtuse, on older branchlets to 4 × 1.5 mm, mostly appressed but several with free apex; margins entire or sometimes minutely and intermittently denticulate; stomata in 2 conspicuous short bands on each side mostly near base; scale leaves abaxially glandular; gland central in a groove, elliptic or oblong, sometimes absent; leaf colour green or yellowish green, sometimes slightly glaucous green. Pollen cones numerous, solitary, terminal on short branchlets, subglobose to globose, 2–3 mm long; microsporophylls 6–8, decussate, peltate-cordate, with rounded entire hyaline margins, bearing 2–3 abaxial pollen sacs. Seed cones terminal on short erect branchlets, maturing in the second season to become ovoid, (7–)8–14 × (6–)7–10 mm, lustrous blue-black or purplish black and soft. Bract-scale complexes 4–6, decussate, entirely fused; bract tip ca. 0.5 mm; surface smooth; scale tissue succulent, resinous. Seeds 1 per cone, ovoid-ellipsoid, laterally compressed, 6–8 × 4.5–6.5 mm, shallowly grooved, light brown.

Taxonomic notes

Russian botanists and ecologists treat the taller shrub in the west as a distinct species *J. turkestanica* Kom. No botanical characters appear to separate the two and *J. turkestanica* is not a species, but only an

ecotype that predominates in the juniper forest and woodland, an ecosystem not present in the eastern parts of the Central Asian mountains.

Distribution

Central Asia: Afghanistan (Takhar), China (Xinjiang), Kazakhstan (southern mountains), Kirgyzstan, Mongolia, Pakistan (Baltistan, Hindu Kush, Karakoram Range), India (Kashmir), Tadjikistan, Uzbekistan (Turkestan Range).
TDWG codes: 32 KAZ KGZ TZK UZB 34 AFG 36 CHX WHM-JK 37 MON 40 PAK

Ecology

Occurring in subalpine conifer forest with *Picea schrenkiana, Pinus sibirica*, or *P. wallichiana*, in juniper woodland (*J. semiglobosa*) and in montane to subalpine scrubland and steppe (predominantly *Seriphidium maritimum* [*Artemisia maritima*] steppe rich in grasses and geophytes), with e.g. *J. sabina, Cotoneaster, Kobresia capillifolia, Rhododendron anthopogon, Rosa*, and *Salix*. The altitudinal range is from 1950 m to 4100 m a.s.l. It is often restricted to rocky outcrops and S-facing slopes, especially in forests, and occurs on various rock types and soil types from coarse gravel terraces to dry S-exposed loess slopes. The climate is extreme continental with short, hot, dry summers and long, cold, snowy winters. Both climatic factors and (possibly) grazing pressures are responsible for a shift from erect to decumbent shrubs from west to east in its range.

Conservation

IUCN: LC

Uses

This species is more often shrubby than a tree and consequently it is less often used for firewood or small timber. The large blue cones ('berries') are soft and probably edible, but no commercial use of them was spotted in local markets on a trip to Kirgyzstan in August 2000. Especially the shrubby form of this species would make a very atractive juniper in cultivation but it seems to be absent in gardens; this is an omission that ought to be rectified. The species occurs in a continental climate at high elevations in mountains similar to the Alps and should be hardy even in high latitudes.

Juniperus recurva Buch.-Ham. *ex* D. Don, Prodr. Fl. Nepal. (2): 55. 1825.

Etymology

The species epithet refers to the (re)curved adult type leaves.

Vernacular names

Drooping juniper, Sacred juniper, Coffin juniper (var. *coxii*); Pama (Hindi); chui zhi bai, xiao guo chui zhi bai (var. *coxii*) (Chinese)

Description

Shrubs or trees to 15(–40) m tall, monoecious, occasionally dioecious; multistemmed or monopodial; trunk up to 2 m d.b.h. Bark on larger stems exfoliating in longitudinal, curling strips, red-brown weathering grey-brown. Branches ascending or spreading, higher order branches assurgent and drooping or very long and pendulous, forming a broad pyramidal to eventually rounded or irregular crown. Foliage branchlets numerous, crowded, lax, more or less terete, covered with incurved or slightly spreading leaves, persistent. Leaves in alternating whorls of 3 (on whip shoots occasionally decussate), imbricate, decurrent, mature type leaves 2–10 × 0.8–1(–1.2) mm, lanceolate-acicular, weakly keeled; margins entire, acute to pungent or acuminate, incurved or straight with a free apex; stomata abaxially in 2 inconspicuous lines on each side mostly near base, in two adaxial white primary bands separated by an obscure midrib; leaf colour green or olive-green. Intermediate leaf shapes, as well as juvenile-type leaves, usually present in mature trees and retained in one variety. Pollen cones numerous, solitary, axillary on dwarfed shoots, ovoid-oblong, 5–6 × 2–3 mm long; microsporophylls 10–16, decussate, more or less remote, peltate-cordate, with entire-hyaline to erose margins, bearing 3 abaxial pollen sacs. Seed cones axillary on dwarfed shoots, maturing in the

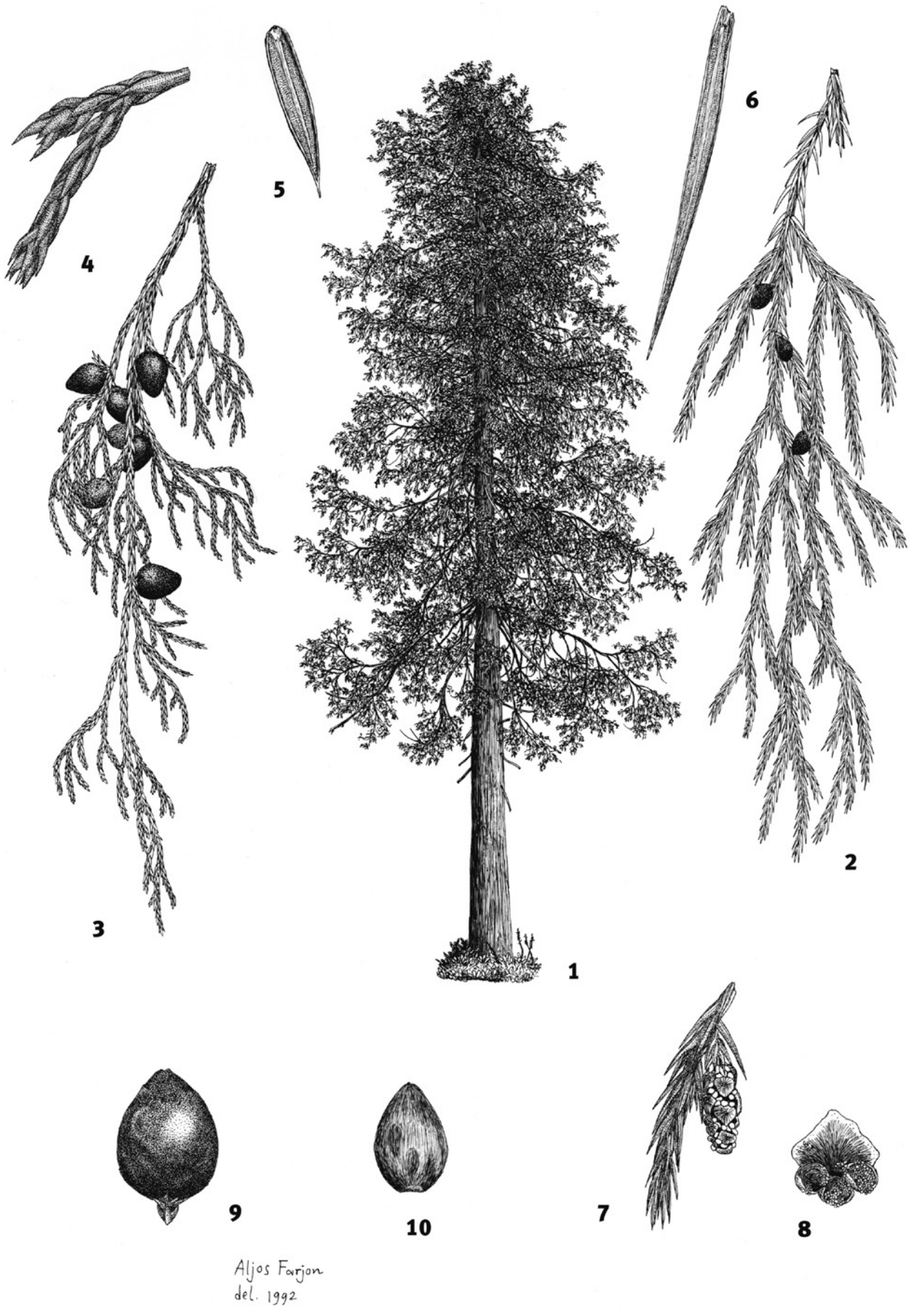


PLATE 18. Juniperus recurva var. recurva. **1.** Habit of tree. **2, 3.** Branches with leaves and seed cones. **4.** Branchlet with leaves. **5, 6.** Leaves. **7.** Branchlet with pollen cone. **8.** Microsporophyll with open pollen sacs and pollen. **9.** Seed cone. **10.** Seed.

second season becoming ovoid or subglobose, 6–12 × 5–9 mm, lustrous purplish black and soft. Bract-scale complexes 3, entirely fused; bract tip subapical, ca. 0.5 mm; surface smooth; scale tissue succulent, resinous. Seeds 1 per cone, ovoid-globose, broadest at base, 6–8 × 5–6 mm, shallowly grooved with dark brown resin pits near base, light brown.

Distribution

Himalaya: Nepal, Sikkim, Bhutan, India (Arunachal Pradesh, Assam); Myanmar [Burma]; China: S Xizang [Tibet], NW Yunnan, SW Sichuan.
TDWG codes: 36 CHC-SC CHC-YN CHT 40 ASS-AS EHM-AP EHM-BH EHM-DJ EHM-SI NEP WHM-UT 41 MYA

Ecology

In montane evergreen rainforest (var. *coxii*) ascending to and beyond the tree line in alpine scrub and rocky meadows (var. *recurva*). The altitudinal range is 2400–4500 m a.s.l. See for more detailed accounts under the varieties.

Uses

In its native countries this species is used for timber as well as ornamental trees in gardens of monasteries and temples. The wood and foliage are burned for incense in Buddhist temples. In Myanmar [Burma] the wood of large trees is used to make coffins. The drooping form *J. recurva* var. *coxii* is a highly ornamental tree much valued and often planted in regions of Europe with a mild, moist climate. Several cultivars have been selected, some with even more pendulous foliage than var. *coxii*. Decumbent shrubs in cultivation under the name *J. recurva* (unless cultivars from proven *J. recurva* provenance) are probably *J. pingii* var. *wilsonii; J. recurva* is not a decumbent shrub in the wild, but is often multi-stemmed. It is one of the few junipers that require a good amount of rainfall and thrive best in a maritime, cool but mild climate.

2 varieties are recognized:

Juniperus recurva Buch.-Ham. *ex* D. Don var. ***recurva***. Type: Nepal: Narainghet (?) ["Narainhetty"], *F. Buchanan-Hamilton s.n.* (holotype BM). Pl. 18

Description

Shrubs or small trees to 15 m tall, foliage branches drooping, not pendulous. Leaves 2–3(–5) × 1–1.2 mm, sometimes a few branches with intermediate leaves slightly longer, incurved. Seed cones 7–12 × 6–9 mm; seeds 6–8 × 5–6 mm.

Distribution

As for the species.

Ecology

In high montane to subalpine coniferous forest, with *Abies* spp. or *Picea* spp. and an understorey of *Rhododendron*, in *Rhododendron* thickets in the ecotone between forest and alpine meadows, and in the latter in mixed shrub communities with e.g. *Rhododendron, Salix, Cotoneaster, Berberis, Lonicera, Spiraea*, and *Potentilla*. The altitudinal range is 2500–4500 m a.s.l. It is common in rocky areas (e.g. moraines) or in alpine meadows strewn with boulders, usually on siliceous rock. In western Yunnan I observed that this variety is a pioneer after destructive forest fires that had killed most trees of *Abies* and *Tsuga* in the area. It was not clear if, but it could be possible that the extensive stands of *J. recurva* var. *recurva* observed in this area (Nu Shan, NW of Caojian) are the result of past forest destruction. The climate is more alpine with much longer periods of deep snow cover with this variety than with var. *coxii*.

Conservation

IUCN: LC

Juniperus recurva Buch.-Ham. *ex* D. Don var. ***coxii*** (A. B. Jacks.) Melville, Bull. Misc. Inf. R.B.G. Kew 1958: 533. 1959. *Juniperus coxii* A. B. Jacks., New Fl. & Silva 5: 33. 1932. Type: United Kingdom: England, cultivated in Exbury Gardens, Hampshire; from *R. Farrer & E. H. M. Cox 1407* collected in Myanmar (Burma), Chimili Valley (26.3 N 98.6 E) in 1920, *R. Farrer 1407* (holotype BM).

Description

Trees up to 40 m tall, 2 m d.b.h., monopodial; foliage branches long, pendulous. Juvenile or transition type leaves retained, 6–10 × 0.8–1 mm, straight or slightly incurved, spreading at 30–45 degrees from the shoot. Seed cones 6–8 × 5–6 mm; seeds 5–6 × 3–4 mm.

Distribution

China: NW Yunnan, SE Xizang [Tibet]; Bhutan; N Myanmar [Burma]; Sikkim; India, Arunachal Pradesh? **TDWG codes:** 36 CHC-YN CHT 40 EHM-BH EHM-DJ EHM-SI 41 MYA

Ecology

In temperate montane evergreen rainforest, either coniferous forest, with *Abies forrestii, A. densa, A. delavayi, Larix griffithii, L. potaninii, Picea spinulosa, P. likiangensis*, and *Pinus wallichiana*, or mixed forest, with e.g. *Abies-Tsuga-Lauraceae-Fagaceae*, often with an understorey of *Rhododendron* spp. The altitudinal range is 2400–3800 m a.s.l. In these forest types the juniper usually occupies rocky slopes or gullies, or disturbed and degraded sites where the canopy has been opened substantially due to felling and grazing.

Conservation

Due to deforestation and logging in many areas of SW China that infringes on the forests in which *J. recurva* var. *coxii* occurs, its area of occupancy (AOO) has been reduced substantially and this form is now difficult to find in many areas of NW Yunnan. However, its Himalayan populations have on the whole been less impacted by logging and there it is still common in many places.
IUCN: NT

Juniperus rigida Siebold & Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4 (3): 233. 1846.

Etymology

The species epithet means 'rigid', or 'stiff' and perhaps refers to the needle leaves.

Vernacular names

Needle juniper, Temple juniper; nezu, muro, nijiko, mezumi-sashi, miyama-nezu (Japanese)

Description

Decumbent or erect shrubs, or small trees to 10 m tall, dioecious, multi-stemmed or monopodial, d.b.h. up to 40–50 cm. Bark on trunks of trees fissured, fibrous, exfoliating in thin, narrow strips, grey-brown. Branches decumbent, spreading or ascending, smaller branches in trees drooping or pendulous, forming a conical or pyramidal crown. Foliage branches dense and short erect or more remote and long pendulous, triangular in cross section when covered in leaves, with leaf whorls dense (8–10 per cm length of shoot) or sparse (2–3 per cm), turning light brown to reddish brown. Leaves ternate, in alternating whorls, spreading 40–90° from shoot axis, not decurrent, (7–)10–20(–23) × 1–1.7 mm, bifacial-triquetrous, narrowly linear-acicular, straight or slightly curved, abaxially ridged or nearly flat; margins entire; apex pungent; episto-matic, stomata in a single, narrow white band often nearly obscured in a narrow groove; leaf colour light green. Pollen cones on dwarf shoots in axils of leaves, subglobose, 3–5 × 3–4 mm; microsporophylls 9–12, ternate, peltate-cordate, with raised midrib and often caudate apex, bearing abaxially 4–6 globose yellow pollen sacs. Seed cones on axillary, very small (1–2 mm) dwarf shoots covered with whorled 1 mm long scale leaves, (sub)globose to broadly ovoid, 5–8(–11) × 5–6(–8) mm, maturing within 18 months, becoming smooth, soft pulpy, resinous, brown to bluish black, often pruinose. Bract-scale complexes 3(–6), ternate, of which only 3 develop to form the cone, completely fused with suture lines only visible at apex, smooth, becoming rugose *in sicco*. Seeds 3, 4–5(–6) × 3–3.5(–4.5) mm, angular, slightly flattened on one or two sides, ridged; apex obtuse or rounded; brown with darker resin pits near the base.

Distribution

China: Gansu, N Hebei, Heilongjiang, Jilin, Liaoning, Nei Monggol [Inner Mongolia], Ningxia, E Qinghai, Shaanxi, Shanxi; Japan: Hokkaido, Honshu, Kyushu, Nansei-Shoto (Ryukyu Islands), Shikoku; North Korea; Russian Far East: Primorje, Sakhalin.
TDWG codes: 31 PRM SAK 36 CHI-NM CHI-NX CHM-HJ CHM-JL CHM-LN CHN-GS CHN-HB CHN-SA CHN-SX CHQ 38 JAP-HK JAP-HN JAP-KY JAP-SH NNS KOR-NK

Ecology

From sandy ocean shores (subsp. *conferta*) to upland moors, grassy or shrubby mountain slopes and open woodland, on a variety of rocks and soils. Altitudinal range 1–2200 m a.s.l. See for more detailed accounts under the subspecies.

Uses

This species, in particular its decumbent growth forms, has been in cultivation since many centuries in Japanese gardens and in temple grounds. The decumbent subsp. *conferta* is used for bonsai culture. It is much less commonly used elsewhere, but is very suitable for ground cover planting in large rock gardens, although its needle leaves are very sharp. The tree form (subsp. *rigida*) is commonly planted in gardens and in temple grounds in Japan, sometimes in Korea and China. The wood is of local importance only and used for furniture, wood carving and other domestic uses.

2 subspecies are recognized:

Juniperus rigida Siebold & Zucc. subsp. ***rigida***. Type: Japan: Honshu ["in Japoniae ad monte Hakone" (Hakonegasaki?)], *J. Bürger, [comm. P. F. von Siebold 1842] s.n.* (lectotype M).

Description

Erect shrubs or small trees, branches spreading. Foliage branchlets drooping to long pendulous; leaf whorls more or less remote with 2–3 whorls per cm length of shoot; leaves 1–1.3 mm wide, with very narrow stomatal band in a deep groove. Seed cones 5–8 × 5–8 mm; seeds 4–5 × 3–3.5 mm.

Distribution

As for the species, but not on Sakhalin Island.

Ecology

Juniperus rigida subsp. *rigida* is common in secondary scrubland or grassland, or in open forest or woodland, sometimes on sparsely vegetated sandhills. The altitudinal range is 10–2200 m a.s.l. In pine forests it occurs with *Pinus densiflora* or *P. koraiensis*, also with *Betula, Quercus*, and *Tilia amurensis*; in the shrub layer with e.g. *Lespedeza bicolor, Cotoneaster* and *Rosa*. It grows equally well on moorland, sand dunes, sand flats, rocky mountain slopes and exposed limestone clifs. The climate is mesic with abundant rainfall throughout the year; its distribution is largely determined by edaphic conditions.

Conservation

IUCN: LC

Juniperus rigida Siebold & Zucc. subsp. ***conferta*** (Parl.) Kitam., Acta Phytotax. Geobot. 26 (1–2): 9. 1974. *Juniperus conferta* Parl., Conif. Nov.: 1. 1863; *Juniperus rigida* Siebold & Zucc. var. *conferta* (Parl.) Patschke, Bot. Jahrb. Syst. 48: 678. 1913. Type: Japan: [locality unknown, (probably Ryukyu Islands)], *C. Wright s.n.* (holotype K).

Juniperus rigida Siebold & Zucc. subsp. *litoralis* Urussov, Bjull. Glavn. Bot. Sada 122: 56. 1981; *Juniperus rigida* Siebold & Zucc. var. *litoralis* (Urussov) Kozhevnikova, Fl. Ross. Dal'nego Vostoka: 42. 2006.

Vernacular names

Shore juniper; Hai-nezu, Hai-muro, Hai-matzu (Japanese)

Description

Decumbent shrubs with assurgent or erect branches. Foliage branchlets short, erect, densely

set with leaves in whorls up to 8–10 per cm length of shoot. Leaves 1–1.7 mm wide with a correspondingly wider stomatal band. Seed cones subglobose to broadly ovoid 8–11 mm long. Seeds 5–6 × 4–4.5 mm.

Taxonomic notes

This decumbent juniper is sometimes still treated as a distinct species. Apart from the different growth form, its leaves are larger (wider) than those in the erect growing form of the species. Ontogenetically, this leads to larger ovuliferous cones and larger seeds as well. As with the Mediterranean coastal subspecies *J. oxycedrus* subsp. *macrocarpa, J. rigida* subsp. *conferta* is apparently a littoral variant that is ecologically separated from the remainder of the species. The two subspecies have quite similar morphological traits, which are perhaps of adaptive value to the shifting dune sands on maritime coasts.

Distribution

Japan: Hokkaido, Honshu, Kyushu; Russian Far East: Sakhalin.
TDWG codes: 31 SAK 38 JAP-HK JAP-HN JAP-KY

Ecology

This subspecies is strictly littoral and occurs on sandy ocean shores, forming dense, spreading mats of shrubby vegetation covering old beaches and dunes. Usually the vegetation is very open and has a pioneer character, but this juniper will sometimes occur (persist) in *Pinus* woodland near the shore.

Conservation

IUCN: LC

Juniperus sabina L., Sp. Pl. 2: 1039. 1753.

Etymology

The origin of this epithet is probably the French name of this species.

Vernacular names

Savin juniper; Savin, Sabine (French); Sabina (Spanish); Sadebaum, Sebenbaum, Stinkwacholder (German); Mozhzhevel'nik kazakij (Russian)

Description

Usually decumbent, sometimes ascending or erect shrubs, rarely a stunted tree to 10–12 m with a short, leaning trunk to 2 m diam., dioecious or monoecious. Bark on branches smooth, soon flaking, yellowish brown, becoming grey-brown. Branches spreading horizontally or assurgent, of higher order mostly assurgent or erect, extending 'broom-like', forming matting crowns in decumbent shrubs and dense, flat crowns in taller plants and small trees. Foliage branchlets numerous, assurgent to erect, slender or sometimes thicker 0.8–1(–1.4) mm diam., subterete to nearly quadrangular in branchlets with scale leaves, persistent. Leaves decussate, ocassionally in alternating whorls of 3, short decurrent, of two types: needle-like and, more commonly, scale-like (acicular leaves in young plants and persisting in one variety). Needle-like leaves linear-subulate, (4–)6–10 × 0.5–1 mm, pungent, with a single or two adaxial stomatal bands wider than green margins. Scale leaves always decussate, imbricate, closely appressed, on ultimate branchlets 1–2.5 × 0.6–1 mm, ovate-rhombic to rhombic-lanceolate, abaxially with a conspicuous central, elliptic, yellowish gland, dark lustrous green to yellowish green, strongly aromatic when bruised; margins entire; apex obtuse to acute; epistomatic or amphistomatic, stomata in two small bands. Pollen cones terminal on ultimate branchlets with scale leaves, 3–4 mm long, ellipsoid; microsporophylls 10–16, decussate, peltate-cordate, convex; upper margin erose, abaxially bearing 2–4 oblong pollen sacs. Seed cones terminal on recurved short shoots 3–10 mm long with small scale leaves, maturing in 1–2 years becoming (irregularly) globose, 4–8 mm, usually soft pulpy, resinous, purplish brown, black-brown or blue. Bract-scale complexes 4, decussate, entirely fused, sutures partly visible as a curved ridge terminating in a minute bract tip. Seeds 1–3(–5) usually 2 per cone, ovoid-flattened, 3–5 mm long, with proximal, shallow resin pits and longitudinal, shallow grooves, yellowish brown.

Distribution

SW, Central & SE Europe, N Africa (Atlas Mts.), Ukraine: Krym [Crimea], Caucasus, Russia (Altai & Ural Mountains), Iran, Kazakhstan, Kirgyzstan, Turkey, Mongolia, N & NW China.

TDWG codes: 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER POL SWI 12 FRA-FR SPA-SP 13 ALB BUL GRC ITA-IT KRI ROM SIC-SI TUE YUG-CR YUG-MA 14 KRY RUE RUS UKR-MO 20 ALG MOR-MO 30 ALT TVA WSB 32 KAZ KGZ TKM 33 NCS TCS 34 IRN TUR 36 CHI-NM CHI-NX CHM-HJ CHN-GS CHN-SA CHQ CHX 37 MON

Ecology

In montane to alpine vegetation formations, ranging from alpine scree and rocks or meadows to nearly closed coniferous forest; in the east of its Asian range also in steppes and deserts. Altitudinal range 400–3350 m a.s.l. More detailed accounts are given under the varieties.

Uses

The decumbent shrub form has long been in cultivation in Europe and is relatively common; several cultivars (some with fastigiate growth habit) have been named. Its cultivation is often more or less restricted to countries where it is also native and where growers have experimented with this stock to produce cultivars; in other countries forms of the similar species *J. chinensis* seem to prevail. Some of the cultivars of *J. sabina* retain juvenile type (needle) leaves, most have predominantly or exclusively scale leaves in mature plants. Forms with needle leaves also occur in nature, so selection of this trait for horticulture is very easy where this variety (var. *davurica*) is available. The wood is of little value, but was traditionally used in the Alps to make walking sticks. Oil is distilled from branches and foliage and used for medicinal purposes; it has powerful diuretic properties.

3 varieties are recognized:

Juniperus sabina L. var. ***sabina***. Type: [locality unknown ("Habitat in Italia, Sibiria, Olympo, Ararat, Lusitania")], *Herb. Burser XXV: 59* (lectotype UPS). Fig. 146

Sabina vulgaris Antoine var. *yulinensis* T. C. Chang & C. G. Chen, Acta Phytotax. Sin. 19 (2): 263. 1981; *Juniperus sabina* L. var. *yulinensis* (T. C. Chang & C. G. Chen) Y. F. Yu & L. K. Fu, Novon 7 (4): 444. 1998.

Juniperus sabina L. var. *monosperma* C. Y. Yang, Fl. Xinjiangensis 1: 305. 1993.

Description

Commonly decumbent shrubs, occasionally spreading shrubs or a small, stunted tree. Branches assurgent, erect or spreading. Leaves of two types: acicular and scale-like; acicular leaves usually on seedlings and young plants to 10 years old, merging to scale leaves on most mature plants. Seed cones with (1–)2–3(–4) seeds, most frequently 2.

Distribution

As for the species.

Ecology

In montane to subalpine coniferous forests of *Larix, Picea* and *Pinus*, gradually replacing these where under human-imposed grazing regimes; also invading into alpine meadows when old grazing patterns are changed, e.g. intensified. In Central Asian mountains it occurs on S-facing slopes in mountain pastures in a characteristic pattern of rounded patches, often mixed with *J. pseudosabina*. Its altitudinal range is 700–3000 m a.s.l. This subspecies is most abundant on sunny, dry slopes in mountains with a mesic climate like the Alps; its drought tolerance accounts for its wider distribution in Asia into the *Artemisia* steppe and desert zones (var. *arenaria*). It is often found on limestone substrates but occurs on granitic rock as well, especially on drier slopes.

Conservation

IUCN: LC

Juniperus sabina L. var. ***arenaria*** (E. H. Wilson) Farjon, Monogr. *Cupressaceae* & *Sciadopitys*: 366. 2005. *Juniperus chinensis* L. var. *arenaria* E. H. Wilson, J. Arnold Arbor. 9: 20. 1928; *Juniperus arenaria* (E. H. Wilson) Florin, Acta Horti Berg. 14 (8): 353. 1948. Type: China: Qinghai, Qinghai Lake, *J. F. Rock 13346* (holotype A).

Juniperus sabina L. var. *mongolensis* R. P. Adams, Phytologia 88 (2): 182. 2006.

Description

Decumbent or spreading shrubs to 1.5 m. Foliage dense, assurgent or ascending, with short ultimate branchlets, more or less glaucous. Leaves scale-like, 1.5–3 × 0.7–1 mm, appressed, obtuse, or longest (2–3 mm) leaves with free apex, acute to pungent. Seed cones more or less broad pyriform, 5–8 mm, with (1–)2–4(–5) seeds, yellowish glaucous.

Distribution

China: N Gansu, Nei Mongol [Inner Mongolia], Qinghai, Shaanxi; Mongolia.
TDWG codes: 36 CHI-NM CHN-GS CHN-SX CHQ 37 MON

Ecology

Artemisia steppes and grass steppes, sand dunes, sparse vegetation on flood plains of scree and gravel, S-facing mountain slopes, canyons and escarpments, forming patches of dwarfed scrub with herbaceous plants and grasses. The altitudinal range is 2150–3350 m a.s.l.

Conservation

IUCN: LC

Juniperus sabina L. var. ***davurica*** (Pall.) Farjon, Monogr. *Cupressaceae* & *Sciadopitys*: 367. 2005. *Juniperus davurica* Pall., Fl. Ross. 1 (2): 13, t. 55. 1789. Type: Russia: Russian Far East, Amur River, ["E Sibir. orientali"], *P. S. Pallas [ex herb. Pallas] s.n.* (lectotype BM).

Juniperus davurica Pall. subsp. *maritima* Urussov, Bjull. Glavn. Bot. Sada 122: 55. 1981.

Decumbent shrubs to 50 cm. Branches ascending to erect, whip shoots assurgent. Leaves of two types: acicular and scale-like; acicular leaves usually present from seedling to maturity, merging on some shoots to scale leaves, in some populations scale leaves predominate. Pollen cones and seed cones invariably on branchlets with scale leaves. Dimensions of leaves and cones not different from var. *sabina*.

Taxonomic notes

The reduction to a variety of *J. davurica* Pall. under the widespread species *J. sabina* L. is discussed and explained in the Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a: 369).

Distribution

China, Heilongjiang, Nei Mongol [Inner Mongolia]; North Korea; Russia, E Siberia, Russian Far East; Austria and probably occasionally elsewhere within the wide range of the species.
TDWG codes: 11 AUT-AU 30 (?) 31 AMU KHA PRM 36 CHI-NM CHM-HJ 38 KOR-NK

Ecology

Juniperus sabina var. *davurica* is a decumbent or low shrub in more or less open conifer forests with *Larix gmelinii, Picea obovata* or *P. koraiensis*. Outside these forests it occurs along rocky streams as well as on open slopes, sometimes between stands of *Pinus pumila*, more often in alpine meadows and among rocks. Its main stem is usually buried in (peaty) top soil and in exposed situations it is extremely decumbent. The altitudinal range is 400–1400 m a.s.l. Rock types vary from granitic, metamorphic or volcanic to calcareous; soils are usually peaty or leached and acidic. The climate is maritime temperate near the coast and in N Korea, but becomes increasingly

FIGURE 121. *Falcatifolium falciforme* trees in the Crocker Range, Borneo

FIGURE 123. *Falcatifolium falciforme* seedling at Fraser's Hill, Malaysia

FIGURE 126. *Fitzroya cupressoides* foliage and seed cones

FIGURE 122. *Falcatifolium falciforme* flushing leaves

FIGURE 124. *Falcatifolium taxoides* on Mt. Panié, New Caledonia

FIGURE 125. *Fitzroya cupressoides* in the N.P. Alerce Andino (photo P. Woltz)

FIGURE 128. *Glyptostrobus pensilis* pollen cones and seed cones (photo D. White)

FIGURE 127. *Fokienia hodginsii* foliage and cones

FIGURE 129. *Halocarpus bidwillii* in North Island, New Zealand

FIGURE 130. *Halocarpus bidwillii* foliage

FIGURE 131. *Halocarpus biformis* foliage

FIGURE 132. *Juniperus californica* in Anza Borrego Desert State Park, California

FIGURE 133. *Juniperus californica* seed cones

FIGURE 134. *Juniperus chinensis* var. sargentii foliage and seed cones

FIGURE 135. *Juniperus communis* var. communis foliage and seed cones

FIGURE 138. *Juniperus deppeana* var. deppeana trunk with bark

FIGURE 141. *Juniperus oxycedrus* subsp. macrocarpa foliage and seed cones

FIGURE 136. *Juniperus communis* var. saxatilis in Mt. Rainier N.P., Washington

FIGURE 139. *Juniperus flaccida* var. flaccida tree in Oaxaca, Mexico

FIGURE 137. *Juniperus deppeana* var. deppeana in Puebla, Mexico

FIGURE 140. *Juniperus occidentalis* var. australis tree in the Sierra Nevada

FIGURE 142. *Juniperus phoenicea* subsp. phoenicea at Cape St. Vincent, Portugal

FIGURE 143. *Juniperus phoenicea* subsp. phoenicea foliage and cones

FIGURE 144. *Juniperus pseudosabina* in the Alaj Mountains, Kirgyzstan

FIGURE 145. *Juniperus pseudosabina* seed cones in Kirgyzstan

FIGURE 146. *Juniperus sabina* var. sabina in Kirgyzstan

FIGURE 148. *Juniperus semiglobosa* foliage and seed cones.

N.B. Figure 147 top left on facing page.

FIGURE 147. *Juniperus semiglobosa* in Kirgyzstan

FIGURE 150. *Juniperus virginiana* var. virginiana tree in North Carolina, USA

FIGURE 154. *Lagarostrobos franklinii* foliage and pollen cones

FIGURE 153. *Lagarostrobos franklinii* tree at Riveaux Creek, Tasmania

FIGURE 149. *Juniperus semiglobosa* pollen cones

FIGURE 151. *Keteleeria davidiana* var. davidiana foliage and seed cones

FIGURE 152. *Keteleeria davidiana* var. davidiana seed cone

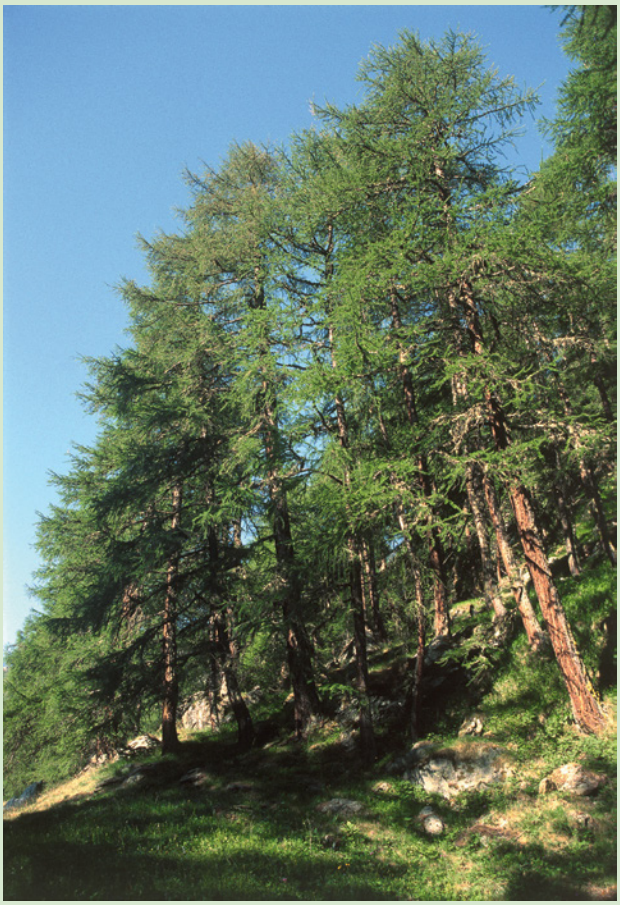


FIGURE 155. *Larix decidua* var. decidua in the Alps, Switzerland

FIGURE 156. *Larix decidua* var. decidua bark

FIGURE 157. *Larix decidua* var. decidua seed cones

FIGURE 159. *Larix griffithii* var. griffithii seed cone

FIGURE 158. *Larix gmelinii* var. principis-rupprechtii seed cones

FIGURE 160. *Larix kaempferi* seed cones

FIGURE 161. *Larix lyallii* in the Wenatchee Mts., Washington, USA

FIGURE 162. *Lepidothamnus fonkii* in Chile (photo M. Gardner)

FIGURE 164. *Libocedrus bidwillii* foliage and seed cones

FIGURE 163. *Libocedrus bidwillii* in North Island, New Zealand

FIGURE 165. *Libocedrus plumosa* foliage

FIGURE 168. *Metasequoia glyptostroboides* seed cones

FIGURE 166. *Manoao colensoi* seed cones (photo B. P. J. Molloy)

FIGURE 167. *Metasequoia glyptostroboides* bark

FIGURE 169. *Microbiota decussata* foliage

FIGURE 170. *Microcachrys tetragona* foliage and seed cones

FIGURE 172. *Nageia nagi* flushing leaves

FIGURE 171. *Nageia fleuryi* leaves and seed cones (photo L. Averyanov)

FIGURE 173. *Nageia wallichiana* tree in Viet Nam (photo L. Averyanov)

FIGURE 174. *Nageia wallichiana* leaves and seed cones (photo L. Averyanov)

FIGURE 175. *Neocallitropsis pancheri* in New Caledonia

FIGURE 176. *Neocallitropsis pancheri* foliage

continental further west, with long and cold winters and deep snow especially at higher altitudes. This variety has also been found in a few localities in the Alps, where conditions are similar to the localities in mountains away from the coast in the Far East of the species range.

Conservation

IUCN: LC

Juniperus saltillensis M. T. Hall, Fieldiania Bot. 34 (4): 45. 1971. *Juniperus ashei* J. T. Buchholz var. *saltillensis* (M. T. Hall) Silba, Phytologia Mem. 7: 32. 1984. Type: Mexico: Coahuila, Sierra Madre Oriental, ca. 30 km SE of Saltillo, *M. T. Hall 66305* (holotype F).

Etymology

The species epithet refers to Saltillo, a town in Coahuila, Mexico, from the vicinity of which the species was first described.

Vernacular names

Saltillo juniper

Description

Shrubs to 7 m, dioecious, sometimes monoecious; trunk multistemmed, branching at ground level or slightly above. Bark on larger stems relatively thick, shredding, exfoliating in long, scaly or fibrous strips; inner bark red-brown; outer bark grey. Branches numerous, spreading in all directions, forming a bushy crown usually wider than tall. Foliage branches forming more or less dense tufts, rigid, (pen)ultimate branchlets short, straight or curved distally, 3–10(–14) mm long, 1.2–1.8 mm wide, ultimate branchlets quadrangular in cross-section, older branchlets more or less terete. Leaves decussate on ultimate branchlets, in alternating whorls of 3 on older branchlets and on whip shoots, imbricate, appressed, all scale-like except on the most vigorous whip shoots, rhombic to ovoid-rhombic, 1.2–1.5 × 1–1.2 mm on ultimate branchlets, small leaves more or less gibbous; margins minutely denticulate; apex obtuse or acute; few stomata abaxially near base and scattered stomata adaxially from base to apex; glands present on older leaves and most leaves of ultimate branchlets, not active, central or near leaf base, oval and flat; leaf colour greyish green, sometimes yellowish green. Pollen cones terminal, solitary, ovoid-oblong, 2–3.5 mm long; microsporophylls 8–10(–12), decussate, peltate; margins minutely denticulate, keeled towards the obtuse apex, bearing 3–4 abaxial pollen sacs. Seed cones terminal on very short branchlets, maturing in one year, when full grown globose or ovoid-globose, 5–7 × 4.5–7(–8) mm, sometimes wider than long and slightly bilobed, wine-red with thick whitish blue bloom (pruinose). Bract-scale complexes in 2 decussate pairs (total 4), rarely including an upper whorl of 3 (total 5), completely fused, with minutely exserted triangular bract tips; surface smooth (rugose *in sicco*); fibrous and resinous inside. Seeds 1–2(–3) per cone, (broad) ovoid or ovoid-oblong, 4–5(–6) × 3–3.5 mm, grooved or 2-ridged, with resin pits towards the base; hilum a third to half of length of seed, lighter than (dark) brown seed coat.

Distribution

Mexico: Chihuahua, Coahuila, Nuevo León, Zacatecas.
TDWG codes: 79 MXE-CO MXE-CU MXE-NL MXE-ZA

Ecology

Juniperus saltillensis is sometimes an understorey shrub in Pinyon-Juniper woodland or open *Pinus-Quercus* or *Quercus* forest, with *Pinus cembroides, Juniperus* spp., and *Acacia* sp., or it occurs in the ecotone to *Bouteloua* grassland with e.g. *Opuntia* sp., *Agave* sp., and *Ephedra* sp.; predominantly on limestone in the semi-arid zone (rainshadow) of mountain ranges. The altitudinal range is from 1800 m to 2900 m a.s.l.

Conservation

Increasing pressure from grazing livestock and conversion of natural habitat to semi-natural pasture is causing serious decline in the core area of its distribution.
IUCN: EN [B2ab ii, iii, v)]

Uses

No uses have been recorded of this species and it appears not to have been introduced to cultivation.

Juniperus saltuaria Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 61. 1914. Type: China: Sichuan, Min River, Songpan, mountains N of town, *E. H. Wilson 3013* (lectotype K).

Etymology

The species epithet [Latin *saltuarius* = forester] means 'of mountain forests'.

Vernacular names

Sichuan juniper; fang zhi bai (Chinese)

Description

Shrubs or trees to 15(–20) m, monoecious; multi-stemmed or monopodial; trunk to 1 m d.b.h. Bark on larger stems exfoliating in longitudinal strips, weathering grey-brown or grey. Branches spreading, with dense foliage forming a broadly rounded or irregular crown. Foliage branchlets spreading, curved or drooping, ultimate branchlets quadrangular, 1.0–1.7 mm wide and covered with appressed scale leaves, persistent. Leaves decussate, or 3-whorled on whip shoots, imbricate, decurrent, on ultimate branchlets 1–2 × 0.7–1 mm, triangular-rhombic, gibbous, obtuse, ridged abaxially, acute to pungent; weakly amphistomatic, adaxial stomata in two bands separated by an inconspicuous midrib; leaves on ultimate branchlets abaxially glandular; gland near the base, ovate to orbicular, convex or flat to slightly depressed; leaf colour green, without cuticular wax. Pollen cones solitary, terminal on short branchlets, subglobose, 2–3 mm diam.; microsporophylls (4–)6–8, decussate, peltate-orbicular, with entire hyaline margins, bearing 2–3 abaxial pollen sacs near lower margin. Seed cones terminal on short erect branchlets, maturing in the second season to become globose or ovoid-ellipsoid, 5–8(–10) × 4–8 mm, lustrous blue-black or purplish black and soft. Bract-scale complexes 6, decussate, entirely fused; bract tips usually hidden or minute; surface smooth; scale tissue succulent, resinous. Seeds 1 per cone, irregularly ovoid-globose, 3.5–7 × 3–5 mm, shallowly or deeply grooved, with resin pits, yellowish to light brown.

Distribution

China: Gansu, Qinghai, Sichuan, NW Yunnan, E Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHQ CHT

Ecology

Juniperus saltuaria occurs in high montane to subalpine coniferous forest, with *Abies* spp., *Larix potaninii* or *Picea* spp., and an understorey of *Rhododendron, Sorbus*, and *Salix*; in more or less pure juniper groves or with *J. convallium, J. pingii, J. squamata* and *Rhododendron* spp. in the ecotone between forest and alpine meadows; and in the latter in mixed shrub communities with e.g. *Rhododendron, Salix, Cotoneaster, Berberis, Lonicera*, and *Spiraea*. The altitudinal range of this species is from 2100 m to 4600 m a.s.l. It is common in rocky areas, e.g. at the foot of limestone cliffs and crags and in deep gorges, most abundantly on steep S-SW-facing slopes, but occurs also in deeper mountain soils on less steep slopes. It is not very drought tolerant and needs abundant seasonal rainfall or snowmelt.

Conservation

IUCN: LC

Uses

This species is often too small to be a timber tree, but may be used for firewood or local carpentry in some parts of its natural range. It is rare in cultivation, restricted to a few arboreta or pineta, and not available in the horticultural trade.

Juniperus saxicola Britton & P. Wilson, Bull. Torrey Bot. Club 50: 35. 1923. *Juniperus barbadensis* L. subsp. *saxicola* (Britton & P. Wilson) Borhidi, Acta Bot. Acad. Sci. Hungarica 37 (1–4): 90. 1992; *Juniperus barbadensis* L. var. *saxicola* (Britton & P. Wilson) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 25. 2000. Type: Cuba: Granma, Sierra Maestra, *J. S. S. Léon 10798* (holotype NY).

Etymology

The species epithet refers to its rocky habitat (Latin *saxum* = rock, *colere* = to grow).

Vernacular names

No common names are recorded for this species.

Description

Small, shrubby trees to 5–8 m tall, often multi-stemmed, densely branched. Bark on branches smooth, red-brown, soon flaking, thin, stringy, exfoliation on stem(s) in strips or thin plates. Branches numerous, spreading, ascending or irregularly disposed, forming a dense, rounded or irregular crown. Foliage apparently in a fixed neotenic stage with only juvenile leaves including fertile branchlets. Leaves decussate, imbricate, decurrent, with proximal part clasping shoot, distal part spreading 30–60° and much longer, total leaf length (4–)5–8(–9) mm, ca. 1 mm wide at the point of divergence, subulate-acicular; margins entire, slightly incurved; apex acute-pungent; epistomatic, stomatal band undivided by a weakly developed, proximal midrib; glands absent; leaf colour lustrous mid-green with whitish stomatal band. Pollen cones not observed. Seed cones terminal on very short ultimate branchlets, broadly ellipsoid when growing, becoming subglobose to slightly reniform at maturity, 4–5 × 3–5 mm, dark blue with white bloom (pruinose). Bract-scale complexes 4, in two decussate pairs, not visible in mature cones. Seeds usually 2 per cone, sometimes slightly divergent apically, ca. 4 × 3 mm, ovoid-globose, light brown.

Taxonomic notes

Proposals to include *J. saxicola* as an infraspecific taxon with *J. barbadensis* are apparently based on insufficient knowledge of the characters and traits of these species. Adams (1995, 2000) studied the chemistry of all relevant taxa in the Carribean and beyond, and also provided a key and descriptions to support the distinctiveness of *J. saxicola* from *J. barbadensis*. The most striking distinction is the retention of juvenile type leaves with decurrent bases; this is a feature rarely if ever found in any of the other sabinoid junipers of the western hemisphere. It is, on the other hand, not a reliable distinction at species level in sabinoid junipers of Eurasia (see e.g. *J. chinensis, J. sabina*). Other characters that separate *J. saxicola* from its Carribean congeners are the distribution of stomata (epistomatic versus amphistomatic) and the absence of leaf glands. Both may be traits of juvenile leaves; so that the only real distinction may indeed be the consistent formation of juvenile leaves and the absence of scale leaves. The chemistry, whilst perhaps not giving conclusive evidence, at least indicates that these plants, well separated geographically from other junipers, are members of a separate species.

Distribution

Cuba (Granma, Sierra Maestra, Pico Turquino).
TDWG codes: 81 CUB

Ecology

This species is found at the higher altitudes in the Sierra Maestra, on ridges and rocky outcrops in a low (ca. 8 m), xeromorphic variant of the cloud forest, at altitudes between 1200 m and 1850 m a.s.l. Associated species are *Cleyera ekmanii, Clusia tetrastigma, Haenianthus salicifolius, Lyonnia turquini*, and *Ternstroemia microcalyx*. The juniper occurs where the rocky terrain prevents these angiosperms from becoming dominant.

Conservation

Due to its very restricted areas of occurrence and occupancy this species, growing in a densely

populated region of Cuba, is considered to be at risk of becoming extinct.
IUCN: CR [B1ab(ii, iii, v)+2ab(ii, iii, v); C2a(ii)]

Uses

No uses have been recorded of this species; due to its shrubby habit it is unlikely to be exploited and firewood is available from other sources. It is not known to be in cultivation.

Juniperus scopulorum Sarg., Silva N. Amer. 14: 93, t. 739. 1902. Type: USA: New Mexico, Santa Fe Co., Santa Fe, *A. Fendler 835* (lectotype K).

Juniperus maritima R. P. Adams, Phytologia 89 (3): 278. 2007.

Etymology

The species epithet means 'of the rocks', i.e. the species grows in rocky places.

Vernacular names

Rocky Mountain juniper, Red-cedar, Rocky Mountain red-cedar, River juniper; Cedro rojo (Spanish)

Description

Shrubs or small trees to 10–15(–20) m, dioecious, rarely monoecious; multistemmed or monopodial, (short) trunk with a diam. up to 0.8–1(–2) m, rarely a prostrate shrub in exposed rocky sites. Bark of thick branches and trunk fibrous, rough, exfoliating in long, ragged strips or more compact, red-brown weathering grey-brown. Branches ascending from base or spreading, often contorted, those of higher orders ascending or spreading, forming a pyramidal or conical crown in young trees, to a broad, rounded or more irregular and open crown in old trees. Foliage branches numerous, irregularly disposed, often drooping to subpendulous in old trees, ultimate branchlets spreading to erect or drooping, stiff or lax, slender, 5–35 mm long, 0.8–1.2 mm thick, more or less quadrangular in cross section, covered with scale leaves, persistent. Leaves decussate on ultimate branchlets, on whip shoots of young trees sometimes ternate, imbricate, scale-like, 1–2 × 0.5–1 mm on lateral branchlets, decurrent, ovate-rhombic; apex appressed, obtuse or mostly acute; margins entire; stomata on abaxial side limited to leaf base, on adaxial surface in two tapering bands; glands conspicuous, large, elliptical or oblong, slightly depressed, exudate often present; leaf colour yellowish green to dark green. Pollen cones numerous, terminal, solitary, ovoid or subglobose, 1.5–3.5 × 1.5–2 mm; microsporophylls 6–8(–10), decussate, peltate, acute, with entire or erose upper margins and with 3–4 abaxial pollen sacs. Seed cones terminal on straight or curved, short branchlets, maturing to purplish orange or reddish brown with glaucous or blue bloom in (1–)2 years, subglobose to transversely broadened or bilobed, (5–)6–8(–9) mm wide (often wider than long), internally soft pulpy. Bract-scale complexes 4–6, entirely fused, decussate, mostly indiscernible in mature cones, bract apices minutely exserted, surface smooth, rugose *in sicco*. Seeds 1–2(–4) per cone, with apices often diverging, broadly ovoid or more or less flattened, 3.5–5 × 3.5–4 mm, with rounded base and acutish apex, grooved and ridged on sides, pitted with resin concentrated in the pits near the base, lustrous light yellowish brown, with a large darker hilum proximally.

Taxonomic notes

Bilobed cones with two seeds are commonly found in *J. scopulorum* (e.g. *R. P. Adams 837* from North Dakota) and are not a character that is unique for *J. blancoi* in North America. In Asia this character is most common and pronounced in *J. semiglobosa*, but not rare in *J. sabina* and *J. chinensis*. Recently, Adams (*op. cit.*) separated plants from islands in Puget Sound, British Columbia and Washington, as a distinct species *Juniperus maritima*. The morphological data presented show no clear separation between *J. scopulorum* and *J. maritima* and are in fact nearly similar, with the exeption of some that may have environmental causes.

Distribution

Canada: Alberta, British Columbia; USA: Arizona, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota,

Texas, Utah, Washington, Wyoming; Mexico: Chihuahua, Coahuila.

TDWG codes: 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 74 NEB NDA SDA 76 ARI NEV UTA 77 NWM 79 MXE-CO MXE-CU

Ecology

A major component of the Rocky Mountain foothills in a woodland coniferous zone (in the southern portions of its range Pinyon-Juniper woodland, with *Pinus edulis* and *Juniperus osteosperma*) and extending upwards into montane coniferous forest (mainly with *Pinus contorta, P. ponderosa, P. flexilis*, in the north also *Picea engelmannii, Abies lasiocarpa*), where it often occupies exposed rocky slopes and ridges. Downslope it extends into scrubland often dominated by *Seriphidium tridentatum* (*Artemisia tridentata*), with e.g. *Amelanchier* spp., *Chrysothamnus* spp., and *Prunus* spp., and into *Quercus* woodland; along streams it occurs on dry sites in *Populus-Salix* woodland. Only in the northern parts of its range, at lower and middle elevations, does it form pure stands.The altitudinal range is (5–)500–2300(–2770) m a.s.l. It is most common in rocky terrain on soils derived from basalt, limestone and shale, usually eroded and shallow, quickly drained and mostly nutrient-poor. The climate is mostly continental, dry (in the rain shadow of coastal mountain ranges and in the SW) or subhumid with scattered summer storms, and has extreme differences in temperature between summer and winter.

Conservation

IUCN: LC

Uses

This juniper is still being used as a source of firewood in rural areas especially by Native Americans; its use for fenceposts by ranchers has now almost entirely been superseded by steel. It is in cultivation particularly in the USA, where a number of cultivars are known; several of these have reached Europe and are there increasingly available in the trade. As with other junipers, emphasis with these is on habit and less so on foliage colours. Due to its very wide latitudinal distribution certain provenances of the species and at least some of its cultivars will be suitable for a particular climate condition in temperate regions of the world, ranging from the colds of Canada to the hot summers of Mexico.

Juniperus semiglobosa Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 6 (2): 487. 1879. Type: Tadjikistan: Zaravshan Range, Saratag Pass, Isfara, *B. A. Fedtschenko s.n.* (lectotype LE). Fig. 147, 148, 149

Juniperus media V. D. Dmitriev, Trudy Sektora Agrolesomelior. Lesn. Khoz. Komiteta Nauk Uzbeksk. S.S.R. 4: 31. 1938.

Juniperus tianschanica Sumnev., Bot. Mater. Gerb. Inst. Bot. Zool. Akad. Nauk Uzbeksk. SSR 8: 24. 1946.

Etymology

The species epithet describes the 'half-round' shape of the seed cones.

Vernacular names

Pencil cedar; kun lun duo zi bai (Chinese)

Description

Arborescent shrubs or trees to 15(–20) m tall, rarely decumbent, dioecious or rarely monoecious; trunk to 1.2(–2) m diam. monopodial or with several stems low above ground. Bark on large trunks fissured, fibrous, exfoliating in long strips, brown weathering grey-brown. Branches long, spreading and ascending, in young trees nearly erect; crown variable from pyramidal to broad and irregular in old trees. Foliage branchlets numerous, slender to thick, terete or sometimes slightly quadrangular, ultimate branchlets to 4 cm long, 1–2.5 mm thick, covered with scale leaves, persistent. Leaves decussate on ultimate branchlets, closely appressed, scale-like, 1–2 × 1–1.2 mm, ovoid-rhombic to nearly triangular, often ternate; margins hyaline, entire; abaxially a few stomata near base and in two tapering bands adaxially; glands central, large and conspicuous, elliptic, often active; leaf colour lustrous light or yellowish green with whitish cuticular wax, sometimes glaucous green. Pollen cones numerous, ter-

minal on ultimate branchlets, subglobose, 3–5 × 2–4 mm; microsporophylls 8–10, decussate, peltate, with entire hyaline margins, bearing 3–4 abaxial pollen sacs near lower margin. Seed cones terminal on branchlets, growing in two seasons from green or purplish to light brown to dark blue with a glaucous white bloom, caducous, subglobose to (tri)angular, 4–8 × 4–6 mm, pulpy or fibrous, more or less resinous, maturing dry and hard, sometimes more succulent. Bract-scale complexes 4(–6), usually decussate or sometimes (in part) in whorls of 3, entirely fused, smooth, rugose when dry, with triangular bract apices protruding 0.3–0.5 mm. Seeds (1–)2–3(–4) per cone, 3–6 × 2–3.5 mm, angular, subovoid or conical, yellowish brown or red-brown, with a large proximal hilum.

Distribution

Central Asia: Kazakhstan (near Chimkent), Kirgyzstan, Tadzhikistan, Uzbekistan; W Asia: Afghanistan, Pakistan (Baltistan, Gilgit Wazarat, Hazara, Hindu Kush, Karakoram Range, Kohistan); China: Xinjiang, W Xizang [Tibet]; India: Himachal Pradesh, Jammu-Kashmir; Nepal.

TDWG codes: 32 KAZ KGZ TZK UZB 34 AFG 36 CHT CHX 40 NEP PAK WHM-HP WHM-JK

Ecology

In (mixed) conifer forests with *Abies pindrow, Cedrus deodara, Picea schrenkiana* or *Pinus wallichiana*, usually on open rocky slopes or outcrops; above this zone and on S-facing slopes extending into a juniper woodland type (often scattered) with *J. excelsa* subsp. *polycarpos* or *J. pseudosabina*, and on glacial moraines, where it can form groves. It also occurs in subalpine scrubland with *J. pseudosabina, J. sabina, J. communis* var. *saxatilis, Fraxinus* sp., *Salix* spp., *Origanum, Pteridium, Rosa, Saussurea, Scabiosa*, etc., extending into interior valleys and semi-arid high plains dominated by *Seriphidium maritimum* (*Artemisia maritima*). The altitudinal range is 1550–4350 m a.s.l. It occurs on river terraces, moraines, scree slopes and other dry, stony ground, both calcareous and siliceous. The climate is alpine-continental, with hot, dry summers especially in the interior valleys and on S-facing mountain slopes, and cold winters, often with perpetual snowfields above the juniper zone supplying moisture through prolonged melting and seepage.

Conservation

IUCN: LC

Uses

This species is primarily used for firewood, but the wood is used on a small scale for wood craft (souvenirs) and the foliage is sold on markets for 'medicinal' purposes (pers. obs. in Kirgyzstan, August 2000). In horticulture Pencil cedar is uncommon and it may on occasion have been introduced as *J. polycarpos* or *J. macropoda*, depending on what part of the range of *J. semiglobosa* such mis-identifications originated from. It is probably confined to collections in arboreta and pineta if at all present in gardens; very few plants are recorded and may not have survived where they were grown.

Juniperus squamata Buch.-Ham. *ex* D. Don, in Lambert, Descr. *Pinus* 2: 17. 1824. Type: Bhutan: [locality unknown ("Habitat in Bhotaniae Alpibus")], *W. S. Webb W 6043C* (lectotype K-W).

Juniperus morrisonicola Hayata, Gard. Chron., ser. 3, 43: 194. 1908; *Juniperus squamata* Buch.-Ham. *ex* D. Don var. *morrisonicola* (Hayata) H. L. Li & H. Keng, Taiwania 5: 81, t. 28. 1954.

Juniperus squamata Buch.-Ham. *ex* D. Don var. *fargesii* Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 59. 1914.

Juniperus baimashanensis Y. F. Yu & L. K. Fu, Novon 7 (4): 443. 1998.

Juniperus squamata Buch.-Ham. *ex* D. Don var. *parvifolia* Y. F. Yu & L. K. Fu, Novon 7 (4): 444. 1998.

Juniperus squamata Buch.-Ham. *ex* D. Don var. *hongxiensis* Y. F. Yu & L. K. Fu, Novon 7 (4): 444. 1998.

Etymology

The species epithet means 'scaly' or 'with scales' and presumably refers to the flaky bark.

Vernacular names

Nepalese juniper, Himalayan juniper, Flaky juniper; Pudma Chundur (India); gao shan bai (Chinese)

Description

Shrubs, procumbent at high altitudes, or small trees 10–12 m tall, monoecious; rarely monopodial, usually multistemmed or branching near the ground. Bark on larger stems becoming fissured, exfoliating in long, thin strips, turning grey-brown. Branches thick and short esp. in mountain forms, twisted, numerous in alpine shrub forms, spreading or ascending. Foliage branches densely crowded or more sparse, patent, ultimate branchlets initially triangular in cross section, green, becoming more or less terete, reddish brown, persistent. Leaves in alternate whorls of 3, decurrent, free part (distal half to two third of total length) more or less spreading to patent, acicular, subulate-lanceolate to linear, straight or slightly curved, (2.5)4–10 × 0.8–1.5 mm, widest below middle part; margins entire; apex acute or acuminate; epistomatic, stomata in two bands separated by a narrow midrib often concealed by a covering of white cuticular wax; abaxial surface with a thin groove or ridge; leaf colour green to glaucous green. Pollen cones terminal on axillary dwarfed shoots, solitary, subglobose to ovoid, 2–2.5 × 3–4 mm; microsporophylls 9–12, ternate, more or less cordate-peltate, obtuse or cuspidate, with entire, hyaline margins, abaxially bearing 3 ovoid pollen sacs. Seed cones terminal on axillary dwarfed shoots covered with whorls of small scale leaves, growing in two seasons via a green phase to bluish black, subglobose to ovoid, 4–8 × 4–6 mm, soft and succulent. Bract-scale complexes 3, of equal size, fused with invisible margins; outer surface smooth, lustrous, with 3 subapical bract tips just visible or hidden. Seeds ovoid-globose, light brown, 3.5–6 × 2–5 mm with several faint, darker resinous grooves or pits.

Distribution

Afghanistan; N Pakistan; India (Himalaya); Nepal; Bhutan; N Myanmar [Burma]; China: S Anhui, Chongqing, W Fujian, S Gansu, E Guizhou, W Hubei, Shaanxi, Sichuan, Xizang [Tibet], Yunnan; Taiwan.

TDWG codes: 34 AFG 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHQ CHS-AH CHS-FJ CHT 38 TAI 40 ASS-AS EHM-AP EHM-BH EHM-DJ EHM-SI NEP PAK WHM-HP WHM-JK WHM-UT 41 MYA

Ecology

Occuring from subalpine coniferous forest and mixed woodland with *Abies* spp., *Picea* spp., *Larix* spp. and *Juniperus semiglobosa, J. recurva, J. saltuaria, Betula* spp., and *Quercus* spp., up to subalpine *Rhododendron* thickets and *Juniperus* thickets or alpine dwarf shrub or grass/forb communities. In thickets and alpine scrub it is commonly associated with *Juniperus indica, J. pingii* var. *wilsonii, Berberis, Caragana* (in NE of range), *Cotoneaster, Polygonum bistorta, Rhododendron, Rosa, Sorbus, Spiraea* etc. The altitudinal range is 1340–4850 m a.s.l. It is found on various rock types, from calcareous to siliceous, and often predominant on moraines, scree slopes or rocky ridges, but also on gravelly flood plains. The climate is high montane to alpine with strong monsoon influence, which however diminishes towards the NE of its range.

Conservation

IUCN: LC

Uses

Juniperus squamata is widely cultivated as a garden ornamental and several shrubby and prostrate forms are propagated as cultivars. Forms with glaucous leaves are much in demand and accordingly a constant stream of new cultivars with this trait runs into the horticultural market. *Juniperus squamata* 'Wilsonii' is not a cultivar of this species, but the taxon *J. pingii* var. *wilsonii*.

Juniperus standleyi Steyerm., Publ. Field Mus. Nat. Hist., Bot. Ser. 23 (1): 3. 1943. Type: Guatemala: San Marcos, Volcán de Tacaná, *J. A. Steyermark 36137* (holotype F).

Etymology

This species was named after the botanist P. C. Standley, co-author (with J. A. Steyermark) of the Flora of Guatemala.

Vernacular names

Huitó, Huitum; Cipres (Spanish)

Description

Decumbent to erect dioecious shrubs or trees of medium to large size, trees to 15–20 m, multi-stemmed or monopodial. Bark becoming rough and scaly, exfoliating in long flakes, at first reddish brown or purplish brown, turning dark brown. Branches numerous, spreading or ascending, foliage branches mostly ascending, on decumbent plants creeping over rocks, forming a spreading or bushy, dense crown. Foliage branchlets mostly 5–15 mm long, sometimes longer to 20 mm, 1.1–1.4 mm wide, quadrangular in cross-section, straight or curved. Adult type leaves (scale leaves) decussate, on (pen) ultimate branchlets appressed and imbricate, with smallest leaves 1–1.5(–1.7) × 0.7–1.1 mm; on older branches leaves substantially larger and becoming acute, with free or recurved apex, acute-mucronate, on whip shoots ovoid-rhombic, gibbous; margins entire, incurved; apex obtuse or rounded. Stomata mostly adaxially, a few abaxially on two sides near margins of leaves; glands inconspicuous, in a slight depression below leaf centre, usually inactive, but on whip shoots often producing a drop of resin, becoming oblong in elongated leaf shape. Juvenile type leaves recurring on mature trees after damage and resprouting, lanceolate-subulate, naviculate, stiff, (4–)5–7 × 1 mm (at base), acute-pungent; epistomatic, with two stomatal bands separated by a narrow midrib. Leaf colour light green or glaucous green, leaves at tips of branchlets yellowish green. Pollen cones numerous, terminal, on usually recurved branchlets, solitary, subglobose or ovoid, 2–3 × 1.5–1.8 mm; microsporophylls 6–10, decussate, peltate, more or less gibbous, with rounded, erose-hyaline margins, abaxially bearing 3–4 pollen sacs. Seed cones terminal on very short, curved branchlets, growing in one year to subglobose (5–)6–7(–9) mm diam., purplish brown or brown, often with a glaucous bloom. Bract-scale complexes 6, two upper pairs entirely fused, surface smooth or rugose (*in sicco*), with minute bract apices of upper scales protruding; cone tissue dry, dense, resinous. Seeds (2–)3–4 per cone, broadly ovoid, 2.3–3.5 × 2–2.5 mm, more or less angular, with grooves and pits filled with hard resin, brown with lighter hilum.

Distribution

Mexico: Chiapas (Volcán de Tacaná); Guatemala: Huehuetenango, San Marcos (highlands).
TDWG codes: 79 MXT-CI 80 GUA

Ecology

This species occurs in open pine woodland (*Pinus* spp.), or sometimes in pure stands, often on rocky edges and talus slopes of mesas, or on limestone ridges. It grows there with shrubs, grasses, and forbs, sometimes on land under some extensive cultivation (*Agave*). The altitudinal range is from 3000 m to 4250 m a.s.l. At its upper limit it occurs in high altitude pine forest with *Pinus hartwegii*, where in some places it reaches the tree line.

Conservation

This species is geographically restricted to an area of ca. 700 km², but within that range less than a third of the original stock historically present remains (Islebe, 1993). The scarcity has led to municipal boundary disputes. Official permission is now needed to cut the trees (shrubs are not used) but the local inhabitants largely ignore this rule. In the rainy season there is extensive sheep grazing on the altiplano, which prevents successful regeneration.
IUCN: EN [A2a,c,d; B2ab (ii, iii, v)]

Uses

The local Todosanteros Indians use the wood for fence posts and shingles. Smaller wood may serve as firewood. This rare species does not appear to be in

cultivation; its precarious conservation status merits *ex situ* conservation efforts, which include taking the species into cultivation. Due to its high altitude habitat it should prove hardy in temperate regions of the world.

Juniperus taxifolia Hook. & Arn., Bot. Beechey Voy. 6: 271. 1838. Type: Japan: Bonin Islands, Ogasawara Group, ["Bonin"], *G. T. Lay & A. Collie s.n.* (holotype K).

Juniperus lutchuensis Koidz., Bot. Mag. (Tokyo) 32: 138. 1918.

Etymology

The species epithet means 'with leaves as of *Taxus*' (yew).

Vernacular names

Luchu juniper, Yew-leaved juniper; hainezu, Okinawa-hainezu, fitcheisi (Japanese)

Description

Decumbent to erect shrubs or small trees to 3–4 m, dioecious; trunk or stems prostrate, or erect and multistemmed, rarely monopodial, up to 20 cm diam. Bark on stems with papery flakes, grey-brown. Branches spreading horizontally, rooting in decumbent forms, often covering large areas, or assurgent, forming a variable crown from decumbent to erect or more or less conical. Foliage branches spreading or upright on decumbent plants, drooping or subpendulous on (older) shrubs to small trees, young shoots triangular in cross-section, becoming terete with age, persistent, internodes 1–3 mm long, on erect plants with drooping foliage to 6 mm. Leaves in alternating whorls of 3, non-decurrent, sessile, articulate at base, spreading forward or at right angle from shoot, acicular-linear, 7–12(–16) × 1–1.5(–1.8) mm, straight or more often curved at base, with parallel sides or slightly wider towards base, obtusely keeled abaxially, concave adaxially; margins entire and thick, adaxial midrib mostly continuous to the obtuse, or occasionally acute apex; epistomatic, stomata in two conspicuous bands separated by a thin, raised midrib; leaf colour light green or glaucous, with white stomatal bands. Pollen cones axillary, solitary, ovoid to cylindrical, obtuse, ca. 5 × 3 mm; microsporophylls 9–12, in alternating whorls of 3, imbricate, subpeltate, broadly triangular, weakly keeled; margins entire, bearing 5–6(–7) abaxial pollen sacs. Seed cones axillary on very small dwarf shoots with 2–3 whorls of small scale leaves, maturing in 2 years, becoming subglobose, often more or less triangular towards apex, 8–10 mm diam., changing from orange-brown to reddish brown or more often purplish red or dark purplish blue with a light blue bloom (pruinose). Bract-scale complexes in 2–3 alternating whorls of 3, upper whorl much enlarged, completely fused but sutures visible near distal pole of the cone; upper 3 bract tips exserted, minute; cone tissue soft pulpy, succulent when ripe. Seeds 3 per cone, ovoid-conical, 4.5–6 × 3 mm, more or less triangular in cross-section, oblique; resin grooves and pits conspicuous; apex mucronate; seed colour light brown or tan.

Distribution

Japan: Ryukyu Islands (Okinawa Group, Amami Group); NW Pacific (admin. by Japan): Ogasawara Group [Bonin Is.]. Also reported from two localities in Honshu, on the coasts of the Izu and Bozo Peninsulas.
TDWG codes: 38 JAP-HN NNS OGA

Ecology

Juniperus taxifolia forms a prostrate or decumbent shrub close to the seashore above the tide mark, on rocks or rocky slopes from sea level to the highest parts of some of the islands. It is also present further inland, where it can be a small, erect tree, in tall grassland and thickets on deeper, though usually rocky or gravely soils. It is obviously subjected to strong and moist, salt-laden ocean winds.

Conservation

In the Status Survey and Conservation Action Plan for Conifers of IUCN/SSC (Farjon & Page, 1999), this species is listed with other conifers that had been earlier listed as endangered (Farjon *et al.*, 1993). *Juniperus taxifolia* occurs on isolated oceanic islands

and in two localities on two peninsulas in Honshu. Its extent of occurrence (EOO) and area of occupancy (AOO), if calculated separately for each island (this was not done) could fall within the threshold for EN, while it is known from fewer than 10 localities if each island is taken as a locality, but there is no evidence of threats and/or decline.
IUCN: NT

Uses

In some of the larger islands (e.g. Okinawa) this species is being used as a shore windbreak and also cultivated in gardens. It is in cultivation in gardens in Japan, but rare. In the past its wood was used to a limited extent in house building, for posts and as fuel. Seeds were sent to the Arnold Arboretum in Massachussetts, USA by Ernest Wilson in the early part of the 20th century; it remains a rarity in horticulture outside the islands where it is also native.

Juniperus thurifera L., Sp. Pl. 2: 1039. 1753. Type: Spain: Teruel, Mansana, Camarena River, *E. Reverchon 788* (neotype BM).

Juniperus thurifera L. var. *africana* Maire, Bull. Soc. Hist. Nat. Afrique N. 17: 125. 1926; *Juniperus africana* (Maire) Villar, Types Sols Afrique N. 1: 91. 1947; *Juniperus thurifera* L. subsp. *africana* (Maire) Romo & Borantinsky, Ann. Bot. Fennici 44: 73. 2007.

Etymology

The epithet is from Latin *turifer* = yielding or producing incense.

Vernacular names

Spanish juniper, Incense juniper; Cedro de España, Trabina, Sabina blanca, Enebro (Spanish); Aoual, Taoualt, Arâr (Algeria, Morocco)

Description

Shrubs or trees to 10–15(–20) m tall, dioecious; trunk monopodial or branching near the ground, to 1.5–2 m d.b.h. Bark on trunks scaly, exfoliating in strips, dark brown, weathering grey-brown. Branches spreading or ascending, numerous, foliage open or more dense, forming a pyramidal crown, in old shrubs and trees more rounded and wider than tall. Foliage branches spreading or drooping to subpendulous, branchlets slender or stout, 1–1.3 mm thick, more or less quadrangular in cross-section, covered with scale leaves, persistent. Leaves decussate, imbricate, scale leaves on ultimate branchlets all appressed, on older branchlets some with spreading apex, on ultimate branchlets 1.3–2.7 × 0.7–1 mm, ovate-rhombic, more or less gibbous or keeled distally; margins entire or hyaline-erose; apex obtuse or acute; stomata on abaxial side in two small areas near base, on adaxial side in two bands converging to apex, covered with white or glaucous wax; gland conspicuous or inconspicuous, mostly inactive, central on rhombic scale leaves, in slight depression, oval to oblong; leaf colour light green. Pollen cones terminal, solitary, subglobose, 2–3 mm long; microsporophylls 10–12, decussate, peltate, convex, with rounded, hyaline-erose margins, bearing (2–)3–4 abaxial, angular-subglobose pollen sacs. Seed cones terminal on straight or slightly curved ultimate branchlets, growing in two seasons becoming globose or subglobose, 7–8(–10) mm diam., finally blackish blue or purplish black. Bract-scale complexes 4–6, decussate, completely fused; surface usually smooth; bract tips exserted, less than 0.5 mm, with sutures of individual scales often visible; scale tissue hard and dry pulpy. Seeds (1–)2–3 per cone, irregular in size and shape in a single cone, 3–5 × 3–4.5 mm, triangular or flattened, with shallow pits and grooves, lustrous light brown, with a dull tan hilum at base.

Distribution

SW Europe: S France (Alpes Maritimes), N and SE Spain; North Africa: Morocco, N Algeria.
TDWG codes: 12 FRA-FR SPA-SP 20 ALG MOR-MO

Ecology

In semi-arid woodland with *Quercus ilex*; on the Saharan slopes of the Haut Atlas in Morocco with *Cedrus atlantica* and *Quercus ilex*, but extending above these in groves with only very sparse scrub

vegetation. The altitudinal range is (300–)900–2500(–3300) m a.s.l. At middle altitudes (1800–2500 m) with e.g. *Adenocarpus anagyrifolius, Ephedra major*, and *Fraxinus xanthoxyloides*, at highest altitudes (to 3300 m) with *Alussum spinosum, Prunus prostrata, Bupleurum spinosum, Berberis hispanica*, and *Daphne laureola*. In Spain it has a prevalence for calcareous soils, e.g. on marls, but in the Atlas Mts. it seems indifferent to soil type, usually growing on very rocky, skeletal soils. The climate is continental, semi-arid, with cold winters (Atlas Mts.) to continental-Mediterranean, with long dry summers.

Conservation

This species is not considered to be threatened with extinction. However, in Europe gradual alterations of woodlands due to resumed forest succession after abandonment of traditional land use systems could eventually reduce the abundance of the juniper component. Conversely, in the Haut Atlas of Morocco heavy grazing and browsing pressures have caused damage and prevent regeneration.
IUCN: LC

Uses

This species has traditionally been utilised in France and Spain for construction wood, firewood, and special uses (fences, various farming tools). The foliage served as fodder for donkeys and goats and was, and perhaps still is, used in Spain for incense. The use as animal fodder is still prevalent in North Africa. In horticulture Spanish juniper is virtually limited to botanic gardens and arboreta, mainly in southern Europe, but some specimens are grown or have been grown as far north as Ireland and the south of England.

Juniperus tibetica Kom., Bot. Mater. Gerb. Glavn. Bot. Sada RSFSR 5: 27. 1924. Type: China: Xizang (Tibet), Jinsha River, in forest near temple ["Tschunkor gomba"], *V. F. Ladygin 25* (holotype LE).

Juniperus distans Florin, Acta Horti Gothob. 3: 6. 1927.

Etymology

The species epithet denotes its origin in Tibet.

Vernacular names

Tibetan juniper; da guo yuan bai (Chinese)

Description

Trees or shrubs to 15 m, usually 5–10 m, monoecious, rarely dioecious; multistemmed or monopodial; trunk up to 2 m d.b.h. Bark on larger stems fissured and exfoliating in longitudinal fibrous strips, cinnamon-brown, weathering grey. Branches ascending or spreading, foliage branches very dense, short, stiff and spreading at highest altitudes, elsewhere drooping or nearly pendulous, forming a dense, broad pyramidal to eventually rounded or irregular crown. Foliage branchlets ultimately stout, subterete, 1–1.5(–2) mm wide, 0.5–2 cm long, covered with appressed leaves, persistent. Leaves on mature plants scale-like, decussate or in alternate whorls of 3, imbricate, decurrent, 1.5–3 × 1–1.5 mm, ovate-rhombic, obtuse; margins entire; stomata in 2 lines on each side mostly near base; gland abaxial and central in a depression or groove, elliptic or oblong, sometimes inconspicuous, weakly active; leaf colour green or yellowish green. Pollen cones numerous, solitary, terminal on short branchlets, globose to subglobose, 1.5–2 mm diam.; microsporophylls 6–8, decussate, peltate-cordate, with rounded entire hyaline margins, bearing 2–3 abaxial pollen sacs near lower margin. Seed cones terminal on short branchlets, maturing in the second season to become globose or ovoid, 10–16(–18) × 7–13(–14) mm, lustrous reddish brown or brownish black to purplish black, soft. Bract-scale complexes 4–6, decussate, entirely fused; bract tip subapical, triangular, 1–1.5 mm; surface smooth; scale tissue succulent, resinous. Seeds 1 per cone, subglobose to ovoid, or acutish at both ends, laterally compressed, 7–11 × (5–)6–8 mm, ridged and grooved, with deep resin pits, yellowish brown.

Distribution

China: S Gansu, SE Qinghai, Sichuan, S and E Xizang [Tibet].
TDWG codes: 36 CHC-SC CHN-GS CHQ CHT

Ecology

Juniperus tibetica is a species that forms groves or small forests at high altitudes, often together with *J. convallium*. The altitudinal range is 2600–4780(–4900) m a.s.l. These woods are often grazed by cattle (yaks) and degraded, being transformed into parkland with mats of *Cyperaceae* and low grasses and herbs, or further to *Berberis-Juniperus* scrub and *Artemisia* steppe. At lower altitudes it may occur in clearings of *Picea* forest, usually on S-facing slopes; at the tree limit, where it may be the only species, it returns to S-facing slopes indicating that temperature is the limiting factor. Locally it occurs in open stands of *Cupressus torulosa* var. *gigantea*. It occurs on rocky slopes and ridges, as well as old gravel terraces, on rocky soils from siliceous as well as calcareous parent material. The climate, mostly in the monsoon shadow of the main crest of the Himalayas, is continental with extremes of solar radiation and frost.

Conservation

This species is widespread and not imminently threatened with extinction in the wild due to its longevity. There is, however, considerable pressure from both direct uses by indigenous peoples (firewood in particular) and from grazing by domestic animals, which are likely to increase and have a detrimental effect on regeneration and possibly its long term survival in many areas (G. & S. Miehe, pers. comm.).
IUCN: VU [B2ab (ii, iii, v)]

Uses

As the principal high altitude tree in large parts of Xizang [Tibet] and adjacent areas, this species is an important source of wood to local people, who use it for firewood and on a limited scale for other purposes, such as incense in Buddhist rituals. Increased population pressures in recent decades have resulted in shortages of a resource that renews itself only very slowly. It is rare in cultivation; seeds were collected by Joseph Rock in southern Gansu in 1926 (and distributed under the synonym *J. distans*); plants raised in the UK grew into a columnar habit with light green leaves. Recent seed collections from Tibet by Georg and Sabine Miehe have germinated in the Botanic Garden of the University of Göttingen in Germany. This tree forming species should be grown more widely.

Juniperus virginiana L., Sp. Pl. 2: 1039. 1753.

Etymology

The species epithet means 'from Virginia'; in the time of Linnaeus used for much of what is now the SE USA

Vernacular names

Eastern Redcedar, Pencil cedar, Red juniper, Redcedar; Savin, Cèdre rouge (French)

Description

Trees or arborescent shrubs, usually 15–20 m, exceptionally to 25–27 m tall, dioecious; monopodial or multistemmed; trunk with a maximal diam. of 1–1.2(–1.7) m, often fluted at base and forked in crown. Bark of trunk very fibrous, shredding, exfoliating in long, ragged strips, light red-brown weathering grey-brown. Branches ascending or spreading in older trees, forming a pyramidal or conical crown usually in young trees but locally in mature trees, to a broad, rounded or more irregular and open crown in old trees. Foliage branches numerous, ascending or spreading, often drooping to subpendulous in old trees, ultimate branchlets spreading or drooping, lax, slender, 5–25 mm long, 0.8–1 mm thick, quadrangular or subterete in cross section, covered with scale leaves, persistent. Leaves decussate on ultimate branchlets, scale-like, 1.3–3 × 0.7–1 mm, decurrent, ovate-rhombic; apex usually free, acute or apiculate; margins entire; stomata on abaxial side limited to leaf base, on adaxial surface in two tapering bands; glands conspicuous, mostly well below middle of visible part of leaf, large, elliptical to circular, exudate often present; leaf colour light green to dark green or glaucous green. Pollen cones numerous, terminal, solitary, ovoid or oval, 2–3 × 1.5 mm; microsporophylls (8–)10–12, decussate, peltate, acute, with entire or erose upper margins and with 3–4 abaxial pollen sacs. Seed cones terminal on straight, short branchlets, maturing to purplish blue with glaucous

bloom in (1–)2 years, subglobose to ovoid, 4–6.5 × 3–5.5 mm, internally soft pulpy, aromatic. Bract-scale complexes 4–6, entirely fused, decussate, mostly indiscernible in mature cones, bract apices minutely exserted, surface smooth, rugose when dry, usually strongly glaucous. Seeds 1–2(–4) per cone, broadly ovoid-conical or more or less flattened on one side, 3.5–5 × 3.5–4 mm, with broad base and acutish apex, grooved and ridged on sides, pitted with resin concentrated in the pits near the base, light yellowish brown, with a darker apex.

Taxonomic notes

In the Checklist of United States Trees (Little, 1979) and in Silvics of North America (Burns & Honkala, 1990) *Juniperus silicicola* (Southern Redcedar) and *J. virginiana* (Eastern Redcedar) were treated as distinct species. In Flora of North America 2 (1993), Adams treated the former as a variety of the latter. In Flora of Florida (Wunderlin & Hansen, 2000), *J. silicicola* has been sunk into the synonymy of *J. virginiana*. Ecologically, there appears to be a distinction which has been observed in other species in the genus as well: a form largely restricted to coastal sand dunes and sand flats as opposed to populations further inland on different soil types. Numerous reports on hybridization and introgression with *J. horizontalis*, which borders on *J. virginiana* in the north, and with *J. scopulorum* in the west are generally confirmed by subsequent research, but hybridization with *J. ashei* in the southwest has been refuted in subsequent studies (Adams, 1986).

Distribution

E North America: from S Quebec to Florida, westward to North Dakota and Texas.
TDWG codes: 72 ONT QUE 74 ILL IOW KAN MIN MSO NDA NEB OKL SDA WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 77 TEX 78 ALA ARK DEL FLA GEO KTY LOU MRY MSI NCA SCA TEN VRG WDC

Ecology

This species occurs in a wide range of habitats, from old, eroded sandstone or limestone plateaux covered in open pine or pine-oak woodland, or stream banks of clay or sand in the Midwest, to abandoned fields and road verges and stabilised sand dunes on the Atlantic coast. The altitudinal range is 1–1000 m a.s.l. More details are given under the two varieties.

Uses

This species is used as an amenity tree in landscaping and as an ornamental. The wood is also exploited on a small scale for special purposes such as wood turning. In the past it was exploited extensively for the manufacture of pencils, but more recently that use has declined. From the leaves essential oils are extracted. *Juniperus virginiana* has been the source of numerous cultivars, many of which are still in the horticultural trade. It is similar in general appearance to *J. chinensis* and if they do not bear cones, e.g. because of the retaining of juvenile leaf types, and if the distinct leaf arrangement holds true in cultivars, juvenile leaves on lateral branchlets beyond the seedling stage of *J. virginiana* should be in pairs, not in threes. Scale leaves of *J. virginiana* are acute, of *J. chinensis* usually obtuse.

2 varieties are recognized:

Juniperus virginiana L. var. ***virginiana***. Type: USA: locality unknown, *leg. ign. LINN 1198.7* (lectotype LINN). Fig. 150

Description

Tree habit variable, including fastigiate branching and conical crown but often broad and rounded in mature trees. Leaves 1.5–3 × 0.8–1.2 mm, acute-apiculate or apiculate on whip shoots.

Distribution

Canada: SE Ontario, S Quebec, USA: Arkansas, Connecticut, Delaware, D.C., N Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachussetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin.

TDWG codes: 72 ONT QUE 74 ILL IOW KAN MIN MSO NDA NEB OKL SDA WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 77 TEX 78 ALA ARK DEL FLA GEO KTY LOU MRY MSI NCA SCA TEN VRG WDC

Ecology

Juniperus virginiana var. *virginiana* is a very widespread conifer in the eastern United States, extending both its area of extent (total range) and its area of occupancy. This happens primarily through colonisation on disturbed ground which is subsequently left to settle; foremost are abandoned arable fields and pastures, second in importance are verges of highways, old mine tailings, etc. Other tree species invading these fields are *Pinus* spp., *Ulmus americana, Populus grandidentata, Sassafras albidum*, and *Zanthophyllum americanum*. In the primary range of this more continental and upland variety, the most commonly associated trees are *Pinus virginiana, P. echinata, Quercus alba, Q. rubra, Carya* spp., and *Juglans nigra*, all of these frequently on shallow, rocky or sandy soils ('glades'). It is also common in moister places near streams, especially in the western part of its range bordering the Great Plains, and can grow well on a range from acid to neutral soils. Annual precipitation is less than for var. *silicicola*, with an effective summer drought limit of around 350 mm.

Conservation

IUCN: LC

Juniperus virginiana L. var. ***silicicola*** (Small) E. Murray, Kalmia 13: 8. 1983. *Sabina silicicola* Small, J. New York Bot. Gard. 24: 5. 1923; *Juniperus silicicola* (Small) L. H. Bailey, Cult. Conif. N. Amer.: 18. 1933; *Juniperus virginiana* L. subsp. *silicicola* (Small) E. Murray, Kalmia 13: 8. 1983. Type: USA: Florida, Dixie Co., Suwannee River, Hog Island ["shell mound south of mouth of Suwanee River"], *J. K. Small & G. K. Small 10030* (lectotype NY).

Vernacular names

Southern red-cedar, Red-cedar, Sand cedar, Coastal red-cedar, Coast juniper

Description

Trees not conical with ascending branching habit when mature. Leaves small, 1.3–2 × 0.7–1 mm on ultimate branchlets, acute-acuminate, not apiculate.

Distribution

SE USA: Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina (near the coast).

TDWG codes: 78 ALA FLA GEO LOU MSI NCA SCA

Ecology

Juniperus virginiana var. *silicicola* is restricted to a narrow coastal strip near sea level of the Atlantic Ocean and the Mexican Gulf and the lowlands of central Florida. It is there associated with limestone and prehistoric shell middens, often bordering tidal marshes or occurring in old dunes. *Pinus elliottii, Quercus virginiana, Q. laurifolia, Magnolia grandiflora, Persea borbonia*, and *Ilex opaca* are commonly associated trees. Over large areas the small palm *Sabal palmetto* can dominate the understorey, but a more diverse shrub layer occurs especially on more stabilised sites. Past selective cutting of this variety (Southern Red-cedar) has led to dominance of oaks and pines in many former 'cedar' forests. Further inland, var. *silicicola* becomes a minor component of pine forests and in some areas it is sympatric with the more widespread var. *virginiana*. The climate is subhumid to humid (1000–1600 mm of rain p.a.) with very mild winters.

Conservation

IUCN: LC

Excluded names

Juniperus gaussenii W. C. Cheng, Trav. Lab. Forest. Toulouse T. 1 (3, 8): 3. 1940.

Taxonomic notes

W. C. Cheng (Wanjun Zheng) described *Juniperus gaussenii* when he was a research fellow at the

Laboratoire Forestier de Toulouse, France working under H. Gaussen. Its type, *F. Ducloux 3928* (holo. P) is one of several gatherings Ducloux made in Kunming (Yunnan-sen) early in the 20th century. Cheng only cites one further collection, *R. P. Maire s.n.*, coll. 10 Aug 1921, which had pollen cones and "fruit roux" so perhaps indicating a monoecious plant (if gathered from a single tree). On this basis Cheng (*op. cit.*) compared his new species with *J. chinensis*, to which it is in his opinion very close. Differences cited are very slight though, and some, e.g. the colour of seed cones, an artifact resulting from comparison of very few specimens. Cheng had no experience with living plants of his species; had he seen them he might have concluded that there was much less affinity with *J. chinensis*. Numerous plants in the Botanic Garden of the Institute of Botany, Chinese Academy of Sciences, Kunming (it is even used in hedges there), labeled as *J. gaussenii*, show characteristics in growth and habit, including foliage, suggesting affinity with *J. squamata* as well as with *J. chinensis*. These plants strongly suggest a cultivar, which fits well with the virtual absence of cones (retained juvenile stage of leaves) and an uncommon crown shape not found in any true species. Verification of herbarium collections in KUN and PE confirmed the cultivated status of *J. gaussenii* in all cases where data on habitat were given. Serious doubts therefore arise concerning the status of this species, which is probably best regarded as a cultivar of possible hybrid origin.

Distribution

China: Yunnan, only known from cultivation in some numbers in and around Kunming and in Xichou in SE Yunnan. Also present in other ancient cultural centres in Yunnan, e.g. Dali.

Ecology: Not known to occur in the wild and apparently producing very few seed cones, most of which may be sterile.

Uses

A highly ornamental shrub which can attain large size; it is not known in cultivation outside China.

Keteleeria Carrière, Rev. Hort. 37: 449. 1866. Type: *Keteleeria fortunei* (A. Murray bis) Carrière (*Pinaceae*).

Named after Jean-Baptiste Keteleer, a Belgian horticulturist.

Description

Monoecious evergreen trees with a monopodial trunk. Resin canals in wood (few), leaves and seed cones. Banches in pseudo-whols, spreading more or less horizontally and ascending (Massart's and/or Rauh's model); capacity to coppice present. Bark scaly and often longitudinally fissured on lower part of trunk. Terminal buds ovoid conical to subglobose, axillary lateral buds subglobose, with numerous, more or less triangular, imbricate and persistent bud scales without resin. Leaves spirally inserted and pectinately arranged, weakly dimorphic; leaves on saplings, young trees and coppicing shoots relatively broad, lanceolate, thin and flat, with acute acuminate apices and usually larger than leaves on mature trees, which are linear, narrower, thicker, with more obtuse apices; all leaves with two primary stomatal bands on abaxial side and a variable but much lesser number or no stomata on adaxial side. Pollen cones in umbellate clusters of approximately 5–10 from a single axillary bud, cylindrical, 1–1.5 cm long; microsporophylls with 2 pollen sacs containing bisaccate pollen. Seed cones on leaved peduncles, erect, oblong to cylindrical. Bracts relatively small, sometimes trilobate and always cuspidate. Seed scales persistent (cone rachis finally breaking up after a few to several seasons), flabellate with a relatively broad, pedicellate base. Seeds large, held in a deep cup, fully covered on one side and for a fourth on other side; membrane continuing in a persistent, oblique wing 1.5–2.5 times length of seed. Germination hypogeal (unique in *Pinaceae*); seedling with 2–4 cotyledons.

3 species.

Distribution

Central and SE China, Viet Nam, N Lao PDR, Taiwan.

Taxonomic notes

A total of 14 species and 1 variety have been described in this genus, the majority of which were based on small differences in variable characters observed in few specimens or collections. In the first revision of the genus *Keteleeria* since Flous (1936), Farjon (1989) has reduced the number of species to the three accepted by most authors prior to 1936: *K. davidiana* (Bertr.) Beissner, *K. evelyniana* Masters and *K. fortunei* (Andr. Murray) Carrière. This taxonomy is now generally accepted, although in Flora of China 4: 42–44 (1999) two more species, *K. hainanensis* and *K. pubescens*, were maintained (with some caveats).

Key to the species of *Keteleeria*

It should be observed, that only the seed scales of the central part of mature cones show these diagnostic characters fully; likewise, only shoots and leaves on branches of mature trees, not of (relatively) young plants or regrowth of coppiced plants, should be compared using this key. Trees in cultivation often tend to retain juvenile characters longer than is observed in natural habitats.

1a. Seed scales of mature cones with convex, rounded or truncate upper margin. Leaves short (less than 4 cm long). Shoots usually glabrous ***K. fortunei***

1b. Seed scales of mature cones with a more or less obtuse-acute, concave or recurved apex. Leaves often longer than 4 cm, but variable. Shoots glabrous or pubescent **2**

2a. Seed scales equally wide as long or slightly longer, lateral margins straight. Leaves with an obtuse or truncate apex. Shoots brown pubescent ***K. davidiana***

2b. Seed scales longer than wide, lateral margins usually concave. Leaves with a more or less mucronate apex. Shoots weakly pubescent or glabrous ***K. evelyniana***

Keteleeria davidiana (Bertrand) Beissn., Handb. Nadelholzk.: 424, f. 117. 1891.

Etymology

This species has been named after Armand David (1826–1900), a French Lazarist missionary to China and an avid naturalist.

Vernacular names

David's Keteleeria; tijian yushan (Chinese)

Description

Trees to 40–50 m tall, d.b.h. to 2–2.5 m; trunk monopodial; bark rough and scaly, fissured in lower part of trunk, dark grey brown. Branches of first and second order long, heavy, spreading and ascending; crown broad conical or domed, often open in old trees. Branchlets slender, firm, (light) reddish brown or yellowish brown, becoming grey; surface ridged and grooved; young shoots usually densely brown pubescent, but soon glabrous, leaf scars small, circular. Vegetative buds ovoid globose, 3–5 × 2–4 mm, not resinous; bud scales triangular, obtuse, appressed, persisting several years. Leaves directed forward, (1.5–)2–5(–5.5) cm long, 2.5–4.5 mm wide, slightly twisted and/or narrowed at base, narrowly linear, ligulate linear, or lanceolate in young plants, flattened, with slightly recurved margins, obtuse or truncate (in young plants acute) at apex, with a longitudinal midrib on both surfaces; stomata none or a few near apex above, in two broad bands below; leaf colour (glaucous) green above, greenish white stomatal bands below. Pollen cones pedunculate, 1–1.5 cm long, yellow with brown perular scales. Seed cones lateral or (sub)terminal, solitary or paired; peduncles 1.5–6 cm long, leaved as shoots, at an angle to axis of cone; cones short or long cylindrical, with obtuse apex, (5–)8–21 cm long, 3.5–6 cm wide with opened scales, ripening to light or dark brown; cone rachis deciduous with cone, or slowly disintegrating, narrowly conical. Seed scales subcordate, with often reflexed apical end or margin, 2.6–3.2 × 2.2–2.8 cm at mid-cone; abaxial surface striated, sometimes pubescent in young cones, but soon glabrous; upper margin erose denticulate in young cones, becoming entire. Bracts narrowly spathulate, with cuspidate or tridentate apex, 1.5–2 cm long, straight, slightly exserted with opened seed scales. Seeds oblong, grooved with resin vesicles, 10–15 × 6–8 mm, dull brown, on one side covered by the seed wing; seed wing semi-trullate, 25–30 × 10–12 mm, lustrous light brown.

Taxonomic notes

Keteleeria davidiana is a highly variable species and this has led several authors to describe new species based on such aberrant specimens as seemed distinct. Most if not all of these have later been reduced to synonymy or, at most, to varieties of this widespread species. In Farjon (1989, 1990) *K. formosana* was reduced to synonymy, but in Flora of China 4: 44 (1999) it has been retained as a variety, based on a single and rather obscure distinction. As a clearly disjunct element within the species, endemic to Taiwan, it may be appropriate to give it the benefit of the doubt as a mere variety of *K. davidiana*, as is done here.

Distribution

China: NE Yunnan, SE Sichuan, Chongqing, SE Gansu, S Shaanxi, NW Guizhou, SW Hubei, SW Hunan, N Guangxi; Taiwan; Viet Nam.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHS-GX CHS-HN 38 TAI 41 VIE

Ecology

Keteleeria davidiana occurs from hills to low mountains throughout much of E China, at elevations of (300–)600–1000(–1300) m a.s.l. It grows on the red and yellow earth, which are acid, podzolic soils poor in nutrients, or on brown forest soils. The climate is humid, continental warm temperate to subtropical, with annual precipitation between 1000 and 2000 mm. It is a constituent of the mixed mesophytic forest formation (Wang, 1961), together with many genera and species of broad-leaved deciduous trees, and some other gymnosperms, such as *Pinus massoniana, P. bungeana, Cunninghamia lanceolata, Cupressus funebris, Torreya grandis*, and *Podocarpus nakaii* (Taiwan). It also occupies the evergreen broad-leaved forest formation (Guizhou, Taiwan), with numerous (sclerophyllous) evergreen tree species and *Pinus* spp. It rarely forms pure stands. It

occurs in the parts of China where deforestation has been going on for millennia, leaving very little of the primeval forest. *Keteleeria* survives coppicing and, like many species of *Pinus*, appears to act as a pioneer in secondary vegetation.

Uses

The timber of this species is used for construction, carpentry and firewood. It is commonly planted in China as an amenity tree in parks, near temples and sometimes as a street tree. It was introduced to Europe on several occasions and is the most commonly grown species in arboreta and botanic gardens. Outside tree collections in Europe and the USA it is very rarely found growing, even though, under good conditions, it can be grown easily from cuttings. This species, which seems to be more hardy than the others, should receive more attention from dendrologists and arboriculturists in parts of the world with mild winters, now apparently expanding northwards at least in Europe and North America.

2 varieties are recognized:

Keteleeria davidiana (Bertrand) Beissn. var. ***davidiana***. *Pseudotsuga davidiana* Bertrand, Bull. Soc. Philom. Paris, sér. 6, 9: 38. 1872. Type: China: Sichuan, Lunganfu ["Longan-fou"], *A. David 36* (holotype P). Fig. 151, 152

Keteleeria calcarea W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 82. 1975; *Keteleeria davidiana* (Bertrand) Beissn. var. *calcarea* (W. C. Cheng & L. K. Fu) Silba, Phytologia 68: 34. 1990.
Keteleeria pubescens W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 82. 1975; *Keteleeria davidiana* (Bertrand) Beissn. var. *pubescens* (W. C. Cheng & L. K. Fu) Silba, Phytologia 68: 34. 1990.
Keteleeria xerophila J. R. Xue & S. H. Hao, Acta Bot. Yunnanica 3 (2): 249–250, f. 1–5. 1981; *Keteleeria fortunei* (A. Murray bis) Carrière var. *xerophila* (J. R. Xue & S. H. Hao) Silba, Phytologia 68: 36. 1990.

Description

Leaves (1.5–)2–5(–5.5) cm long, 2.5–4.5 mm wide; leaf scars obscurely protruding on branches.

Distribution

China: Chongqing, SE Gansu, N Guangxi, Guizhou, SW Hubei, SW Hunan, S Shaanxi, Sichuan, NE Yunnan; Viet Nam (Bac Can Prov.).
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHS-GX CHS-HN 41 VIE

Conservation

IUCN: LC

Keteleeria davidiana (Bertrand) Beissn. var. ***formosana*** (Hayata) Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25 (19): 221, f. 11. 1908. *Keteleeria formosana* Hayata, Gard. Chron., ser. 3, 43: 194. 1908; *Keteleeria davidiana* (Bertrand) Beissn. subsp. *formosana* (Hayata) E. Murray, Kalmia 12: 21. 1982. Type: Taiwan: locality unknown, *N. Konishi s.n.* (holotype BM).

Description

Leaves 2–4 cm long, 3–4 mm wide; leaf scars protruding on branches, dark.

Distribution

Taiwan (Taipei Co., Hualien Co., Pingtung Co.).
TDWG codes: 38 TAI

Conservation

IUCN: EN [C2a (i)]

Keteleeria evelyniana Mast., Gard. Chron., ser. 3, 33: 194. 1903. Type: China: Yunnan, Jiangchuan, *A. Henry 11815* (holotype NY).

Keteleeria hainanensis Chun & Tsiang, Acta Phytotax. Sin. 8 (3): 259. 1963; *Keteleeria evelyniana* Mast. var. *hainanensis* (Chun & Tsiang) Silba, Phytologia 68: 35. 1990.
Keteleeria evelyniana Mast. var. *pendula* J. R. Xue, Acta Phytotax. Sin. 21 (3): 253. 1983.

Etymology

This species commemorates the English arboriculturist John Evelyn.

Vernacular names

Yunnan yushan (Chinese); Du sam núi dất, Ngo tùng (Vietnamese)

Description

Trees to 30–40 m tall, d.b.h. to 1–1.5 m; trunk monopodial, usually straight; bark becoming rough and scaly, dark grey brown. Branches of first and second order long, curved, spreading, ascending near the top; crown (broad) conical, irregular in old trees. Branchlets slender, firm, (light) reddish brown or yellowish brown, turning grey brown; pubescence on young shoots only, weak or absent; leaf scars small, circular. Vegetative buds ovoid globose or ovoid conical, 4–6 × 3–4 mm, not resinous; bud scales triangular, obtuse, appressed, dull brown, persisting several years. Leaves usually pectinate, on terminal shoots sometimes assurgent, directed forward, (2–)3–6.5(–8) cm long, 2–4 mm wide, slightly twisted or only narrowed at base, linear, often falcate, lanceolate in young or coppiced plants, flattened; apex usually mucronate, sometimes obtuse (acute in young plants); stomata usually in several lines near central rib above, in two broad bands separated by a midrib below; leaf colour (glaucous) light or dark green above, greenish white stomatal bands below. Pollen cones pedunculate, 1–1.5 cm long, yellow, with brown perular scales. Seed cones lateral, usually solitary, erect; peduncles at an angle to cone axis, 2–6 cm long, leaved as shoots; cone long cylindrical (when fully developed!), with obtuse apex, (4–)9–20(–25) cm long, (3–)4–6.5(–9?) cm wide with opened scales, ripening to (light) brown, often lustrous; cone rachis narrowly conical. Seed scales subcordate oblong, with narrowed apex and more or less concave margins, straight or recurved, 3–4 × 2.5–3 cm at mid-cone; abaxial surface striated, glabrous; upper margin erose denticulate in young cones, later entire or erose. Bracts ligulate spathulate, with cuspidate or trilobate apex, 1–1.5 cm long, straight, slightly exserted with opened seed scales. Seeds oblong, grooved with resin vesicles, 9–14 × 5–7 mm, dull brown, on one side covered by the seed wing; seed wing semi trullate, 20–30 × 12–15 mm, lustrous yellowish brown.

Distribution

China: Hainan Island, SW Sichuan, Yunnan; Lao PDR; Viet Nam.

TDWG codes: 36 CHC-SC CHC-YN CHH 41 LAO VIE

Ecology

Keteleeria evelyniana is one of the few species of *Pinaceae* occurring in near tropical environments (the others are species of *Pinus*). It is found in mountainous areas in SE Asia at elevations of 700 to 2700 m a.s.l. (to 3000 m according to Wilson, 1926), but generally not above 2000 m. The soil is mainly red earth (in China and Lao PDR); the climate is humid, tropical to temperate at high altitudes, often with more than 2000 mm precipitation annually. It is a minor constituent of the evergreen broad-leaved forest formation, which occurs in mountains above the tropical lowland rainforest. In Yunnan and N Lao PDR, it also occurs in mixed evergreen oak forest, with *Cunninghamia lanceolata* (Yunnan), *Podocarpus* spp., *Cephalotaxus fortunei, Fagaceae, Lauraceae, Magnoliaceae*, etc.

Conservation

In Viet Nam, this species has been assessed as Vulnerable (VU, criteria A2cd), because it has been over-exploited for local use of the timber and large parts of its natural habitat have been converted to agriculture. Some stands of this tree are protected within protected areas and, officially at least, exploitation is now limited by government forest policy. The overall situation in China cannot be much different, but at least in parts of Sichuan and Yunnan *K. evelyniana* is widespread and still more common. Overall decline is very likely to occur and subpopulations are often small and scattered. The conservation status in Lao PDR is unknown.

IUCN: VU [A2cd; B2b (ii, iii, v)]

Uses

The timber of this species is used locally for construction purposes and firewood. It has been introduced to the U.K. by George Forrest and to the USA (California) by Joseph Rock, but until recently it remained a rarity in arboreta and botanic gardens. It is now quite commonly planted in the USA. Its extensive N-S range indicates growing conditions from mild temperate to near tropical; with the universal requirement of warm, moist summers.

Keteleeria fortunei (A. Murray bis) Carrière, Rev. Hort. 37: 449. 1866. *Picea fortunei* A. Murray bis, Proc. Roy. Hort. Soc. London 1862 (2): 419–425, f. 85–97. 1862. Type: China: Fujian, Min River, Fuzhou, *R. Fortune 52* (lectotype BM). Pl. 19

Keteleeria oblonga W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 82. 1975; *Keteleeria fortunei* (A. Murray bis) Carrière var. *oblonga* (W. C. Cheng & L. K. Fu) L. K. Fu & Nan Li, Novon 7 (3): 261. 1997.

Etymology

This species was named after Robert Fortune (1812–1880), an early English collector of plants in China.

Vernacular names

Fortune's Keteleeria; yushan (Chinese)

Description

Trees to 30 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight, often short and branching low; bark becoming thick and fissured, dark grey brown. Branches of first order heavy, long, spreading wide; crown broad, often dome shaped. Branchlets slender, firm, (light) reddish brown or yellowish brown, glabrous, or rarely with some short hairs in grooves; leaf scars small, circular. Vegetative buds ovoid conical or subglobose, 3–5 × 2–4 mm, not resinous; bud scales triangular, obtuse and appressed, persisting several years. Leaves spreading at 45–90° from shoot, (1.2–)1.5–3(–4) cm long, 2–4 mm wide, slightly twisted and narrowed at base, narrowly linear to ligulate, flattened, with a raised midrib on both surfaces; apex obtuse, rarely somewhat acute (but acute on young or coppiced plants); stomata absent or a few near apex above, in two broad bands separated by the midrib below; leaf colour green, greenish white below. Pollen cones peduncled, 1–1.5 cm long, yellow, with brown perular scales. Seed cones lateral or (sub)terminal, erect; peduncles 2–5 cm long, leaved; shape cylindrical, with obtuse apex, 6–18 cm long, 3.5–6.5 cm wide with opened scales, ripening to (greyish) brown. Seed scales subcordate orbicular, with convex, rounded or nearly straight upper margin, 1.8 3.2 × 2 3.3 cm at mid-cone; surface smooth, usually striated longitudinally, in immature cones often puberulent, soon glabrous; upper margin erose denticulate in young cones, later finely denticulate or entire. Bracts ligulate spathulate; apex cuspidate, sometimes weakly trilobate, 1–1.5 cm long, included or slightly exserted, visible when seed scales are opened. Seeds oblong, grooved with resin vesicles, 10–13 × 5–6 mm, dull brown, on one side covered by the seed wing; seed wings more or less cuneate, with oblique end, 13–20 × 8–12 mm, yellowish brown.

Distribution

China: Fujian, N Guangdong, Guangxi, Guizhou, Hong Kong, S Hunan, SW Jiangxi, SE Yunnan, Zhejiang.

TDWG codes: 36 CHC-GZ CHC-YN CHS-FJ CHS-GD CHS-GX CHS-HK CHS-HN CHS-JX CHS-ZJ

Ecology

Keteleeria fortunei occurs in the hills or low mountains of SE China, in the "red and yellow earth region" (Wang, 1961), at elevations between 380 and 1200 m a.s.l. The climate is humid, warm temperate to subtropical, with annual precipitation between 1300 and 2000 mm. It occurs in two forest formations: the mixed mesophytic forest, and, more usually, the evergreen broad-leaved forest. Besides many angiosperm trees, such as evergreen sclerophyllous oaks and lauraceous trees, a few additional gymnosperms are also found in the latter formation: *Pseudotsuga sinensis, Cryptomeria japonica, Cephalotaxus fortunei*, and *Taxus chinensis*.

Conservation

Although relatively widespread in distribution, centuries of deforestation in southern China have undoubtedly reduced the forests in which this species naturally occurs. It is, however, capable of regeneration in secondary vegetation; a decline in primary forest can therefore not be directly translated into a decline of the species.
IUCN: NT

Uses

The wood of this species is used locally for construction and firewood. It is quite commonly planted in China, but rare in cultivation elsewhere; it was introduced to England from seed collected in Hong Kong.

PLATE 19. *Keteleeria fortunei*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Seed cone. **4.** Immature seed cone. **5.** Seed scale with seeds. **6.** Seeds. **7.** Leaves. **8.** Leaf apices. **9.** Pollen cones.

Lagarostrobos Quinn, Austral. J. Bot. 30 (3): 316. 1982. Type: *Lagarostrobos franklinii* (Hook. f.) Quinn [Dacrydium franklinii Hook. f.] (*Podocarpaceae*).

Greek: *lagaros* = narrow; *strobilos* = cone.

Description

See the species description.

Distribution

As for the species.

Lagarostrobos franklinii (Hook. f.) Quinn, Austral. J. Bot. 30 (3): 316. 1982. *Dacrydium franklinii* Hook. f., London J. Bot. 4: 152, t. 6. 1845. Type: Australia: Tasmania, Huon River, ["grows at Mcq Harb"], *A. Cunningham s.n. (a-c)* (lectotype K). Fig. 153, 154

Etymology

The species epithet commemorates Sir John Franklin, a Governor of Tasmania in the early years of the colony.

Vernacular names

Huon pine

Description

Evergreen, predominantly dioecious trees to 25 m or perhaps 30 m tall; trunk to 1.5(–2) m d.b.h. (few trees of this size now exist). Bark becoming longitudinally fissured, fibrous, exfoliating in scales and strips, ultimately 4–6 cm thick, grey-brown. Crown of young trees more or less conical or pyramidal, of old mature trees spreading, with large ascending main branches. Frequently layering, sometimes extending over large areas. Foliage branchlets slender, 1–1.2 mm diam. including scale leaves, long on seedlings and young plants, or on shaded, pendulous branches, short and more rigidly spreading on sun-exposed branches in the crown of mature trees. Juvenile leaves on seedlings and young plants, spirally arranged, decurrent, spreading to all sides with free apex, 1–2 mm long, keeled abaxially, concave adaxially; apex curved forward, acute. Adult leaves spirally arranged, imbricate and appressed, rhomboid in appearance, 1–1.5 × 1 mm, keeled abaxially; apex obtuse. Leaves amphistomatic, stomata conspicuous, scattered. Pollen cones terminal, sessile, 4–6 mm long, 2–2.5 mm wide; microsporophylls 10–15(–20), rhombic to triangular, with minutely denticulate upper margins and with two basal pollen sacs containing trisaccate pollen. Seed cones terminal on decurved short branchlets, 4–5 mm long, consisting of 5–8(–10) spirally arranged fertile bracts, each with a single erect ovule on the adaxial side. Seeds up to 5–8 per cone, usually fewer, morphologically erect but topographically pendent, ca. 2.2 × 2 mm, dorsiventrally compressed to nearly rounded in cross-section, notched ar apex, light brown, enclosed at base in a dry, papery epimatium.

Distribution

Australia: Tasmania (mainly S & W parts, along rivers).
TDWG codes: 50 TAS

Ecology

Lagarostrobos franklinii is mostly a riparian species, usually on river banks or close to rivers, but occasionally occurring on wet hill sides away from main water courses in temperate rainforest. It forms groves dominated by Huon pine, marking stream courses at low altitudes from sea level to 150 m, and it grows on some hills to 750 m in the mountainous west country. In a few areas it is observed to have spread by layering, most notably on Mt. Read, where several hectares are believed to be occupied by stems forming a single clone. It is often accompanied by *Nothofagus cunninghamii, Eucryphia lucida, Anopterus glandulosus* and ferns, with *Eucalyptus obliqua* growing nearby on higher ground.

Conservation

This species is not threatened under current (2001) IUCN criteria; it was listed as LRcd in the Conifer

Action Plan (Farjon & Page, 1999), but the subcategory "conservation dependent" is no longer recognized. An estimated 15% of its habitat has been lost through inundation for hydroelectric schemes and to fire over the past 100 years or so. Extensive logging in the past has removed nearly all large trees, but there is regrowth nearly everywhere; ca. 85% of the remaining area of occupancy (AOO) of Huon pine is now protected in reserves. One stand of the species has been made available for access to craft wood from dead and downed timber, but there is no cutting of living Huon pine allowed. Fire management appears to be the main priority at present to ensure its continued conservation under the currently prevailing policies.

IUCN: LC

Uses

Huon pine was once the most important timber tree of Tasmania, but its exploitation was unsustainable and resources of good timber trees were exhausted. The timber was exported in the colonial period of the 19th century and convicts were employed in the logging and transport operations by river. Its wood is hard and durable and was mainly used for boat building and decks of sailing ships. Today, virtually all large trees have gone, but a few escaped the loggers and are now assidiously protected. A limited amount of down and dead wood is now used for wood crafts and cabinet work. The species is rare in cultivation, but present in a few botanical collections and arboreta. This tree grows very slow, both in the wild and in cultivation, and is tolerant of light frost.

Larix Mill., Gard. Dict., Abridg. Ed. 4, vol. 1. 1754. Type: *Larix decidua* Mill. (*Pinaceae*).

Larix is the classical Latin name for larches.

Description

Monoecious, deciduous trees with a monopodial trunk. Resin canals in wood, leaves and seed cones. Branches at regular intervals on trunk, spreading and assurging or highest order branches drooping to pendulous (Rauh's model). Bark thick, scaly and fissured, with large plates in some species. Shoot dimorphism pronounced; lateral short shoots give rise to leaves, long shoots and reproductive organs. Leaves narrowly linear, (sub-)flexible, obtuse to acutish at apex, more or less flattened or broad triangular, sometimes diamond shaped in cross section, hypo- or amphistomatic. Pollen cones solitary at apex of short shoots and often numerous; microsporophylls with 2 pollen sacs containing globular, smooth pollen with a narrow equatorial ridge. Seed cones solitary at apex of short shoots on a curved peduncle, more or less erect, persistent, falling attached to branches. Bracts short and hidden or long and exserted. Seed scales rounded or emarginate, more or less convex, with a short pedicellate base and persistent. Seeds ovoid, held in a shallow cup covering one side of the seed, which extends in a relatively short, persistent wing. Seedlings with 5–7 (usually 6) cotyledons.

11 species.

Distribution

North America: central Alaska (disjunct); from the NW Territories to Newfoundland; northern Rocky Mountains and Cascade Range; New England states (USA). Eurasia: Europe (Alps and Carpathians); NE Russia across Siberia to Kamchatka and Sakhalin; Japan (disjunct), NE China; Sino-Himalayan mountain system.

Synopsis

The genus *Larix* has been divided into two groups based on morphological characters in the seed cones and, to a lesser degree, in the leaves. These groups have been formalized in sections:

- Section *Larix* with species *L. decidua* (type), *L. sibirica, L. gmelinii, L. ×czekanowskii, L. laricina* and *L. kaempferi*
- Section *Multiserialis* Patschke with species *L. griffithii* (lectotype), *L. potaninii, L. lyallii, L. occidentalis* and *L. mastersiana*

This classification was adopted im my book *Pinaceae* (Farjon, 1990); but since then a number of papers have been published attempting to reconstruct a phylogeny of the genus. One of these, based on morphological data and including evidence from the fossil record (LePage & Basinger, 1995) divides the genus in two groups: one with short bracts and one with long bracts. This is a similar classification as the one above, but with *L. kaempferi* transferred to section *Multiserialis*; the fossils are all placed with the other, short-bracted group. The results of two analyses of molecular (DNA sequence) data appear to give results that group species according to their geographical distribution when based on plastid DNA (Wei & Wang, 2003) and nuclear ribosomal (ITS) DNA (Wei & Wang, 2004). Here, there is a North American group (*L. occidentalis, L. laricina*), a North Eurasian group and a Sino-Himalayan group, but with *L. sibirica* 'behaving' aberrantly in the cpDNA based analysis and *L. lyallii* (North America) not represented in the analyses. In another study of this kind (Semerikov *et al.*, 2003) conflicting phylogenies were inferred from cpDNA and ITS (with *L. lyallii* included). The only consistently congruent result seems to be a clade with the North American species *L. laricina, L. lyallii* and *L. occidentalis*. These belong to two different traditional sections. It appears therefore, that at present a classification informed by a robust phylogeny that would help to explain character transformations in an evolutionary context still eludes us. No formal classification is therefore presented here.

Key to the species of *Larix*

1a. Bracts of mature seed cones shorter than seed scales, usually barely visible in opened cones; ripe seed cones globose, ovoid or ovoid-conical.

Leaves carinate on invers-dorsal side (below) only **2**

1b. Bracts of mature seed cones (much) longer than seed scales, straight or reflexed; ripe seed cones ovoid-conical to oblong-cylindrical. Leaves carinate on both sides, rarely only on invers-dorsal side **7**

2a. Seed scales concavo-convex, with strongly recurved upper margin; seed cones broad ovoid, (1.5–)2–3(–3.5) cm long ***L. kaempferi***

2b. Seed scales convex or more or less straight, with flat upper margin; seed cones variously shaped **3**

3a. Seed scales 10–20 per cone, not spreading; seed cones 1–2 cm long ***L. laricina***

3b. Seed scales (15–)20–40(–45) per cone, spreading; seed cones (1.5–)1.8–5(–6) cm long **4**

4a. Leaves hypostomatic (all or nearly all stomata on one side) ***L. gmelinii***

4b. Leaves amphistomatic (stomata on both sides, but usually more on one side) **5**

5a. Seed scales of green cones (densely) pubescent, becoming more glabrous with age ***L. sibirica***

5b. Seed scales of green cones always glabrous **6**

6a. Seed scales incurved, straight or slightly recurved; upper margin repand or emarginate, sometimes entire (European species) ***L. decidua***

6b. Seed scales incurved; upper margin entire (Siberian species) ***L. ×czekanowskii***

7a. Apex of bracts in seed cones broadly acute ***L. potaninii***

7b. Apex of bracts in seed cones cuspidate, often narrow and elongated **8**

8a. Mature seed cones 5–8(–11) cm long, cylindrical ***L. griffithii***

8b. Mature seed cones 2.5–5(–6) cm long, variously shaped but longer than wide **9**

9a. Leaves amphistomatic. Bracts straight, with an abruptly narrowing cusp ***L. lyallii***

9b. Leaves hypostomatic. Bracts recurved (at least the cusp) **10**

10a. Seed scales recurved, mostly emarginate (sometimes entire); bracts with a thin, elongated cusp ***L. occidentalis***

10b. Seed scales more or less straight, entire or slightly emarginate; bracts short cuspidate ***L. mastersiana***

Larix ×czekanowskii Szafer, Kosmos 38: 1297. 1913. Type: Russia: Siberia, Tunguska River, below mouth of Tomezoy River, *A. Czekanovsky & F. Müller s.n.* (lectotype LE).

Etymology

This nothospecies was named after Aleksander P. Czekanowski (1833–1876), a Polish geologists who studied the geology of the Lake Baikal Basin while in exile.

Vernacular names

No common names have been recorded for this taxon.

Description

Trees which are 'intermediate' between *Larix sibirica* and *L. gmelinii* and appear to be common in a wide belt stretching N to NW from Lake Baikal share some character states of both species, particularly evident in the cones. The seed cones are smaller than those of *L. sibirica* and resemble those of a large-cone variety of *L. gmelinii*: var. *principis-rupprechtii*; the seed scales are less pubescent than those of *L. sibirica*. They have been interpreted by Russian botanists and foresters as of natural hybrid origin.

Distribution

Central Siberia: from Lake Baikal to the mouth of the Yenisei River

TDWG codes: 30 IRK KRA

Ecology

Larix ×czekanowskii occurs in central Siberia, where it forms taiga forest with *Picea obovata, Pinus sylvestris* and broad-leaved trees such as *Betula pendula* and *Populus* spp., broadly following the Yenissei River. It grows on a great variety of soils, from peat bogs to well drained, sandy or rocky soils, where it has its optimum. The climate is very cold (min. temp. –55° C), continental or subarctic, dry, with very long winters.

Conservation

IUCN: NE

Uses

The wood of this larch is durable and used in construction, traditionally for log houses in Siberia for which the wood is roughly hewn to shape, but untreated. It has been widely used for railroad sleepers e.g. on the famous Trans Siberian Railroad. Larch wood is also milled for construction timber and veneer, and pulped for the paper industry. This natural hybrid larch is not known to be in cultivation, but it may be present in e.g. Scandinavia under the name *L. sibirica*.

Larix decidua Mill., Gard. Dict., ed. 8: Larix No. 1. 1768.

Etymology

The species epithet refers to the deciduous (seasonally falling) leaves.

Vernacular names

European larch; Gemeine Lärche (German); Mélèze d'Europe (French)

Description

Trees to 40–50(–55) m tall, d.b.h. to 1.5–2.5 m; trunk monopodial, straight or curved at base; bark deeply fissured, breaking into large plates, flaking, exposing reddish inner bark. Branches heavy, long, curved down, ascending near the ends; branches of second order long, slender, pendulous; crown pyramidal in young trees, widening in old trees. Branchlets thin, slender, flexible, or stout, pink buff or (pale) yellowish; glabrous, or slightly pubescent when young; short shoots cylindrical or subglobose, 0.3–1 cm long. Vegetative buds ovoid, 3 × 2 mm, not resinous. Leaves on long shoots remote, appressed forward against the shoot or spreading; on short shoots crowded in false whorls, 30–40, (2.3–3.5(–4) cm long, 0.5–1 mm wide, narrowly linear, soft, flexible, in cross-section broad triangular or flattened, carinate below, obtuse or acutish at apex; amphistomatic, stomata on lower side in two narrow bands separated by a keel; leaf colour light green, darkening, yellow in autumn. Pollen cones terminal on short shoots, numerous on pendulous long twigs, 0.5–1 cm long, yellow, perular scales with fimbriate margins, reddish. Seed cones terminal on short shoots, turning erect; peduncles curved, 0.5–1 cm long, subtended by leaves; cones ovoid or ovoid oblong, with obtuse apex, (1.2–)2.5–4(–4.5) cm long, (1.2–)1.5–3(–3.5) cm wide with opened scales; colour (immature) dark red or purplish, sometimes green, maturing to pale green with purplish margins of seed scales, ripening to (dark) brown, old cones grey. Seed scales 25–35, ovate to suborbicular, slightly convex, 7–15 × 6–13 mm; surface striated, shining smooth in older cones, reddish pubescent near base, later glabrous; upper margin entire, incurved, repand or emarginate, sometimes slightly recurved; base narrowed. Bracts ligulate, with acicular or cuspidate apex, length ⅓-½ × seed scales, mostly included, but visible with opened scales. Seeds ovoid-cuneate, 4 × 2.5 mm, dark brown-grey; seed wings oval, 6–10 × 4–6 mm, light brown.

Distribution

Europe: Alps, Carpathians, Slovakian Mts., S Poland.
TDWG codes: 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER POL SWI 12 FRA-FR 13 ITA-IT ROM YUG-SL 14 UKR-MO UKR-UK

Ecology

Larix decidua occurs in the high mountains of central Europe, at altitudes between (600–)1000–2200(2500) m a.s.l., in the Central Alps it usually forms the tree limit. The soils are neutral to acidic, mostly on granitic rock. The climate has cool, moist summers and cold, snowy winters, but annual precipitation rarely exceeds 1000 mm. Pure stands are uncommon, more often it is mixed with *Pinus cembra* in the Alps, below 1800 m also with *Picea abies*.

Uses

The wood of European larch is valued for its durability and has been used for centuries in the Alps and Carpathians to build houses; traditional style houses still use well seasoned wood of this species. Other

traditional uses are fences, gates, feeding racks, and water troughs for animals. Due to its durability the wood of European larch has been used extensively for railway sleepers, until these were replaced by concrete and iron structures in modern times. Trees with a curved base were split and hollowed and the two halves joined to make 'Alphorns', large wind instruments with a far carrying low tone; competitions to blow the horn are still held in some regions of the Alps. This species has been introduced in the lowlands of Europe for plantation forestry as well as an amenity tree. In horticulture for gardens it is not so common, although a modest number of cultivars is known, most with various branching habits.

3 varieties are recognized:

Larix decidua Mill. var. ***decidua***. Type: Illustration "*Larix folio deciduo Conifera*" in Miller, Cat. Pl.: 43, t. 11. 1730 (lectotype). Fig. 155, 156, 157

Description

Seed cones 2.5–4.5 cm long, 1.5–3 cm wide when opened; seed scales with a rounded or more or less repand to emarginate upper margin.

Distribution

Europe: Alps, Carpathians, Slovakian Mts.
TDWG codes: 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER SWI 12 FRA-FR 13 ITA-IT YUG-SL

Conservation

IUCN: LC

Larix decidua Mill. var. ***carpatica*** Domin, Sborn. Vyzk. Ustav Zemed. R.Č.S. 65: 149. 1930. Type: Slovakia, Tatra Mts., *V. Krajina s.n.*, 7 sep 1931 (holotype PR).

Description

Seed cones (1.2)2–2.2(–2.5) cm long, about as wide when opened; seed scales often with an entire, rounded upper margin.

Distribution

Central to East Europe: Sudeten, Tatra, Carpathians.
TDWG codes: 11 CZE-CZ CZE-SL POL 13 ROM 14 UKR-MO UKR-UK

Conservation

IUCN: LC

Larix decidua Mill. var. ***polonica*** (Racib. *ex* Wóycicki) Ostenf. & Syrach, Pflanzenareale 2: 63. 1930. *Larix polonica* Racib. *ex* Wóycicki, Obraz. Rosl. Król. Polsk. 2: 15–16, t. 1. 1912. Type not designated.

Description

Long shoots pale yellowish; leaves flattened. Seed cones ca. 1.5 × 1.2 cm, with suborbicular, convex scales with a round, entire upper margin.

Distribution

Poland (headwaters of Wista River).
TDWG codes: 11 POL

Ecology

This variety has been found in scattered stands in mixed forests at ca. 150–350 m a.s.l. It is commonly associated with *Pinus sylvestris* and *Betula pendula*, sometimes with *Quercus robur*.

Conservation

In forests surrounding the headwaters of the Wista River in Poland, larches have become very rare. In most areas only ancient relict trees survive and there is little or no successful regeneration. This could partly be the result of historical climate change, helped by forest management practice and land uses that have favoured pioneer broad-leaved trees and pines. The geographical extent of this variety is not exactly known but its area of occupancy (AOO) is less than 500 km².
IUCN: EN [B2ab (ii, iv, v)]

Larix gmelinii (Rupr.) Kuzen., Trudy Bot. Muz. Rissijsk. Akad. Nauk 18: 41. 1920.

Etymology

This species was named after Johann Georg Gmelin (1709–1755), a botanist who traveled widely in Siberia.

Vernacular names

Dahurian larch; Listvennitsa daurskaya (Russian); luoye song (Chinese); gui-matsu (Japanese)

Description

Trees to 30–35 m tall, d.b.h. to 1–1.5 m; trunk monopodial; bark on trunk dark red brown, with greyish plates, finely scaly. Branches long, spreading horizontally, ascending near the top; branches of second order relatively short, firm, drooping, not pendulous; crown broad pyramidal, open, flat topped and irregular in old trees; Branchlets thin, slender, light pink brown to orange-brown or dark purplish brown; pubescence variable, weak or dense, or glabrous; short shoots small, 3–6 mm, cylindrical. Vegetative terminal buds ovoid globose, with acute apex, not or slightly resinous; bud scales ovate or obtuse triangular, dark brown or purplish brown. Leaves on short shoots crowded in false whorls, 20–30(–35), 1.5–3(–4) cm long, 0.5–0.8 mm wide, narrowly linear, widest near apex, soft and flexible, cross-section diamond shaped, or flattened and keeled below; apex obtuse or acutish; stomata in two narrow bands separated by a keel below, none or a few above; leaf colour bright green, yellow in autumn. Pollen cones terminal on short shoots, 5–7 mm long, yellow. Seed cones terminal on short shoots, turned erect; peduncles short, curved; cones ovoid or ovoid-oblong, widening with opened scales; apex truncate, 0.8–3.5(–4.5) cm long, 0.8–2(–3) cm wide with opened scales; colour (immature) purplish red or sometimes light green, maturing to rose-purple or greenish purple, ripening to bright or dark red brown; old cones grey. Seed scales (15–)20–40(–45), ovate oblong, slightly recurved or straight, convex, flattening out when opened, 5–10 × 4–8 mm at mid-cone; surface smooth, striated on abaxial side, sometimes strongly reddish pubescent, usually weakly pubescent or glabrous; upper margin entire, rounded or truncate, or weakly to strongly emarginate and slightly or strongly recurved; base narrowed or slightly pedicellate. Bracts broad ligulate-lanceolate, length ½ × seed scales, included except at base of cone, but visible with opened seed scales; apex trilobate with longer cusp. Seeds ovoid, slightly flattened, 2–3 × 1–2 mm, light brown; seed wings ovate-oblong, 5–6 × 3 mm, bright orange-brown, shining.

Distribution

NE China: Hebei, Manchuria, Nei Monggol [Inner Mongolia], N Shanxi; North Korea; NE Mongolia; Russian Federation: E Siberia, Russian Far East; Japan (Hokkaido).
TDWG codes: 30 BRY CTA IRK YAK 31 AMU KAM KHA KUR MAG PRM SAK 36 CHI-NM CHM CHN-HB CHN-SX 37 MON 38 JAP-HK KOR-NK

Ecology

Larix gmelinii occupies a very large area and therefore occurs in a wide range of habitats: on lowland subarctic plains, in river valleys, in mountains and also on the edges of moors and swamps. Its altitudinal range is between 300 m and 1800 m a.s.l. The soils are affected by permafrost over much of the range; the climate in large parts of its range is continental subarctic, with very cold winters, and relatively dry (400 mm to 500 mm in the Greater Hinggan Range) to extremely dry in the subarctic interior. In more maritime areas of the Russian Far East precipitation rises to 1000 mm and more. It is the only tree species in E Siberia reaching the tree limit at 70° N, but in the more southern part of its range it is commonly mixed with *Abies sibirica, Picea obovata* and *Pinus sylvestris*. In the boreal coniferous forest it is a climax species only on permafrost or peaty soils. In the high swamps and bogs in Sakhalin and on the Kuril Islands it usually forms pure stands, but on somewhat drier sites it is mixed with *Abies sachalinensis* var. *sachalinensis, Picea jezoensis, Alnus hirsuta, Betula japonica, B. ermanii*, and *Salix* spp. In central Kamchatka occurs a relict taiga forest with a mixture of *Larix gmelinii* and *Picea jezoensis*, accompanied by *Betula* sp. and with *Pinus pumila* and *Juniperus*

communis var. *saxatilis* common in the understorey. In mountain ranges on the maritime seaboard of NE Asia conditions for mixed coniferous forest are more optimal and here *L. gmelinii* grows with *Abies nephrolepis, A. holophylla, Picea obovata* or *P. jezoensis*, and *Betula ermanii*, locally also with *Juniperus, Pinus pumila* or *Rhododendron* sp. in the understorey.

Uses

Dahurian larch is an extremely important timber tree in the Russian Far East, where it provides building logs for traditional log houses, railway sleepers, fences, and gates, as well as timber for construction, ship building (in Japan and Sachalin), and the pulp industry. Its variability also extends to the suitability as a plantation tree for forestry outside its natural range; provenances from Siberia are prone to 'late' frosts (which actually means: lack of a proper cold winter that lasts until spring definitively arrives), while those of Japan and even Sakhalin are less likely to be frost damaged. Inter-specific hybrids have been produced in cultivation in Denmark and China, but probably have not been planted far beyond the trial nurseries. Due to the risk of frost damage this species and its varieties are rare in cultivation in more temperate parts of the world.

4 varieties are recognized:

Larix gmelinii (Rupr.) Kuzen. var. ***gmelinii***. *Abies gmelinii* Rupr., Beitr. Pflanzenk. Russ. Reiches 2: 56. 1845. Type not designated.

Larix dahurica Turcz. *ex* Trautv., Pl. Imag. Descr. Fl. Russ. 3, 7: 48, t. 32. 1846, *non* Lawson (1836).
Larix gmelinii (Rupr.) Kuzen. var. *genhensis* S. Y. Li & Adair, Sida 16 (1): 183. 1994; *Larix gmelinii* (Rupr.) Kuzen. f. *genhensis* (S. Y. Li & Adair) L. K. Fu & Nan Li, Novon 7 (3): 262. 1997.

Description

Seed cones small, 0.8–2(–2.5) cm long, 0.8–1.5 cm wide when opened; seed scales few (ca. 15–20), glabrous or weakly pubescent; upper margin from entire and rounded to emarginate and slightly recurved.

Distribution

NE. China: Manchuria, Nei Monggol [Inner Mongolia]; Mongolia; Russian Fed.: E. Siberia, Russian Far East (including Kamchatka).
TDWG codes: 30 BRY CTA IRK YAK 31 36 CHI-NM CHM 37 MON

Conservation

IUCN: LC

Larix gmelinii (Rupr.) Kuzen. var. ***japonica*** (Maxim. *ex* Regel) Pilg., in Engler & Prantl, Nat. Pflanzenfam., ed. 2, 13: 327. 1926. *Larix dahurica* Turcz. *ex* Trautv. var. *japonica* Maxim. *ex* Regel, Gartenfl. 20: 105. 1871; *Larix gmelinii* (Rupr.) Kuzen. subsp. *japonica* (Maxim. *ex* Regel) E. Murray, Kalmia 12: 21. 1982. Type: Japan: Hokkaido, Oshima Prov., Hakodate, cultivated on temple grounds, *C. J. Maximowicz s.n.* (holotype not located, isotype K).

Description

This variety differs from var. *gmelinii* in the following characters: Seed cones (when opened) wider than long, 1.2–2.5 × 1.5–2.8 cm; seed scales more numerous, 18–25, ovate oblong, with emarginate and (strongly) recurved apex. Young shoots dark purplish brown, densely pubescent at first. Leaves slightly shorter: 1.5–2.5(–3) cm.

Distribution

Japan: Hokkaido; Russian Far East: Kuril Islands, Sakhalin.
TDWG codes: 31 KUR SAK 38 JAP-HK

Conservation

IUCN: LC

Larix gmelinii (Rupr.) Kuzen. var. ***olgensis*** (A. Henry) Ostenf. & Syrach, Pflanzenareale 2: 62. 1930. *Larix olgensis* A. Henry, Gard. Chron., ser. 3, 57: 109, f. 31–32. 1915. Type: Russia: Russian Far East, Primoriye, Olga, ["St. Olga"], *C. J. Maximowicz s.n.* (holotype K).

Description

The main differences with var. *gmelinii* are: Seed cones larger, 1.8–3.5(–4.5) × 1.5–3 cm; seed scales more numerous (16–30), dark red brown, convex, opening at 45° from the cone rachis. Young shoots (densely) orange brown pubescent, but sometimes nearly glabrous.

Distribution

NE China: Jilin, E Liaoning; North Korea; Russian Far East: Sikhote Alin Range.
TDWG codes: 31 PRM 36 CHM-JL CHM-LN 38 KOR-NK

Conservation

IUCN: NT

Larix gmelinii (Rupr.) Kuzen. var. ***principis-rupprechtii*** (Mayr) Pilg., in Engler & Prantl, Nat. Pflanzenfam., ed. 2, 13: 327. 1926. *Larix principis-rupprechtii* Mayr, Fremdl. Wald-Parkbäume: 309. 1906; *Larix gmelinii* (Rupr.) Kuzen. subsp. *principis-rupprechtii* (Mayr) E. Murray, Kalmia 12: 21. 1982. Type not designated. Fig. 158

Larix principis-rupprechtii Mayr var. *pendula* D. S. Zhang & Y. M. Chen, J. Beijing Forest. Univ. 10 (2): 113. 1988; *Larix gmelinii* (Rupr.) Kuzen. f. *pendula* (D. S. Zhang & Y. M. Chen) L. K. Fu & Nan Li, Novon 7 (3): 261. 1997.

Description

This variety differs from the others mainly by its large female cones (2–4 × 2–2.5 cm), which have numerous seed scales (25–45) and resemble those of *L. decidua*. The first year's shoots are yellowish or orange brown and usually glabrous, but sometimes slightly brown pubescent.

Distribution

North Central China: S Gansu, N Hebei, NW Henan (?), Nei Mongol [Inner Mongolia] (just), Shanxi.
TDWG codes: 36 CHI-NM CHN-HB CHN-GS CHN-SX

Conservation

IUCN: LC

Larix griffithii Hook. f., Himal. J. 2: 44. 1854. [validating descr. in vol. 1: 255]

Etymology

This species has been named after William Griffith (1810–1845), who when Director of the Botanic Garden of Calcutta amassed a large herbarium now held at Kew.

Vernacular names

Sikkim larch; Xizang hong shan (Chinese)

Description

Trees to 15–20(–23) m tall, d.b.h. to 0.5–0.8 m; trunk monopodial, straight or bend; bark on trunk scaly, with broad, shallow fissures and thick ridges, grey. Branches long, spreading horizontally, towards the ends assurgent, finally long pendulous; branches of second order long, slender, extremely pendulous; crown broad conical or pyramidal, in old trees domed. Branchlets long, slender, reddish brown or orange brown, becoming grey, yellowish or light brown pubescent or glabrous, glabrous in the third year; short shoots stout, ringed with reflexed remnants of perular scales, 3–8 mm long. Vegetative buds ovoid or conical, 2 × 1.5 mm, resinous; bud scales triangular, red brown. Leaveson short shoots spirally, densely set in false whorls, 30–50 or more, spreading radially, (1–)1.5–3.5(–4.5) cm long, 1–1.5 mm wide, narrowly linear, soft, flexible, more or less flat above, carinate below, obtuse-acutish at apex; stomata in a few interrupted lines above, in two narrow bands below; leaf colour green, shiny, stomatal bands greenish white, leaves yellow in autumn.

Pollen cones terminal on short shoots, peduncu-late, pendant, often numerous, 1–2 cm long, yellow, with red rachis, perular scales reddish brown. Seed cones terminal on short shoots, erect from pendulous branches; peduncles 1–2 cm, curved, scaly, with leaves; cones cylindrical, with obtuse apex, (3–)5–8(–11) cm long, 2.5–3.2 cm wide with opened scales; colour (immature) purplish, with reddish purple bracts completely covering the seed scales, ripening to dark brown, with purple brown, light fringed bracts. Seed scales more or less orbicular, convex or flat, often undulate, 10–15 × 10–15 mm; surface striated, with yellowish brown, short pubescence persisting only on lower part; upper margin entire at first, soon erose, usually undulate and slightly recurved; base narrowed, often lacerate. Bracts broad or narrow lanceolate, cusp elongated, recurved, edges lacerate, 2–3 cm long, 5–8 mm wide, exserted and strongly or slightly reflexed. Seeds ovoid-cuneate, 5 × 3 mm, yellowish brown; seed wings ovate oblong, 6–10(–12) × 4–6 mm, purplish brown.

Taxonomic notes

The two similar names *Larix griffithii* and *L. griffithiana* have been used more or less interchangeably in the literature on conifers, in fact I used the latter in my book *Pinaceae* (Farjon, 1990). However, the former (1854) has priority over the latter (1855), the presumed basionym *Abies griffithiana* Lindley et Gord. (1850) being a *nomen nudum*, and must be applied to this species following the International Code of Botanical Nomenclature.

Distribution

E. Himalaya; China: NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-YN CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP

Ecology

Larix griffithii occurs in the cloud belt of the E Himalayas, at elevations between (1800–)2400–4000(–4100) m a.s.l., on rocky moraines or various lithosols. The climate is moist to wet (summer monsoon), with annual precipitation exceeding 2000 mm. It occurs in pure forests up to the tree line, at lower elevations it is often mixed with *Abies spectabilis, A. densa, Pinus wallichiana, Picea spinulosa, Tsuga dumosa* and *Juniperus* sp. *Betula utilis* and various large species of *Rhododendron* are the most common broad-leaved trees associated with it.

Uses

Sikkim larch is of minor economic importance as a timber tree due to its occurrence in remote valleys and on high slopes. It was introduced to Britain in the 19th century but was not very successful and remains restricted to a few arboreta and other large gardens with collections of exotic trees, usually in countries or regions with a mild climate and rare occasions of frost. The main problem seems to be early flushing of leaves in regions with erratic warm spells in winter, which then get damaged by 'late' frosts. It would thus be expected to perfom better in countries with a more continental, but not extreme winter cold climate. The name *Larix griffithiana* Carrière is still often applied to this species, but this is a later and therefore superfluous name for the same species (see Taxonomic notes).

2 varieties are recognized:

Larix griffithii Hook. f. var. ***griffithii***. Type: Bhutan: ["Bootan", locality not stated], *W. Griffith 4989* (lectotype C). Fig. 159

Abies griffithiana Lindl. & Gordon, J. Hort. Soc. London 5: 214. 1850, *nom. nud.*
Larix griffithiana hort. ex Carrière, Traité Gén. Conif.: 278. 1855.
Larix kongboensis R. R. Mill, Novon 9 (1): 79. 1999.

Description

Shoots yellowish or light brown pubescent; leaves (1–)1.5–3.5(–3.8) cm long, 1–1.2 mm wide. Bracts of seed cones strongly reflexed.

Taxonomic notes

The smaller cones of *Larix kongboensis* (3–5 cm long) are cited as an important character state separating them from the larger cones of *L. griffithii* (Grimshaw & Bayton, 2009: 438–439), but the cones of the latter show great variation in length and we do not know

if these smaller sizes (as well as the shorter dwarf shoots) are not due to slow growth at high altitudes on the dry side of the Himalayas. More substantial evidence is needed for the separation as a distinct species of this small population in SE Xizang [Tibet]. Rushforth (2009) cited its separation as a species, together with his recognition at that rank of *Picea linzhiensis*, in support of a third new conifer, *Abies fordei* Rushforth, all endemic to the Yarlung Zangbo river drainage.

Distribution

E Himalayas from E Nepal, Sikkim and Bhutan to Arunachal Pradesh (NE India), in the Chumbi Valley it reaches into Xizang [Tibet], China.
TDWG codes: 36 CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP

Conservation

IUCN: LC

Larix griffithii Hook. f. var. ***speciosa*** (W. C. Cheng & Y. W. Law) Farjon, World Checkl. Bibl. Conif.: 139. 1998. *Larix speciosa* W. C. Cheng & Y. W. Law, Acta Phytotax. Sin. 13 (4): 84. 1975.

Description

Long shoots darker than in var. *griffithii*, glabrous; short shoots thicker; leaves 2.5–4.5 cm long, 1–1.5 mm wide. Bracts of seed cones narrower and less strongly reflexed.

Taxonomic notes

In Flora of China 4: 34 (1999) this variety is treated as a distinct species. The distinctive characters appear to be all of a gradual, continuous nature, whereas between species we must expect more discontinuous morphological differences. Both varieties, according to Chinese accounts, occur on the Tibetan side of the Himalayan watershed. Unfortunately, the disputed border area between India and China, as well as extreme N Myanmar [Burma], have long not been visited by botanists making collections, so we do not know whether this variety occurs in valleys draining to the south.

Distribution

China: NW Yunnan, SE Xizang (Tibetan Himalaya).
TDWG codes: 36 CHC-YN CHT

Conservation

IUCN: NT

Larix kaempferi (Lamb.) Carrière, Fl. Serres Jard. Eur. (Ghent) 11: 97. 1856. *Pinus kaempferi* Lamb., Descr. Pinus 2: [Pref.] v. 1824. Type: Illustration: Kaempfer, Delin. Pl. Japon.: t. 218 [ms.] in Bibl. Sloan., Min. 139, Cat. No. 2914 xxvi G (Brit. Mus., Bloomsbury) (lectotype). Fig. 160

Etymology

This species was named after Engelbert Kaempfer (1651–1716), a German botanist and physician, and one of the earliest Europeans to describe and illustrate Japanese plants.

Vernacular names

Japanese larch; karamatsu (Japanese)

Description

Trees to 30–35(–40) m tall, d.b.h. to 1–1.5 m; trunk monopodial; bark on trunk scaly and fissured, dark reddish or purplish brown, with grey plates. Branches long, spreading horizontally, upper ones ascending; branches of second order relatively short, slender, drooping but not pendulous; crown broad pyramidal, dense, or more open and irregular, conical and narrower in forest stands. Branchlets slender, flexible, not pendulous, variable in colour, from yellowish to orange brown or purplish brown, bloomed with grey, shining, glabrous or slightly pubescent; short shoots cylindrical, with rings of perular scale bases, 4–10 mm long. Terminal buds conical, 4–5 mm long, slightly resinous; bud scales triangular ovate, with erose margins, dark red brown. Leaves on long shoots to 6 cm long and 2 mm wide; on short shoots spirally, in false whorls of 20–35, spreading radially, (2–)3–4 cm long, 1 mm wide, linear, widest above the middle, in cross section diamond shaped; apex obtuse; stomata in several lines above,

in two narrow bands separated by a midrib below; leaf colour greyish or bluish green, bright yellow in autumn. Pollen cones terminal on short shoots, often clustered on short branches, 5–10 mm long, yellow. Seed cones terminal on short shoots, erect from drooping branches; peduncles short, curved; cones broad ovoid, with truncate apex, (1.5–)2–3(–3.5) cm long, 1.5–2(–2.5) cm wide with opened scales; colour (immature) violet, the bracts with a green midrib, maturing to yellowish or orange brown, dark, dull brown when old. Seed scales 30–40, sub-orbicular, concavo-convex, 10–13 × 10–13 mm at mid-cone, opening wide when ripe, striated on both surfaces, glabrous; upper margin entire, undulate or emarginate, usually strongly recurved; base narrowed. Bracts ligulate, ending in a short cusp, half the length of seed scales, included, but visible in lower part of cone when seed scales are opened. Seeds ovoid cuneate, slightly flattened, 4 × 3 mm, brownish white, mottled with red; seed wings ovate oblong, 8 × 4 mm, reddish yellow with brown.

Distribution

Japan: central Honshu.
TDWG codes: 38 JAP-HN

Ecology

Larix kaempferi is a species of mesic sites, occurring from the hills to high in the mountains (500 m to 2300 m a.s.l.), on the south face of Fuji san it reaches 2900 m. Unlike the other NE Asiatic larches it occupies better soils, often of recent volcanic origin, and is never found on peat. The climate is cold, with snowy winters and abundant rain in cool summers. It is commonly found in association with other conifers, e.g. *Pinus densiflora, Picea jezoensis* subsp. *hondoensis, Tsuga diversifolia, Abies homolepis* at lower elevations, and *A. veitchii* at higher elevations, but it is clearly a sub-climax species. Several broad-leaved tree genera are present at the lower elevations, e.g. *Quercus, Fagus* and *Betula*. Pure 'scrub stands' may occur at the upper limit of trees.

Conservation

IUCN: LC

Uses

Japanese larch is an important timber tree in Japan and in Europe (Scotland), where it has been introduced in 1834. The wood is similar to that of European larch and is used for construction, railway sleepers, pit props and the pulp industry. It is also a frequently planted amenity tree in parks and large gardens and a limited number of cultivars are known. In Scotland, a spontaneous hybrid occurred around 1900 between *L. kaempferi* and *L. decidua* which was named *Larix* ×*eurolepis* Henry (but is correctly named *Larix* ×*marschlinsii* Coaz based on an earlier crossing event) and shows marked F1 hybrid vigour or heterosis. Its seed cones resemble those of *L. kaempferi* with recurved scale apices, but are larger. This fast growing hybrid became much favoured by foresters and has been propagated and planted widely in many parts of Europe, often involving back-crosses with either parents. Despite this greater production of timber per ha/year of the hybrid, Japanese larch remains an important plantation tree for timber on poorer soils, where neither the hybrid not the other parent do so well and where much of Europe's plantation forestry is situated (the better soils being occupied by agriculture mostly for food crops).

Larix laricina (Du Roi) K. Koch, Dendrol. 2 (2): 263. 1873. *Pinus laricina* Du Roi, Diss. Inaug. Obs. Bot.: 49. 1771. Type not designated.

Larix alaskensis W. F. Wight, Smithsonian Misc. Collect. 1 (50): 174. 1908; *Larix laricina* (Du Roi) K. Koch var. *alaskensis* (W. F. Wight) Raup, Sargentia 6: 105. 1947.

Etymology

The species epithet means 'similar to *larix*' and was given under the genus name *Pinus*, referring to *Pinus larix* L.

Vernacular names

Tamarack, Eastern larch, American larch

Description

Trees to 30–35 m tall, d.b.h. to 0.8–1 m; trunk monopodial; bark on trunk very scaly, reddish brown

with small grey plates. Branches moderately long or short, slender, spreading horizontally or curved downward; branches of second order relatively short, slender, drooping or pendulous; crown (narrowly) conical, broader in the south, narrower in the north. Branchlets slender, flexible, drooping or lower ones pendulous, orange brown or purplish, pruinose, later blackish grey, glabrous or slightly pubescent at first; short shoots cylindrical, 3–10 mm long. Terminal buds ovoid, 3 × 2 mm, resinous; bud scales triangular obtuse, smooth, with ciliate margins, dark brown. Leaves on short shoots in false whorls of (12–)15–20(–25), (1.5–)2–3(–3.5) cm long, 0.5–1 mm wide, narrowly linear, diamond shaped in cross section, keeled, obtuse to acutish at apex; stomata none or a few faint lines above, 2 narrow bands below; leaf colour light green or bluish green, later dark green, stomatal bands greenish white, leaves turn bright yellow in autumn. Pollen cones terminal on short shoots, small, yellow when ripe. Seed cones terminal on short shoots, more or less erect; peduncles short, slender, curved; cones ovoid-globose, widening with opened scales, 1–2 cm long, 1–2 cm wide with opened scales; colour (immature) light red or greenish, maturing to orange brown with a purplish tinge, old cones grey brown. Seed scales 10–20, orbicular or sub-orbicular, convex, 8–10 × 7–9 mm at mid-cone; abaxial surface striated, glabrous; upper margin serrulate or nearly entire, incurved; base narrowed. Bracts ligulate, with tiny cusp, ca. ¼ length of seed scales, included, only lower bracts visible. Seeds triangular ovoid, 3 × 2 mm, yellowish brown; seed wings ovate-oblong, 5–8 × 3–4 mm, yellowish, translucent.

Distribution

N North America: from Newfoundland and Massachusetts to Yukon and British Columbia, disjunct in interior Alaska.

TDWG codes: 70 ASK NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NFL-NE ONT QUE 74 ILL MIN WIS 75 CNT INI MAI MAS MIC NWH NWY OHI PEN VER WVA

Ecology

This is mostly a species of the lowland boreal and subarctic forests across Canada, it is less common in medium high mountains. Its altitudinal range is from 1 m to 1220 m a.s.l., but in British Columbia and Alaska it does not occur above 520 m. Tamarack will grow on a variety of acid soils, but is found most commonly on peaty soils in swamps and muskegs. The climate in its vast range is likewise varied, ranging from cool, moist maritime on the Atlantic coast, to extremely dry, cold continental in the interior. It occurs locally in pure stands (maritime), but elsewhere commonly with *Picea mariana, P. glauca, Abies balsamea*, or *Pinus banksiana*; boreal broad-leaved trees such as *Populus tremuloides* and *P. balsamifera* occur usually after disturbance, *Betula* may be represented with tree and shrub species. The shrub layer is often well developed, with various ericaceous species.

Conservation

IUCN: LC

Uses

Tamarack produces durable, dense wood that is used for outdoor purposes such as posts, railway sleepers, log cabins and mine shaft timbers. Its main industrial use is for pulp wood feeding the manufacture of paper, in particular transparent envelope windows. In Alaska, dog sled runners are made from sapling trees. In the past, the northern tribes of Native Americans used the roots of Tamarack to sew birch bark canoes and the wood supplied the shafts for arrows. Its use as an amenity tree outside its natural range is limited due to damage from 'late' frosts; however there should be some southern provenances that are more suitable.

Larix lyallii Parl., Conif. Nov.: 3. Jan 1863. [& J. Bot. 1: 35. 1863]. Type: USA: Washington, North Cascades, ["East side of Cascade Mts. latit. 49°"], *D. Lyall s.n.* (holotype K). Fig. 161

Etymology

This species was named after David Lyall (1817–1895) who collected the type specimen.

Vernacular names

Alpine larch, Subalpine larch, Lyall larch

Description

Trees to 20–25 m tall, d.b.h. to 0.5–0.8 m; trunk monopodial; bark scaly and fissured below in old trees. Branches moderately long, slender or massive, ascending to nearly erect, or more horizontal; branches of second order short, flexible, not pendulous; crown broad or narrow, conical, irregular and open in old trees. Branchlets rather stout, firm, orange red, but young shoots densely covered with lanate, yellowish hairs, in second year almost glabrous, grey, later blackish grey; short shoots ovoid-conical or barrel-shaped, with grey, pubescent rings and apex, 5–10 mm long. Vegetative buds ovoid globose, 3 × 2 mm, not resinous, yellowish pubescent; bud scales obtuse triangular, brown. Leaves on short shoots spirally, close, in false whorls of 25–35(–40), (1.5–)2–3.3 cm long, 0.6–1 mm wide, narrowly linear, curved or twisted, more or less rhombic in cross section, keeled on both sides, obtuse or acute at apex; amphistomatic, but more lines of stomata below; leaf colour light green, later bluish green, yellow in autumn. Pollen cones terminal on short shoots, 10–15 mm long, yellow. Seed cones terminal on short shoots, more or less erect; peduncles short, thick, curved; cones ovoid-conical to cylindrical, obtuse or truncate at apex, 3.5–5 cm long, 2–2.5 cm wide with opened scales; colour (immature) yellowish pubescent, almost hidden by purplish red bract scales, maturing to light or pale brown with purplish bracts. Seed scales ovate oblong or sub-orbicular, recurved when opened, 10–14 × 6–12 mm at mid-cone; abaxial surface densely pubescent when young, later glabrous, finely striated or smooth; upper margin entire, rounded, not incurved; base cuneate or narrowed. Bracts broad ligulate-lanceolate, narrowing into a long, caducous cusp, length 1.5 × seed scales, exserted, straight; cusps recurved. Seeds triangular or ovoid, flattened, 4 × 3 mm, light brown; seed wings ovate oblong, 8–10 mm long, light brown or rose-brown, tinged with red.

Distribution

Canada: SW Alberta, SE British Columbia; USA: N Idaho, W Montana, N Washington.
TDWG codes: 71 ABT BRC 73 IDA MNT WAS

Ecology

Larix lyallii is a subalpine larch which occurs at or near tree line, at elevations between 1520 m and 2440 m (max. 3020 m) a.s.l. It grows usually on shallow, rocky mountain soils, but occasionally on deeper, well drained soils if there are no competitive species. The climate is cold, with short, cool summers and long, snowy winters. It may occur in pure stands or mixed with e.g. *Abies lasiocarpa, Pinus albicaulis, P. flexilis, Picea engelmannii*, and *Tsuga mertensiana*, forming small groves near the tree line or scattered, solitary, stunted trees, sometimes surrounded by very little vegetation taller than alpine meadows.

Conservation

IUCN: LC

Uses

Due to its usually scattered occurrence at high altitude Subalpine larch has no commercial value as a timber tree. Its wood properties are similar to other larches. It establishes as a pioneer in avalanche chutes and can minimize the destructive impact of snow avalanches better than most other conifers. In horticulture, it is very susceptible to 'late' frosts and therefore seldom planted except in regions with long, consistently cold winters.

Larix mastersiana Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 19. 1914. *Larix griffithii* Hook. f. var. *mastersiana* (Rehd. & E. H. Wilson) Silba, Phytologia Mem. 7: 39. 1984. Type: China: Sichuan, Qionglai Shan, Wolong Reserve ["Kuan Hsien"], *E. H. Wilson 906* (holotype A).

Etymology

The epithet commemorates Maxwell T. Masters (1833–1907), a physician and honorary botanist at the Royal Botanic Gardens, Kew, who contributed much to the study of conifers.

Vernacular names

Masters larch; chuan hong shan (Chinese)

Description

Trees to 20–25 m tall, d.b.h. to 0.8 m; trunk monopodial, straight or curved; bark on trunk irregularly fissured and breaking into grey plates. Branches long, the topmost ascending, the lower spreading horizontally or descending; branches of second order slender, pendulous, but less so than those of *L. potaninii*; crown usually broad, domed in free standing trees, or more conical in forest stands. Branchlets long, slender, pendulous, yellowish or reddish brown, becoming grey, glabrous, or very young shoots sparsely pubescent; short shoots cylindric, with rings of revolute scale bases, 3–15 mm long. Vegetative buds conical or ovoid, 2 × 1.5 mm, resinous; bud scales triangular, light brown, shining. Leaves on on short shoots spirally, densely set in false whorls of 20–40, (1.2–)2–3(–3.5) cm long, 1 mm wide, narrowly linear, slightly wider near the obtuse to acutish apex, more or less rhombic in cross section, keeled on both sides, most clearly near base; stomata none or only a few faint lines above, in 2 narrow bands below; leaf colour bright green, yellow in autumn. Pollen cones terminal on short shoots, pedunculate, erect or pendant, 10–15 mm long, yellow. Seed cones terminal on short shoots, more or less erect from pendulous branches; peduncles curved, 5 mm long; cones ovoid-cylindrical, curved or straight; apex obtuse, 2.5–4.5 cm long, 1.5–2.5 cm wide with opened scales; colour (immature) greenish, with orange yellow bracts covering seed scales, maturing to light brown, with dark brown bracts, old cones dull, dark brown, with blackish bracts. Seed scales 30–40, obcordate-orbicular, convex, 6–10 × 7–12 mm at mid-cone; surface smooth or slightly striated, puberulent when young, later glabrous; upper margin entire, slightly emarginated, base very short pedicellate or cuneate. Bracts broad, lanceolate, exposed part triangulate, reflexed, with lacerate margins, cuspidate, 2–2.3 cm long, exserted. Seeds ovoid-cuneate, 3 × 2 mm, yellowish brown or light brown; seed wings obovate, 6–8 × 4–5 mm, light yellowish brown.

Distribution

China, W Sichuan (Motian Ling, Min River drainage, Jiajin Shan). Some localities based on collections made in the early decades of the twentieth century may no longer have any trees left; a recent survey found only the following three localities: Min River drainage, Dadu River drainage, and "upstream of Qingyijiang" (State Forestry Bureau, 2009).
TDWG codes: 36 CHC-SC

Ecology

Larix mastersiana is a high mountain species of rare occurrence, its altitudinal range is between 2000 m and 3500 m a.s.l. It grows in podzolic mountain soils, usually on steep slopes with good drainage. The climate is cold-temperate and moist. It has not been reported from climax forest with other conifers, but seems to be a tree thriving in secondary growth after forest clearing, as inferred from photographs by E. H. Wilson taken at the beginning of the 20th century [collection of the Arnold Arboretum, Mass., USA and a 4-volume photo-album entitled "Vegetation of Western China" (Wilson, 1912), copy in the Herbarium of the Natural History Museum at Paris].

Conservation

Exploitation beyond sustainability has led to serious decline of this species in the more accessible parts of its limited natural range. It is now largely confined to the steeper and higher localities where forest road building has not advanced. Recent Chinese policies to discontinue logging of the natural forests in western regions may halt or even reverse the decline.
IUCN: EN [A2cd; B2ab (ii–v)]

Uses

A timber tree used for construction, pit props, railway sleepers and furniture; the bark yields tannins. It has been over-exploited in its natural range, especially in more accessible localities. Outside China, where it is used in afforestation, this species is not in cultivation except for a few specimens in living tree collections (arboreta).

Larix occidentalis Nutt., N. Amer. Sylva 3: 143, t. 120. 1849. Type not designated.

Etymology

The species epithet means 'from the west'.

Vernacular names

Western larch

Description

Trees to 45–55(–65) m tall, d.b.h. to 1.5–2(–2.2) m; trunk monopodial, straight; bark on trunk scaly, rough, deeply fissured below, grey brown, old bark plates grey. Branches relatively short, slender, spreading horizontally or curved down below, assurgent towards the top; branches of second order short, stout, the smallest slender, drooping to pendulous; crown narrowly conical, especially so in old trees, dense or open. Branchlets slender, flexible, the longest becoming pendant, (pale) orange brown or reddish brown, turning grey, glabrous or sparsely pubescent when young; short shoots cylindrical, blackish grey, 4–15 mm long. Vegetative buds ovoid globose, 3 × 2 mm, resinous; bud scales triangular, dark reddish brown. Leaves on long shoots to 6 cm long, on short shoots spirally, close, in false whorls of (15–)30–40(–45), spreading radially, (1.5–)2–4(–4.5) cm long, 0.5–1 mm wide, narrowly linear, soft and flexible, in cross section triangular, flattened, keeled below; apex obtuse or acutish; hypostomatic, stomata in two narrow bands separated by a midrib or keel below; leaf colour bright green, later dull green, turning bright yellow in autumn. Pollen cones terminal on short shoots, 8–15 mm long, yellow. Seed cones terminal on short shoots, more or less erect from pendulous branches; peduncles 5–10 mm, curved; cones ovoid oblong or conical, with obtuse apex, 2.5–4(–6) cm long, 2–2.5(–3) cm wide with opened scales; colour (immature) purplish red, with green bract scales, maturing to violet-brown or reddish brown, finally light brown or grey-brown. Seed scales 35–45, cuneate-orbicular, emarginate at apex, or sometimes rounded, 8–14 × 08–12 mm at mid-cone; surface smooth, abaxial side finely striated, glabrous; upper margin entire, often deeply emarginated, base narrowed or short pedicellate. Bracts ligulate, tapering to an elongated cusp, length ca. 2 × seed scales, exserted with recurved cusps. Seeds ovoid-triangular, 3–4 × 2.5 mm, light brown, with dark spots; seed wings obliquely ovate, 6–9 × 4–5 mm, pale yellowish brown.

Distribution

Canada: Alberta, British Columbia; Pacific NW of USA: Oregon, Washington, Idaho, NW Montana.
TDWG codes: 71 ABT BRC 73 IDA MNT ORE WAS

Ecology

Larix occidentalis occurs in the mountains, at elevations between 600 m and 2100 m a.s.l., usually on grey brown, well drained podzolic mountain soils, which are moderately acid. The climate is cold, with cool summers and moist winters, the annual precipitation ranges from 450 mm to 875 mm, much of it falls as snow. It may occur in pure stands; in an initial stage after disturbance (e.g. fire) *Pinus contorta* var. *latifolia* can become dominant, followed by *P. ponderosa* in certain areas; later in the succession *P. monticola, Pseudotsuga menziesii, Abies grandis* and *A. lasiocarpa*, finally *Thuja plicata* and *Tsuga heterophylla* take their place. *Picea engelmannii* and *Tsuga mertensiana* occur mainly above *Larix occidentalis* and may be associated with *L. lyallii.*

Conservation

IUCN: LC

Uses

Western larch is an important timber tree. It can grow to great size with straight boles and grows rapidly in height though it takes longer to increase in girth. The wood is durable, hard and strong and used for long poles, railroad sleepers, mine timbers, fine veneer, and pulpwood for the paper industry. The resin from the wood has useful water soluble properties for a variety of industrial products especially applied in ink, paint and offset lithographic printing. The use of this species in amenity planting is limited, although some provenances should grow well in cooler climates.

Larix potaninii Batalin, Trudy Imp. S.-Peterburgsk. Bot. Sada 13: 385. 1894. PL. 20

Etymology

This species was named after the Russian botanist Grigorii N. Potanin (1835–1920), who travelled and collected in western China in the 1880's.

Vernacular names

Chinese larch; hong shan, hung sha (Chinese)

Description

Trees to 40–50 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight or curved; bark on trunk rough and scaly, dark brown in fissures, plates grey. Branches long, ascending or spreading, drooping at the ends; branches of second order long, slender, pendulous; crown (broad) conical or domed. Branchlets slender, firm, later long, flexible and pendulous, deep reddish brown or yellowish orange, with grey grooves, later grey, glabrous, or with some scattered hairs in the grooves; short shoots small, cylindrical, 3–5 × 3–8 mm. Vegetative buds ovoid globose, 3 × 2.5 mm, resinous; bud scales obtuse triangular, with erose margins, dark red brown. Leaves on short shoots spirally, dense, in false whorls of 20–40, 1.2–3.5 cm long, ca. 1 mm wide, narrowly linear, widest above the middle, soft, more or less triangular in cross section, flattened, keeled below, obtuse acutish at apex; stomata in several faint lines above, in two narrow bands below; leaf colour bright green, turning yellow in autumn. Pollen cones terminal on short shoots, ca. 10 mm long, yellow. Seed cones terminal on short shoots, erect from pendulous branches; peduncles short, curved; cones cylindrical or elliptical, obtuse at apex, (2.5–)3–5(–9) cm long, 1.5–2.5(–3.5) cm wide with opened scales; colour (immature) violet, with purple bracts, ripening to dark brown, with purplish black bracts. Seed scales 35–65(–80), sub-orbicular, 9–13 × 9–12 mm at mid-cone; surface finely striate or smooth, glabrous; upper margin entire or erose, round or truncate, not incurved, base very short pedicellate. Bracts broad ligulate-lanceolate; apex acute or mucronate-cuspidate, 1.2–2.2 cm × 4–5 mm, exserted, straight, dark purple or blackish, with lighter midrib. Seeds triangular-ovoid, slightly flattened, 3 × 2.5 mm, pale brown, with dark spots; seed wings ovate oblong, 6–8 × 4–5 mm, brown, tinged with purple.

Distribution

China: S Gansu, S Shaanxi, W Sichuan, NW Yunnan, E & S Xizang [Tibet]; Nepal.

TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHN-SA CHT 40 NEP

Ecology

Larix potaninii and its varieties are high mountain larches occurring between 2350 m and 4300 m altitude a.s.l. The soils are acidic mountain podzols. The climate is cold, the precipitation varies from 800 mm to 2000 mm annually according to location. At high elevations it grows often pure, with undergrowth of *Juniperus squamata*, elsewhere it is usually mixed with *Abies* spp., *Picea* spp., *Tsuga dumosa* or *T. chinensis, Cephalotaxus* spp. and *Taxus* spp.

Uses

Chinese larch is an important timber tree in the western mountains of China. Its wood is durable and can be used for construction purposes, mining props and railway sleepers, as well as milled for veneer and pulped for the paper industry. It is rarely used in forestry plantations outside China and for amenity planting. It is in cultivation only as specimen trees in some arboreta and pineta; most trees in Europe and the USA derived from seed collected by Ernest Wilson and other plant collectors early in the 20th century and often have not survived. There are numerous recent collections planted, however these are still confined to arboreta. This species should be planted more often in suitable regions (climate) as it has large, attractive cones with conspicuous upturned bracts.

4 varieties are recognized:

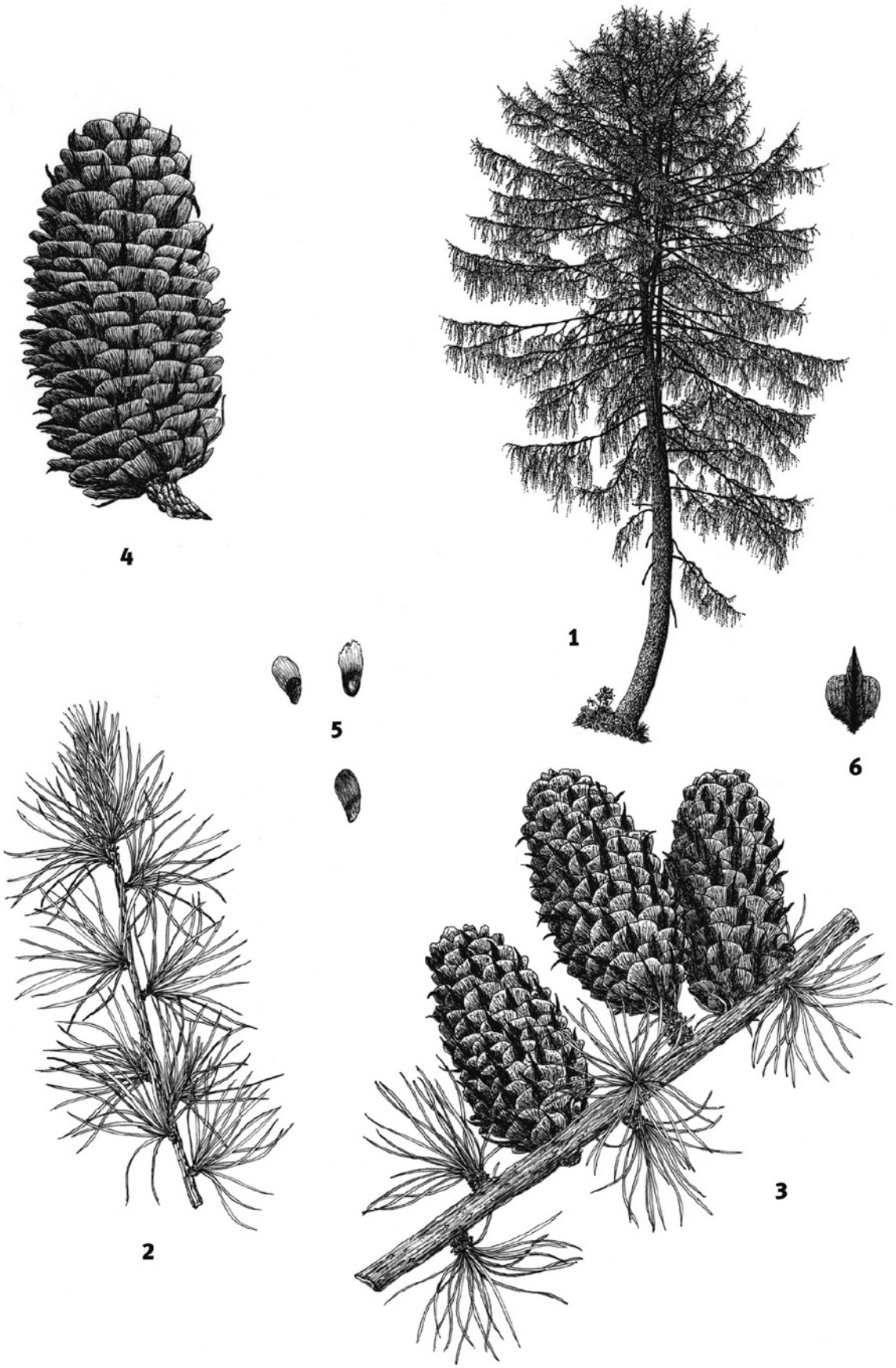


PLATE 20. *Larix potaninii*. **1.** Habit of tree. **2.** Branchlet with foliage. **3.** Branch with seed cones (var. potaninii). **4.** Seed cone (var. macrocarpa). **5.** Seeds. **6.** Seed scale with bract.

Larix potaninii Batalin var. ***potaninii***. Type not designated.

Description

Seed cones 3.5–5.5 cm long, 1.5–3 cm wide when scales are opened; seed scales 35–65 in number.

Distribution

China: S Gansu, S Shaanxi, W Sichuan, NW Yunnan, E Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHN-SA CHT

Conservation

IUCN: LC

Larix potaninii Batalin var. ***chinensis*** (Beissn.) L. K. Fu & Nan Li, Novon 7 (3): 262. 1997. *Larix chinensis* Beissn., Mitt. Deutsch. Dendrol. Ges. 1896 (5): 68. 1896, *non* Mill. (1768). Type: China: Shaanxi, ["northern Shanxi, Kuon-tou-san" (mountain)], *J. Giraldi 6* (lectotype K).

Description

Short shoots 3–4 mm diam., densely yellow pubescent. Seed cones 2.5–5 cm long, 1.5–2.8 cm wide when opened; seed scales striate abaxially.

Distribution

China, S Shaanxi (Taibai Shan, Foping Xian, Baoji Shi).
TDWG codes: 36 CHN-SA

Conservation

IUCN: VU (A2d)

Larix potaninii Batalin var. ***himalaica*** (W. C. Cheng & L. K. Fu) Farjon & Silba, Phytologia 68: 37. 1990. *Larix himalaica* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 84. 1975. Type: China, Xizang [Tibet], north side of Xomolungma [Mt. Everest], *Chinese collector No. 80A* (holotype PE).

Description

Seed cones max. 6.5 cm long; bracts mucronate cuspidate. Young shoots yellowish orange.

Taxonomic notes

In Flora of China 4: 34 (1999) this variety has been treated as a distinct species. The morphological differences appear to be of a quantitative and more or less gradual nature and it shares the typical upright bracts of *L. potaninii*.

Distribution

China: S Xizang [Tibet] (Gyirong River); Nepal (Langtang Khola).
TDWG codes: 36 CHT 40 NEP

Conservation

This variety apparently occupies a limited area as it is known with certainty only from two valleys in the Himalaya, one on the Chinese and one on the Nepalese side of the border. In Xizang [Tibet] it occurs in the valley of the Gyirong River (no protected status); in Nepal in Langtang National Park.
IUCN: NT

Larix potaninii Batalin var. ***macrocarpa*** Y. W. Law, Acta Phytotax. Sin. 13 (4): 84. 1975. Type: China: Yunnan, locality not known, *Chinese collector No. 9347* (holotype PE).

Description

Seed cones 5–8(–9) × 2.5–3.5 cm; seed scales 50–80 in number.

Distribution

China: SW Sichuan, NW Yunnan.
TDWG codes: 36 CHC-SC CHC-YN

Conservation

IUCN: LC

Larix sibirica Ledeb., Fl. Altaica 4: 204. 1833. *Larix decidua* Mill. var. *sibirica* (Ledeb.) Regel, Gartenfl. 20: 101. 1871; *Larix decidua* Mill. subsp. *sibirica* (Ledeb.) Domin, Acta Bot. Bohem. 10: 6. 1931. Type: Russia: Siberia, Altai Mts., *C. F. von Ledebour et al. s.n.* (holotype LE).

Pinus larix L. var. *russica* Endl., Syn. Conif.: 134. 1847; *Larix russica* (Endl.) Sabine *ex* Trautv., Trudy Imp. S.-Peterburgsk. Bot. Sada 9 (1): 212. 1884.

Etymology

The species epithet refers to its origin in Siberia.

Vernacular names

Siberian larch; Listvennitsa sibirskaya (Russian); xian bei luo ye song (Chinese)

Description

Trees to 30–40 m tall, d.b.h. to 1–1.5; trunk monopodial, straight or curved; bark on trunk light brown, rough and scaly. Branches spreading horizontally, near the top ascending; branches of second order slender, long, drooping or pendulous; crown broad conical, often irregular. Branchlets slender, flexible, pale yellowish, lustrous, usually glabrous or with minute pubescence in grooves; short shoots conical-globose or short cylindrical, 4–10 mm long. Vegetative buds ovoid, 3 × 2 mm, not resinous; bud scales ovate, more or less pubescent, dark greyish brown. Leaves on short shoots spirally, close, in false whorls of 20–40, (2–)2.5–4(–5) cm long, 0.5–1 mm wide, narrowly linear, soft, flexible, flattened, faintly keeled below, obtuse or acutish at apex; stomata in a few lines above, in two narrow bands below; leaf colour (light) green, turning bright yellow in autumn. Pollen cones terminal on short shoots, 5–10 × 5–6 mm, pale yellow. Seed cones terminal on short shoots, more or less erect from pendulous branches; peduncles thick, curved, 5–10 mm long; cones ovoid or subglobose, (2.5–)3–4.5(–5.5) cm long, (1.8–)2.5–3.5(–4) cm wide with opened scales; colour (immature) reddish or rose-green, ripening to (light) red-brown, old cones grey-brown. Seed scales 25–40, sub-orbicular to ovate, strongly convex or less so in transitional forms, 12–20 × 12–18 mm at mid-cone; surface smooth or slightly striated, in the typical form densely ferruginous pubescent, the exposed part of scales becoming glabrous with age; upper margin entire, rounded, truncate or slightly emarginate, usually incurved; base rounded or cuneate. Bracts ligulate-linear, length ¼-⅓ × seed scales, included. Seeds ovoid-cuneate, flattened, 5 × 3.5 mm, (light) brown with dark spots; seed wings oblique-ovate, 8–16 × 4–8 mm, lustrous red-brown or orange-brown.

Taxonomic notes

The correct name for this species is *Larix sibirica* Ledeb. (1833) as it is the earliest binomial published under *Larix* for this species. In my book *Pinaceae* (Farjon, 1990) I incorrectly used *L. russica* (Endl.) Sabine *ex* Trautv., based on *Pinus larix* L. var. *russica* Endl. (1847) as the accepted name. This name was also used in Dallimore & Jackson's well known Handbook of Coniferae and Ginkgoaceae (e.g. edition 4, 1966) and in other compilations of conifers. This species was long considered a mere form or variety of the European larch, *L. decidua*, first described as *Pinus larix* by Linnaeus (1753). When raised to species rank, it is compulsory to take up the earliest species epithet published for it, which was given by Ledebour in his Flora Altaica (*op. cit.*).

Distribution

Russia: from the White Sea to Lake Baikal in Siberia; China: Xinjiang (Altai Mts., E Tien Shan); Mongolia (Altai Mts.).
TDWG codes: 14 RUN RUE 30 ALT IRK KRA TVA WSB 36 CHX 37 MON

Ecology

Larix sibirica is common in the lowland taiga of W Siberia, where it forms the northern limit of trees alternately with *Picea obovata* and with *Pinus sylvestris*. It also occurs in the mountains (from 500 m to 2400 m a.s.l.). It grows on a great variety of soils, from peat bogs to well drained, sandy or rocky soils, where it has its optimum. The climate is very cold (min. temp. –55° C), continental or subarctic, dry, with very long winters. There are pure stands on peat or on mountains above the steppe (Altai Mts.), but more common it is mixed with *Pinus sylvestris, P. sibirica, Picea obovata, Abies sibirica* and broad-leaved trees such as *Betula pendula* and *Populus* spp.

Conservation

IUCN: LC

Uses

Siberian larch is an important timber tree in Russia. It is logged from natural coniferous forests as well as from plantations, which are established in Russia outside its natural range as well as in Finland, Poland and Sweden. The wood is durable and used in construction, traditionally for log houses in Siberia for which the wood is roughly hewn to shape, but untreated. It has been widely used for railroad sleepers e.g. on the famous Trans Siberian Railroad. Larch wood is also milled for construction timber and veneer and pulped for the paper industry. Siberian larch is in cultivation as an amenity tree, but it is vulnerable to 'late' frosts in climatic zones with mild, fluctuating winter temperatures. For this reason it is not used in western Europe but successfully planted in central and eastern Europe, in Scandinavia, and as far afield as Iceland. A few cultivars are known, but with limited distinction from habit forms that also occur in nature.

Lepidothamnus Phil., Linnaea 30: 730. 1861. Type: *Lepidothamnus fonkii* Phil. (*Podocarpaceae*).

Greek: *lepis, lepidos* = scale; *thamnos* = bush, shrub.

Description

Creeping or erect (dwarf) shrubs or trees, dioecious or sometimes monoecious, evergreen. Resin canals in leaves absent (unique in family). Bark on trees thin, with minute lenticels, becoming scaly and flaking. Branching irregular, ascending in trees. Leaves spirally arranged or opposite-decussate in juvenile plants, dimorphic, with linear, spreading juvenile leaves usually gradually giving way to subulate, decurrent leaves and finally appressed, keeled, ovate-rhombic and gibbous scale leaves. Stomata on all sides (leaves amphistomatic). Pollen cones terminal or sometimes lateral and axillary on scale-leaved branchlets, solitary, short cylindrical; microsporophylls spirally inserted, triangular, with two globose pollen sacs at base containing bisaccate pollen. Seed cones terminal, solitary, very small, consisting of 3–5 bracts slightly larger but similar to scale leaves, becoming distinct by colouring yellow or reddish, swelling to become succulent or not, 1–2 bracts fertile with an erect, axillary ovule. Seeds 1 per cone, maturing in the second year, ovoid, not compressed, ripening to lustrous purplish brown or black and surrounded at base by a membranous, greenish sheath formed by the epimatium.

3 species.

Distribution

S Argentina; S Chile; New Zealand.

Key to the species of *Lepidothamnus*

1a. Erect shrubs or small trees to 15 m tall ***L. intermedius***

1b. Prostrate, creeping or sometimes erect dwarf shrubs to 50 cm tall **2**

2a. Adult scale leaves on ultimate branchlets 1–1.5 × 1 mm, slightly keeled. Native in New Zealand ***L. laxifolius***

2b. Adult scale leaves on ultimate branchlets 1.5–3 × 1–1.5 mm, strongly keeled to gibbous. Native in Chile and Argentina ***L. fonkii***

Lepidothamnus fonkii Phil., Linnaea 30: 731. 1861. *Dacrydium fonkii* (Phil.) Benth. & Hook. f., Gen. Pl. 3 (1): 433. 1880. Type: Chile: Aisén, Archipelago de los Chonos, *F. Fonk 263* (holotype SGO). Fig. 162

Etymology

This species was named after Francis Fonk, who collected the type specimen in 1857.

Vernacular names

Chilean pygmy cedar, Chilean rimu [rimu is the Mauri (New Zealand) name for *Dacrydium cupressinum*]; ciprés enano (Spanish).

Description

Dioecious or occasionally monoecious dwarf shrubs to 50 cm tall, creeping or sometimes more or less erect. Stems mostly decumbent, with foliage branches ascending to erect. Juvenile leaves restricted to seedlings, decurrent, often distichous, acicular, 4–6 mm long, bilaterally flattened, slightly curved, acute. Adult leaves spirally arranged, on leading branches scale-like, appressed, ovate-oblong, keeled towards apex, 4–7 mm long, 2–3.5 mm wide, on ultimate branchlets scale-like, imbricate, 1.5–3 mm long, 1–1.5 mm wide, strongly keeled to gibbous towards the distal part of branchlets, with membranous margins; apex slightly incurved, obtuse. Stomata on adaxial side of juvenile leaves numerous from base to apex, only a few short lines on abaxial side near base, on adult leaves conspicuous on abaxial side, scattered but mostly absent on keel and apex. Pollen cones solitary, terminal, sessile, 5–6 × 1.5–2 mm; microsporophylls 12–16, triangular, with acute apex and two reddish basal pollen sacs. Seed cones solitary, terminal, consisting of 3–5 leaf-like bracts with a narrow

base, distal 1–2 bracts fertile. Bracts may or may not fuse and swell to form a succulent, red receptacle. Seeds at base enclosed by a membranous epimatium, 4–5 mm long, ovoid-oblong with an apiculate apex, maturing to dark brown or black.

Distribution

S Argentina: Chubut, Santa Cruz; S Chile: Aisén, Los Lagos, Magallanes.
TDWG codes: 85 AGS-CB AGS-SC CLS-AI CLS-LL CLS-MG

Ecology

This dwarf conifer occurs in *Sphagnum* bogs and moorlands; its stems are usually hidden in moss or other vegetation and only upright foliage branches protrude. It can form quite extensive low thickets that exclude all or most other plants, rooting on the decumbent stems. Its altitudinal range varies with latitude as it occurs roughly between 40° S and 55° S, between 900 m in the north to near sea level in the south. In the north it is growing in bogs in forested areas with *Pilgerodendron uviferum, Fitzroya cupressoides* and *Nothofagus antarctica*. The latter 'antarctic beech' is virtually the only tree at its southern limit, in between *Pilgerodendron uviferum* also occurs frequently. Sedges (*Carex* spp.) and other plants characteristic of these bogs are also common.

Conservation

This species is threatened mainly in the northern part of its range, where it is associated with *Fitzroya cupressoides* and/or *Pilgerodendron uviferum*. As a result of extensive exploitation of these tree species, habitats have been modified (usually drained at minimum, in many areas converted to pasture). However, it is unlikely that similar habitat degradation has occurred where these conifer tree species are either absent (*Fitzroya cupressoides*) or of a smaller stature no longer of interest for their timber. This is the case in the southern part of the range (Magallanes) of *L. fonkii* and it can be assumed that the species is there fairly safe. What is less well known is its overall abundance in this botanically little explored, remote region and what proportion of the total area of occupancy (AOO) these occurrences represent. A comprehensive geographical survey of this species (not an easy task given the vastness and remoteness of the Chilean southern archipelago) is wanting.
IUCN: LC

Uses

There are no economic uses of this species. In cultivation it is only represented in a few botanic gardens and perhaps an occasional private collection. It should make an interesting and quite hardy ground covering, evergreen conifer shrub in wet areas around ponds or lakes, but, judging from its natural habitat, evidently prefers low pH water and substrate and a paucity of nutrients.

Lepidothamnus intermedius (Kirk) Quinn, Austral. J. Bot. 30 (3): 316. 1982. *Dacrydium intermedium* Kirk, Trans. New Zealand Inst. 10: 386. 1878. Type: New Zealand: South Island, Westland, Hokitika, *T. Kirk 806* (syntype K, lectotype not designated).

Dacrydium intermedium Kirk var. *gracilis* Kirk, Trans. Proc. New Zealand Inst. 17: 224. 1885. Type: New Zealand: Stewart Island, Ruggedy, *T. Kirk 1072* (lectotype K, designated here).

Etymology

The species epithet refers to intermediacy of characters compared to other species of *Lepidothamnus*.

Vernacular names

Yellow silver pine

Description

Shrubs or small trees to 15 m tall; trunk to 60 cm d.b.h., often multi-stemmed. Bark on larger trunks exfoliating in irregular, thin flakes; freshly exposed bark purplish brown, older patches turning dull brown and finally grey-white, densely pitted with brown dots. Branches ascending, forming a broad, rounded and more or less open crown. Juvenile leaves on seedlings and young plants, distinct from adult leaves (but intermediate forms occur), acicular, spreading at near right angles to shoot, 6–8(–10) mm long, more or less four-ranked, straight or slightly curved, slightly bilaterally flattened, tapering to an acute apex. Intermediate leaves shorter, 3–5

mm long, triangular in cross-section, tapering to an acute or apiculate apex. Adult leaves gradually appearing above these, decurrent at base, spreading towards the free apex on most vegetative branchlets, appressed on ultimate branchlets with seed cones or on dense sun-exposed foliage of old trees, 1.2–2 × 1 mm (appressed leaves 1 × 1 mm), keeled abaxially, obtuse. Stomata on all sides of juvenile and adult leaves, in two indistinct bands separated by the keel on adult leaves. Pollen cones terminal, sessile, cylindrical, 5–6 × 2 mm; microsporophylls triangular with a constricted, more or less free apex, with two basal red pollen sacs. Seed cones terminal, consisting of a short axis with 4–6 leaf-like bracts which turn yellow, the distal one fertile, not swelling. Seeds surrounded at base by a drying epimatium with erose margin, erect, ovoid, 4–5 × 2.5 mm, constricted at apex, green ripening to lustrous purplish black.

Taxonomic notes

Thomas Kirk described and named *Dacrydium intermedium* var. *gracilis* from Stewart Island. At K there are three small specimens on one sheet alledgedly collected by him and numbered 1071–1073. The collecting date of *No. 1071* is given as December 1883 but Kirk visited the island only twice, in January 1882 and again in January 1884. *Nos. 1072* and *1073* are undated as to collection time but were "communicated" in May 1884. These can have been collected by Kirk in January 1884 and then sent to J. D. Hooker at Kew. Brian Molloy selected *No. 1072* as the lectotype of Kirk's variety on this sheet in September 1991 and that specimen is here designated as the lectotype of *D. intermedium* var. *gracilis* Kirk. Both of us have concluded upon examination that this variety is not taxonomically different from the species, *Lepidothamnus intermedius* (Kirk) Quinn.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Lepidothamnus intermedius is most common on Stewart Island, where it forms the main shrub or tree in swamp forests. On the west coast of South Island and in North Island it is more scattered and grows in boggy terrain on slopes and sometimes on hill summits and ridges to ca. 900 m a.s.l. The species is accompanied by tall shrubs or tussock grasses and the 'grass trees' *Dracophyllum latifolium* or *D. pyramidale* on Great Barrier Island.

Conservation

IUCN: LC

Uses

The wood of the Yellow silver pine was formerly used for railway sleepers and telegraph poles due to its strength and durability. It is reddish yellow and contains much resin in the sapwood, which probably renders it highly flammable. As with most other native trees in New Zealand, commercial exploitation has ceased after most of the lowland forests were destroyed and is now prohibited. This species is very rare in horticultural cultivation, it may be present in a few botanic gardens in New Zealand and abroad; in colder climates it would likely only grow under glass, but in milder ones it may be more or less hardy depending on provenance.

Lepidothamnus laxifolius (Hook. f.) Quinn, Austral. J. Bot. 30 (3): 316. 1982. *Dacrydium laxifolium* Hook. f., London J. Bot. 4: 143. 1845. Type: New Zealand: North Island, Wellington, Tongariro N.P., Tongariro Volcano, near the summit, *J. C. Bidwill 5; W. Colenso 60* (syntypes K, lectotype not designated). Pl. 21

Etymology

The species epithet means 'with soft (lax) leaves', but the leaves are rather stiff. It may instead describe the foliage shoots.

Vernacular names

Pygmy pine

Description

Low, usually prostrate dioecious or monoecious dwarf shrubs forming mats or trailing through vegetation. Stems slender, creeping, rarely sub-erect, to

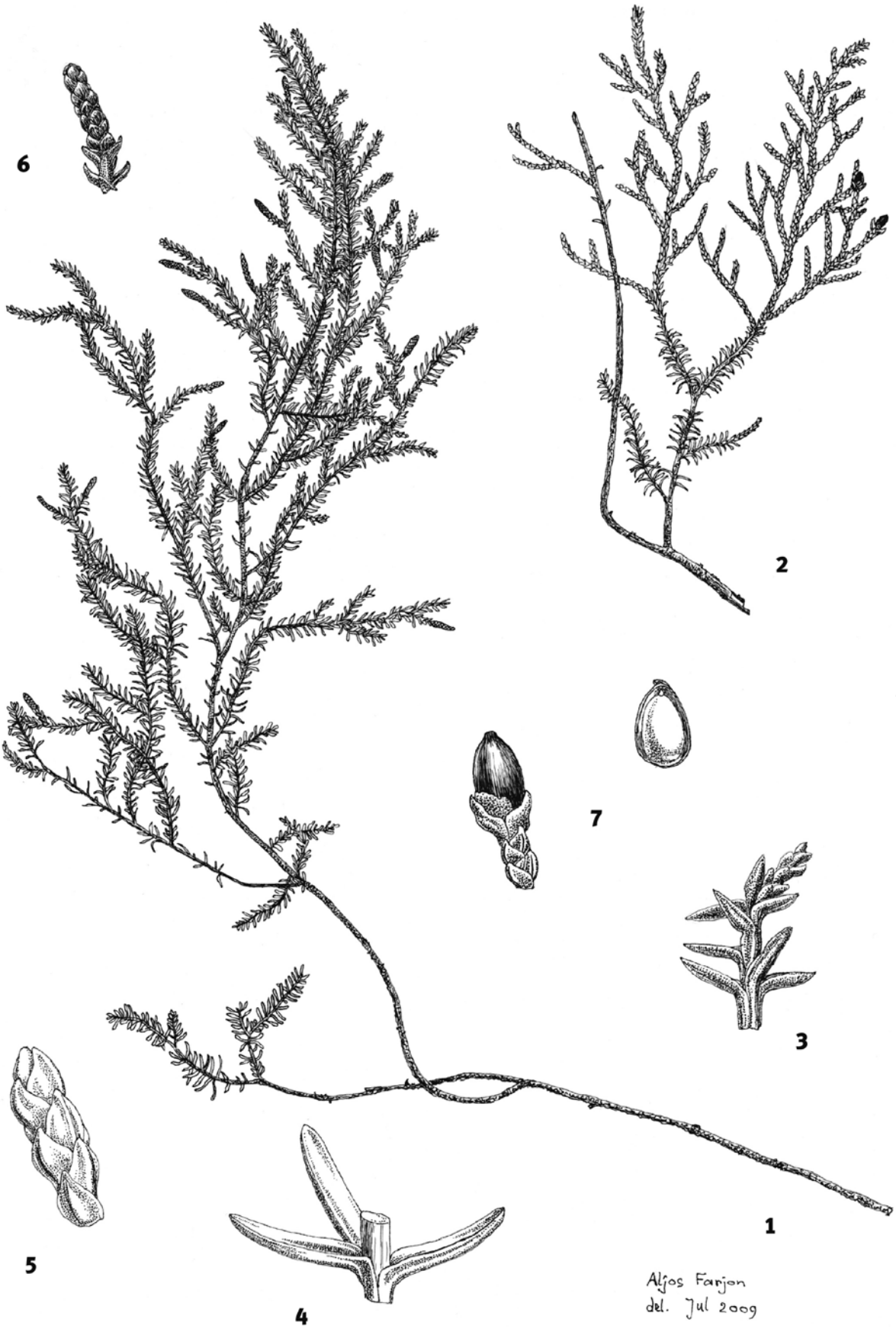


PLATE 21. *Lepidothamnus laxifolius*. **1.** Habit of shrub. **2.** Branch with foliage and seed cones. **3.** Branchlet with juvenile leaves. **4.** Juvenile leaves. **5.** Adult leaves. **6.** Pollen cone. **7.** Seed cone and seed.

1 m long, occasionally branching. Foliage branches very slender and flexuous, 1–2 mm thick, spreading or ascending, sparse or more crowded. Leaves of two types, juvenile and adult (intermediates occur), often mixed on a single leading branch but adult leaves distal from juvenile leaves. Juvenile leaves alternate, subulate to linear, stiff and spreading at more or less right angles to shoot, 3–8 mm long, keeled abaxially, flat or slightly concave adaxially, obtuse. Transitional leaves shorter but similar, 1.5–3 mm long, spreading at less than 90°. Adult leaves spirally arranged, imbricate, appressed, oblong-ovate, 1–1.5 × 1 mm, slightly keeled, obtuse. Stomata on juvenile leaves numerous on adaxial side, in two sparse bands on abaxial (keeled) side; scattered on adult leaves. Pollen cones solitary, terminal, sessile, 5–7 × 2 mm; microsporophylls broadly triangular with acute-apiculate apex and two basal red pollen sacs. Seed cones solitary, terminal, consisting of a short axis with 3 slightly spreading bracts that fuse and swell to a globose, succulent (but sometimes dry and not swollen) receptacle and turn orange-red. Seeds enclosed at base by an epimatium, 4–5 mm long, ovoid-oblong, with a small, curved apiculus, ripening brown or purplish brown with longitudinal lighter striations.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Lepidothamnus laxifolius is one of the smallest conifers. It occurs in moorlands, peat bogs, and tussock grass slopes in the mountains, usually between 750 m and 1200 m a.s.l., on Stewart Island down to sea level. It can form extensive mats creeping over rocks and long runners trailing through the vegetation. It is associated with tussock grass (*Chionochloa rubra*) and with *Halocarpus bidwillii, H. biformis, Podocarpus nivalis, Hebe* (*Veronica s. l.*), *Olearia, Dracophyllum, Pseudopanax, Gleichenia, Phormium*, and other shrubby plants and ferns.

Conservation

IUCN: LC

Uses

Pygmy pine has no commercial value, but would be an interesting and probably excellent dwarf shrub for rock gardens. It is currently only present in a few botanic gardens and perhaps an occasional private collection. With plants only 7–8 cm long known to have borne ripe seeds, it may well be the smallest conifer species known.

Libocedrus Endl., Syn. Conif.: 42. 1847. Type: *Libocedrus plumosa* (D. Don) Sarg. [*Dacrydium plumosum* D. Don] (*Cupressaceae*).

Stegocedrus Doweld, Novosti Sist. Vyssh. Rast. 33: 42. 2001. Type: *Stegocedrus austrocaledonica* (Brongn. & Gris) Doweld [*Libocedrus austrocaledonica* Brongn. & Gris].

Greek: *libos* = tear, drop (referring to resin exudations); *Cedrus* is the classical name for (true) cedars.

Description

Shrubs or trees to 35 m, evergreen, monoecious, multistemmed or monopodial. Bark scaly, exfoliating in longitudinal strips or plates, reddish brown or brown. Branches spreading or ascending, forming a pyramidal, conical or bushy crown. Foliage branches frondose and plagiotropic, sometimes more irregularly disposed, spreading or ascending. Leaves scale-like, decussate, decurrent, imbricate, strongly dimorphic on flattened (pen)ultimate branchlets, facials smaller than laterals or nearly equal in size; facials rhombic, 1–5 mm long; laterals divergent, 2–7 mm long, conduplicate, falcate, both eglandular; margins entire; apex free or appressed, obtuse to acute; stomata predominantly in conspicuous bands on underside of branchlets. Pollen cones terminal, solitary, 2.5–10 × 2–3.5 mm; microsporophylls 8–24, decussate, peltate, bearing 4(–6) abaxial pollen sacs. Seed cones terminal on flattened or quadrangular branchlets, subtended by 4–5 transitional leaf pairs, 8–18 mm long; bract-scale complexes forming the cone in 2 decussate pairs; upper fertile pair of scales spreading at maturity, with a long subapical bract tip; lower pair similar but smaller; columella a small spike. Seeds 1–4 per cone, with 2 very unequal wings. Seedlings with 2 cotyledons.

5 species.

Distribution

New Zealand, New Caledonia.

Taxonomic notes

Phylogenetic relationships among genera in *Cupressaceae* based on DNA sequence data have only more recently been analysed. Based on *rbc*L sequences (Gadek & Quinn, 1993; Brunsfeld *et al.*, 1994) and on *mat*K sequences (Gadek *et al.*, 2000) it was found that there is no close relationship between *Libocedrus s. str.* and *Calocedrus*, the northern hemisphere genus that was long included. Phylogenetic analysis based on morphology as well as on "combined data" (Gadek *et al.*, 2000) confirmed this, so there is strong support for at least the separation of these two. Phylogenetic relationships are much closer with the southern hemisphere taxa, but how close and with which taxa has not been unambiguously demonstrated. Here the data have so far produced conflicting results in phylogenetic analysis. Molecular data have placed *Pilgerodendron* nested within *Libocedrus* (Gadek *et al.*, 2000) but morphology did not (Hill & Brodribb, 1999; Farjon, 2005a).

Key to the species of *Libocedrus*

Leaves should be examined on ultimate branchlets of full grown, not young plants.

1a. Large trees. Pollen cones with 8–14 microsporophylls. Native to New Zealand **2**

1b. Shrubs or small trees. Pollen cones with 16–24 microsporophylls. Native to New Caledonia **3**

2a. Ultimate branchlets more or less quadrangular, with facial leaves only slightly smaller than lateral leaves. Free part of the bract a third of the size of the seed cone scale and not exceeding beyond the cone scale ***L. bidwillii***

2b. Ultimate branchlets remain flattened, with facials less than half the size of laterals. Free part of the bract half the size of the seed cone scale and exceeding beyond the cone scale ***L. plumosa***

3a. Leaves on ultimate branchlets of nearly equal size. Lower pair of seed cone scales only slightly smaller than upper pair ***L. chevalieri***

3b. Leaves on ultimate branchlets very unequal in size. Lower pair of seed cone scales much smaller than upper pair **4**

4a. Apex of facial leaves not reaching the next facial leaf above, obtuse. Bract of lower, smaller seed cone scales twice as long as these ***L. austrocaledonica***

4b. Apex of facial leaves reaching the next facial leaf above, apiculate. Bract of lower, smaller seed cone scales as long as these ***L. yateensis***

Libocedrus austrocaledonica Brongn. & Gris, Bull. Soc. Bot. France 18: 140. 1871. *Stegocedrus austrocaledonica* (Brongn. & Gris) Doweld, Novosti Sist. Vyssh. Rast. 33: 42. 2001. Type: New Caledonia: Grande Terre, Province Sud, Mont Humboldt, *B. Balansa 2503* (holotype P).

Etymology

The species epithet refers to its (predominant) occurrence in the southern part of New Caledonia.

Vernacular names

No common names have been recorded for this species.

Description

Shrubs or small trees 2–4(–6) m tall, multistemmed or sometimes monopodial, diam. ca. 10 cm. Bark rough and scaly, reddish brown, exfoliating in longitudinal thin fibrous strips or plates. Branches sparse, slender, spreading, foliage branches more numerous, spreading nearly horizontally, forming a narrowly conical crown in young trees but irregular in shrubs. Foliage frondose, ultimate branchlets opposite, of equal length but towards end of foliage branches gradually shortening, entirely covered with leaves, persistent. Leaves decussate, on leading shoots long decurrent, on lateral (ultimate) branchlets adnate at base, imbricate, strongly dimorphic, facials small, visible part 1–2 mm, rhombic-apiculate, keeled, appressed, partly covered at base by much larger 3–6(–7) × 1.5–3 mm, divergent, bilaterally flattened, falcate laterals with scarious margins; amphistomatic, stomata on facials near base, on laterals much reduced on upperside, in a conspicuous band on underside, upperside lustrous olive green or slightly glaucous, underside with glaucous white stomatal band. Pollen cones terminal, solitary, (ovoid-)oblong, 5–8 × 2–2.5 mm; microsporophylls decussate, 16–24, peltate with acute apex, weakly keeled, with entire margins, bearing 4 small abaxial yellow pollen sacs. Seed cones terminal on flattened branchlets, developing within one growing season to become thin woody, 10–12 mm long. Bract-scale complexes 6–8 × 3–5 mm, slightly rugose, spreading free parts of the bracts 5–7 × 1 mm on laterals and 8–10 × 1.5 mm on facials. Columella a small spike ca. 1 mm long. Seeds 1–2, ovoid-oblong, slightly flattened, with an acute to bifid apex, 5–6 × 2.5 mm, light brown, with 2 opposite, thin membranous wings, the smaller a narrow strip less than 1 mm wide, the larger oval-oblong, 6–8 × 2.5–3 mm, yellowish brown.

Distribution

New Caledonia: Province Sud, Province Nord (Mt. Paéoua).
TDWG codes: 60 NWC

Ecology

In low, shrubby rain forest on exposed ridges of the higher mountains at altitudes between 750 m and 1400 m a.s.l., with *Falcatifolium taxoides, Neocallitropsis pancheri, Podocarpus* spp. *Prumnopitys ferruginoides* and here and there emergent *Araucaria humboldtensis*; also with various angiosperms e.g. *Myrtaceae, Trimeniaceae*, and *Winteraceae*, with a well developed understorey of mainly ferns and abundant epiphytic mosses and lichens. The soils are mostly skeletal, strongly humic and very acid; this species seems to avoid ultramafic rock types. Rainfall above 1000 m altitude usually exceeds 3500 mm and the vegetation remains under a blanket of cloud most of the time. Temperatures in these tropical mountains are therefore substantially cooler than at lower altitudes.

Conservation

This species is restricted to high mountains in southern New Caledonia and one mountain in the north. The populations are small; regeneration seems to be absent in the northern locality. Wildfires and mining operations (there is a causal relationship between the two through access roads to remote areas) are the major causes of threat. Substantial populations are protected in the Parq National de la Rivière

Bleue; protection of the population on Mt. Paéoua in Province Nord is urgent as it occurs near a mining concession.
IUCN: NT

Uses

No uses have been recorded of this species and, apart from a few plants in botanic gardens, it is not known to be in cultivation.

Libocedrus bidwillii Hook. f., Handb. New Zealand Fl. 1: 257. 1864 Type: New Zealand: South Island, Marlborough, Richmond Range, ["Nelson Mts."], *J. C. Bidwill [ex herb. W. J. Hooker] 126* (holotype K).
Fig. 163, 164

Etymology

This species was named after John C. Bidwill (1815–1853), who was an early botanical collector in New Zealand and has sent many specimens to William Hooker, the first Director at the Royal Botanic Gardens, Kew.

Vernacular names

Cedar; pahautea (Maori)

Description

Trees to 25(–28) m tall, monopodial, d.b.h. to ca. 1–1.5 m. Bark thin, scaly, greyish brown, exfoliating in longitudinal thin strips. Branches long, spreading or ascending, foliage branches numerous, arranged in dense tufts above each other, forming a pyramidal crown in young trees, conical or irregular with a clear bole in forest stands. Foliage in flattened sprays in young trees, in old trees more irregular and ascending, ultimate branchlets subopposite to alternate, 5–40 mm long, entirely covered with leaves, changing with age of plant from flattened to more or less quadrangular, persistent. Leaves decussate, on lateral (ultimate) branchlets short decurrent, imbricate, dimorphic in young trees, with facials small, rhombic, 1.5–2 × 1 mm, apiculate to acute, appressed, partly covered at base by larger 2–4(–6) × 1.5–2.5 mm, divergent, bilaterally flattened, slightly curved laterals with entire margins and free apices, leaves on older trees smaller and nearly monomorphic; amphistomatic, stomata on facials near base, on laterals much reduced on upperside, in a short, conspicuous band on underside, upperside dull (dark) green, underside with whitish green stomatal band. Pollen cones terminal, solitary, subglobose to ovoid, 2.5–5 mm; microsporophylls decussate, 8–10(–14), peltate, with entire margins, bearing 4 abaxial yellow pollen sacs. Seed cones terminal on branchlets with monomorphic leaves of equal size; upper pair of leaves developing within one growing season, becoming thin woody, together 8–12 mm long. Bract-scale complexes 7–10 mm long, slightly rugose, recurved in upper half above abaxially exserting bract tip, subtended by the lower, smaller (3–4 mm) less modified pair. Columella present, in mature cones a small spike 1–2 mm long. Seeds 2–4, ovoid, flattened, with an acute apex, 2–3 mm long, brown, with a whitish hilum and 2 opposite, thin membranous wings; smaller wing a narrow strip less than 1 mm wide; larger wing irregularly oval-oblong, 4–5 × 2–3 mm, yellowish brown.

Distribution

New Zealand: North Island, South Island.
TDWG codes: 51 NZN NZS

Ecology

Libocedrus bidwillii is a co-dominant or canopy emergent tree in montane-subalpine evergreen rainforests of the mixed angiosperm-conifer class, growing together with the podocarps *Dacrydium cupressinum* (at lower altitudes), *Halocarpus biformis, Phyllocladus trichomanoides* var. *alpinus*, and *Podocarpus cunninghamii*. Frequent angiosperm trees are *Metrosideros umbellata, Nothofagus solandri, Quintinia acutifolia* and *Weinmannia racemosa*. *Libocedrus bidwillii* is a good example of a long-lived conifer (max. 800–1000 years) dependent for regeneration on stand-replacing episodal disturbances. The altitudinal range is from 250 m to 1370 m a.s.l. The soil in these forests has a high organic content and is usually saturated with water. In many places at higher altitudes the forest is confined to drainage systems, surrounded by peaty moorland dominated by tussock-forming sedges. The climate is superhumid,

with high rainfall and frequent fog, summers are short and cool.

Conservation

This species is not currently threatened with extinction. Nearly all remaining natural 'old-growth' stands are now protected, but decline is likely to have occurred.
IUCN: NT

Uses

The reddish wood of this species is not very valuable for timber as it splits easily. As an ornamental tree it has been planted more often than *Libocedrus plumosa*, the lowland species of New Zealand, but it remains restricted to arboreta and other tree collections in large gardens.

Libocedrus chevalieri J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 283. 1949. *Stegocedrus chevalieri* (J. T. Buchholz) Doweld, Novosti Sist. Vyssh. Rast. 33: 42. 2001. Type: New Caledonia: Grande Terre, Province Sud, Mont Humboldt, *J. T. Buchholz 1567* (holotype ILL).

Etymology

This species was named after L. Chevalier, who collected plants in New Caledonia in the 1940s and 1950s.

Vernacular names

No common names have been recorded for this species.

Description

(Spreading) shrubs or small trees 2–5 m tall, multistemmed or sometimes monopodial, diam. ca. 10 cm. Bark rough and scaly, brown, exfoliating in thin irregular strips or plates. Branches numerous, ascending, forming a dense, bushy, often rounded crown. Foliage more or less frondose, forming dense sprays, ultimate branchlets alternate to subopposite, of nearly equal length but towards end of foliage branches gradually shortening, 2–5 cm long, rhombic in cross-section, slightly flattened, 3–4 mm wide, entirely covered with leaves, persistent. Leaves decussate, on leading shoots broad decurrent, especially laterals apically recurved or spreading, on ultimate branchlets imbricate, weakly dimorphic to nearly monomorphic; facials and laterals nearly equal in size, 2.5–5 × 2–2.5 mm; facials triangular-rhombic, appressed, keeled near apex, apiculate, partly covered at base by bilaterally flattened, apically more or less recurved laterals with acute-acuminate apex; amphistomatic, stomata on facials near the base, on laterals more conspicuous, more or less equally distributed on both faces; leaf colour (light) green, often with reddish brown in older leaves. Pollen cones terminal, solitary, cylindrical, 8–10 × 2.5–3.5 mm; microsporophylls decussate, 16–24, peltate with apiculate apex, weakly keeled, with entire margins, bearing 4(–6) small abaxial yellow pollen sacs. Seed cones terminal on branchlets, developing within one growing season to become thin woody, (10–)12–16 mm long. Bract-scale complexes slightly different in size, with upper pair 10–14 × 5–7 mm and lower pair 10–12 × 3–4 mm, slightly rugose, excluding the spreading free parts of the bracts which are 6–8 × 1 mm on the larger pair and 5 × 1 mm on the smaller pair. Columella a small spike ca. 1 mm long. Seeds 1–2, ovoid-oblong, slightly flattened, with an acute apex, 5–6 × 2.5 mm, yellowish brown, with 2 opposite, thin membranous wings; smaller wing a narrow strip less than 1 mm wide; larger wing oval-oblong, 8–10 × 3–4 mm, often curved, yellowish brown.

Distribution

New Caledonia: Province Sud (Mt. Humboldt, Mt. Kouakoué), Province Nord (Poindimié).
TDWG codes: 60 NWC

Ecology

On slopes near the summits of some of the highest peaks in usually steep terrain covered by a 2–5 m tall 'maquis' vegetation, in the contact zone between schists and serpentines. The altitudinal range is from 650 m to 1620 m a.s.l. These mountain summits receive high levels of precipitation.

Conservation

This rare species is known from only three very small populations on isolated mountain summits, where growth is slow and regeneration poor. There is risk of wildfires even though two of the three populations are within floristic reserves. There is a likelihood of mining in the unprotected area.
IUCN: CR [B1ab(iii)]

Uses

No uses are recorded of this species; it is grown in only a few botanic gardens, as young plants in research greenhouses.

Libocedrus plumosa (D. Don) Sarg., Silva N. Amer. 10: 134. 1896. *Dacrydium plumosum* D. Don, in Lambert, Descr. Pinus, ed. 3, App.: –. 1832. Type: New Zealand: locality unknown, *A. Cunningham 330* (neotype K). Fig. 165

Etymology

The species epithet (Latin *plumosus*) means 'feathery' and refers to the appearance of the foliage.

Vernacular names

New Zealand cedar; kawaka (Maori)

Description

Trees to 30(–35) m tall, monopodial, d.b.h. to 2–3 m. Bark thin, scaly, light brown to greyish brown, exfoliating in longitudinal, ca. 10 cm wide, thin strips. Branches long, spreading or ascending, foliage branches numerous, spreading, arranged in dense sprays above each other, forming a pyramidal crown in young trees, conical, rounded or irregular with a clear bole in forest stands. Foliage in flattened sprays except in cone-bearing branches, ultimate branchlets subopposite to alternate, 15–35 mm long, entirely covered with leaves, flattened, 2–6 mm wide, persistent. Leaves decussate, on lateral (ultimate) branchlets short decurrent, imbricate, dimorphic, with facials small, rhombic, 1–2 × 1 mm, apiculate to acute, appressed, partly covered at base by larger 2–5(–6) × 1.5–2 mm, divergent, bilaterally flattened, slightly curved laterals with entire margins and free apices, leaves on older trees smaller and nearly monomorphic; amphistomatic, stomata on facials near base, on laterals in a small groove on upperside, in a broad, conspicuous band of irregularly but densely arranged stomata on underside; upperside green, underside with whitish green stomatal band. Pollen cones terminal, solitary, subglobose to ovoid, 3–5 mm; microsporophylls decussate, 8–12, peltate, with entire margins, bearing 4 abaxial yellow pollen sacs. Seed cones terminal on branchlets with weakly dimorphic leaves of nearly equal size, developing within one growing season to become thin woody, 12–18 mm long. Bract-scale complexes 10–15 mm long, with upper pair slightly recurved in distal half and with an obtuse to truncate apex, subtended by the smaller (5–9 mm) acute pair, each with long excerted, reflexed and upcurved bract tips and finely rugose abaxial surface. Columella present in mature cones, a small conical spike 2–3 mm long. Seeds 2–4, ovoid, flattened, with an acute apex, 3–5 mm long, brown, with a whitish hilum and 2 opposite, thin membranous wings; smaller wing a narrow strip less than 1 mm wide; larger wing irregularly oval-oblong, 6–8 × 3–4.5 mm, yellowish brown.

Distribution

New Zealand: North Island, in South Island restricted to the Tasman District.
TDWG codes: 51 NZN NZS

Ecology

This species occurs in the lowland evergreen rainforests of the mixed angiosperm-conifer class, where it is a canopy tree with other conifers, e.g. *Dacrycarpus dacrydioides, Dacrydium cupressinum, Halocarpus kirkii, Manoao colensoi, Phyllocladus trichomanoides, Podocarpus cunninghamii, P. totara, Prumnopitys ferruginea, P. taxifolia* and in the far north of North Island *Agathis australis*. Undisturbed forest of this type can have as many as eight conifer genera (and species) on a single hectare, but forest clearance as well as selective logging of 'pines' have drastically reduced these species-rich forests

especially in the lowlands. Various angiosperms are mixed in, e.g. *Beilschmiedia tarairi, Dysoxylum spectabile*, and *Leptospermum scoparium*, but conifers (especially *Agathis*) can form groves with few angiosperms, forming a mozaic pattern rather than an evenly mixed forest. Especially in gaps tree ferns can become abundant. The altitudinal range is from near sea level to 600 m a.s.l. These forests receive abundant rainfall throughout the year and temperatures are mild in winter and warm in summer.

Conservation

Lowland forests have been greatly reduced since European settlement in New Zealand began about two centuries ago. There is no quantitative record available to indicate the reduction rate for this species as a result of this wholesale removal of indigenous natural forest. Long term survival of this species in natural ecosystems requires large tracts of unmanaged old growth forest, where natural cyclic processes of disturbance and regeneration can span many centuries (see e.g. Ogden & Stewart in Enright & Hill, 1995). Such forests are still, despite the creation of large reserves, under threat of being 'managed' with selective logging one of the permitted uses. As with other long-lived conifers which act as episodal pioneers, this form of management is incompatible with their long-term existence.
IUCN: NT

Uses

The wood of this species is dark reddish brown, fine-grained and often beautifully figured and therefore prized for furniture and wood panelling. Its rarity and at least in recent times protection from exploitation causes it to be of little economic value. As an ornamental tree it is uncommon, as it is less hardy than its congener *Libocedrus bidwillii*, but it should do well in California, southern Europe, and areas with a similar mild climate, provided there is no prolonged dry period.

Libocedrus yateensis Guillaumin, Bull. Mus. Hist. Nat. (Paris), ser. 2, 21: 457. 1949. *Stegocedrus yateensis* (Guillaumin) Doweld, Novosti Sist. Vyssh. Rast. 33: 42. 2001. Type: New Caledonia: Grande Terre, Province Sud, Rivière Bleue, *J. Bernier s.n.* (lectotype P).

Etymology

The species epithet indicates the locality, Yaté, near where it was found when first described.

Vernacular names

No common names have been recorded for this species.

Description

Shrubs or small trees 2–10(–12) m tall, multistemmed or monopodial, diam. ca. 10–30 cm. Bark rough and scaly, reddish brown, exfoliating in thin longitudinal strips or plates. Branches spreading to ascending, forming a conical young tree but later a bushy, often rounded crown. Foliage more or less frondose, forming dense sprays, ultimate branchlets alternate to subopposite, unequal in length and towards end of foliage branches gradually shortening, flattened, ca. 4 mm wide, entirely covered with leaves, persistent. Leaves decussate, especially laterals apically recurved or spreading, on ultimate branchlets imbricate, strongly dimorphic; facials 1.5–2 mm long, rhombic, appressed, keeled near apex, apiculate, partly covered at base by divergent, bilaterally flattened, falcate-lanceolate 2–5 × 1–2 mm laterals with entire to scarious margins and acute-acuminate apex; amphistomatic, stomata on facials near base, on laterals reduced on upperside, more conspicuous on underside in a depressed band extending to apex; leaf colour (lustrous) olive green, stomatal band glaucous white. Pollen cones terminal, solitary, cylindrical, 5–8(–10) × 2–2.5 mm; microsporophylls decussate, 16–24, peltate with apiculate apex, keeled, with entire margins, bearing 4 small abaxial yellow pollen sacs. Seed cones terminal on branchlets with leaves of nearly equal shape and size, developing within one growing season, becoming thin woody. Bract-scale complexes much different in size; upper

pair 8–9 × 3–4 mm; lower, smaller pair 4–6 × 2 mm; both slightly rugose, forming a cone 9–10 mm long excluding the erect free parts of the bracts which are 5–8 × 1 mm on larger pair and 4–5 × 1 mm on smaller pair. Columella a small spine less than 1 mm long. Seeds 1–2, ovoid-oblong, slightly flattened, 5–6 × 2.5 mm, light brown, with 2 opposite, thin membranous wings; smaller wing a narrow strip less than 1 mm wide; larger wing oval-oblong, 6–7 × 2.5–3 mm, often curved, yellowish brown.

Distribution

New Caledonia: Province Sud (Rivière Bleue-Yaté River, Ouinné River), Province Nord (Povila).
TDWG codes: 60 NWC

Ecology

This species is restricted to riparian habitat along a few rivers at low altitude, from 150 m to 600 m a.s.l., where both individual trees and small groves occur. It is one of only two species of *Cupressaceae* that occurs in the lowland tropics; the other is *Neocallitropsis pancheri*, which may occasionally grow with it but also occurs in the mountains. *Libocedrus yateensis* grows on sediments of river terraces or on river banks, surrounded by various shrubs and ferns.

Conservation

The populations of this species are small and each of them is vulnerable to fires. Most are protected in the Parq Rivière Bleue de Yaté, but not those in the vicinity of the Ouinnée River and near Povila in Province Nord.
IUCN: EN [B2ab(iii)]

Uses

No uses are recorded of this species; it is grown in only a few botanic gardens, as young plants in research greenhouses.

Manoao Molloy, New Zealand J. Bot. 33: 196. 1995. Type: *Manoao colensoi* (Hook.) Molloy [*Dacrydium colensoi* Hook.] (*Podocarpaceae*).

Manoao is the Maori name for at least one other podocarp (*Halocarpus kirkii*) as well as for this one, between which the Maori presumably saw no distinction.

Description

See the species description.

Distribution

As for the species.

Manoao colensoi (Hook.) Molloy, New Zealand J. Bot. 33: 196. 1995. *Dacrydium colensoi* Hook., Icon. Pl., n.s., 2: t. 548. 1843; *Lagarostrobos colensoi* (Hook.) Quinn, Austral. J. Bot. 30 (3): 317. 1982. Type: New Zealand: North Island, ["High hills near the eastern coast…], *W. Colenso 27* (lectotype BM). Fig. 166

Etymology

The species epithet commemorates the missionary William Colenso (1811–1899) who collected many plants in New Zealand.

Vernacular names

Silver pine

Description

Evergreen, predominantly dioecious trees to 20 m tall; trunk to 0.7(–1) m d.b.h., often strongly tapered. Bark on mature trees exfoliating in large scales, leaving distinct wave and hammer marks, grey or grey-brown. Crown of young trees broadly pyramidal, of old mature trees rounded, with large and steeply ascending main branches. 'Sucker' shoots from horizontal underground stems prolific. Foliage branchlets with adult leaves slender, 1.2–1.5 mm diam. including scale leaves, variable in length from 0.5–5 cm, spreading. Juvenile leaves on seedlings and young plants distinct from adult leaves, acicular, 6–10(–12) mm long, bifacially flattened with a midrib on both sides, straight or curved, stomata in two distinct bands mainly on adaxial side; apex acute. Branchlets with juvenile leaves may re-appear among those with adult leaves. Intermediate phase leaves often on 'sucker' shoots, 4–5 mm long, distichous, bilaterally flattened. Adult leaves spirally arranged, imbricate and appressed, rhomboid in appearance, 1–1.5 × 1 mm, keeled abaxially; apex obtuse. Leaves amphistomatic, stomata conspicuous, scattered. Pollen cones terminal, sessile, 4–6 mm long, 2–2.5 mm wide; microsporophylls (6–)8–12, rhombic to triangular, with minutely denticulate upper margins and with two basal red pollen sacs. Seed cones terminal, solitary or sometimes in pairs on distally curved short branchlets, 3–4 mm long, consisting of 2–5(–6) fertile bracts. Seeds 1–3(–5) per cone, crowded, morphologically and topographically erect, ca. 3–4 × 2–3 mm, rounded in cross-section, notched ar apex, dark purple to black, basal half or more of seed enclosed in a swollen, fleshy, yellowish green epimatium.

Taxonomic notes

Brian Molloy (*op. cit.*) segregated the New Zealand species (originally described by William Hooker as *Dacrydium colensoi*) from *Lagarostrobus*, a genus erected by Chris Quinn (1982) to include this species and *L. franklinii* from Tasmania. He chose a new genus name, *Manoao*, the Maori name for the Silver pine. Subsequent DNA-based investigations by Quinn and co-workers alledgedly refuted this segregation, but with only two species ('terminal taxa') represented in any cladistic analyses they will come out as sister taxa at their closest (as they do, see Conran *et al.*, 2000) and at what rank you then recognize them remains a matter of judgement and could involve phyletic considerations (Stuessy, 2009). Molloy has given quite a number of differences between the two, including numbers of chromosomes, and together with their likely long (>85 million years) separation across a widening ocean, we may as well recognize them as two separate

genera. That these genera thereby become monotypic I do not consider a problem (e.g. Gregg's Paradox: genus = species); given the likely age of the separation event we can postulate more than a single species in each genus, all but one now extinct.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Manoao colensoi is a component of lowland conifer-dominated rainforest occurring from near sea level to ca, 950 m. It is shade tolerant and grows on well developed soils of volcanic or igneous origin with good drainage. In places with high precipitation it can occur outside forest cover, overtopping scrub. It is a very slow growing species which can maintain itself through all successional phases from forest disturbance to canopy tree in old growth. Its usual associates are other species in *Podocarpaceae* common in New Zealand lowland rain forest, in South Island (Westland) it is often mixed with *Nothofagus*.

Conservation

IUCN: LC

Uses

The wood of Silver pine is dense and compact but not heavy, strong and not shrinking when seasoned, and taking a high polish. It is sometimes beautifully figured or mottled and is then highly prized for cabinet making and furniture. As native trees are now protected in New Zealand, its commercial use is negligable. It is not known to be in cultivation outside a few botanic gardens.

Metasequoia Hu & W. C. Cheng, Bull. Fan Mem. Inst. Biol., ser. 2, 1 (2): 154. 1948 (*nom. cons.*). Type: *Metasequoia glyptostroboides* Hu & W. C. Cheng (*Cupressaceae*).

Greek *meta-* = changed; i.e. a changed or transformed *Sequoia*, denoting its close relationship and similarity.

Description

See the species description.

Distribution

As for the species.

Metasequoia glyptostroboides Hu & W. C. Cheng, Bull. Fan Mem. Inst. Biol., ser. 2, 1 (2): 154. 1948. Type: China: Hubei, W Hubei, Modaoxi, ["E Szechuan, Wanhsien, Mo-tao-hsi"], *C. T. Hwa 2* (lectotype NF). Fig. 167, 168

Metasequoia glyptostroboides Hu & W. C. Cheng var. *caespitosa* Y. H. Long & Y. Wu, Bull. Bot. Res. North-East. Forest. Inst. 4 (1): 149. 1984.

Etymology

The species epithet refers to its likeness with *Glyptostrobus*.

Vernacular names

Dawn Redwood; shui shan (Chinese)

Description

Trees to 50 m tall (but most trees now under 35 m), deciduous, monoecious; trunk monopodial, large trees often buttressed, d.b.h. to 2.2 m. Bark becoming fissured, exposing purplish brown inner bark, exfoliating in long, thin plates or strips. Branches long, spreading to ascending, or foliage subpendulous, forming a pyramidal crown in young trees, becoming broader and more open, with a rounded top, in older trees. Foliage branchlets opposite or nearly so, mostly distichous, 5–15 cm long, 0.7–1 mm thick including decurrent leaf bases, glabrous, terminating in small seasonal buds, deciduous. Leaves opposite on foliage branchlets, the free part proximally constricted and twisted, merging with alternating left and right trending decurrent bases, lamina linear, curved or nearly straight, spreading at nearly right angles to branchlet, 8–15 mm (–30 mm in young trees) × 1.5–2.5 mm, generally longest in middle section of branchlet, with parallel entire margins and a midrib, shortly tapering to obtuse or mucronate apex. Leaves hypostomatic, stomata in two broad bands of 4–8 lines divided by a narrow raised midrib, leaf colour light green or sometimes slightly glaucous green. Pollen cones numerous in spike-like shoot systems, opposite, ovoid, 5–6(–10) × 2.5–4 mm when full grown; microsporophylls 15–20, proximally helically arranged, but irregularly attached in mature cones, peltate, with 3 abaxial pollen sacs near lower margin. Seed cones terminal on 2–5 cm long, sparsely (scale-)leaved shoots, solitary, subglobose, barrel-shaped or fusiform when still tightly closed, with nearly concentric grooves, glaucous green, maturing in one year to 15–25(–30) × 10–23 mm, parting the scales in the grooves, turning dull brown or grey-brown. Bract-scale complexes 16–24(–28), decussate, more or less peltate, dilated into a transversely elliptic or broadly triangular disk with a transverse indentation, 5–8 mm long, 8–15 mm wide, 2–4 mm thick, distally rugose, proximally moderately lignified, striate, yellowish to dark brown at base. Seeds numerous, more or less inverted by displacement, 4–6 × 4–5 mm including wings, irregular, compressed, emarginate at apex, with two broad, membranous yellowish or light brown wings encircling the seed.

Distribution

Central China: Chongqing (Shizhu), Hubei (Lichuan), Hunan (Longshan).

TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHS-HN

Ecology

The ecology of *Metasequoia* in undisturbed valley forests can only be reconstructed from palynological data and from clues obtained from field observations in the lower sections of some little side valleys of the Shuishaba Valley, where relatively undisturbed stands occur on probably suboptimal sites. Remaining large trees in the valley proper are surrounded by cultivated fields (mainly rice) and both native and introduced tree species, constituting in its most natural state a secondary vegetation. Though some of the trees of *Metasequoia* have also been planted, it is likely that the largest and oldest trees in the valley are survivors. It is a riparian species that occupies a habitat similar to that of *Taxodium distichum*; the remnant old trees may be the vestiges of an extensive flood plain forest that existed before this valley was transformed to agriculture only a few centuries ago. Away from the valley floor the trees are restricted to the moist bottoms of ravines and in contact with seepage water. The valley forest would not have been pure *Metasequoia*, but mixed with angiosperms, among which were very likely species of *Acer, Castanea, Populus*, and *Quercus*, as well as *Liquidambar acalycina, Nyssa chinensis, Pterocarya hupehensis* and other trees tolerant of periodic flooding. The soil is clay and sand derived from sandstone, with slightly acid to neutral pH and a strongly fluctuating but not deep water table. The climate is characterized by hot summers and cold winters.

Conservation

This 'conservation flagship' conifer species occurs in a limited region in the border area of two Chinese provinces and Chongqing Municipality (formerly E Sichuan province) in what is now intensively cultivated and utilised countryside. It appears that at least the older trees are relicts of a riparian *Metasequoia* forest, which may have stretched unbroken in valley bottoms before farmers moved into the area only a few centuries ago (Chii & Cooper, 1950). The several subpopulations are all reduced to a few to several hundred mature trees, sometimes even a single tree, with little chance of natural generation due to changes in land use by a growing agrarian population. Secondary woodland in some narrow side valleys, where *Metasequoia* may occur along permanent streams, are under pressure of grazing and cutting of firewood. The mature, large trees have all been declared protected but habitat protection is overall inadequate (Bartholomew *et al.*, 1983; Fu & Jin, 1992; Wang & Guo, 2009), which means that the survival of this very interesting species in its natural habitat is not guaranteed.

IUCN: EN [B1ab (iii, v)]

Uses

In the past, trees of this species must have been used for construction timber locally. Evidence of branch cutting for firewood can be seen in the photograph of one of the earliest discovered trees, a picture that has been widely published. Its use is now prohibited in the '*Metasequoia* area' but the species has been widely planted, as an amenity or forest tree in China and as an ornamental in many other countries with temperate climates. This conifer is one of the most remarkable success stories of introduced trees to date; since its first introduction to the USA and Europe in 1948 it has spread to almost every country with a temperate climate. Several cultivars have been named, especially in the Netherlands. The phenotypic variation observed in planted trees obtained from early seed introductions may indicate genetic diversity, but trees with somewhat stunted and contorted lower trunks may also be due to suboptimal growing (climatic?) conditions. It would seem that warm and humid summer conditions are conducive to rapid growth, producing straight, erect trunks and long branches.

Microbiota Kom., Bot. Mater. Gerb. Glavn. Bot. Sada RSFSR 4: 180. 1923. Type: *Microbiota decussata* Kom. (*Cupressaceae*).

Greek: *mikros* = small; *bios* = life; *Biota* is another name for *Thuja*; therefore a small *Thuja*.

Description

See the species description.

Distribution

As for the species.

Taxonomic notes

Recent molecular phylogenetic analysis (Gadek *et al*., 2000) of all genera in *Cupressaceae* consistently found a clade with *Microbiota* and *Platycladus*, related to *Tetraclinis* as sister group, not to *Juniperus* or *Thuja*. Phytogeographically, *Microbiota* and *Platycladus* are nearly sympatric at present, although with a much smaller range for the former. Perhaps a shrubby form of the latter became isolated, due to the retreat to the south of *Platycladus* in Pleistocene cold phases. It could then have evolved to become the decumbent shrub with minimalised cones that is adapted to subalpine, cool and highly maritime mountains on the fringe of the Asian continent, where it still occurs today in a limited area.

Microbiota decussata Kom., Bot. Mater. Gerb. Glavn. Bot. Sada RSFSR 4: 180. 1923. Type: Russia: Russian Far East, Primoriye, Mt. Zamo-Dynza, ["in monte Zamo-dinzsa"], *I. K. Schischkin 158* (lectotype LE). Fig. 169

Etymology

The species epithet refers to the pairwise alternating opposed scale leaves.

Vernacular names

Siberian cypress (USA); the species is also known as *Microbiota* in cultivation; no common name was given in Flora URSS Vol. 1 (1963).

Description

Decumbent shrubs, evergreen, monoecious, spreading by layering of branches, without distinct stem or trunk, up to 50–100 cm tall, often lower and prostrate on rocks. Bark at first orange-brown or red-brown, then purplish brown, smooth, thin, exfoliating in small flakes, turning dark brown on thicker stems. Branches numerous, decumbent, spreading and curved down in more or less plagiotropic frondose sprays, the whip shoots drooping, forming a dense, spreading shrub several meters across. Foliage branchlets spreading at narrow angles of ca. 20–40 degrees, slender, lax, slightly flattened, ultimate branchlets to ca. 30 mm long, all covered with scale leaves. Leaves decussate, weakly dimorphic, broad decurrent, imbricate, appressed but with some apices free, rhombic, leaf margins mostly entire; apex acuminate or acute-pungent, 1.5–3(–3.5) × 0.6–1.5 mm; abaxial stomata few, adaxial stomata in two bands merging distally; glands central, slightly depressed, conspicuous on facials, inconspicuous on laterals; leaf colour green or yellowish green, turning copper-brown or purplish brown in winter. Pollen cones terminal, solitary, ovoid-globose, 2–3 mm long; microsporophylls 10–12, decussate, peltate-rounded, abaxially bearing 2 relatively large, angular-globose, yellow pollen sacs. Seed cones somewhat hidden by foliage sprays, terminal on very small branchlets, developing in one season to a 'minimal' cone of a lower small and upper larger pair of bract-scale complexes enveloping lower two third of single seed, spreading at maturity to 3–5 mm wide; upper pair cup-like from having surrounded the seed, both pairs thin woody, with papillose margins and with long protruding, subapical, incurved bract tips. Seeds broadly ovoid, often with two longitudinal lines or ridges marked by scale edges, 2–3 mm long; apex acutish, lustrous chestnut-brown or blackish brown, with a lighter hilum at base.

Distribution

Russian Far East: Sikhote Alin Prov., Primoriya.
TDWG codes: 31 PRM

Ecology

Microbiota decussata is a decumbent shrub in montane habitats both in and outside forests, at altitudes between 800 m and 1200 m a.s.l. It occurs in mixed conifer or angiosperm-conifer forest with e.g. *Abies nephrolepis, Picea jezoensis, Pinus koraiensis, Acer ukurunduense, Alnus maximoviczii, Betula ermanii*, and *Sorbus amurensis*. In subalpine non-forest vegetation it can be assosiated with *Pinus pumila, Juniperus sabina* var. *davurica*, or *Rhododendron mucronulatum*, often growing on talus slopes or mossy granitic boulders with small accumulations of soil. The climate is cold maritime with deep snow cover for several months in winter. The 'copper-brown' discoloring of the foliage in winter is due to chemical (anthocyanin) changes in the pigment of the mesophyll cells that may enhance the rate of photosynthesis under low light conditions.

Conservation

Based on available data from herbarium collections, this species is most common in the southern part of the Sikhote Alin Mountains, but extends northwards to beyond Kabarovsk. It is listed as rare in the Red Book of Russia and it is included in Nedoluzhko's (1999) Endangered woody plants of the Russian Far East. Its range is larger than the threshold for Vulnerable (VU) and its habitat is on the whole not threatened as it occurs in remote localities and in vegetation types that are not subject to changes in land use, except for some forested localities nearer Vladivostok. There is no evidence of decline.

IUCN: LC

Uses

Its decumbent habit and attractive colouring foliage (green in summer and bronze in winter), combined with hardiness in cold-winter climates and easy vegetative propagation, have made this species a desirable, but still not very commonly available garden shrub. Given a well-drained, open site and cool conditions, it will spread to cover the ground quickly. It has only been available in the trade since the 1980s and no cultivars are known.

Microcachrys Hook. f., London J. Bot. 4: 149. 1845. Type: *Microcachrys tetragona* (Hook.) Hook. f. [*Athrotaxis tetragona* Hook.] (*Podocarpaceae*).

Greek: *mikros-* = small; *kachrys* = catkin, cone.

Description

See the species description.

Distribution

As for the species.

Microcachrys tetragona (Hook.) Hook. f., London J. Bot. 4: 149. 1845. *Athrotaxis tetragona* Hook., Icon. Pl., n.s., 2: t. 560. 1843, ["*Arthrotaxis*"]; *Dacrydium tetragonum* (Hook.) Parl., in Candolle, Prodr. 16 (2): 496. 1868. Type: Australia: Tasmania, ["V. D. L."], *R. C. Gunn [367]* (lectotype K). Fig. 170

Pherosphaera hookeriana Hook. f., Fl. Tasmania 1 (5): 355. 1857, *non* W. Archer (1850).

Etymology

The species epithet describes the four-angled branchlets due to decussate phyllotaxis of the scale leaves.

Vernacular names

Creeping pine, Strawberry pine

Description

Evergreen, monoecious or (temporarily) dioecious, prostrate shrubs 10–30 cm tall. Leading stems to ca. 1 m long, branching frequently. Foliage branches numerous, spreading or ascending; whip shoots elongated, creeping out over rocks; (pen)ultimate branchlets with scale leaves quadrangular in cross-section. Leaves on whip shoots mostly decussate, decurrent, lanceolate, to ca. 5 mm long, the distal part slightly spreading, with minutely denticulate margins tapering to an acute apex. Leaves on lateral branchlets strictly decussate, imbricate, appressed, short triangular in appearance, 1–1.5 × 1 mm; margins minutely denticulate; dorsal side of leaves keeled towards an obtuse, incurved apex. Stomata restricted to adaxial side of leaves, subapical, hidden from view. Pollen cones terminal, more or less recurved, 2.5–4 mm long, ovoid; microsporophylls helically arranged, strongly incurved, enclosing two basal pollen sacs containing bisaccate or trisaccate pollen. Seed cones usually on different branching systems from pollen cones, terminal, maturing to 6–8 mm long, ovoid, comprising of an axis with ca. 20 helically arranged, rounded bracts which become fleshy, slightly swollen and red at maturity. Ovules 1 per fertile scale, inverted; seeds broadly ovoid, 1.5 × 1.2 mm, slightly flattened when ripe, at base partly covered by the epimatium.

Distribution

Australia: Tasmania.
TDWG codes: 50 TAS

Ecology

Microcachrys tetragona occurs in Tasmanian alpine dwarf scrubland on exposed rock outcrops, usually above 1000 m altitude. This prostrate little shrub spreads over rocks and through low mossy or herbaceous vegetation in wet areas with long, whip-like running shoots capable of rooting and ramifying towards open spaces, often over bare rock. It is, despite being so low to the ground, wind pollinated as are all conifers; its tiny mulberry-like red cones are succulent and undoubtedly eaten by animals (birds?), but these vectors of its seed dispersal are not known. This dwarf conifer is often growing near other, taller conifers like *Athrotaxis cupressoides, Diselma archeri, Pherosphaera hookeriana, Podocarpus lawrencei*, and various angiosperms, e.g. *Nothofagus gunnii, Epacris serpyllifolia, Orites* spp., *Richea* spp., *Astelia alpina, Leptospermum ruprestre*, etc.

Conservation

IUCN: LC

Uses

This extremely dwarfish conifer is extremely rare in cultivation. Despite having been introduced to the Royal Botanic Gardens, Kew in 1862 by W. Archer, it is still only known from a few botanical collections. At Kew it was grown successfully in the Temperate House and in the Himalayan House, but it has long since disappeared. In view of its natural habitat and climate, this species should be an interesting plant for the rock garden in mild winter regions where frost is uncommon.

Nageia Gaertn., Fruct. Sem. Pl. 1: 191. 1788. Type: *Nageia nagi* (Thunb.) Kuntze [*Myrica nagi* Thunb.] (*Podocarpaceae*).

From nagi, the vernacular name of the species that occurs in Japan.

Description

Dioecious or monoecious evergreen trees, rarely shrubs. Numerous narrow resin canals in leaves. Bark thin, hard, becoming scaly. Branching irregular, non-rhytmic, vegetative shoots terminating in small buds. Leaves spirally inserted or subopposite on leading shoots, petioles twisted to position the leaves in a plane, large, flat, broadly ovate-elliptic to lanceolate, lacking a midrib and with many parallel, converging veins, coriaceous and more or less rigid, amphistomatic or hypostomatic (stomata on abaxial side only). Pollen cones single or in small, spicate groups of 2–6 on axillary peduncles, ovoid-cylindric, surrounded at base by small scales; microsporophylls triangular to apiculate with 2 basal, subglobose pollen sacs containing bisaccate pollen. Seed cones solitary and long pedunculate, or with two or more on slender shoots in the axil of a leaf and short pedunculate, consisting of several spirally arranged bracts; bracts either drying up or fusing and enlarging at their bases, forming a weakly developed, fleshy receptacle being usually only slightly thicker than the peduncle. Only a single terminal bract fertile, having an inverted ovule enveloped by the epimatium; epimatium swelling greatly, forming a drupe-like, fleshy to succulent, red or purple 'fruit' around the globose seed.

5 species.

Distribution

India (Assam, Kerala, Meghalaya, Nicobar Islands); S China; Taiwan; Japan; Indochina (including Malay Peninsula); Malesia: from Sumatera to New Guinea (excluding most of the Lesser Sunda Islands, New Britain and New Ireland).

Key to the species of *Nageia*

Leaf shapes and sizes are extremely variable and these characters form a continuum from seedlings, saplings and young trees to mature trees. Maxima in size are in some species informative, but require the examination of sufficient samples.

1a. Leaf venation indistinct; stomata only present on the lower leaf surface **2**

1b. Leaf venation distinct; stomata present on both leaf surfaces **3**

2a. Leaf blades 2–9 cm long, 0.7–3 cm wide; apex acute or obtuse to truncate; pollen cones 0.5–2 cm long, 2–3 mm wide; seeds always single, including the epimatium 10–15 mm diam ***N. nagi***

2b. Leaf blades 8–18 cm long, 2.5–5 cm wide; apex acute or acuminate. Pollen cones 1.5–4(–6.5) cm long, 3.5–4 mm wide. Seeds single or 2–3 together, including the epimatium 15–18 mm diam ***N. fleuryi***

3a. Leaf blades 2–5(–7.5) cm long, 1.5–2.5 cm wide. Pollen cones solitary, sessile, 5–6 mm wide. Seeds including the epimatium 13–16 mm diam ***N. motleyi***

3b. Leaf blades 5–30(–34) cm long, 2–9.5 cm wide. Pollen cones usually in groups of 3–10, pedunculate, 2.5–4 mm wide. Seeds including the epimatium 15–20 mm diam **4**

4a. Shrubs or small trees to 10 m tall. Leaf blades (8–)16–30(–34) cm long; apex acute to acuminate. Pollen cones 2.5–3 mm wide; microsporophylls lanceolate. Receptacle below seed absent ***N. maxima***

4b. Trees to 50 m tall, rarely shrubs. Leaf blades 5–15(–23) cm long; apex acute or obtuse. Pollen cones 3–4 mm wide, microsporophylls apiculate. Receptacle 12–20 mm long and succulent red when mature ***N. wallichiana***

Nageia fleuryi (Hickel) de Laub., Blumea 32 (1): 210. 1987. *Podocarpus fleuryi* Hickel, Bull. Soc. Dendrol. France 76: 75. 1930; *Decussocarpus fleuryi* (Hickel) de Laub., J. Arnold Arbor. 50: 355. 1969. Type not designated (syntypes *J. F. Fleury 30180, 38017, E. Poilane 5963, Forest St. 8408* in P). Fig. 171

Etymology

This species commemorates the 19th century French botanist J. F. Fleury.

Vernacular names

Kim giao núi đá (Vietnamese); changye zhubai (Chinese)

Description

Trees to 25 m tall; trunk to 70 cm d.b.h.. Bark scaly, peeling in small, thin flakes, purplish brown; inner bark fibrous, reddish. Crown with ascending or spreading branches, pyramidal. Foliage branchlets opposite (but often one of the pair not developed) spreading rigidly, terete or angular, often twisted, glabrous; terminal buds with narrowly lanceolate scales extending to a fine point. Leaves opposite or subopposite (towards end of branchlets often alternate), decussate or nearly in one plane on shaded branches; petiole twisted ca. 90° at base, 2–5(–10) mm long; leaf blade variable in size and shape, 8–18 × 2.5–5 cm (largerst on young plants and shaded leaves), from elliptic to ovate-lanceolate or ovate with acute to acuminate apex, coriaceous, with indistinct parallel veins, dark green above, pale green below. Stomata only on lower surface, in numerous, intermittent lines, usually conspicuous but sometimes poorly visible. Pollen cones axillary, in clusters of 3–6, (nearly) sessile, variable in length from 1.5–4(–6.5) cm, becoming long cylindrical at full length, with a diam. of 3.5–4 mm; microsporophylls imbricate, triangular, with two pollen sacs. Seed cones axillary, solitary or rarely in pairs, pedunculate, lacking a receptacle, with a few deciduous red bracts at base of fertile branchlet. Seeds single or in pairs or threes on fertile branches, enclosed in a light green (bloomed glaucous white) but when ripe purple epimatium, the whole globose, 15–18 mm diam. when succulent, wrinkled and dark brown when dry with a loose seed inside.

Distribution

China: Guangdong (Gaoyao, Longmen, Zengcheng), Guangxi (Chongzuo, Hepu, Xingan), Yunnan (Mengzi, Pingbian); Indochina: Lao PDR, Viet Nam.
TDWG codes: 36 CHC-YN CHS-GD CHS-GX 41 LAO VIE

Ecology

Nageia fleuryi is most often found on limestone formations (karst) in mixed angiosperm/conifer forest; also in montane tropical rainforest dominated by evergreen broad-leaved angiosperm trees. It is a montane species, but its altitudinal range (in Viet Nam) is somewhat broadly defined as between 500 m and 1200 m. Its large leaves indicate tolerance of shade and it grows up well under canopy of most taller trees. As do other conifers in the main area of its range (northern Viet Nam and adjacent southern parts of China) it evades competition from angiosperms by growing mostly on exposed rocky ridges, presumably this is an edaphic adaptation using mycorrhizal symbiosis to cope with the lack of water and nutrients. Other conifers that grow here frequently are *Pinus fenzeliana* (*P. kwangtungensis*), *Pseudotsuga sinensis*, and on slightly better sites *Fokienia hodginsii*.

Conservation

Widely distributed but in disjunct populations throughout NE Viet Nam and SE China. Both the extent of occurrence (EOO) and area of occupancy (AOO) (not calculated as herbarium specimen data were considered to be incomplete) would fall outside the threshold for VU. The timber is valued and is being selectively logged, therefore it is suspected that there is a global threat to this species. In Viet Nam, where this species probably has its main distribution, it has been assessed as Vulnerable (VU) according to Nguyen Tien Hiep *et al.* (2004). It has been recorded from northern parts of Taiwan in Flora of Taiwan (ed. 2, 2001), but these sightings more likely refer to *N. nagi*, of which young trees growing in shade may have larger leaves.
IUCN: NT

Uses

The wood of this species has good properties, such as straight grain, evenly texture and softness, that make it useful for special purposes such as fine furniture and musical instruments. The rather small stature of many trees growing in exposed situations makes it less valuable as a timber tree and the wood is therefore only used locally. The seeds contain 36% oil with a low volatility and are harvested on a modest scale for this. The species has horticultural merit, but has not been taken into cultivation widely and would only do well in (sub)tropical countries.

Nageia maxima (de Laub.) de Laub., Blumea 32 (1): 210. 1987, [*maximus*"]. *Decussocarpus maximus* de Laub., J. Arnold Arbor. 50: 353. 1969. Type: Malaysia: Sarawak, Sibu District, Naman F. R., *J. A. R. Anderson 3361/7* (holotype L).

Etymology

The species epithet refers to the very large leaves.

Vernacular names

A very local name, 'landin paya', is cited in Flora Malesiana ser. 1, 10 (3): 394 (1988).

Description

Shrubs or trees to 10 m tall; trunk to 20 cm d.b.h. Bark smooth, brown; inner bark slightly fibrous, reddish. Crown with spreading branches, bushy. Foliage branchlets opposite (but often one of the pair not developed) spreading rigidly, terete or angular, often twisted, glabrous; terminal buds with narrowly lanceolate scales extending to a fine point. Leaves opposite or subopposite (towards end of branchlets often alternate), decussate or nearly in one plane on shaded branches; petiole twisted ca. 90° at base, 4–10 mm long; leaf blade variable in size and shape, (8–)16–30(–34) × (3–)6–9.5 cm (largerst on young plants and shaded leaves), from elliptic to ovate-lanceolate with acute to acuminate apex, coriaceous, with distinct parallel veins, dark green above, pale green below. Stomata on both surfaces, in numerous, intermittent lines, usually conspicuous but sometimes poorly visible. Pollen cones axillary, in clusters of 3–9, on a 3–10 mm long peduncle, cylindrical, 12–20 × 2.5–3 mm; microsporophylls imbricate; apex lanceolate, 0.5–1 mm long, with two basal pollen sacs. Seed cones solitary or in groups of up to 5 on axillary branchlets, short pedunculate, lacking a receptacle, with a few deciduous bracts at base of fertile branchlet. Seeds single on each bare peduncle, enclosed in a green but when ripe dark purple epimatium, the whole globose, 15–18 mm diam. when succulent, wrinkled and blackish brown when dry with a loose seed inside.

Taxonomic notes

This species was originally described as *Decussocarpus maximus* but later transferred to *Nageia*, where it indeed belongs. [The genus *Decussocarpus* turned out to be an illegitimate name under the current rules of the International Code for Botanical Nomenclature.] De Laubenfels (*op. cit.*) originally cited specimens from Sarawak (the type) and Sumatera under his new species, but later [in Flora Malesiana ser. 1, 10 (3): 394 (1988)] he omitted the Sumatera references, which more accurately belong with *N. wallichiana*. This species remains little known and, if more material were available, could turn out to be a form with extra large leaves of *N. wallichiana*, whose leaves can match it in width if not in length.

Distribution

Borneo: Sarawak.
TDWG codes: 42 BOR-SR

Ecology

This rare species is only known from a few localities, one is on a ridge in moist rainforest and the others are in peat swamps. All are in lowland from near sea level to 120 m a.s.l. This taxon is described as a small understorey tree and has apparently the largest (length × width) leaves of all conifers.

Conservation

This rare species is threatened by deforestation in relation to the expansion of oil palm plantations and expanding 'shifting agriculture'.
IUCN: EN [B2ab (ii–v)]

Uses

No uses have been recorded of this species and it does not appear to be in cultivation.

Nageia motleyi (Parl.) de Laub., Blumea 32 (1): 210. 1987. *Dammara motleyi* Parl., Enum. Sem. Hort. Florent. 1862: 26. 1863; *Decussocarpus motleyi* (Parl.) de Laub., J. Arnold Arbor. 50: 352. 1969. Type: Indonesia: Borneo, Kalimantan Selatan, Bandjarmasin, ["Bangarmassing"], *J. Motley s.n.* (holotype K).

Etymology

This species was named after the 19th century botanist James Motley.

Vernacular names

podo kebal musang (Peninsular Malaysia); kayu bawa, setebal (Sumatera); medang buloh (Sarawak).

Description

Trees to 50 m tall; trunk to 1 m d.b.h., forming a straight, clear bole. Bark hard and scaly, peeling in thin flakes, brown or reddish brown; inner bark fibrous, reddish. Crown with spreading branches, becoming rounded. Foliage branchlets opposite (but often one of the pair not developed) spreading rigidly, terete but ultimately more or less quadrangular and often twisted, with grooves, glabrous; terminal buds with lanceolate scales extending to a fine point. Leaves opposite or subopposite (towards end of branchlets often alternate), decussate or nearly in one plane on shaded branches; petiole twisted ca. 90° at base, 2–3 mm long; leaf blade somewhat variable in size and shape, 2–5(–7.5) × 1.5–2.5 cm (largerst on young plants and shaded leaves), lanceolate, elliptic to obovate with obtuse, acute or acuminate apex, coriaceous, with distinct parallel veins, dark green above, mid green below. Stomata on both surfaces, in numerous, continuous or intermittent lines, conspicuous on both sides. Pollen cones axillary, solitary, sessile, 1.5–2 cm long, with a diam. of 5–6 mm; microsporophylls imbricate; apex acuminate, 2 mm long, with two basal pollen sacs. Seed cones axillary, solitary, long pedunculate, with a few deciduous bracts near base of peduncle and cone bracts fused to a swelling green then red 8–15(–20) mm long receptacle with 5–9 exserted bract tips. Seeds at apex of receptacle, single, enclosed in a green, when ripe dark purple epimatium, the whole globose, 13–16 mm diam. when succulent, wrinkled and nearly black when dry with a loose seed inside.

Distribution

S Thailand, Borneo, Peninsular Malaysia, Sumatera.
TDWG codes: 41 THA 42 BOR-KA BOR-SB BOR-SR MLY-PM SUM

Ecology

This species grows as tall as *N. wallichiana* in lowland tropical rainforest from ca. 15 m to ca. 500 m a.s.l. *Nageia motleyi* occurs usually on dry soil but has also been found in peat swamps ("ramin-peat swamp") in Sarawak. It is a rare constituent of lowland "bindang-dipterocarp" forest in Sarawak, but is more often found in less tall evergreen forests on podzolic sands, where it is scattered among numerous angiosperm tree species and occasional conifers. It apparently regenerates after disturbance and is also found in secondary forest.

Conservation

Logging of *Nageia* spp. in lowland forests can involve this species or the much more widely distributed species *N. wallichiana*; the ranges and ecology of both species partly overlap in Peninsular Malaysia, Sumatera and Borneo. Identification of logged trees to species is impossible if the foliage is no longer available. It is likely that logging has affected this species more seriously than was previously realized.
IUCN: VU (A2c)

Uses

Nageia motleyi is a valuable timber tree, especially where it grows into tall, straight trees with a long, clear bole. It is traded as podocarp wood. Long timber is sawn into planks for construction (mainly

house building); other uses of the wood are plywood, veneer, interior finishing, and furniture making. As it occurs within the general distribution of *N. wallichiana* and develops into a similar tree, it is difficult to assess whether uses apply to the less frequently encountered species or to the widespread species. *Nageia motleyi* is probably not grown in cultivation.

Nageia nagi (Thunb.) Kuntze, Revis. Gen. Pl. 2: 798. 1891. *Myrica nagi* Thunb., in Murray, Linn. Syst. Veg., ed. 14: 884. Mai-Jun 1784; *Decussocarpus nagi* (Thunb.) de Laub., J. Arnold Arbor. 50: 357. 1969. Type not designated. Fig. 172

Podocarpus formosensis Dummer, Gard. Chron., ser. 3, 52: 295. 1912; *Decussocarpus nagi* (Thunb.) de Laub. var. *formosensis* (Dummer) Silba, Phytologia 58: 366. 1985; *Nageia formosensis* (Dummer) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 382. 1989; *Nageia nagi* (Thunb.) Kuntze var. *formosensis* (Dummer) Silba, Phytologia 68: 38. 1990.
Podocarpus nankoensis Hayata, [Icon. Pl. Formos. 6, Suppl.: 74. 1917, *nomen*] Icon. Pl. Formos. 7: 39. 1918; *Nageia nankoensis* (Hayata) R. R. Mill, Novon 9 (1): 77. 1999.
Podocarpus nagi (Thunb.) Pilg. var. *koshunensis* Kaneh., Trans. Nat. Hist. Soc. Formosa 21: 145. 1931; *Podocarpus formosensis* Dummer var. *koshuensis* (Kaneh.) Merr. & Yamam., J. Soc. Trop. Agric. 7: 142. 1935; *Podocarpus koshunensis* (Kaneh.) Kaneh., Formosan Trees, ed. 2: 36. 1936; *Nageia nagi* (Thunb.) Kuntze var. *koshuensis* (Kaneh.) D. Z. Fu, Acta Phytotax. Sin. 30 (6): 524. 1992.

Etymology

The species epithet refers to the Japanese vernacular name as recorded by Carl Peter Thunberg.

Vernacular names

naki (Japanese); zhu bai (Chinese)

Description

Trees or shrubs to 20 m tall; trunk to 50 cm d.b.h. Bark scaly, peeling in small, thin flakes, reddish or purplish brown, weathering grey. Crown with ascending or spreading branches, becoming rounded, or bushy. Foliage branchlets opposite (but often one of the pair not developed) spreading rigidly, more or less tetragonal, often twisted, with grooves in the edges, glabrous; terminal buds with narrowly lanceolate scales extending to a fine point. Leaves opposite or subopposite (towards end of branchlets often alternate), decussate or nearly in one plane on shaded branches; petiole twisted ca. 90° at base, 3–8(–15) mm long; leaf blade variable in size and shape, 2–9 × 0.7–3 cm (largerst on young plants and shaded leaves), from narrowly elliptic to ovate-lanceolate or obovate with acute to obtuse or nearly truncate apex, coriaceous, with indistinct parallel veins, dark green above, pale green below. Stomata only on lower surface, in numerous, intermittent lines, usually conspicuous but sometimes poorly visible. Pollen cones axillary, in clusters of up to 10 or sometimes solitary, (nearly) sessile, variable in length from 0.5–2 cm, becoming cylindrical at full length, with a diam. of 2–3 mm; microsporophylls imbricate, apiculate, with two pollen sacs. Seed cones axillary, solitary and long pedunculate, or rarely in pairs, with a few deciduous bracts near base of fertile branchlet and some remaining dried bracts subtending a single seed enclosed in a green, when ripe dark purple epimatium, usually bloomed white, the whole (sub)globose and 10–15 mm diam. when succulent, wrinkled and dark brown when dry with a loose seed inside.

Taxonomic notes

Nageia formosensis (Dummer) C. N. Page was listed in A World Checklist and Bibliography of Conifers (Farjon, 1998, [2001]) as an accepted species. It was by some considered a mere variety of *N. nagi*, while other sources suggest that perhaps there are no fewer than three distinct species in Taiwan: *Nageia formosensis, N. nankoensis* (Hayata) R. R. Mill and *N. fleuryi* (Hickel) de Laub. Given the variability I have observed in specimens considered to belong to *N. nagi* from mainland China, Taiwan and Japan (some of which came from planted trees), a broader concept of *N. nagi* is here adopted (as in Flora of China 4, 1999), until it can be clearly demonstrated that there are distinct and sufficient character state differences in the Taiwanese trees that merit the recognition of one or more separate species, or even varieties of *N. nagi*.

Distribution

S China: Anhui, Fujian, Guangdong, Guangxi, Hainan, Hunan, Jiangxi Zhejiang; Japan: Kyushu, Nansei-Shoto [Ryukyu Is.], S Honshu, Shikoku; Taiwan.
TDWG codes: 36 CHC-HU CHH CHS 38 JAP-HN JAP-KY JAP-SH NNS TAI

Ecology

Nageia nagi occurs in mixed mesophytic evergreen forest and mixed mesophytic deciduous forest (Wang, 1961). It occurs in hills and low mountains from about 200 m to 1200 m a.s.l. In evergreen oak forest it is one of several shade tolerant conifers that may occur under canopy or take advantage of small gaps to break through: *Taxus chinensis, Cephalotaxus fortunei, Keteleeria fortunei*, and *Fokienia hodginsii* are the most common of these. Besides *Castanopsis* spp. and *Quercus* spp. (the oaks), numerous angiosperm trees occur in these forests or forest remnants. In Taiwan and southern Japan the coniferous element of this vegetation is more dominant, with *Pseudotsuga sinensis* or *P. japonica* and *Tsuga sieboldii* often added to the mixture. In forest or woodland on drier mountain slopes *N. nagi* tends to follow streams, but it is known to regenerate in more open thickets after forest disturbance.

Conservation

This species is widely distributed, but it is almost impossible to establish from herbarium collection data where it is truly indigenous (growing in the wild) and where it has been introduced and planted. Wilson (1916) noted that he did not meet with any trees growing in the wild whilst traveling in Japan. In the wild, it is limited to a few forest remnants in the most southern parts of that country, including the oceanic Ryukyu Islands. One can take the view (as the Chinese and Japanese mostly do), that such a taxon is not threatened with extinction even if its wild (sub)populations are greatly reduced. In Taiwan, S. Y. Lu (1996) has assessed the species as Critically Endangered (CR), with wild growing trees restricted to Taipei Co. in the north and Taitung Co. in the far south of the island. Similar inventories based on intimate knowledge of the forest flora are lacking for most of mainland China.
IUCN: NT

Uses

Nageia nagi is a valuable timber tree, but its most common use is as an amenity tree in China and Japan, where it is found in many of the climatically milder parts of these countries planted in gardens, parks, sanctuaries, and even as street trees. It is also popular as a tree for bonsai cultivation. It is much less commomly planted in Europe, the USA and New Zealand, where it is almost restricted to botanical collections.

Nageia wallichiana (Presl) Kuntze, Revis. Gen. Pl. 2: 800. 1891. *Podocarpus wallichianus* C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5, 3: 540. 1846; *Decussocarpus wallichianus* (C. Presl) de Laub., J. Arnold Arbor. 50: 349. 1969; *Podocarpus latifolius* Wall., Pl. Asiat. Rar. 1 (2): 26, t. 30. 1830, *non* Mirb. (1825); *Nageia latifolia* (Wall.) Gordon, Pinetum: 138. 1858. Type: India: Pundu Mts., Mt. Sillet, ["in montibus Punduae"], *N. Wallich 6050* (holotype K-W). Fig. 173, 174

Etymology

This species was named after Nathaniel Wallich (1786–1854), who was an early student of the Indian flora.

Vernacular names

Due to its wide range numerous local names have been recorded; Flora Malesiana 1, 10 (3): 393 (1988) lists many for the Malesian region; in China it is known as rou tuo zhu bai and in Viet Nam it is called Kim giao núi đất.

Description

Trees (rarely shrubs) to 50 m tall; trunk to 1m d.b.h., forming a straight, clear bole. Bark hard and scaly, peeling in thin flakes, dark brown or reddish brown; inner bark 5–6 mm thick, slightly fibrous, pinkish

or reddish. Crown with spreading branches, becoming rounded. Foliage branchlets opposite (but often one of the pair not developed) spreading rigidly, terete but ultimately slightly flattened and often twisted, with grooves, glabrous; terminal buds with lanceolate scales extending to a fine point. Leaves opposite or subopposite (towards end of branchlets often alternate), decussate or nearly in one plane on shaded branches; petiole twisted ca. 90° at base, 5–10(–15) mm long; leaf blade extremely variable in size and shape, 5–15(–23) × 2–6(–9) cm (largerst on young plants and shaded leaves), from narrowly elliptic to ovate-lanceolate, ovate or falcate (some terminal leaves) with acute to obtuse apex, coriaceous, with distinct parallel veins, dark green above, mid green below. Stomata on both surfaces, in numerous, intermittent lines, usually conspicuous on underside and less so on upperside. Pollen cones axillary, in clusters of up to 7–10 on a 4–10 mm long peduncle, variable in length from 0.8–2 cm, becoming cylindrical at full length, with a diam. of 3–4 mm; microsporophylls imbricate, apiculate, with two pollen sacs. Seed cones axillary, solitary, long pedunculate, with a few deciduous bracts near base of peduncle and cone bracts fused to a swelling green then red to purplish red 12–20(–30) mm long receptacle with 4–7 exserted bract tips. Seeds at apex of receptacle, single, enclosed in a green, when ripe dark purple epimatium, the whole globose, 15–20 mm diam. when succulent, wrinkled and nearly black when dry, with a loose seed inside.

Distribution

China: Yunnan; India: Assam, Kerala (Nilgiri and Palani Hills), Andaman Islands, Nicobar Islands; Indochina; Malesia (but not in Central & E Jawa and on the Lesser Sunda Islands only on Flores).

TDWG codes: 36 CHC-YN 40 ASS-AS ASS-MA ASS-ME IND-KE 41 AND-AN CBD LAO MYA NCB THA VIE 42 BOR-BR BOR-KA BOR-SB BOR-SR JAW LSI-LS MLY-PM MOL PHI SUL SUM 43 NWG-IJ NWG-PN

Ecology

This is the most widespread species in the genus *Nageia* and perhaps also one of the most truly tropical of all conifers, as it occurs near sea level in dipterocarp forest on the equator. It is scattered but often common in primary rainforest with canopy heights to 50 m or more, and occurs from lowlands to montane forested ridges at 2100 m a.s.l. In the lowland rainforest it develops a straight bole lifting its crown into the canopy. It is, however, not a long-lived emergent and boles usually are rather slender without buttresses indicating modest longevity. Unlike *Agathis* (*Araucariaceae*) it is not gregarious. Kerangas (forest on leached sandy soils) can have both species, as well as other conifers like *Dacrydium, Dacrycarpus, Falcatifolium falciforme*, and *Sundacarpus amarus*, mixed with *Myrtaceae* and other angiosperms that have adapted to poor nutrient situations. In China, *N. wallichiana* occurs in evergreen subtropical forest dominated by *Castanopsis* and/or *Quercus* on hillsides but not in high mountains. In margins of peat swamps, in mossy forest on sandstone plateaus of Sarawak, and on mountain ridges with clay or sand amongst rocks it becomes stunted. In New Guinea it is sometimes associated with *Araucaria* and *Podocarpus* in mixed conifer forests, which also have several species of *Fagaceae*, especially in the genus *Castanopsis*.

Conservation

IUCN: LC

Uses

Nageia wallichiana is a highly valued timber tree, especially where it grows into tall, straight trees with a long, clear bole. It is traded as podocarp wood. Long timber is sawn into planks for construction (mainly house building); other uses of the wood are plywood, veneer, interior finishing, furniture making, and sometimes (Fly River, Wagu, Papua New Guinea) the construction of small canoes. Small stems are used for household utensils, drumsticks, etc. It is not grown in cultivation other than in a few botanic gardens.

Neocallitropsis Florin, Palaeontographica B 85 (1–8): 590. 1944. Type: *Neocallitropsis pancheri* (Carrière) de Laub. [*Eutacta pancheri* Carrière] (*Cupressaceae*).

Callitropsis R. H. Compton, J. Linn. Soc., Bot. 45: 432. 1922, *non* Oerst. (1864). Type: *Callitropsis araucarioides* R. H. Compton [*Neocallitropsis pancheri* (Carrière) de Laub.]

Latin: *neo-* = new; *Callitropsis* (genus name) means 'similar to *Callitris*'; the prefix is here used to avoid a later homonym.

Description

See the species description.

Distribution

As for the species.

Neocallitropsis pancheri (Carrière) de Laub., Fl. Nouv. Calédonie Dépend. 4: 161. 1972. *Eutacta pancheri* Carrière, Traité Gén. Conif., ed. 2, 2: 864 [615]. 1867. Type: New Caledonia: Grande Terre, Province Sud, Montagnes de Yaté, *E. Vieillard 1274* (holotype P). Fig. 175, 176

Callitropsis araucarioides R. H. Compton, J. Linn. Soc., Bot. 45: 432. 1922; *Neocallitropsis araucarioides* (R. H. Compton) Florin, Palaeontographica B 85 (1–8): 590. 1944.

Etymology

The species epithet commemorates the French botanist Jean A. I. Pancher (1814–1877).

Vernacular names

No common names have been recorded for this species.

Description

Shrubs or small evergreen trees to 4–6(–10) m tall, multistemmed or monopodial, stem to 30–50 cm diam. Bark on large stems exfoliating in narrow strips, grey. Branches spreading wide or ascending, higher order branches assurgent or erect, forming a conical or more often a rounded or flat-topped open 'candelabra' crown. Foliage branchlets in dense tufts of 20–30, crowded at the terminal 10–15 cm of main branches, assurgent or erect, sparsely branched or unbranched, to 20 cm long, 5–10(–12) mm wide, densely covered with imbricate leaves, mostly determinate and deciduous, some continuous. Leaves in alternate whorls of 4, whorls turned 45 degrees around shoot axis relative to the previous whorl, seemingly in 8 rows, short decurrent or nearly sessile with broad base, lanceolate, incurved, thick, coriaceous, rigid, keeled, 6–15 × 1.8–2.5 mm; margins minutely serrate; apex acute-pungent; stomata in two bands abaxially, in more scattered rows adaxially; leaf colour yellowish green or green. Pollen cones terminal, 10–12 × 6–7 mm, subglobose to ovoid; microsporophylls in 3–4 alternating whorls of 4, 3–6 × 2 mm, peltate-rhombic with a long, acute or acuminate apex, bearing (2–)6–14 abaxial, small pollen sacs. Seed cones terminal on short branchlets, maturing within a year to an opened cone up to 15 mm long with spreading bract-scale complexes. Mature bract-scales in two alternating whorls of 4, with lower scales slightly larger than upper ones, 10–12 × 3 mm and 8–10 × 2 mm, subulate to linear, similar to mature foliage leaves but with adaxial thickening, leaving margins of outer bracts and apices unaltered but reflexed, rostrate; margins of thickened tissue papillose. Columella short pyramidal, 1.5 mm tall. Seeds 1–2(–4) per cone, angular-ovoid, acutish, 6–7 × 2.5–3.5 mm, light brown, with 2(–3) marginal 0.5–0.7 mm wide wings.

Distribution

New Caledonia: Province Sud (SE part), one location in Province Nord (Mt. Paéoua).
TDWG codes: 60 NWC

Ecology

In scrubland ('maquis minier') on ultramafic rock (serpentine, 'cuirasse maquis'), following stream

courses and along lower mountain ridges up to about 950 m a.s.l., rarely higher. This species is often associated along streams with the podocarps *Dacrydium araucarioides, D. guillauminii*, and *Dacrycarpus vieillardii*, elsewhere with *Agathis ovata, Callitris neocaledonica, Podocarpus novae-caledoniae*, and angiosperms, including many shrubs as well as *Cyperaceae*. Several of the trees and shrubs also develop the candelabra-like crowns typical for low trees and shrubs in this environment, but grow more solitary than *Neocallitropsis*, which is strongly gregarious. The climate is tropical with abundant rainfall through most of the year.

Conservation

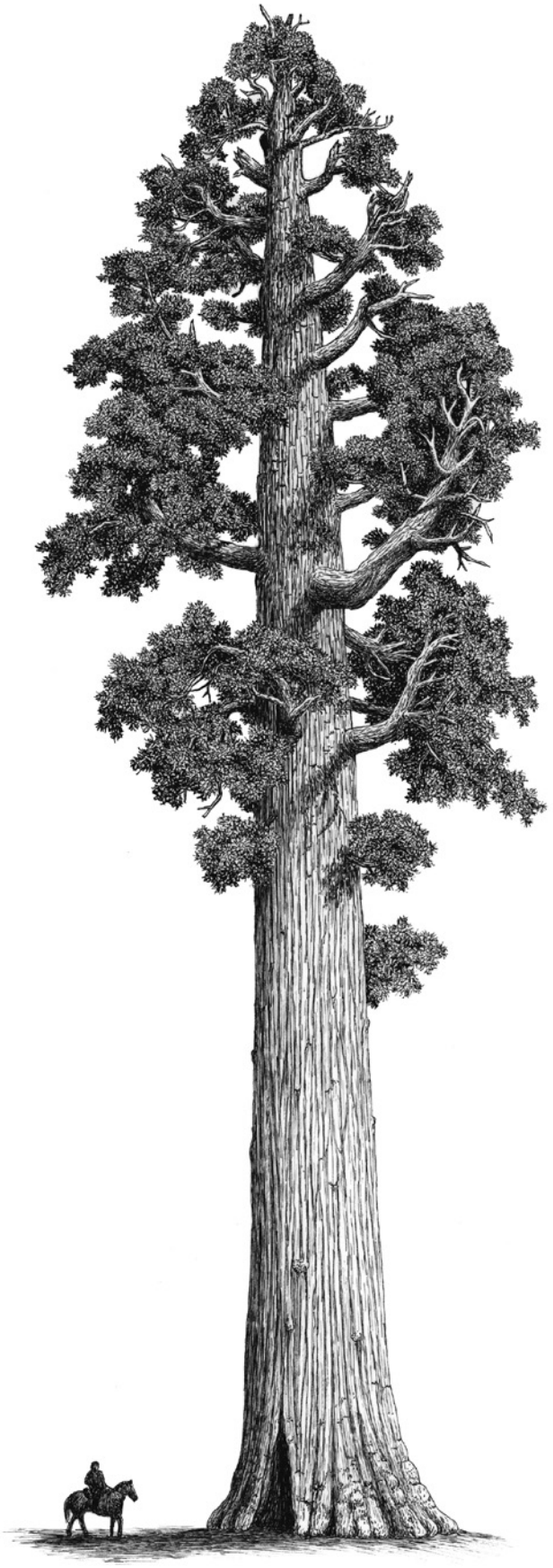
The habitat of this species is extremely susceptible to fire and wildfires are a widespread hazard in New Caledonia. With less than 10 populations known in the southern mountains and one, recently discovered, in the northern part of Grande Terre, conservation issues are apparent. In the past, there was unsustainable exploitation of the wood of this slow growing conifer for oil extraction, but this use has now virtually ceased. No assessment of any decline due to this exploitation has come to the attention of the Conifer Specialist Group of IUCN-SSC, yet the slow growth of this species makes it likely that this has occurred. A large population covering ca. 122 ha is protected in the Montagne des Sources (Parq de la Rivière Bleue) and smaller populations are under protection at the Chûte de la Madeleine (17.5 ha) and in the Plaine des Lacs (3.5 ha). Despite this protection, continued decline and fragmentation of populations are projected.

IUCN: EN [A2c, B1ab(iii)+2ab(iii)]

Uses

The resin in the wood of this species is used to make an oil extract, which is sold as '*Araucaria* oil'; this is now only locally traded. It is also locally used as an ornamental shrub, but does not appear to have been taken into cultivation outside New Caledonia.

A HANDBOOK OF THE WORLD'S CONIFERS



Giant Sequoia (*Sequoiadendron giganteum*) Drawing by Aljos Farjon

A HANDBOOK OF THE WORLD'S CONIFERS

BY

ALJOS FARJON

VOLUME II

SECOND, REVISED EDITION

BRILL
LEIDEN-BOSTON
2017

This book is printed on acid-free paper.

Library of Congress Cataloging-in-Publication Data

The Library of Congress Cataloging-in-Publication Data is available from the Publisher.

front cover:
Cunninghamia konishii foliage

back cover:
top left: *Pinus wallichiana* seed cones
bottom right: *Cephalotaxus haringtonii* ripe seeds

VOLUME ISBN: 978 90 04 32450 3
SET ISBN: 978 90 04 32442 8
E-ISBN: 978 90 04 32451 0

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Nothotsuga Hu *ex* C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 390. 1989. Type: *Nothotsuga longibracteata* (W. C. Cheng) Hu *ex* C. N. Page [*Tsuga longibracteata* W. C. Cheng] (*Pinaceae*).

Greek: *nothos* = bastard, base-born; i.e. a (putative) hybrid between *Tsuga* and an unnamed genus.

Description

See the species description.

Distribution

As for the species.

Nothotsuga longibracteata (W. C. Cheng) Hu *ex* C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 390. 1989. *Tsuga longibracteata* W. C. Cheng, Contr. Biol. Lab. Sci. Soc. China, Sect. Bot. 7 (1): 1. 1932. Type: China: Guizhou, Yinjiang Tujiazu Miaozu Zizhix, Fanjing Shan, ["Yinkiang"], *Y. Tsiang 7712* (holotype NAS). Pl. 22, Fig. 177, 178

Etymology

The species epithet describes the relatively long bracts on the seed cone.

Vernacular names

Bristlecone Hemlock; changbao tieshan (Chinese)

Description

Trees to 30 m tall, d.b.h. to 1–1.2 m; trunk monopodial, often forked or multi stemmed; bark soon flaking, rough and scaly, brownish grey. Branches long, heavy, curved, ascending or spreading; crown of young trees conical, with a drooping leader, of old trees open and irregular or dense and flat topped. Branchlets slender, firm, not drooping, brownish yellow to brown, in 2nd or 3rd year grey; mostly glabrous, rarely minutely pubescent, with weakly developed pulvini; on 2–3 year old twigs develop numerous small, lateral, leaved shoots (5–15 mm), which do not extend much further. Vegetative buds ovoid, acutish at apex, 2–4 mm long, not resinous, shining brown. Leaves more or less pectinate, on small lateral shoots in false whorls on emergence, otherwise remote, with oblique, twisted petiole, 1.1–2.4 cm long, 1–2(–2.5) mm wide, linear, abruptly tapering at both ends; apex acutish, faintly grooved above, slightly flattened; margins entire; stomata 5–10 lines along the median groove above, two bands separated by a faint midrib below (abaxial side); leaf colour dark glossy green, stomatal bands whitish green. Pollen cones subterminal on small lateral shoots, clustered in umbels from a single bud, pedunculate, pendant, 5–10 mm long, yellowish brown (*in sicco*). Seed cones lateral, or subterminal on small shoots, more or less erect on 5–10 mm long peduncles, ovoid oblong to cylindrical, with obtuse truncate apex, (2–)2.5–5(–5.8) cm long, 1.5–2.5(–3) cm wide with opened scales, purplish or red when immature, ripening to dark brown; old cones persisting several years, breaking off at peduncle, or sometimes disintegrating; cone rachis blackish brown. Seed scales 20–30, suborbicular to broadly peltate-auriculate, convex, opening slightly or very wide (reflexed), 1–2.2 × 1.2–2.5 cm at mid-cone; abaxial surface sparsely pubescent when immature, soon glabrous, finely striated; upper margin rounded, entire or erose; base short pedicellate. Bracts subspathulate, erose-denticulate at acute apex, 7–18 mm long, straight, not exserted beyond margins of more distal seed scales. Seeds ovoid, 4 × 2.5–3 mm, brown; seed wings ovate-oblong, 7–12 × 5–6 mm, reddish brown.

Taxonomic notes

This taxon was first described as a species of *Tsuga* by the well-known Chinese botanist W. C. Cheng in 1932. Hu (1951) proposed a separate genus *Nothotsuga* for this species, but failed to give a Latin description; the genus name was then validated by Page (1989). French botanists in the 'School of Gaussen' at Toulouse proposed a generic hybrid origin between *Keteleeria* and *Tsuga*, but gave no evidence for this

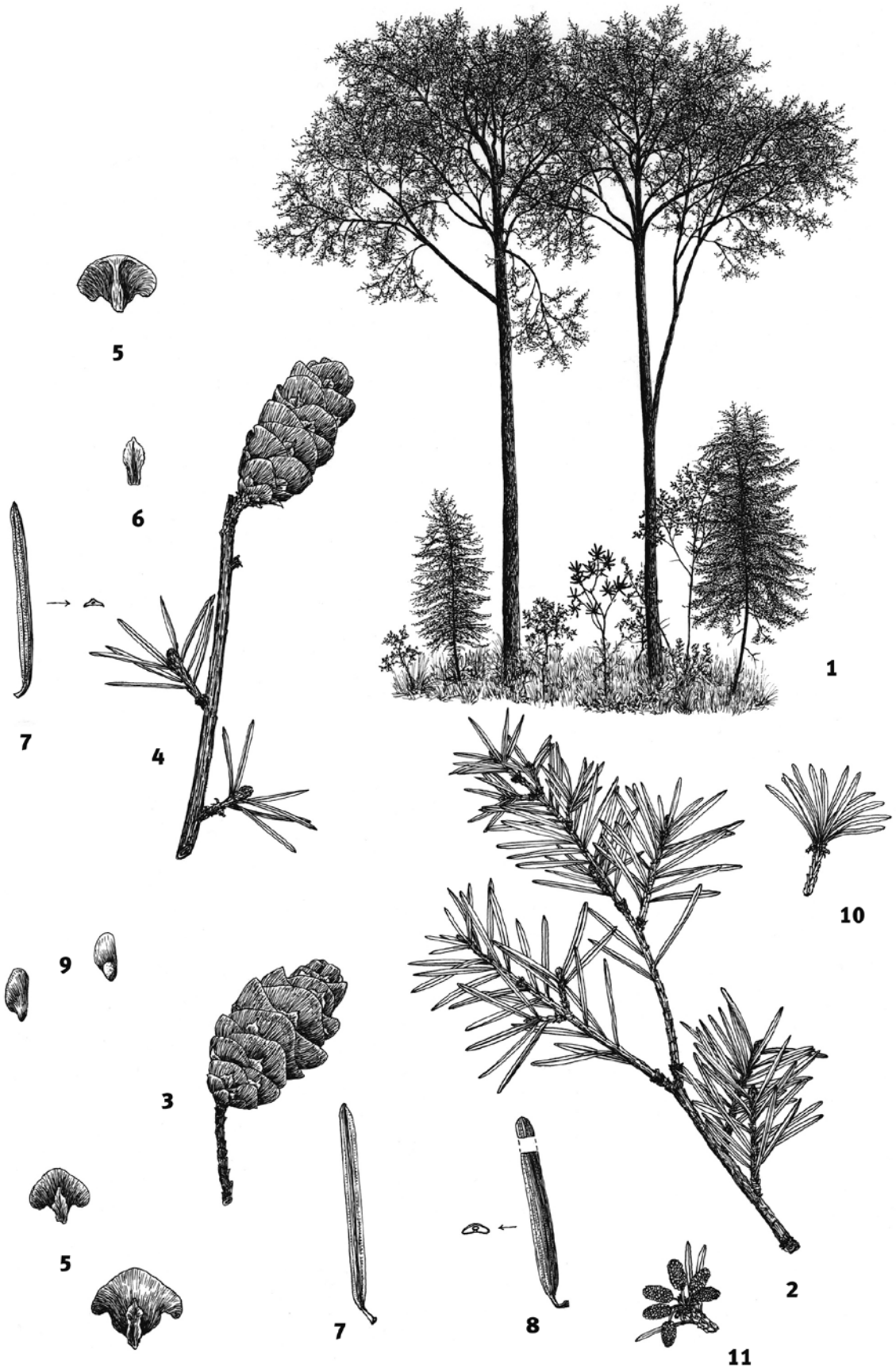

PLATE 22. *Nothotsuga longibracteata*. **1.** Habit of trees. **2.** Branch with foliage. **3, 4.** Seed cones. **5.** Seed cone scales. **6.** Bract. **7, 8.** Leaves. **9.** Seeds. **10.** Short shoot with leaves. **11.** Pollen cones.

and applied an illegitimate name. Chinese botanists (e.g. Flora of China 4: 39–40, 1999) do not recognize its status as a distinct genus, but there are several distinctive characters in both male and female cones not shared by other species of *Tsuga* in Asia or North America that appear to justify generic recognition. Its phylogenetic position based on both morphological and DNA data confirms this taxonomy. Despite its name, there is no evidence that this taxon is of hybrid origin.

Distribution

China: Fujian, N Guangdong, NE Guangxi, NE Guizhou, SW Hunan, SE Jiangxi.
TDWG codes: 36 CHC-GZ CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JX

Ecology

Nothotsuga longibracteata occurs on low to medium high mountains, at elevations between 300 and 2300 m a.s.l. It grows on both red and yellow earth. The climate is humid and warm-temperate to wet and cool, with annual precipitation between 1000–2000 mm. The species occurs in two forest formations (Wang, 1961). In the evergreen broad-leaved forest formation mostly with sclerophyllous broad-leaved trees such as *Castanopsis* spp., *Lithocarpus* spp., *Quercus* spp., and with *Fokienia hodginsii*; in the deciduous mixed mesophytic forest at higher elevations with *Fagus longipetiolata, Tetracentron sinensis, Nyssa sinensis, Acer angustilobium, Davidia involucrata, Sorbus* spp., etc. In the evergreen broad-leaved forest formation there are stands of pure *Nothotsuga longibracteata* and *Tsuga chinensis. Pinus massoniana* or *P. fenzeliana* (syn. *P. kwangtungensis*) locally dominate the general canopy of broad-leaved trees on poorer sites, where *N. longibracteata* is also concentrated.

Conservation

This species has been considered to be Endangered, because it is very rare despite its relatively wide distribution. Large scale logging has depleted the number of trees to an unquantified extent (Fu & Jin, 1992) and substantial parts of forest with this species must have gone, especially at lower elevations. In spite of the rarity of the species throughout its range, it is not felt that the population reduction could have exceeded 70% or even 50% over the past three generations which would prevent a category of threat from being applied.
IUCN: NT

Uses

In China this species is considered to be a desirable forest tree suitable for afforestation. Its use as a timber tree must be limited due to its rarity. It is not in general cultivation outside China and rare in botanical collections.

Papuacedrus H. L. Li, J. Arnold Arbor. 34: 25. 1953. Type: *Papuacedrus papuana* (F. Muell.) H. L. Li [*Libocedrus papuana* F. Muell.] (*Cupressaceae*).

Papua = New Guinea; *Cedrus* is the classical name for (true) cedars.

Description

See the species description.

Distribution

As for the species.

Papuacedrus papuana (F. Muell.) H. L. Li, J. Arnold Arbor. 34: 25. 1953.

Etymology

The species epithet refers to Papua, a collective name for the island of New Guinea and the Australasian people who were its first settlers.

Vernacular names

De Laubenfels, in Flora Malesiana 1, 10 (3): 446 (1988), cites numerous local names applied in New Guinea to this species.

Description

Trees to 20(–50) m tall, evergreen, monoecious, often appearing dioecious; trunk normally monopodial, slender, to 60 cm d.b.h. Bark often spirally twisted, exfoliating in shaggy scales or strips; outer bark light brown, weathering grey. Branches short and spreading in sheltered (younger) trees, long, ascending to nearly erect in high montane forest, forming conical to pyramidal crowns, or ± umbellate, flat-topped crowns at higher altitudes. Foliage branches mostly in flattened sprays, denser and assurgent in older and exposed crowns, branching distichous, frondose, ultimate branchlets gradually shorter, entirely covered with flattened leaves. Leaves on lateral branchlets scale-like, in whorls of 4 or decussate, strongly dimorphic, imbricate; facials much smaller than laterals, 1 mm on old, 'mature' foliage, up to 8 mm long on whip shoots of young plants, rhombic to lanceolate in appearance, carinate, cuspidate; laterals bilaterally flattened, 2–3 mm long on old, 'mature' foliage, up to 20 mm long on whip shoots of young plants, lanceolate to oblong; margins entire, with incurved, appressed or free, obtuse or acute apex; few stomata on upperside and 2 broad primary stomatal bands on underside; gland absent or inconspicuous at base of facials; leaf colour lustrous olive green to dark green, with glaucous green stomatal bands. Pollen cones terminal, solitary, cylindrical, 6–25 × 2–3 mm; microsporophylls 8–30, decussate or in whorls of 4, peltate, with acute or rounded apex, bearing (2–)4(–6) abaxial pollen sacs near lower margin. Seed cones (sub)terminal, on 2–10 mm long branchlets with rhombic, acute scale leaves, thin woody, 8–18 × 5–8 mm when closed, changing from green to glaucous green to brown or dark blackish brown. Bract-scale complexes consisting of 2 decussate pairs; lower pair 4–7 × 2–5 mm, curved, widest at base; upper pair much larger, 7–17 × 3–7 mm, elliptic, widest in the middle section where the recurved, acute bract tip emerges, distal part slightly reflexed, truncate or obtuse, rugose with grooves radiating from bract tip abaxially, smooth or striate adaxially, with whitish seed scars near base. Seeds 2–4, angular-ovoid or oblique, 2–5 × 1–3 mm, red-brown with a whitish hilum; wings 2 on opposite sides, thin membranous; largest wing 4–7 × 2–5 mm; smallest wing often reduced to a strip 1–2 mm wide, translucent yellowish brown.

Taxonomic notes

The morphological differences in the leaves between *Papuacedrus papuana* var. *papuana* and *P. papuana* var. *arfakensis* are minor and disappear with the 'maturation' of the foliage. As in many other conifers, leaves in a juvenile stage differ markedly in shape and size from leaves in an adult stage and, as in this case, there are often transitional forms as well. The ranges

of both varieties overlap, but var. *arfakensis* only occurs in the western parts of New Guinea and is presumably the only variety in the Moluccas, where the species remains undercollected (Johns, 1995). From herbarium specimens with adult-type foliage and without pollen cones it becomes impossible to determine whether the sample represents either one of the varieties. Van Royen (1979), perhaps with this difficulty in mind, recognized one species without any infraspecific distinctions.

Distribution

Malesia: Maluku [Moluccas]; Papuasia: New Guinea.
TDWG codes: 42 MOL 43 NWG-IJ NWG-PN

Ecology

This species, as it occurs along a substantial altitudinal gradient, is present in different forest zones from montane tropical rainforest to subalpine scrubland. The altitudinal range is (620–)900–3600(–3800) m a.s.l.; its greatest extent and abundance is reached in the mossy cloud forest zone from ca. 1500 m to the tree line. In the lower montane rainforest it is a scattered emergent associated with angiosperms such as *Casuarina, Castanopsis, Cinnamomum, Engelhardtia, Halfordia, Lithocarpus, Schizomeria*, and *Xanthostemon*; in higher montane forest it becomes more prevalent with *Nothofagus*, *Cryptocarya*, and *Eugenia*. It can also form conifer dominated forest, occasionally with *Araucaria cunninghamii* var. *papuana*, but more often with *Dacrydium* spp., *Phyllocladus hypophyllus*, and *Podocarpus* spp. These small conifer forests are often surrounded by fire-induced grasslands (*Imperata cylindrica*) with a mantle zone of ericaceous shrubs, or by tree fern grassland. Many of these conifers are often present in lower densities in the lower montane rain forests as well. At lower altitudes *Papuacedrus* grows mostly on basic soils. In mossy forest, along high mountain streams and in subalpine scrubland the trees are stunted and the soils are often acidic and water-logged; at around 3000 m or higher swamps are often surounded by *Papuacedrus-Phyllocladus-Podocarpus* woodland with tussocks of *Gahnia* dominant in the understorey (Johns, 1995). Rainfall is generally high but seasonal, with up to 4000 mm per year on the highest slopes.

Uses

The timber of this species is widely used for construction (mainly building of houses in villages); in some areas the fibrous bark is used for roof covering and insulating house walls. It is rarely cultivated, although individual trees may be planted at 'sing-sing' or dance grounds of villages (Johns, 1995). In horticulture it is only known from a few botanic gardens.

2 varieties are recognized:

Papuacedrus papuana (F. Muell.) H. L. Li var. ***papuana***. *Libocedrus papuana* F. Muell., Trans. Roy. Soc. Victoria 1 (2): 32. 1889. Type: Papua New Guinea: Owen Stanley Range, Mt. Knutsford, [probably Owalama Range], *W. MacGregor 286* (holotype MEL). Fig. 179, 180

Description

Lateral pair of transitional leaves on young plants spreading widely from base up to 6 mm at the farthest point below apex, falcately curved; apex turned upwards or slightly recurved; intermediate leaves similar but less widely spreading. Pollen cones 6–15 mm long, with up to 16 decussate or whorled microsporophylls.

Distribution

New Guinea
TDWG codes: 43 NWG-IJ NWG-PN

Conservation

Despite logging activities in large parts of its range that have been associated with human habitation for a very long time, this variety is still abundant and not considered threatened with extinction.
IUCN: LC

Papuacedrus papuana (F. Muell.) H. L. Li var. ***arfakensis*** (Gibbs) R. J. Johns, Curtis's Bot. Mag. 12 (2): 70. 1995. *Libocedrus arfakensis* Gibbs, Contr. Phytogeogr. Fl. Arfak Mts.: 84, f. 6a-b. 1917; *Papuacedrus arfakensis* (Gibbs) H. L. Li, J. Arnold Arbor. 34: 25. 1953; *Libocedrus papuana* F. Muell. var. *arfakensis* (Gibbs) de Laub., Fl. Malesiana, ser. 1, 10 (3): 446. 1988. Type: Indonesia: Papua, Arfak Mts., Koebre Ridge, *L. S. Gibbs 5594* (lectotype BM).

Description

Lateral pair of transitional leaves on young plants spreading slightly from base up to 3 mm at the farthest point below apex, apically recurved towards base of the following pair; intermediate leaves like adult leaves but larger. Pollen cones 15–25 mm long, with up to 30 whorled microsporophylls.

Distribution

Malesia: Maluku [Moluccas] (Bacan and Obi Islands); Papuasia: New Guinea: Papua (Bird's Head Peninsula, Sudirman Mts.).
TDWG codes: 42 MOL 43 NWG-IJ

Conservation

The known range of this variety is relatively wide and its extent of occurrence (EOO), calculated at 160,929 km², falls well outside the threshold for a threatened category. However, it is also disjunct, with two localities in Maluku (Moluccas) and one around the Wissel Lakes in New Guinea. The timber of this tree is widely used for the construction of houses in rural villages. It is therefore suspected that some decline may have occurred in more densely populated areas such as around the Wissel Lakes. Its most widespread stands are probably in the Arfak Mountains. It is appropriate to flag this variety as Near Threatened as it nearly meets B2ab (ii, iii) for Vulnerable.
IUCN: NT

Parasitaxus de Laub., Fl. Nouv. Calédonie Dépend. 4: 44. 1972. Type: *Parasitaxus usta* (Vieill.) de Laub. [*Dacrydium ustum* Vieill.] (*Podocarpaceae*).

Latin: *parasitus* = a parasite; *Taxus* is the classical Latin name for yew. [While now understood as a distinct family, podocarps were formerly classified with *Taxaceae*].

Description

See the species description.

Distribution

As for the species.

Parasitaxus usta (Vieill.) de Laub., Fl. Nouv. Calédonie Dépend. 4: 45. 1972, ["ustus"]. *Dacrydium ustum* Vieill., Ann. Sci. Nat. Bot., sér. 4, 16: 56. 1861; *Podocarpus ustus* (Vieill.) Brongn. & Gris, Bull. Soc. Bot. France 13: 426. 1866; *Nageia usta* (Vieill.) Kuntze, Revis. Gen. Pl. 2: 800. 1891. Type: New Caledonia: Grande Terre, Province Sud, Poila, (mountains around Poila), *E. Vieillard 1267* (holotype P). Fig. 181, 182

Etymology

Usta is a Latin word for a red pigment and here refers to the red colour of the branchlets. [The ending of the epithet changes with the gender of the genus name: -a = feminine, -um = neuter, -us = masculine.]

Vernacular names

Cèdre rabougri (NC French)

Description

Small erect monoecious shrubs to 150 cm tall but usually less than 100 cm, multi-stemmed or sometimes with a single stem. Bark thin, with large lenticels, on lower stem breaking into small grey scales. Branches numerous, spreading and ascending, contorted, the higher order branchlets covered in reddish scale leaves, the (pen)ultimate branchlets 2–3 mm thick, scaly with leaves, purple. Leaves scale-like, spirally arranged, imbricate and decurrent, 2–3 mm long, 1–2 mm wide (on older branches larger and being forced apart by the thickening branch), broadly lanceolate to more or less triangular; apex appressed or free, obtuse or acute. Stomata on both sides of leaves, conspicuous and scattered on abaxial side. Pollen cones usually on the same branching systems as seed cones, terminal, solitary, more or less oval, 3–3.5 mm long, 1.5–2 mm wide; microsporophylls 8–13, imbricate, broadly triangular with erose upper margin, terminating in an incurved apex, with two basal pollen sacs. Fertile ovulate branchlets numerous, erect. Seed cones mostly terminal, some lateral, consisting of 3–6 spreading narrow and apically incurved red bracts of which the distal 1–2 subtend short pedunculate fertile scales bearing a single terminal and inverted ovule. Young seeds ovoid-oblong with an apical crest, when mature completely surrounded by a globose, hard, glaucous white epimatium, the whole 3–4 mm diam.

Taxonomic notes

This remarkable little conifer was first described as a species of *Dacrydium* in 1861 and a few years later transferred to the genus *Podocarpus* and then, in 1891, incomprehensibly at least under the present circumscription of that genus, to *Nageia*. Not until 1959, when David de Laubenfels published a brief note on it in the journal Science, was it demonstrated to be parasitic on another conifer in the *Podocarpaceae, Falcatifolium taxoides*. It is the first and only parasitic gymnosperm ever recorded. Its species epithet under *Dacrydium* (neuter) was *ustum*, under *Podocarpus* (masculine) *ustus*, but under *Parasitaxus*, which may not be a *Taxus* taxonomically but certainly is so for purposes of Latin nomenclature, it has to be *usta* (feminine).

Distribution

New Caledonia (Grande Terre).
TDWG codes: 60 NWC

Ecology

Parasitaxus usta is the only known parasitic gymnosperm. Its host is another podocarpaceous conifer, *Falcatifolium taxoides*, a small tree. The parasite attaches to the roots (sometimes the [underground] stem base) of the host, but how the seed of *P. usta* germinates and how the seedling makes the connection is still not fully understood. The most likely scenario involves the help of a fungus (*Deuteromycotina* or '*fungi imperfecti*'), which establishes a mycelian endophyte that enters the root cambium of the host and the haustorial base of the parasite (Woltz *et al.*, 1995). Plants of *P. usta* are nearly always found growing (seemingly in the litter-covered soil) under trees of *F. taxoides*, but sometimes on the base of the trunk. The leaves of *P. usta* contain chlorophyll and are stomatiferous, but are not green and its capacity of independent carbon fixation is severely reduced. Its habitat is therefore that of its host: moist tropical montane angiosperm forest with scattered conifers, commonly with emergent *Araucaria* spp. or less often *Agathis* spp. *Parasitaxus usta* grows usually in the deep shade of a multi-layered canopy, never in full sunlight.

Conservation

Parasitaxus usta is found scattered across the main island (Grande Terre), with a concentration of sites in the Montagnes des Sources and another in the mountain range culminating in Mont Panié in the north. Its actual abundance is difficult to ascertain due to its cryptic habit in dense, shady undergrowth; most individuals are being observed close to established mountain trails. Its host is a small tree not exploited for timber. Due to its shunning of sunlight, closed-canopy primary forest is essential habitat for this strange conifer, and local deforestation may already have reduced populations and would threaten others. It is present in a number of well protected mountain forest areas, including the Montagnes des Sources and Mont Panié.

IUCN: VU [B1ab(iii)+2ab(iii); C2a(i)]

Uses

There are no uses recorded of this unique species and attempts to cultivate it in some botanic gardens have thus far remained unsuccessful. It is a sacred plant in the tradition of the Kanaks, the first people to colonize New Caledonia from Melanesia.

Pherosphaera W. Archer, Hooker's J. Bot. Kew Gard. Misc. 2: 52. 1850, *p.p., quoad descr. foem*. Type: *Pherosphaera hookeriana* W. Archer (*Podocarpaceae*).

Microstrobos J. Garden & L. A. S. Johnson, Contr. New South Wales Natl. Herb. 1 (6): 315. 1951. Type: *Microstrobos fitzgeraldii* (F. Muell.) J. Garden & L. A. S. Johnson

Greek: *phero* = to bear; *sphaira* = ball, globe; referring to the shape of the seed cones.

Description

Dioecious evergreen shrubs. Resin cavities in leaves. Bark smooth or rough and scaly. Branches spreading and rigid or pendulous and creeping. Adult and juvenile leaves similar, spirally arranged, 2–4(–6) mm long and mostly scale-like. Stomata on adaxial side, hidden from view. Pollen cones terminal, globose to ovoid, 2–6 mm long; microsporophylls (6–)8–15, spirally arranged, with two basal pollen sacs; pollen with 2–3 air sacs. Seed cones terminal on small branchlets, more or less globular, 2–4 mm long, with (3–)5–8 spreading, fertile scales, not fleshy at maturity. Mature seeds usually 1–4 per cone, solitary and basal on adaxial side of a fertile scale (bract), exposed, erect, ovoid with a slightly constricted and truncated apex.

2 species.

Distribution

Australia: New South Wales, Tasmania.

Key to the species of *Pherosphaera*

- Branches drooping to pendulous; foliage branches very lax and slender; leaves 2–4 × 1 mm *P. fitzgeraldii*
- Branches spreading, contorted; foliage branches assurgent or spreading; leaves 1 × 1 mm *P. hookeriana*

Pherosphaera fitzgeraldii (F. Muell.) Hook. f., Hooker's Icon. Pl. 4: t. 1383. 1882. *Dacrydium fitzgeraldii* F. Muell., Fragm. 11: 102. 1880; *Microstrobos fitzgeraldii* (F. Muell.) J. Garden & L. A. S. Johnson, Contr. New South Wales Natl. Herb. 1 (6): 316. 1951. Type: Australia, New South Wales, Blue Mountains, *R. Fitzgerald s.n.*, 1880, 1881 (syntypes, ?MEL, *n.v.*).

Etymology

This species was named by Ferdinand von Mueller after R. Fitzgerald, who presented him with the first botanical specimens.

Vernacular names

Dwarf mountain pine

Description

Ascending, erect or drooping shrub to 1 m tall and 2 m wide. Bark smooth, brown, weathering grey. Branches slender, drooping to pendulous or straggling over rocks; foliage branches very lax and slender, irregularly branched two to four times. Leaves monomorphic, spirally arranged, decurrent at base, the free part spreading, 2–4 mm long (varying in length on a single branchlet), ca. 1 mm wide (wider at base, narrower at apex), subulate, apically incurved, keeled on abaxial side, convex on adaxial side; apex obtuse or apiculate; leaf colour dark olive green, whitish on adaxial side where stomata are situated. Pollen cones terminal, solitary, globose maturing to ovoid, 4–6 × 3 mm; microsporophylls 10–15, spirally arranged, ovate-oblong with erose-denticulate margin and two basal pollen sacs. Seed cones terminal and solitary on erect branchlets, more or less globular, 2–4 mm long, with 4–8 fertile, spreading, broadly lanceolate to ovate bracts. Mature seeds usually 1–3 per cone, solitary and basal on adaxial side of a fertile scale (bract), exposed, erect, ovoid with a slightly constricted and truncated apex, ca. 1 × 0.7 mm, dull brown.

Distribution

Australia: New South Wales (Blue Mountains, from Katoomba Falls to Wentworth Falls).
TDWG codes: 50 NSW-NS

Ecology

Pherosphaera fitzgeraldii has an extremely limited distribution and specific habitat. This species occurs on the sides (on ledges) and at the bottom of waterfalls which cascade off the sandstone escarpment on the eastern side of the Blue Mountains. These falls have fluctuating amounts of water dependent on precipitation levels that have occurred on the plateaus above. The altitude where the species grows ranges from 600 to 930 m a.s.l. This shrubby, often trailing species is only found within the spray zone of the waterfalls. It occurs there with other shrubs, ferns and mosses, in part under tree canopy, in part in the open but then often shaded part of the day as it predominantly grows on S-facing precipices. Invasive weeds (*Hedera, Rubus*) occur among several populations.

Conservation

This species is extremely rare and has suffered a substantial decline. Baker & Smith (1910) wrote: "at the base of most of the chief falls on the Blue Mountains" but it is now known to grow only on a few cliffs in the Wentworth Falls and Katoomba Falls, an extent of occurrence ca. 9 km long. A survey in 1988 reported 455 individual plants in 7 populations. Five of these populations were on government land (Blue Mountains National Park), two on private land. Recruitment is very low or almost negligible and a slow decline has been observed directly over several years. Threats are or have been urban development, water pollution, habitat degradation, and competition from invasive species (*Hedera helix, Rubus* sp.), as well as native shrubs and trees.
IUCN: CR [B1ab (iii)]

Uses

Dwarf mountain pine is rare in cultivation, but makes an attractive rock-dwelling small shrub. It is presently mostly confined to botanic gardens, but should be suitable for rock gardens close to water features including fountains. Its growth in cultivation would also contribute substantially to *ex situ* conservation of this endangered species.

Pherosphaera hookeriana W. Archer, Hooker's J. Bot. Kew Gard. Misc. 2: 52. 1850, *p.p., excl. typ.* *Dacrydium hookerianum* (W. Archer) Eichler, in Engler & Prantl, Nat. Pflanzenfam. 2 (1): 107. 1887. Type: Australia: Tasmania, ["V. D. Land"], *R. C. Gunn s.n.* (lectotype K). Fig. 183

Microstrobos niphophilus J. Garden & L. A. S. Johnson, Contr. New South Wales Natl. Herb. 1 (6): 316. 1951, *non rite publ.* (Art. 36); *Pherosphaera niphophila* (J. Garden & L. A. S. Johnson) Florin, Taxon 5 (8): 191. 1956, *non rite publ.* (Art. 36).

Etymology

This species was named after the English botanist Joseph Dalton Hooker (1817–1911), the second Director at the Royal Botanic Gardens, Kew.

Vernacular names

Mount Mawson pine

Description

Erect, densely branched shrub to 2.5 m tall. Bark on larger stems rough, exfoliating with small scales, brown weathering blackish grey. Branches spreading, contorted; foliage branches assurgent or spreading, divided up to four times until very small; (pen)ultimate branchlets 1–1.5 mm thick, forming dense and stiff tufts of foliage. Leaves spirally arranged, scale-like, in seedlings and young plants short lanceolate, 2–2.5 × 1 mm, largely free but incurved, keeled, replaced higher up the plant by smaller leaves; in mature plants all imbricate and closely appressed, broadly triangular, mostly ca. 1 × 1 mm, on whip shoots to 2.5 × 1.5 mm, on older, thicker branchlets to 2 × 2 mm, concave with a blunt keel; margins minutely serrate; apex obtuse; leaf colour yellowish green. Stomata on adaxial side, hidden from view. Pollen cones numerous, terminal, globose, ca. 2 mm diam. colour red-brown at anthesis; microsporo-

phylls (6–)8–12, spirally arranged, rounded with serrulate margins and two basal pollen sacs. Seed cones terminal on distally down-curved branchlets, more or less globular, 3–4 mm long, with (3–)5–8 spreading, fertile, ovate and concave scales with an acute apex, browning at maturity. Mature seeds usually 1–4 per cone, solitary and basal on adaxial side of a fertile scale (bract), exposed, erect, ovoid with a slightly constricted and truncated apex, ca. 1.3 × 1 mm, lustrous brown.

Distribution

Australia: Tasmania (central and western mountains).
TDWG codes: 50 TAS

Ecology

Pherosphaera hookeriana occurs in the subalpine regions of the Tasmanian highlands, usually above 1000 m a.s.l. It is frequent in wet moors and often fringes the lakes and tarns that are numerous in these mountains. Precipitation is high and occurs year-round; temperatures are cool with sleet and snow falling in most months of the year, but mostly in winter. There is no extended period of snow cover as the climate is extremely oceanic. Bedrocks are acidic granites, gabbro, and gneiss and the waters have a low pH of 4.5–5 on average. This species is often associated with *Athrotaxis cupressoides, Microcachrys tetragona* and, usually on somewhat drier sites, with *Diselma archeri*; frequent angiosperms are *Nothofagus gunneri, Richea pandanifolia, R. scoparia*, and *Eucalyptus coccifera*, while cushion forming peat mosses (*Sphagnum*) cover the ground in many places.

Conservation

IUCN: NT

Uses

This shrubby species is rare in cultivation, being grown in some specialist nurseries and often confused with *Diselma archeri* (*Cupressaceae*). It should be hardy in areas with mild and wet winters where frost is light. It will make a suitable shrub for rock gardens or for pot-grown balcony or patio evergreens.

Phyllocladus Rich. *ex* Mirb., Mém. Mus. Hist. Nat. 13: 48. 1825 (*nom. cons.*). Type: *Phyllocladus aspleniifolius* (Labill.) Hook. f. [*Phyllocladus billardieri* Mirb. (*nom. illeg.*) (*Podocarpus aspleniifolius* Labill.)] (*Phyllocladaceae*).

Brownetera Rich. *ex* Tratt., Ann. Mus. Natl. Hist. Nat. (Paris) 16: 299. 1810. Type: *Brownetera aspleniifolia* (Labill.) Tratt. [*Podocarpus aspleniifolius* Labill.] *Thalamia* Spreng., Anleit. Kennt. Gewächse, ed. 2, 2: 218. 1817. Type: *Thalamia aspleniifolia* (Labill.) Spreng. [*Podocarpus aspleniifolius* Labill.]

Greek: *phyllos* = leaf; *klados* = branch, shoot; in botanical Latin: *phyllocladium* = a leaf-like branch or shoot.

Description

Shrubs or trees, usually dioecious, occasionally monoecious, evergreen. Resin in bark and phylloclades. Bark smooth, becoming scaly. Branches in pseudo-whorls at intervals along a main or single stem, plagiotropic and/or ascending (Rauh's model); lateral branches of highest order transformed to simple or compound (pinnate) phylloclades (green planated branchlets of variable size and shape) arranged spirally or in pseudo-whorls. Indeterminate shoots ending in a globose bud with imbricate scales. True leaves on seedlings on the main stem, linear, changing gradually to subulate and scaly, inconspicuous and deciduous on lateral branchlets in older plants. Stomata in mature plants restricted to phylloclades. Pollen cones crowded in a low spiral at or below apex of leading normal shoots, becoming more or less remotely placed with shoot elongation, subtended by perular scales, stalked, cylindrical; microsporophylls with a small triangular head and two relatively large pollen sacs containing bisaccate pollen. Seed cones (sub)marginal or terminal on petiolate or foliate parts of phylloclades, in rows, in pairs or solitary; consisting of a few to many bract scales, of which 1–several are fertile; ovules axillary to a bract scale, solitary, erect, subtended by an aril, which arises after the ovule has been formed. Seeds ovoid, dorsiventrally compressed, partly embedded by the fused, swollen and succulent bract scales of the cone and subtended by a filmy white aril leaving the apical part free. Seedlings with 2 cotyledons.

4 species.

Distribution

Malesia: Borneo, Sulawesi, Philippines, Maluku [Moluccas], New Guinea; Australia: Tasmania; SW Pacific: New Zealand.

Key to the species of *Phyllocladus*

Reproductive organs (pollen and seed cones) are not always present but have some diagnostic characters necessary for correct determination. As a further aide therefore the country or region of origin is also given with each species.

1a. Phylloclades simple or pinnately compound; margins crenately or obtusely lobed. **2**

1b. Phylloclades pinnately compound; margins entire to deeply dissected **3**

2a. Phylloclades mostly simple. Pollen cones on a short branching system, solitary or with 2–5 together. Native of Tasmania ***P. aspleniifolius***

2b. Phylloclades pinnately compound or simple. Pollen cones from a terminal bud with up to 10 in a pseudo-whorl. Native of New Zealand ***P. trichomanoides***

3a. Seed cones 4–8(–10) alternately on either side of the petiolate phylloclade base. Pollen cones from a terminal bud with 15–20 in a pseudo-whorl. Native of New Zealand ***P. toatoa***

3b. Seed cones on the margins or in an apical notch of phylloclades, solitary or with 2–3 together. Pollen cones on a short branching system, up to 15 together. Native throughout Malesia ***P. hypophyllus***

Phyllocladus aspleniifolius (Labill.) Hook. f., London J. Bot. 4: 151. 1845. *Podocarpus aspleniifolius* Labill., Nov. Holl. Pl. Sp. 2: 71, t. 221. 1806. Type: Australia: Tasmania, North Esk River, Cataract Gorge, ["Habitat in capite Van-Diemen"], *J. J. H. de Labillardière s.n.* (lectotype FI). Fig. 184

Etymology

The species epithet compares this species with the foliage of *Asplenium ruta-muraria*, a small European fern common on rocks and ancient walls.

Vernacular names

Celery-top pine

Description

Shrubs or trees to 20 m tall, in tall forest with a clear bole to 10 m or more, d.b.h. to 50 cm. Bark to 20 mm thick, with large lenticels; outer bark deeply furrowed and scaly in old trees, exfoliating in small to medium sized flakes, dark brown weathering dark grey or blackish; inner bark close to wood red or pink, slightly fibrous. Branches spreading or ascending, forming a narrow or wide pyramidal crown. Foliage branches mostly straight, spreading at an angle of less than 90°, robust , terete, smooth, newest shoots tinged red, becoming green then light brown, terminating in a short bud with spreading, triangular to acicular scales. True leaves on seedlings 10–15 mm long, subulate-linear, 1 mm wide, with a midvein and stomata on abaxial (lower) side, acute; along new shoots and on margins of phylloclades filiform leaves appear in young plants, 1–3 mm long, deciduous. Phylloclades axillary to reduced, deciduous, filiform scale leaves, mostly simple, bifacially flattened, leaf-like, (1.5–)2.5–5(–8) cm long, mostly cuneate or rhombic in outline, with crenately to obtusely lobed margins, narrowing to a cuneate or petiolate base, sometimes more or less pinnatifid; phylloclades on old trees smallest and least dissected, on seedlings often pinnatisect. Venation of phylloclades penniparallel, with a midvein from base to (near) apex and few to numerous veins running parallel to each other from midvein or midvein line to margins under a narrow but sometimes widening angle (i.e. they curve outwards). Flushing phylloclades reddish or rusty brown; new phylloclades bright green or tinged red; old phylloclades lustrous deep green or dark green above, pale green below, sometimes glaucous. Stomata numerous on the underside (abaxial) in irregular lines. Pollen cones on a short branching system from a terminal bud, solitary or with up to 5 cones together, with one or two small bracts ('foliola') at their base, cylindrical, 5–8 mm long, 2–2.5 mm wide, pink or reddish when immature, becoming yellow. Microsporophylls ovoid-triangular, with two basal, globose pollen sacs. Seed cones axillary to reduced scale leaves on margins or at base of reduced phylloclades, or on terminal short branching systems without phylloclades, solitary or with 2–4 together, each consisting of several bracts, 2–5 of which are fertile and merge to a red or purplish structure 3–5 mm long, which becomes slightly swollen and pinkish red (drying leathery brown). Seeds 2–5 per cone, 1 per fertile bract, each in a white aril covering the lower two third of seed; distal part free, 5 mm long, semi-ovoid (laterally flattened) with a lateral ridge and a small protrusion at apex, greenish black to black.

Distribution

Australia: Tasmania.
TDWG codes: 50 TAS

Ecology

Phyllocladus aspleniifolius occurs in montane temperate rainforest up to the tree line from near sea level on the west coast of Tasmania to 1200 m a.s.l. in the central highlands. The largest trees grow in mixed forest with *Eucalyptus* spp. at lower elevations. At higher altitude (above 700–800 m a.s.l.) it is found in open woodland with *Eucalyptus coccifera, Nothofagus cunninghamii, N. gunnii, Richea pandanifolia, R. scoparia, Athrotaxis cupressoides, A. selaginoides, A. laxifolia*, and various shrubs. Towards the tree line it grows with *Orites acicularis, O. revoluta, Tasmannia lanceolata, Podocarpus lawrencei, Diselma archeri, Pherosphaera hookeriana, Nothofagus gunnii, Olearia* spp., and heath-like dwarf shrubs and alpine herbs. The substrate is acidic and derived from dolerite, granite, or quarzite, and is usually well drained, such as thin soil on boulder or scree slopes. Precipitation is abundant

through much of the year, with no marked periods of drought.

Conservation

IUCN: LC

Uses

Celery-top pine varies from a medium size tree in the forests at middle altitudes to a shrub in the subalpine zone. The wood of good size trees is straight grained and dense, pale brown, and not dissimilar to yew (*Taxus*). It is used for construction, flooring, ship masts, furniture, and cabinet work. This species is rare in cultivation, limited to botanic gardens and arboreta and a few private gardens.

Phyllocladus hypophyllus Hook. f., Icon. Pl., n.s., 5: t. 889. 1852. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N.P., *H. Low s.n.* (holotype K). Fig. 185, 186

Etymology

The species epithet is composed of Greek *hypo* = below or under and *phyllus* = leaved.

Vernacular names

Celery pine, Celery-top pine; bindang, pelayo (Borneo-Sarawak); kayu karongan, rapak-rapak (Borneo-Kalimantan); kayu empire (Sulawesi); bejalin (Maluku); dalung (Pilippines).

Description

Shrubs or trees to 40 m tall, in tall forest with a clear bole to 20 m or more, d.b.h. to 100 cm, usually more slender. Bark to 25 mm thick, with large lenticels; outer bark becoming scaly, exfoliating in small to medium sized flakes, dark brown weathering dark grey or blackish; inner bark close to wood red or pink, slightly fibrous. Branches spreading or ascending, forming a narrow or wide crown much depending on location. Foliage branches mostly straight, spreading at an angle of less than 90°, robust, terete, smooth, newest shoots tinged red, becoming green then light brown, terminating in a short bud with spreading, triangular to acicular scales. True leaves on seedlings 5–10 mm long, subulate-linear, 0.5–0.7 mm wide, with a midvein and stomata on abaxial (lower) side, acute; at base of phylloclades and on their margins filiform leaves appear in young plants, 2–5 mm long, deciduous. Phylloclades axillary to reduced, deciduous, filiform scale leaves, pinnately compound, the pinnate segments bifacially flattened, leaf-like, extremely variable in size and shape, 1–13 cm long, 0.5–5 cm wide, generally rhombic in outline but also parabolic to lanceolate, with entire to deeply dissected margins (crenate to laciniate), the latter type mostly on seedlings to saplings, narrowing to a petiolate base; phylloclades with seed cones smaller than sterile ones, irregularly dissected, with few lobes, often cuneiform or deeply emarginate. Venation of phylloclade segments penni-parallel, with a midvein from base to (near) apex and few to numerous veins running parallel to each other from the midvein or midvein line to margins under a narrow but sometimes widening angle (i.e. they curve outwards). Flushing phylloclades yellow-green, red, or rusty brown; new phylloclades bright green or tinged red or copper, sometimes glaucous; old phylloclades lustrous deep green or dark green above, pale green below, sometimes glaucous. Stomata numerous on the underside (abaxial) in irregular lines. Pollen cones at base of a new shoot or from a terminal large bud, usually on a branching system with up to 15 cones, each cone on a 5–25 mm long peduncle subtended by a strap-like, scarious bract, sometimes with a few reduced phylloclades and with two small bracts ('foliola') at their base, cylindrical, 10–15 mm long, 3 mm wide, pink or reddish when immature, becoming yellow. Microsporophylls ovoid-triangular, often acuminate, with two basal, globose pollen sacs. Seed cones axillary to reduced scale leaves on margins of phylloclades or in an apical notch, or on terminal short branching systems without phylloclades or with a few much reduced phylloclades, solitary or with 2–3 together, each consisting of several bracts, 1–3 of which are fertile and merge to a red or purplish cupulate structure 5–7 mm long, which becomes slightly swollen and bright red (drying leathery brown). Seeds solitary to each fertile bract, with a white or yellow aril covering the lower half of seed only, 5–7 mm long, semi-ovoid (laterally flattened) with a small

protrusion at apex, ripening to lustrous tan or chestnut brown.

Distribution

Malesia: Borneo, Maluku [Moluccas], Philippines, Sulawesi; Papuasia: New Guinea.
TDW|G codes: 42 BOR-BR BOR-KA BOR-SB BOR-SR MOL PHI SUL 43 NWG-IJ NWG-PN

Ecology

Phyllocladus hypophyllus occurs in lower montane to subalpine evergreen rainforests at altitudes between (310–)600 m and 3400(–4000) m a.s.l. At lower altitudes it grows as a canopy tree of considerable size with other conifers, e.g. *Agathis* sp. in kerangas on white sand derived from sandstone, or in mixed forests with *Podocarpaceae, Fagaceae* and *Lauraceae* as the dominant families of trees. It is also found in high montane cloud forest or 'mossy' forest, which remains lower than 20 m and is characterized by epiphytic growth of ferns and mosses. Conifers, including *P. hypophyllus, Dacrydium* sp., *Dacrycarpus* sp., and *Podocarpus* sp. may dominate, or these forests are mixed with angiosperms. In New Guinea *Nothofagus grandis* is often the dominant tree species, with *Phyllocladus* and podocarps mixed in. At still higher altitudes the forest is dwarfed and *P. hypophyllus* becomes shrubby, often growing on the edges of boggy grasslands (especially in New Guinea) or on rocky ridges. This species is found on a variety of substrates, such as granite, serpentine, sandstone, peaty soils, and sometimes volcanic deposits or eroded limestone.

Conservation

IUCN: LC

Uses

As a timber tree this species is of local importance only due to its scarcity as a big forest tree. In Papua New Guinea, a ban on the export of its unsawn timber is in force in order to stimulate domestic processing. The wood is very similar to that of *Podocarpus* and straight grained, fine textured and easy to work, but non-durable for outdoor purposes. It is used for light construction, flooring, interior finish, joinery, cupboards, and to a limited extent for the making of furniture. It has excellent properties for plywood and veneer. More specialized uses are for laboratory bench tops, foundry patterns and storage batteries. The resin (copal) has been collected by tapping the trees. The bark is used for roofing in New Guinea and the phylloclades are used to make tea in Borneo. This species is in cultivation, but rare and mainly limited to botanic gardens.

Phyllocladus toatoa Molloy, New Zealand J. Bot. 34: 290. 1996. *Phyllocladus glaucus* Kirk, Trans. New Zealand Inst. 1: 149. 1869 ['*glauca*'], *non* Carrière (1855). Type: New Zealand: North Island, Great Barrier Island, Kiwiriki, *T. Kirk WELT 37785* (holotype WELT).

Etymology

Toatoa is the Maori name for this species.

Vernacular names

Celery-top pine; toatoa (Maori)

Description

Small trees to 15 m tall, d.b.h. to 60 cm. Bark with large lenticels; outer bark becoming fissured and scaly, exfoliating in small to medium sized flakes, dark brown weathering dark grey or blackish. Branches ascending, forming a narrow or wide pyramidal or rounded crown. Foliage branches mostly straight, spreading at an angle of less than 90°, robust, terete, smooth, newest shoots green then light brown, terminating in a short bud with free, triangular, acuminate and dorsally keeled scales. True leaves on seedlings 5–10 mm long, linear, 0.5–0.7 mm wide, acute, often interspersed with juvenile, deeply pinnatifid, 3–5 cm long phylloclades; at base of phylloclades and on their margins filiform leaves appear in young plants, 2–5 mm long, deciduous. Phylloclades axillary to reduced, deciduous, filiform scale leaves, pinnately compound, pinnate segments bifacially flattened, leaf-like, 1.5–6 cm long, 1–4 cm wide, rhombic to obovate-flabellate in outline, with entire to deeply dissected margins (crenate to laciniate on

seedlings), narrowing to a subsessile to petiolate base. Venation of phylloclade segments penni-parallel, with a midvein from base to half length and few to numerous veins running nearly parallel to each other to margins (i.e they gradually curve outwards). Flushing phylloclades copper coloured; new phylloclades lustrous bright green or glaucous green; old phylloclades with a bronze tinge. Stomata numerous on underside (abaxial) in irregular lines. Pollen cones at base of a new shoot or from a terminal large bud, in pseudo-whorls of up to 15–20 cones, each cone on a 10–25 mm long, stout peduncle subtended by a strap-like, scarious bract, cylindrical, 10–20(–25) mm long, 3–4 mm wide, with two small bracts ('foliola') at base, greenish to lemon when immature, becoming yellow. Microsporophylls ovoid-triangular, with two basal, globose pollen sacs. Seed cones 4–8(–10) alternately on either side of the long petiolate base of fertile phylloclades, on short stalks and subtended by a single ligulate bract, consisting of 10–20 spirally arranged, imbricate bracts, which swell slightly at maturity and turn from green with purple tips to lustrous purplish green. Seeds 8–20 per cone, 1 to each fertile bract, with a white aril mostly hidden below bracts and covering the lower half of seed only, 3–4 mm long, semi-ovoid (laterally flattened) with a faint lateral ridge, purple ripening to blackish brown, sometimes tan.

Taxonomic notes

This species is still known in many books on New Zealand trees as *Phyllocladus glaucus*, or wrongly spelled '*glauca*', but it has been demonstrated by Brian Molloy (1996) that this name was wrongly applied by Kirk as a later homonym of Carrière's name (1855) to a different taxon. Carrière described a live plant in cultivation at the Jardin des Plantes in Paris, which in all likelihood was just a glaucous form of *P. aspleniifolius* from Tasmania. The New Zealand taxon was still unknown to European botanists in 1855 and in the second edition of Carrière's book (1867) the author states that *P. glaucus* ['*glauca*'] was introduced from Tasmania to France in 1853. Consequently, the taxon known by its Maori name toatoa was in need of a new species name, for which Molloy chose to use the native name.

Distribution

New Zealand: North Island (on or N of the 39° S parallel).
TDWG codes: 51 NZN

Ecology

Phyllocladus toatoa occurs in mixed subtropical to warm temperate rainforest from near sea level to 600 m a.s.l. It is a minor constituent of the kauri forest (*Agathis australis*) which is dominated by conifers, with as many as eight species per hectare in some places. In podocarp-hardwood forest where angiosperms usually dominate, it will be restricted to poorer sites. Much of this forest has gone and the remnants are often opened up by past logging of bigger trees, leaving a more open secondary growth in which *P. toatoa*, being a sub-canopy tree in mature tall forest, has a better chance to thrive.

Conservation

IUCN: LC

Uses

The wood of toatoa or celery-top pine is nearly white, straight grained and strong; it is used for furniture, but being rare and now protected from commercial exploitation not of economic importance. It is only cultivated in some botanic gardens in mild climate regions, but should be an ideal small tree for horticulture with its bright bluish young phyllodes of new growth.

Phyllocladus trichomanoides D. Don, in Lambert, Descr. *Pinus*, ed. 8°, 2: 159. 1832.

Etymology

The species epithet (Latin *trichoma* = hair) means 'hair-like' and refers to the shape of true leaves in *Phyllocladus*.

Vernacular names

Celery pine; tanekaha (Maori); Mountain toatoa (Maori in part)

Description

Shrubs or trees to 23 m tall, in tall forest with a clear bole to 10 m or more, d.b.h. to 100 cm, at high altitudes a spreading shrub. Bark to 25 mm thick, with large lenticels; outer bark smooth, becoming scaly in old trees, exfoliating in small flakes, dark brown weathering grey with blackish patches; inner bark close to wood red or pink, slightly fibrous. Branches spreading or ascending, forming a narrow or wide pyramidal crown. Foliage branches mostly straight, spreading at an angle of less than 70°, robust , terete, smooth, green turning light brown, terminating in a short bud with spreading, triangular scales. True leaves on seedlings 10–15 mm long, filiform to subulate-linear, 1 mm wide, with a midvein and stomata on abaxial (lower) side, acute; along new shoots and margins of phylloclades subulate leaves may appear, 1–4 mm long, semi-deciduous. Phylloclades axillary to reduced, deciduous, subulate scale leaves, pinnately compound or simple, bifacially flattened, leaf-like, (0.5–)2–8(–12) cm long, (segments) cuneate, rhombic or trullate in outline, with crenate to obtusely lobed margins, narrowing to a cuneate or petiolate base; phylloclades on old trees smallest and least dissected, on seedlings pinnatifid or pinnately compound. Venation of phylloclade segments penni-parallel, with a midvein (or axis) from base to (near) apex and few to numerous veins running parallel to each other from midvein or midvein line to margins under a narrow but sometimes widening angle (i.e. they curve outwards). New phylloclades bright green or tinged red; old phylloclades lustrous deep green or dark green above, pale green below, sometimes glaucous. Stomata numerous on the underside (abaxial) in irregular lines. Pollen cones from a terminal bud, in semi-whorls of up to 10 cones together, sessile or on 3–10 mm long peduncles, with one or two small bracts ('foliola') at their base, cylindrical, 8–10 mm long, 2.5–3 mm wide, purple to brick red when immature, becoming red-brown with yellow pollen sacs. Microsporophylls ovoid-triangular, acute, with two basal, globose pollen sacs. Seed cones axillary to reduced and deciduous scale leaves on the margin or apex of reduced phylloclade segments, or at base of undivided phylloclades, solitary or with 2–4 together, each consisting of several bracts, 2–3 of which are fertile and merge to a reddish or purplish green structure 3–5 mm long, which becomes slightly swollen and purple (drying brown). Seeds 2–3 per cone, 1 per fertile bract, each in a white aril covering lower two third or more of seed; distal part free, 5 mm long, semi-ovoid (laterally flattened) with a lateral ridge and a small protrusion at apex, greenish black to black.

Taxonomic notes

Keng (1978) keyed out the species in *Phyllocladus* based on the distinction between simple and pinnate phylloclades, with the result that he classified *Phyllocladus alpinus* Hook. f. as a variety of the Tasmanian species *P. aspleniifolius*. This taxonomic treatment has been followed by subsequent authors. However, it would imply a rather unlikely occurrence of one species on two disparate island groups that have been widely separated for millions of years. New Zealand and Tasmania share some genera of conifers, both extant and extinct (Farjon, 2008: 173) but no species. The distinction between the two types of phylloclades is actually less sharp and, as Keng himself acknowledged, forms a morphological continuum, with both forms occurring in all species (Tomlinson & Takaso, 1989). In similar high montane to subalpine habitats, the phylloclades (or their segments) are likely to have converged in their shapes between the New Zealand and Tasmanian species. The reproductive organs of *P. alpinus* are similar to those of *P. trichomanoides*, but differ in more characters from those of *P. aspleniifolius*. It is for these reasons that *P. alpinus* is here classified as a variety of *P. trichomanoides*, which leaves two species in New Zealand and one species in Tasmania.

Distribution

New Zealand: North Island, South Island.
TDWG codes: 51 NZN NZS

Ecology

Phyllocladus trichomanoides occurs in lowland to subalpine forests and woodlands, from near sea

level to 1800 m a.s.l. In mixed lowland conifer forests *Phyllocladus trichomanoides* is growing with *Agathis australis* in Northland and with *Phyllocladus toatoa, Prumnopitys ferruginea, Podocarpus totara*, and *Dacrydium cupressinum*. In areas with highest rainfall there is usually a mixed angiosperm-conifer forest with e.g. *Metrosideros umbellata, Weinmannia racemosa*, and *Quintinia acutifolia* as the dominant angiosperms and, besides the already mentioned conifers, *P. trichomanoides* can here be associated with *Dacrycarpus dacrydioides, Prumnopitys taxifolia* and *Manoao colensoi*.

Uses

The wood of Celery pine is straight grained, heavy, and strong and used for construction, carpentry, ship masts, mine props, furniture making, and cabinet work. Some of this wood is nicely figured with reddish, yellowish, and whitish and resembles yew (*Taxus*); it is excellent for parket floors and cabinets. Native forests are now mostly protected from exploitation, so the avaialble quantities of Celery pine wood are now very limited. The Maoris made a red dye with the use of tannins contained in the bark and this can be used with certain types of soft leather. In cultivation Celery pine is not uncommon in some countries with a mild winter climate, especially Cornwall and Ireland, where it can be seen in large gardens and parks. The shrubby alpine form is more hardy and is also in cultivation.

2 varieties are recognized:

Phyllocladus trichomanoides D. Don var. ***trichomanoides***. Type not designated.

Description

Trees to 23 m tall. Phylloclades mostly pinnately compound or pinnatifid. Pollen cones with 5–10 mm long peduncles.

Distribution

New Zealand: North Island, N South Island.
TDWG codes: 51 NZN NZS

Ecology

Var. *trichomanoides* is found as far south as the northern end of South Island and is from there replaced by the more ubiquitous var. *alpinus*. At higher altitudes var. *trichomanoides* grows with *Libocedrus bidwillii, Podocarpus cunninghamii, Halocarpus biformis*, and various angiosperm shrubs and small trees. It can form dense thickets interspersed with tussock grassland and dwarf shrubs. It is also a component of subalpine beech forest (*Nothofagus solandri*), which can vary from pure beech to mixed beech-conifer forest.

Conservation

IUCN: LC

Phyllocladus trichomanoides D. Don var. ***alpinus*** (Hook. f.) Parl., in Candolle, Prodr. 16 (2): 498. 1868. *Phyllocladus alpinus* Hook. f., Fl. Nov.-Zel. 1: 235, t. 53. 1853; *Phyllocladus aspleniifolius* (Labill.) Hook. f. var. *alpinus* (Hook. f.) H. Keng, J. Arnold Arbor. 59: 263. 1978. Type: New Zealand: South Island, Nelson, *J. C. Bidwill 137*; [locality unknown], lectotype K, here designated). Fig. 187

Description

Shrubs or small trees to 9 m tall with a conical or pyramidal habit. Phylloclades mostly simple, shallowly or deeply lobed. Pollen cones on short peduncles.

Distribution

New Zealand: North Island, South Island.
TDWG codes: 51 NZN NZS

Ecology

Var. *alpinus* is found from ca. 500 m a.s.l. upwards, but in the far south and west of South Island it is found at sea level as well.

Conservation

IUCN: LC

Picea A. Dietr., Fl. Gegend Berlin 2: 794. 1824. Type: *Picea abies* (L.) H. Karst. [*Pinus abies* L.] (*Pinaceae*).

Veitchia Lindl., Gard. Chron. 1861: 265. 1861. (*nom. rej.*). Type: *Veitchia japonica* Lindl. [*incertae sedis*].

Picea is the classical name for spruces.

Description

Monoecious evergreen trees with a monopodial, straight trunk. Resin canals in the wood, bark, leaves and seed cones. Branching in rhythmic pseudowhorls at regular intervals on trunk, largely plagiotropic, sometimes pendulous (Massart's model). Bark usually flaking with papery scales, becoming rough and scaly. Vegetative buds ovoid or conical, resinous or not resinous, often completely covered by subterminal leaves. Leaves spirally and usually radially arranged, firmly attached to pulvini, linear, more or less equifacial (quadrangular in cross section, amphistomatic) or dorsiventral (flattened, epistomatic); apex acute or acuminate (rarely obtuse). Pollen cones small, 1–2(–3) cm long, ovoid oblong, solitary, but crowded, from axillary buds on the previous year's shoots, reddish when immature, yellow when ripe; microsporophylls with two pollen sacs containing bisaccate pollen. Seed cones subterminal from long shoots, erect when immature, pendulous at maturity, soon falling or semi-persistent. Bracts only conspicuous at pollination, not growing with the seed scales. Seed scales spirally arranged on a central rachis, imbricate, persistent, spreading at maturity. Seeds held in a shallow cup covering one half of the seed; this membrane is continued in a well developed seed wing, together these are easily detached from the ripe seed. Seedlings with 4–15 cotyledons.

38 species.

Distribution

North America: from Alaska to Newfoundland, becoming disjunct southward to Mexico. Eurasia: from the Alps and Scandinavia to Kamchatka, Sakhalin and Japan; disjunct in Caucasus/ NE Turkey; Tian Shan; Sino-Himalayan mountain system to NE China; Taiwan.

Synopsis

The classifications of the genus *Picea* since those of Willkomm (1887) and Mayr (1890) up to Liu (1982), have exclusively or primarily the vegetative characters of the species as their basis and virtually ignore the important characters of the female cones. They can only be interpreted as 'artificial'. More recently, Schmidt (1989) has given a classification primarily based on cone characters, with the characters of the leaves as a secondary criterion. Schmidt's system is largely followed here, but with the rank of subgenus equivalent to the two sections used here. The number of studies into the phylogeny of the genus, based on DNA sequence data and following cladistic methods, is still very limited. Only one (Sigurgeirsson & Szmidt, 1993) included a wide sampling (31) of species, but they analyzed only molecular data from chloroplast (cpDNA). The results confirm some relationships based on morphology, but not others. More such work, with comprehensive sampling of all species and analysing nucleotide sequences of several genes, is needed before we can amend or replace Schmidt's classification given below.

Genus *Picea* A. Dietr.
(Type: *P. abies*)
- Sect. *Picea*
  - Subsect. *Picea*
    - Series *Picea*
      - Species: *P. abies* (type of sect., subsect. and ser.), *P. obovata, P. ×fennica, P. koraiensis, P. koyamae, P. asperata, P. aurantiaca, P. retroflexa, P. chihuahuana, P. martinezii, P. crassifolia, P. meyeri, P. schrenkiana, P. neoveitchii, P. torano, P. alcoquiana, P. maximowiczii, P. morrisonicola, P. wilsonii, P. smithiana, P. glauca*
    - Series *Rubentes* Bobrov
      - Species: *P. mariana, P. rubens* (type), *P. glehnii, P. orientalis*
  - Subsect. *Omorikae* E. Murray (as "*Omorika*")
    - Species: *P. omorika* (type), *P. brachytyla, P. farreri, P. spinulosa, P. breweriana*

Sect. *Casicta* Mayr
(Type: *P. jezoensis*)
Subsect. *Sitchenses* E. Murray
Species: *P. sitchensis* (type), *P. jezoensis, P. likiangensis, P. linzhiensis, P. purpurea*
Subsect. *Pungentes* E. Murray
Species: *P. pungens* (type), *P. engelmannii, P. ×lutzii*

Key to the sections, subsections and series of *Picea*

1a. Seed scales of cones thin and flexible, more or less papery, sometimes coriaceous, usually undulate, with erose margins, loosely imbricate before ripening of the cone **Sect. *Casicta* 2**
1b. Seed scales of cones rigid, more or less thin woody, smooth or undulate, with entire or denticulate margins, closely imbricate before ripening of the cone **Sect. *Picea* 3**
2a. Leaves quadrangular in cross-section, nearly equifacial or bilateral, amphistomatic, glaucous green or glaucous on all sides **Subsect. *Pungentes***
2b. Leaves more or less flattened, not equifacial, epistomatic or epi-amphistomatic (with more lines of stomata on the dorsal side of the leaf), differently coloured on two sides **Subsect. *Sitchenses***
3a. Leaves epistomatic, usually distinctly flattened, sometimes transversely rhombic in cross-section **Subsect. *Omorikae***
3b. Leaves amphistomatic, quadrangular (equifacial) or rhombic (bilateral, keeled) in cross-section **Subsect. *Picea* 4**
4a. Young shoots (densely) pubescent; leaves not wider than 1(-1.5) mm, not longer than 1.5 cm. Seed cones usually small **Ser. *Rubentes***
4b. Young shoots (mostly) glabrous; leaves wider than 1 mm (usually more than 1.5 mm), if ca. 1 mm wide much longer than 1.5 cm. Seed cones usually large **Ser. *Picea***

Key to the species (and some subspecies and varieties, but excluding hybrids) of *Picea* Sect. *Picea*, Subsect. *Picea*, Ser. *Picea*

1a. Seed cones large, broad (8–15(-18) × 4–7 cm), with very large, convex seed scales (2–3 × 1.5–3 cm), with incurved, rounded margins **2**
1b. Seed cones smaller, or if longer than 10 cm less than 5 cm wide (measured with opened seed scales), with smaller seed scales **4**
2a. Leaves very rigid, curved, 1.8–2.5 mm wide, spreading radially or assurgent. Young shoots thick, very firm **3**
2b. Leaves flexible, nearly straight, ca. 1mm wide, not assurgent. Young shoots thin and flexible ***P. smithiana***
3a. Vegetative buds large (8–12 × 4–8 mm), ovoid or ovoid-oblong, smooth, shining chestnut-brown; leaves strongly curved and assurgent on thick branchlets ***P. torano***
3b. Vegetative buds smaller (5–6 × 3.5–4 mm), conical or ovoid-conical, not smooth and shining, slightly pubescent; leaves not assurgent, on firm but less thick branchlets ***P. neoveitchii***
4a. Seed cones small (3–6 × 1.5–2.5 cm), narrowly tapering at both ends, light red-brown when ripe; seed scales thin, convex, longer than wide, with rounded or truncate apex; upper margin not erose. Leaves glaucous ***P. glauca***
4b. Seed cones and seed scales different. Leaves green or glaucous- green **5**
5a. Seed cones relatively small (not longer than 8 cm), with obtuse apex; seed scales small (max. 2 × 1.6 cm), with usually rounded, entire upper margins **6**
5b. Seed cones usually larger (but variable according to altitude and latitude in several species!), seed scales variable **11**
6a. Leaves very dense above the shoot, curved **7**
6b. Leaves more remote, leaving the shoot visible from above, usually straight **8**
7a. Leaves pressed forward above the shoot, the apices curved towards it. Young shoots nearly white; buds small (3–4 mm), slightly resinous ***P. morrisonicola***
7b. Leaves strongly assurgent, the apices curved upward. Young shoots yellowish to orange-brown; buds larger, very resinous ***P. koyamae***
8a. Young shoots (branchlets) pale buff-grey; buds not resinous ***P. wilsonii***
8b. Young shoots yellowish brown to orange-brown; buds usually slightly resinous **9**
9a. Leaves small (8–13 × 1–1.4 mm), spreading and/or appressed forward above the shoot ***P. maximowiczii***
9b. Leaves larger, spreading radially **10**
10a. Young shoots (pale) yellowish brown or pale red-brown; leaves with obtuse or acute apex

P. koraiensis

10b. Young shoots bright orange or red-brown; leaves with acute apex ***P. obovata***

11a. Seed scales with a narrowly elongated, often emarginate apex (in *P. abies* var. *abies* cones with weakly elongated or even obtuse-rounded seed scales occur, but these types are less common) **12**

11b. Seed scales not elongated at apex, but obtuse, rounded or truncate **17**

12a. Seed cones small (4–7.5 cm long); apex of seed scales entire, reflexed ***P. alcoquiana*** var. ***reflexa***

12b. Seed cones usually longer than 6 cm; apex of seed scales emarginate, (slightly) incurved **13**

13a. Seed cones 6–10(–12) cm long. Leaves dense, curved forward; stomata in 1–3 lines on each ventral face, in 3–6 lines on each dorsal face ***P. alcoquiana*** var. ***alcoquiana***

13b. Seed cones 12–16 cm long. Leaves radially spreading; lines of stomata equally numerous on all sides of leaves **14**

14a. Seed scales rhombic-oblong; apex strongly elongated **15**

14b. Seed scales angular-obovate (obtrullate) to more or less rhomboid; apex slightly elongated **16**

15a. Leaves (especially young leaves) glaucous green; branches not pendulous ***P. asperata var. notabilis***

15b. Leaves (dark) green; branches spreading or pendulous ***P. abies var. acuminata***

16a. Young leaves glaucous green ***P. asperata*** var. ***ponderosa***

16b. Young leaves green ***P. abies var. abies***

17a. Seed cones narrowly tapering towards apex; seed scales rounded or truncate at apex. Young shoots pubescent ***P. alcoquiana var. acicularis***

17b. Seed cones obtuse at apex, more cylindrical; seed scales obtuse or rounded at apex. Young shoots glabrous or pubescent **18**

18a. Seed cones narrowly cylindrical, usually 7–11 × 2.5–3.5 cm, of very regular shape; seed scales obovate, broad, with very regularly rounded apex **19**

18b. Seed cones broadly cylindrical, 8–14 × 3–5 cm, of less regular shape; seed scales with more or less rounded or obtuse apex **21**

19a. Buds resinous; bud scales recurved near bud apex ***P. meyeri***

19b. Buds not resinous (or only slightly so); bud scales appressed **20**

20a. Bark grey, inner bark orange ***P. schrenkiana***

20b. Bark orange-brown to red-brown ***P. crassifolia***

21a. Young shoots pale yellowish brown, entirely glabrous; buds slightly resinous **22**

21b. Young shoots orange or orange-brown, usually variously pubescent; buds resinous **23**

22a. Leaves with 3–5 lines of stomata on each face; upper margin of seed scales entire. Resin canals in leaves usually present ***P. martinezii***

22b. Leaves with 4–10 lines of stomata on each face; upper margin of seed scales denticulate. Resin canals in leaves absent ***P. chihuahuana***

23a. Young shoots sparsely pubescent; buds glabrous at base. Seed scales not spreading wide or reflexed in ripe cones **24**

23b. Young shoots often ferruginous pubescent; buds pubescent at base. Seed scales spreading wide or slightly reflexed in ripe cones ***P. retroflexa***

24a. Seed scales large (2–2.4 × 1.5–1.8 cm), with nearly rounded apex ***P. aurantiaca***

24b. Seed scales smaller (1.2–2 × 0.8–1.6 cm), with obtuse or rounded apex ***P. asperata var. asperata***

Key to the species (and some subspecies and varieties, but excluding hybrids) of *Picea* Sect. *Picea*, Subsect. *Picea*, Ser. *Rubentes*

1a. Seed cones narrowly cylindrical, tapering towards apex, usually 5–9 cm long. Leaves less than 1 cm long, dark glossy green on all sides, some white lines of stomata on ventral side, more lines on the dorsal side. Basal scales of buds obtuse-triangular ***P. orientalis***

1b. Seed cones ovoid, ovoid-oblong or broad-cylindrical, with obtuse or truncate apex. Leaves longer than 1 cm (if shorter, cones smaller than 4 × 2.8 cm), with a different colour. Basal scales of buds acute-cuspidate **2**

2a. Seed scales undulate, with undulate or emarginate, erose-denticulate upper margin; cones 3.5–8.5 cm long, often with a truncate apex ***P. glehnii***

2b. Seed scales not undulate, abaxial surface rough or smooth, upper margin not emarginate; cones

smaller (max. 6 cm long), with an obtuse apex **3**

3a. Seed cones very small (1.5–4 × 1.5–2.8 cm), often numerous in the top of the tree, persisting several years. Leaves usually 0.8–1.2 cm long, dark green or glaucous green above ***P. mariana***

3b. Seed cones usually larger (2.5–6 × 1.8–3.5 cm), soon deciduous after shedding seeds. Leaves usually 1–1.5 cm long, shiny light green above ***P. rubens***

Key to the species (and some subspecies and varieties, but excluding hybrids) of *Picea* Sect. *Picea*, Subsect. *Omorikae*

1a. Leaves transversely rhombic in cross-section, acute and pungent at apex, up to 3.5 cm long, radially spreading ***P. spinulosa***

1b. Leaves distinctly flattened, obtuse or acutish, not pungent, pressed against the shoot above, pectinate below **2**

2a. Seed cones small (5–8 × 2–3 cm); seed scales suborbicular, remaining imbricate. Young shoots distinctly pubescent ***P. omorika***

2b. Seed cones larger; seed scales of different shape, spreading after ripening of the cone. Young shoots glabrous to pubescent **3**

3a. Seed scales obovate, convex, with a rounded, more or less incurved upper margin **4**

3b. Seed scales obovate-oblong or rhombic, with (usually) recurved and sometimes elongated upper margin ***P. brachytyla***

4a. Leaves long and wide (15–35 × 1.5–2 mm), curved and spreading. Branches of second order extremely long pendulous. Seed cones sessile; seed scales regular, with rounded margins and much resin ***P. breweriana***

4b. Leaves smaller (15–25 × 1–1.1 mm), straight. Branches shorter and less pendulous. Seed cones with an oblique peduncle; seed scales obovate, but more irregularly shaped ***P. farreri***

Key to the species (and some subspecies and varieties, but excluding hybrids) of *Picea* Sect. *Casicta*, Subsect. *Sitchenses*

1a. Immature seed cones yellowish green or green, ripening to yellowish brown or (pale) reddish rown **2**

1b. Immature seed cones red or purple, ripening to purplish brown or (dark) red-brown **3**

2a. Leaves thin (ca. 1 mm), nearly quadrangular in cross-section, acute and pungent. Bracts 5–8 mm long (nearly half length of seed scales) ***P. sitchensis***

2b. Leaves broader (1.5–2 mm), obtriangular in cross-section, acutish or mucronate. Bracts 4–5 mm long (less than a third length of seed scales) ***P. jezoensis subsp. jezoensis***

3a. Seed cones small (2.5–5 × 1.7–3 cm), purple, violet or crimson when immature; seed scales rhombic, with incurved, papery apex ***P. purpurea***

3b. Seed cones larger or with different seed scales **4**

4a. Young shoots glabrous, reddish brown in the second year; buds not resinous; leaves distinctly flattened, epistomatic. Seed cones with nearly obovate, flat seed scales ***P. jezoensis subsp. hondoensis***

4b. Young shoots lighter, yellowish, or pubescent; buds (slightly) resinous; leaves variable. Seed cones mostly with rhombic or less often with angular-obovate (obtrullate) seed scales **5**

5a. Young shoots brown pubescent, hairs glandular; leaves (almost) epistomatic ***P. linzhiensis***

5b. Young shoots glabrous or slightly pubescent, hairs not glandular; leaves amphistomatic ***P. likiangensis***

Key to the species (and some subspecies and varieties, but excluding hybrids) of *Picea* Sect. *Casicta*, Subsect. *Pungentes*

1a. Seed cones of medium size (5–8 × 3–4.5 cm); seed scales obtrullate or rhombic; apex usually narrowly elongated. Leaves more or less assurgent, rigid; apex very acute, pungent ***P. pungens***

1b. Seed cones usually small (3–6 × 2–2.5 cm); seed scales obovate-obtrullate; apex not narrowly elongated. Leaves directed forward, flexible; apex acute but not pungent **2**

2a. Leaves 1.5–2 mm wide ***P. engelmannii subsp. engelmannii***

2b. Leaves 1–1.2 mm wide ***P. engelmannii subsp. mexicana***

Picea abies (L.) H. Karst., Deutsche Fl.: 324. 1881.

Etymology

The species epithet '*abies*', given by Linnaeus under *Pinus*, is the classical name for fir (*Abies*), not for spruce (*Picea*), and has led to much confusion.

Vernacular names

Norway spruce; Gemeine Fichte (German); Epicéa commun (French); Jel europeiskaya (Russian)

Description

Trees to 40–50(–60) m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight; bark becoming grey at lower part of trunk, rough, scaly, breaking into small plates. Branches of first order slender, spreading horizontally or curved downward; branches of second order highly variable, spreading horizontally (German: Plattenfichte) or extremely pendulous (Kammfichte); crown (broad) pyramidal or narrowly conical. Branchlets slender, bright orange or red-brown, becoming grey, smooth, ridged and grooved, (sparsely) pubescent or glabrous; pulvini 1 mm, oblique. Vegetative buds ovoid conical, 4–5 × 3–4 mm, not or slightly resinous; bud scales triangular-obtuse, light brown or reddish brown, persisting several years. Leaves spreading radially around shoot, directed forward, parting below, 0.8–2(–3) cm long, 1–1.8 mm wide, linear, straight or curved, quadrangular in cross-section, acute at apex; amphistomatic, with 2–4 lines of stomata on each face; leaf colour (dark) green. Pollen cones near end of shoot, 1–1.5 cm long, yellow. Seed cones terminal, sessile, cylindrical, rarely ovoid-oblong, (2.5–)6–15(–20) cm long, 1.5–4(–5) cm wide with opened scales; colour (immature) green or red, maturing to orange-brown or (light) red-brown. Seed scales highly variable, ovoid-oblong to rhomboid-oblong or rhombic, 1.5–3 × 1–2 cm at mid-cone; surface smooth, shining, glabrous; upper margin variable, obtuse or acuminate, with retuse apex, entire or erose-denticulate; base cuneate. Bracts rudimentary, ligulate, 2–3 mm, entirely included. Seeds ovoid-oblong, 2–5 mm, dark brown or blackish brown; seed wings ovate-oblong or cuneate, (6–)10–20 mm long, light brown.

Taxonomic notes

Populations in northern Scandinavia and especially in NE Russia differ from the otherwise very variable species elsewhere in having smaller cones with more or less rhombic seed scales with obtuse, often serrulate margins and more pubescent shoots. These characters are intermediate between *P. abies* and *P. obovata* and in some populations even seem to merge into those of the latter, making the boundary between the two species 'fuzzy' which led to the postulated hybrid taxon *Picea ×fennica* (Regel) Komarov. Other botanists have included these populations with *Picea abies* subsp. *obovata* (Ledeb.) Hultén, a view which would either extend the range of *Picea abies* across Siberia or that of *P. obovata* into Scandinavia, depending on the taxonomic rank one prefers. The variability in Central Europe has given rise to the recognition of numerous additional taxa, at ranks from species to forma. Only two varieties are recognized here: var. *abies* and var. *acuminata*. There are several distinct ecotypes within this species, which are not named taxonomically.

Distribution

Central (on mountains), N and E Europe, eastward to the Ural Mts., where the species merges with *P. obovata*.

TDWG codes: 10 FIN NOR SWE 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER HUN POL SWI 12 FRA-FR 13 ALB BUL GRC ITA-IT ROM YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL14BLR BLT-ES BLT-LA BLT-LI RUC RUG RUE RUN RUW UKR-MO UKR-UK

Ecology

Picea abies is widespread and dominant in boreal conifer forests of N and NE Europe, where it replaces *Pinus sylvestris* on wetter sites because *Picea abies* can avoid the water table with a very shallow root system. The natural distribution shows continental tendencies but in the western mountains of Central Europe an ecotype has evolved that is adapted to sub-Atlantic weather conditions with heavy 'wet' snowfall in early winter. Its inability to compete with more shade tolerant *Abies alba* and *Fagus sylvatica* as well as historical factors have limited its natural

expansion into W Europe. In the Alps *Picea abies* occupies the montane to subalpine zones (dependent on local climate) especially on moist sites and in cold air pockets. Although it can occur on most substrates, acidic soils are most common and widespread as is testified by the undergrowth, if present, of ericaceous shrubs and sub-shrubs. Commonly growing with *Picea abies* in the boreal forests are *Betula* sp. and *Populus tremula*, with willows (*Salix*) alongside streams and lakes. In the Alps *Picea abies* occurs with *Larix decidua, Pinus cembra*, and *P. sylvestris* or *P. nigra*, if not in pure stands. In E Europe, *Picea abies* is a constituent of mixed conifer-broadleaved woodland from the Bialowiecza Forest in the north to the valleys of the eastern Alps and the Carpatians.

Uses

Norway spruce is an important timber tree in Europe, where outside the boreal forest zone most commercial timber is now harvested from plantations or from managed forests in which other trees are suppressed. Forestry has expanded the range of this species considerably further west. The wood is used for pulpwood as well as construction, furniture (most of the popular 'pine' furniture is made with wood from Norway spruce), and special uses like the sound boards of pianos and the bodies of guitars and violins. The famous Stradivarius violins were made with wood of Norway spruce from the Alps. In Europe this species is the most popular Christmas tree, a tradition that actually started in Germany, with the extensive afforestation beginning in the 18th century. Norway spruce is not much planted as an amenity tree, but in horticulture more than 200 cultivars have been selected, with different habits including 'weeping', prostrate and dwarf forms, red, white or yellow flushing leaf forms, and (other) monstrosities.

2 varieties are recognized:

Picea abies (L.) H. Karst. var. ***abies***. *Pinus abies* L., Sp. Pl. 2: 1002. 1753. Type: Illustration "*Picea*" in Camerarius, Pl. Epit.: 47. 1586 (lectotype).

Abies alpestris Brügger, Jahresber. Naturf. Ges. Graubündens, ser. 2, 29: 167. 1886; *Picea alpestris* (Brügger) Stein, Gartenfl. 37: 346. 1887; *Picea abies* (L.) H. Karst. var. *alpestris* (Brügger) P. A. Schmidt, Haussknechtia 4: 38. 1988.

Description

Seed cones variable in size, (2.5–)6–15(–20) cm long; seed scales ovoid-oblong to rhomboid-oblong; apex variable but not narrowly elongated.

Distribution

Central, N and E Europe, eastward to the Ural Mountains.

TDWG codes: 10 FIN NOR SWE 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER HUN POL SWI 12 FRA-FR 13 ALB BUL GRC ITA-IT ROM YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 BLR BLT-ES BLT-KA BLT-LA BLT-LI RUC RUE RUN RUW UKR-MO UKR-UK

Conservation

IUCN: LC

Picea abies (L.) H. Karst. var. ***acuminata*** (Beck) Dallim. & A. B. Jacks., Handb. Conif., ed. 2: 390. 1931. *Picea excelsa* (Lam.) Link var. *acuminata* Beck, Ann. K. K. Naturhist. Hofmus. 2: 61. 1887. Type: Illustration in M. Kienitz, Über Formen und Abarten heimischer Walbäume, t. 3, f. 5a. 1879 (holotype).

Description

Seed cones generally large, 12–16 cm long; seed scales rhombic, with narrowly elongated, acuminate and incurved, erose-denticulate apex.

Distribution

Europe: Jura, Alps, Carpathian Mts., S Norway, Sweden?

TDWG codes: 10 NOR 11 AUT-AU CZE-CZ CZE-SL POL ROM SWI 12 FRA-FR 13 ITA-IT 14 UKR-UK

Conservation

IUCN: LC

Picea alcoquiana (Veitch *ex* Lindl.) Carrière, Traité Gén. Conif., ed. 2, 1: 343. 1867.

Etymology

This species was named after Rutherford Alcock, at the time H.M. Minister at the Court of Jeddo in Japan.

Vernacular names

Alcock's spruce; matsuhada, ira-momi (Japanese)

Description

Trees to 30–35 m tall, d.b.h. to 1 m; trunk monopodial, straight; bark of trunk dark grey, breaking into irregular plates. Branches of first order long, slender, spreading horizontally, but lower ones downward; branches of second order spreading or slightly assurgent; crown (broad) pyramidal or conical, in old trees open. Branchlets slender, firm, yellowish brown or pale orange-brown, smooth, shining, ridged and grooved, glabrous or more or less pubescent; pulvini small, 0.5 mm, at 50–80° from shoot axis. Vegetative buds ovoid-conical or subglobose, 3–5 mm long, resinous; bud scales triangular, brown, persisting several years. Leaves curved forward above shoot, parted and spreading below, 0.8–1.5(–2.5) cm long, 1–1.5 mm wide, linear, often curved, quadrangular; apex acute, pungent in young trees; stomata on all sides, in 1–3 lines on each ventral face, in 3–6 lines on each dorsal face; leaf colour dark blue green, with bluish white stomatal lines. Pollen cones axillary, clustered, 1–1.5 cm long, rose-red, later yellow. Seed cones terminal, erect at first, soon pendant, sessile or very short pedunculate, ovoid-oblong, (4–)6–10(–15) cm long, (2.5–)3–5(–5.5) cm wide with opened scales, violet when immature, ripening to reddish brown or (pale) brown. Seed scales obovate-rhombic to oblong-spathulate, opening wide, 1.5–2.5 × 0.8–1.5 cm at mid-cone, thin and flexible, undulate; surface smooth, finely striated, glabrous, upper margin undulate, serrulate, notched at apex and often reflexed, or entire and rounded to truncate, base narrow cuneate, dark brown. Bracts rudimentary, ligulate, 2–3 mm, entirely included. Seeds ovoid-oblong, 2–3 mm long, blackish brown; seed wings ovate-oblong, 13–18 mm long, light yellowish brown.

Distribution

Japan: central Honshu (mainly in Kanto Mts. and Chubu Mts.).
TDWG codes: 38 JAP-HN

Ecology

Picea alcoquiana is a scattered mountain species, occurring at elevations from 700 m to 2180 m (var. *acicularis* between 1200 m and 1950 m) a.s.l. The soils are of volcanic origin and podzolic. The climate is cool, with cold, snowy winters, and wet (annual precipitation 1000 mm to 2500 mm), while typhoons are frequent. The forests on these mountains are mixed coniferous, with *Picea jezoensis* subsp. *hondoensis* as the most common of the spruces, *Tsuga diversifolia* and *Larix kaempferi*, both also common, *Pinus parviflora* and *Abies veitchii* in some areas, *A. mariesii* usually at higher elevations, and broad-leaved trees, e.g. *Betula ermanii, B. grossa, Sorbus commixta, Quercus mongolica* var. *grosseserrata, Alnus hirsuta* var. *sibirica*, and *Prunus maximowiczii*.

Uses

Alcock spruce is a timber tree of minor importance due to its scarcity, but it has undoubtedly been logged with other spruces (*P. jezoensis* subsp. *hondoensis*) and conifers. Much of its wood is processed to pulp for the paper industry, but more specialized uses are furniture making and (in Japan) musical instruments. This species has been introduced to Europe and the USA but remains uncommon there and mostly restricted to arboreta and some large parks of private estates, where it may still be known under the later name *Picea bicolor*.

3 varieties are recognized:

Picea alcoquiana (Veitch *ex* Lindl.) Carrière var. ***alcoquiana***. *Abies alcoquiana* Veitch *ex* Lindl., Gard. Chron. 1861: 23. 1861 ["*alcockiana*"]. Type: Japan, Honshu, Fuji-yama, coll. *J. G. Veitch* (type not designated). Pl. 23

Abies bicolor Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 10: 488. 1866; *Picea bicolor* (Maxim.) Mayr, Monogr. Abiet. Japan. Reich.: 49. 1890.

Description

New shoots glabrous; leaves 0.8–1.5(–2) cm long, slightly curved forward. Seed cones (5–)6–10 (–12) cm long; seed scales thin, flexible, spreading wide; upper margin undulate, notched at apex, serrulate.

Distribution

Japan: central Honshu.
TDWG codes: 38 JAP-HN

Conservation

IUCN: LC

Picea alcoquiana (Veitch *ex* Lindl.) Carrière var. ***acicularis*** (Maxim. *ex* Beissn.) Fitschen, in Beissner, Handb. Nadelholzk., ed. 3: 258. 1930. *Picea acicularis* Maxim. *ex* Beissn., Handb. Nadelholzk.: 380. 1891; *Picea bicolor* (Maxim.) Mayr var. *acicularis* (Maxim. *ex* Beissn.) Shiras., Bot. Mag. (Tokyo) 27: 130. 1913. Type: Japan, coll. *C. J. Maximowicz* (type not designated).

Picea shirasawae Hayashi, Ill. Useful Trees (Forest Trees): sub f. 43. 1969.

Description

New shoots pubescent; leaves strongly curved, glaucous, 1.3–2.5 cm long. Seed cones 6–15 cm long with a narrowed apex; seed scales with a rounded or truncate, entire or denticulate upper margin.

Distribution

Japan: Honshu (Yatsugadake Mts.).
TDWG codes: 38 JAP-HN

Conservation

IUCN: EN [B2ab (ii, iii, v)]

Picea alcoquiana (Veitch *ex* Lindl.) Carrière var. ***reflexa*** (Shiras.) Fitschen, in Beissner, Handb. Nadelholzk., ed. 3: 258. 1930. *Picea bicolor* (Maxim.) Mayr var. *reflexa* Shiras., Bot. Mag. (Tokyo) 27: (129), t. 2, f. 9–12. 1913. Type: Illustration in Bot. Mag. (Tokyo) 27, t. 2, f. 9–12. 1913. (holotype).

Description

New shoots pubescent; leaves curved forward, 0.8–1.3 cm long. Seed cones 4–7.5 cm long; seed scales entire, apically narrowed and reflexed.

Distribution

Japan: Honshu (Akaishi Range).
TDWG codes: 38 JAP-HN

Conservation

IUCN: EN [B2ab (ii, iii, v)]

Picea asperata Mast., J. Linn. Soc., Bot. 37: 419. 1906.

Etymology

The species epithet (Latin *asperatis* = roughness) perhaps refers to the foliage branches.

Vernacular names

Dragon spruce; yunshan (Chinese)

Description

Trees to 30–45 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight; bark orange brown, turning grey brown, in large trees rough and scaly. Branches of first order relatively short, spreading horizontally, upturned at ends; branches of second order spreading or slightly assurgent; crown (narrowly) conical, gradually tapering towards the top. Branchlets slender, firm, shining yellowish brown or orange, turning grey with age; surface smooth, prominently ridged and deeply grooved, glabrous, or variously, but not densely, pubescent; pulvini rigid, 2 × 1 mm, erect or

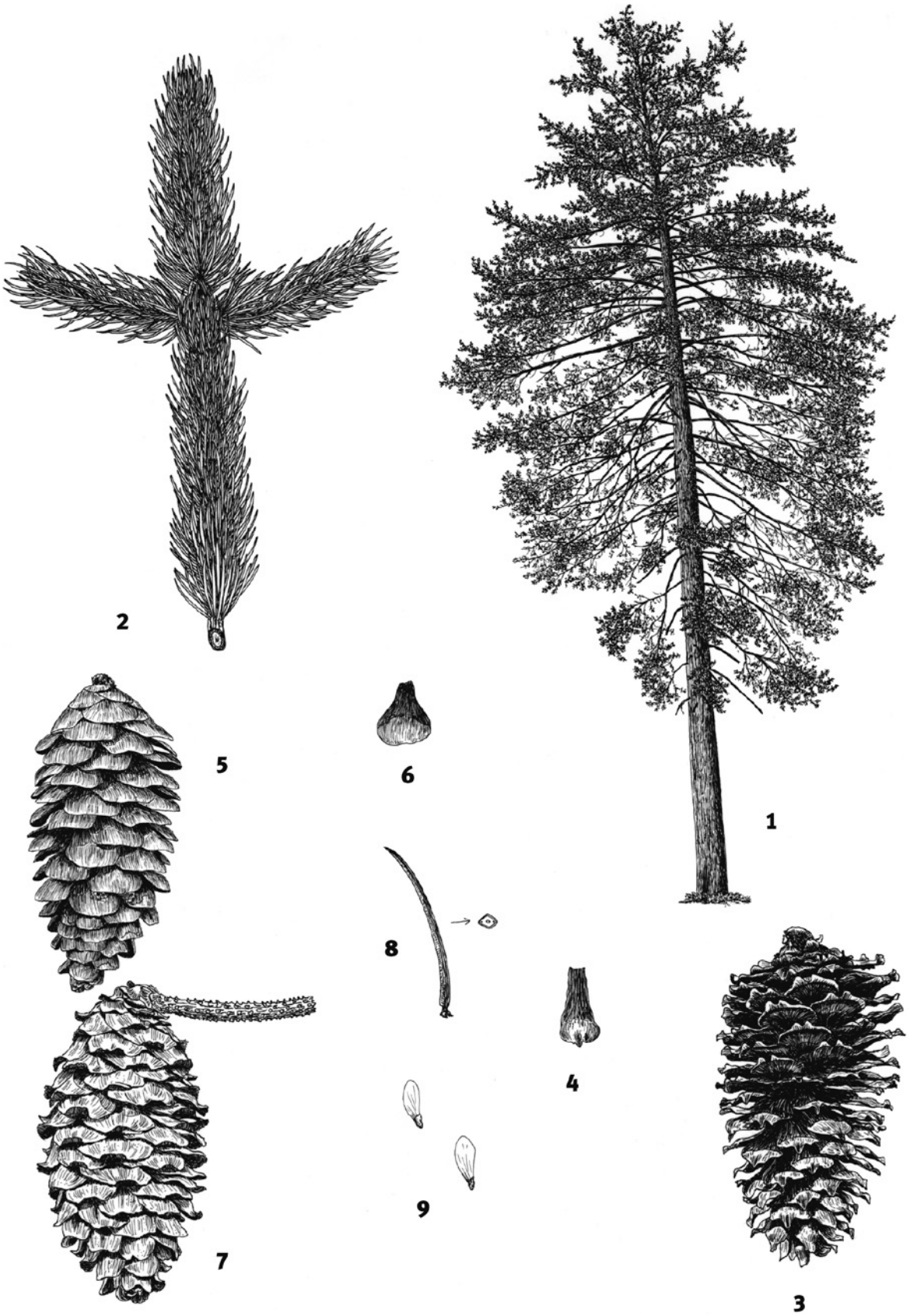

PLATE 23. *Picea alcoquiana*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Seed cone (var. *alcoquiana*). **4.** Seed scale (var. *alcoquiana*). **5.** Seed cone (var. *acicularis*). **6.** Seed scale (var. *acicularis*). **7.** Seed cone (var. *reflexa*). **8.** Leaf. **9.** Seeds.

recurved. Vegetative buds ovoid-conical or conical, acute, 6–12 × 5–8 mm, resinous; bud scales triangular acute, keeled, appressed, or the apical scales slightly recurved, yellowish brown with reddish margins, persisting several years. Leaves spreading radially, forward or assurgent above, parted and spreading laterally below, 1–2(–2.5) cm long, 1–1.8 mm wide (widest at base), linear, curved or straight, quadrangular-rhomboid in cross-section, acuminate and very pungent at apex; amphistomatic, with 3–4 lines of stomata on each face; colour of young leaves glaucous green, later dull green. Pollen cones near end of shoots, axillary, 1–1.5 cm long, reddish, then yellow. Seed cones terminal, erect at first, pendulous at maturity, short pedunculate or sessile, ± cylindrical, tapering at both ends (fusiform), obtuse at apex, (5–)6–12(–15) cm long, (2.5–)3–4(–4.5) cm wide with opened scales; colour (immature) purplish green or purple, ripening to (dark) brown or reddish brown. Seed scales obovate or rhombic-oblong, 1.2–2 × 0.8–1.6 cm at mid-cone; surface striated to nearly smooth, glabrous; upper margin obtuse, rounded or truncate to emarginate, usually slightly incurved; base cuneate. Bracts rudimentary, ligulate, 2–3 mm, entirely included. Seeds ovoid, with acute apex, 2–4 × 1.5–2.8 mm, dark brown or grey-brown; seed wings ovate-oblong, 8–12 × 5–6 mm, yellowish brown, transparent.

Taxonomic notes

Picea asperata is a variable Chinese spruce, not unlike *Picea abies* in Europe, and it might be better taxonomic practice to recognize this as such and not to name varieties as they seem to appear in the limited numbers of specimens (both in herbaria and grown from seed in arboreta) available for study. Population based studies in the field on *P. abies* have revealed regional forms or 'races', some related to environmental factors, as well as much introgression. If such detailed studies were available for *P. asperata*, similar patterns would be likely. As some of the varieties have been traditionally recognized and since the above suggested studies are not available, I have tentatively retained them here.

Distribution

China: Gansu, Ningxia (Helan Shan), E Qinghai, SW Shaanxi, Sichuan.

TDWG codes: 36 CHC-SC CHI-NX CHN-GS CHN-SA CHQ

Ecology

Picea asperata occurs in the high mountains of W central China, at elevations between 1500 m and 3800 m a.s.l., usually above 2400 m in Sichuan. The soils are grey-brown mountain podzols. The climate is continental, subalpine, with cold winters and dry summers (annual precipitation less than 500 mm). It forms mostly pure forests on N-facing slopes, or mixtures with other species of *Picea*, in the south of Gansu it may be mixed with *Abies nephrolepis*. *Betula albo-sinensis* is the most common broad-leaved associate.

Uses

Picea asperata is an important timber tree in China. The wood is mainly used for pulpwood and to a lesser extent for construction. Old growth stands of this potentially large spruce have been reduced to less accessible mountain slopes and valleys and plantation forestry has begun to replace the natural stands as a resource for spruce timber, but as yet on a scale that is incapable of meeting growing demands in China's rapidly growing economy. The species and its varieties are in cultivation as amenity trees and in arboreta and pineta in Europe and the USA, mostly still based on seed collections by Ernest Wilson, Joseph Rock and some other early 20th century plant hunters who travelled widely in southern Gansu and western Sichuan.

3 varieties are recognized:

Picea asperata Mast. var. ***asperata***. Type: China: Sichuan, ["Western China"], *E. H. Wilson E. H. 3025* (holotype BM).

Description

New shoots glabrous or variously pubescent; bud scales mostly appressed. Seed cones (5–)6–12 cm long, (2.5–)3–4 cm wide when opened; seed scales obovate-oblong, with obtuse, rounded or truncate upper margin.

Distribution

China: Gansu, Ningxia (Helan Shan), E Qinghai, SW Shaanxi, Sichuan.
TDWG codes: 36 CHC-SC CHI-NX CHN-GS CHN-SA CHQ

Conservation

Logging has led to substantial decline for this species, which affects the two rare varieties disproportionally.
IUCN: VU (A2cd)

Picea asperata Mast. var. ***notabilis*** Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 23. 1914. *Picea notabilis* (Rehd. & E. H. Wilson) Lacass., Trav. Lab. Forest. Toulouse T. 1 (3, 1): 180. 1932. Type: China: Sichuan, Guan Xian, Panlong Shan, ["West of Kuan Hsien, Panlan Shan"], *E. H. Wilson 2068* (holotype A).

Description

Young shoots glabrous, bright orange brown; bud scales loosely imbricate, apically reflexed, yellowish brown. Seed scales rhombic oblong, emarginate.

Distribution

China, W Sichuan.
TDWG codes: 36 CHC-SC

Conservation

IUCN: EN [B1ab (v)]

Picea asperata Mast. var. ***ponderosa*** Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 23. 1914. *Picea ponderosa* (Rehd. & E. H. Wilson) Lacass., Trav. Lab. Forest. Toulouse T. 1 (3, 1): 203. 1932. Type: China: Sichuan, Guan Xian, Panlong Shan ["West of Kuan Hsien, Panlan Shan"], Panlan Shan, *E. H. Wilson 4068* (holotype A).

Description

Seed cones usually large, 12–15 × 4–4.5 cm; seed scales coriaceous, rigid, with slightly elongated, curved and usually emarginate apex.

Distribution

China: W Sichuan (Panlong Shan).
TDWG codes: 36 CHC-SC

Conservation

IUCN: CR [B1ab (v), B2ab (v)]

Picea aurantiaca Mast., J. Linn. Soc., Bot. 37: 420. 1906. *Picea asperata* Mast. var. *aurantiaca* (Mast.) Boom, in Den Ouden & Boom, Man. Cult. Conif.: 253. 1965. Type: China: Sichuan, Daxue Shan, Che-to Shan, ["West of Tachien-lu"], *E. H. Wilson 3029* (holotype BM).

Etymology

The Latin species epithet means 'orange' and refers to the colour of the foliage branches.

Vernacular names

Orange spruce; baipi yun shan (Chinese)

Description

Trees to 20–25 m tall, d.b.h. to 0.7 m; trunk monopodial, straight; bark becoming scaly, grooved and ridged, strongly exfoliating, with irregular plates, pale grey. Branches of first order short, spreading horizontally or curved down, sparse in old trees; branches of second order thick, rigid, spreading, not pendulous; crown narrowly conical in large trees, open. Branchlets thick, firm, rigid, orange or yellowish orange, slightly pruinose, becoming grey with age; surface smooth, deeply grooved, with flat ridges, young shoots sparsely pubescent, soon glabrous; pulvini well developed, 1–2 mm, at right angle from shoot. Vegetative buds broad ovoid-conical, lateral buds subglobose, 4–6 × 4–6 mm, covered with pulvini at base, hidden by leaves, resinous; bud scales triangular, obtuse or acutish, yellowish brown, with red-brown, erose margins, persisting several years. Leaves all around the shoot, curved or directed forward, on shaded shoots parted below, more or less pectinate, 0.8–1.8 cm long, 1.2–2.3 mm wide, linear, straight or curved, quadrangular-rhomboid in cross-section, with ribs on two opposite sides,

acute-mucronate, pungent; amphistomatic, stomata in 4 bands of 3–6 lines; young leaves bluish green, later grey-green. Pollen cones near end of shoot, axillary, 1.5–2 cm long, reddish, then yellow with pollen. Seed cones terminal, erect at first, pendulous at maturity, sessile or short pedunculate, cylindrical-oblong, obtuse at apex, 10–12 cm long, 4–4.5 cm wide with opened scales; immature cones bright red, maturing to reddish brown; ripe cones shining chestnut brown or dull brown. Seed scales rhombic-ovoid, with nearly rounded apex, 2–2.4 × 1.5–1.8 cm at mid-cone; surface striated, shining, glabrous; upper margin slightly erose denticulate; base cuneate. Bracts rudimentary, ligulate, 2–4 mm, entirely included. Seeds ovoid-conical, 3–4 mm long, brown; seed wings ovate oblong, 12–14 × 5–6 mm, transparent, yellowish brown.

Taxonomic notes

Masters (*op. cit.*), in his lecture to the Linnean Society, separated this species from the closely related species *P. asperata* Mast. and *P. retroflexa* Mast., all three newly described there. He already made allegations about their close relationship and possible intermediate forms. These taxa have been variously treated as independent species or varieties of *P. asperata* (Schmidt-Vogt, 1977). In Flora of China 4: 28 (1999) and in Higher Plants of China 3: 37 (Fu *et al.*, 2000) *P. aurantiaca* is treated as a variety of *P. asperata*, while other accounts (e.g. Fu & Jin, 1992; Farjon, 1990, 1998, [2001]) have maintained the species rank. A re-examination of relevant collections and populations seems desirable; this should include work on DNA sequences, looking for markers which may help to distinguish species.

Distribution

China: W Sichuan (Zheduo Shan W of Kangding, from Simaqiao to Xinyulingong).
TDWG codes: 36 CHC-SC

Ecology

Picea aurantiaca is a subalpine species, occurring between 2600 m and 3800 m a.s.l. (–4000 m according to Rehder & Wilson, 1914). It is mostly found on calcareous soils. The climate is cold and precipitation varies from high (no figures recorded) in the lower elevations of the SE of its range to only 500–700 mm in the NW. It occurs in mixed coniferous forest, with e.g. *Picea likiangensis* var. *rubescens, Abies squamata, A. chensiensis, A. recurvata, Tsuga chinensis*, and locally, *Larix potaninii. Betula* spp. are the common broad-leaved trees, while *Pinus* spp. occur mostly after disturbances and at the lower elevations.

Conservation

The limited areas of occurrence and occupancy (EOO and AOO) estimated for this species and the inferred decline from logging operations and extensive deforestation in the area justify the Red List category Endangered.
IUCN: EN (A2cd)

Uses

A timber tree of which no further details of its uses are recorded, presumably because it is not recognized as distinct from *Picea asperata*. It must be logged with this and other spruces and put to the same uses. It was introduced in England and is still found in some arboreta in the south, growing particularly well on shallow soil over chalk.

Picea brachytyla (Franch.) E. Pritz., Bot. Jahrb. Syst. 29: 216. 1900.

Etymology

The species epithet (Greek: *brachy* = short; *tylo* = 'with lumps or projections') refers to the short pulvini on the shoots.

Vernacular names

Sargent's spruce; mai diao yun shan (Chinese)

Description

Trees to 30(–40) m tall, d.b.h. to 1–1.2 m; trunk monopodial, straight; bark becoming rough, scaly, flaking, dark grey, with reddish brown freshly exposed bark plates. Branches of first order long, slender, spreading horizontally; branches of second order slender, pendulous; crown broad conical,

open in old trees. Branchlets slender, flexible, leading shoots stout, creamy white at first, later light brown to orange-brown, sometimes pruinose; surface finely ridged and grooved, glabrous or minutely pubescent; pulvini small, whitish yellow, at 45°–60° to the shoot axis. Vegetative buds ovoid conical, on leading shoots 5–8 × 4 6 mm, smaller on lateral shoots, covered by leaves, (slightly) resinous; bud scales closely appressed, triangular, chestnut brown, persistent. Leaves curved forward and downward, with lower leaves parted, nearly pectinate, on coning shoots more radially spreading, (0.8–)1–2(–2.4) cm long, 1–1.5(–2) mm wide, truncate at base, linear, curved, slightly flattened, keeled on both sides; apex acute or mucronate; stomata on lower side only, in 2 narrow bands separated by a midrib; leaf colour dark green above, white bands below. Pollen cones axillary, 1–2 cm long, yellowish when shedding pollen. Seed cones terminal, erect at first, pendulous at maturity, short pedunculate, cylindrical-oblong or ovoid-oblong, (obliquely) tapering at base; apex obtuse, (5–)6–10(–15) cm long, 3–4(–5) cm wide with opened scales colour (immature) green or purplish green, ripening to dark brown with a purplish band across each scale. Seed scales angular-bovate to nearly rhombic, thin, rigid, 1.6–2(–2.5) × 1–1.4(–1.8) cm at mid-cone; abaxial surface striated or wrinkled, glabrous; upper margin variably undulate or rounded to truncate, usually recurved; apex emarginate or erose; base cuneate. Bracts rudimentary, ligulate, 2–3 mm, entirely included. Seeds ovoid-oblong, 3 × 2 mm, light brown; seed wings ovate-oblong, 10–14 × 5–7 mm, orange-brown.

Distribution

China: S Gansu, NW Hubei, S Shaanxi, W Sichuan, NW Yunnan, SE Xizang [Tibet]; NE India: Arunachal Pradesh (Assam Himalaya); N Myanmar [Burma]; Bhutan (?).
TDWG codes: 36 CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHT 40 EHM-AP 41 MYA

Ecology

Picea brachytyla is a high mountain species, occurring between 1300 m and 3800 m a.s.l. The soils are grey-brown mountain podzols. The climate is cold and wet, with annual precipitation from 1000 mm (N) to more than 2500 mm (S), where the monsoon influence is stronger. It is a constituent of the montane coniferous forest of the eastern parts of the Himalaya and the mountains of the SW Plateau of China (Wang, 1961), with *Abies densa, A. forrestii, Picea likiangensis, Pinus wallichiana, Tsuga dumosa*, and *Larix potaninii* as major species. *Taxus wallichiana* is commonly found as an understorey tree in the Himalayan part of its range.

Uses

This species is a timber tree, used for construction, interior flooring, aircraft, machines, furniture, and wood pulp for the paper industry. In China this species has been intensively exploited, depleting the natural stands, and now is cultivated for afforestation. In Europe and North America it is often present in larger arboreta, mainly derived from seed collections made by European plant hunters who traveled in China in the early decades of the 20th century. It is a more attractive and shapely species than most spruces and new introductions from different parts of its range should be recommended for horticultural uses; it is extremely hardy and tolerant of poor soils.

2 varieties are recognized:

Picea brachytyla (Franch.) E. Pritz. var. ***brachytyla***.
Abies brachytyla Franch., J. Bot. (Morot) 13 (8): 258. 1899. Types: China, Sichuan, *P. Farges 806*; Yunnan, *A. Delavay 4129* (syntypes P).

Picea pachyclada Patschke, Bot. Jahrb. Syst. 48: 630. 1913; *Picea brachytyla* (Franch.) E. Pritz. var. *pachyclada* (Patschke) Silba, Phytologia 68: 39. 1990.

Description

Seed cones 6–10(–12) cm long, 3–4 cm wide when opened; seed scales angular-obovate, 1.6–2 cm long, 1–1.4 cm wide; upper margin variably undulate, emarginate or erose, usually recurved.

Distribution

China: Chongqing, S Gansu, NW Hubei, S Shaanxi, Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHT

Conservation

IUCN: VU (A2cd)

Picea brachytyla (Franch.) E. Pritz. var. ***complanata*** (Mast.) W. C. Cheng *ex* Rehd., Man. Cult. Trees, ed. 2: 30. 1940. *Picea complanata* Mast., Gard. Chron., ser. 3, 39: 146. 1906. Type: China: Sichuan, W Sichuan, *E. H. Wilson 3031* (sheet No. 1, lectotype K, designated here).

Picea brachytyla (Franch.) E. Pritz. forma. *rhombisquamea* Stapf, Bot. Mag. 148: sub t. 8969. 1923. *Picea ascendens* Patschke, Bot. Jahrb. Syst. 48: 632. 1913; *Picea brachytyla* (Franch.) E. Pritz. var. *ascendens* (Patschke) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 28. 2000.

Description

Seed cones 8–15 cm long, 3.5–5 cm wide when opened; seed scales broadly obovate-oblong, 2–2.5 cm long, 1.5–1.8 cm wide at mid-cone, with usually rounded or truncate (sometimes elongate-emarginate) and straight or recurved upper margins.

Taxonomic notes

In K there are three herbarium sheets of *E. H. Wilson 3030* and *3031* (2 sheets) upon which Masters based his species *Picea complanata* and from which the drawings in the protologue were made. *E. H. Wilson 3031* with a mature seed cone (sheet 1) is here designated as the lectotype. Stapf (1923) indicated that *E. H. Wilson 3031* belonged to his forma *rhombisquamea* and this form is therefore treated as a synonym.

Distribution

China: W Sichuan, NW Yunnan; NE India: Arunachal Pradesh (Assam Himalaya); N Myanmar [Burma]; Bhutan (?).
TDWG codes: 36 CHC-SC CHC-YN 40 EHM-AP 41 MYA

Conservation

Logging and deforestation have substantially reduced the extent of coniferous forests in the region and have had an impact especially on this variety with its more restricted range.
IUCN: VU (A2cd)

Picea breweriana S. Watson, Proc. Amer. Acad. Arts 20: 378. 1885. Type not designated.

Etymology

This species was named after William H. Brewer (1828–1910) of the California State Geological survey.

Vernacular names

Brewer spruce, Weeping spruce

Description

Trees to 25(–35) m tall, d.b.h. to 1 m; trunk monopodial, straight or curved at base; bark on trunk scaly, with prominent branch scars, dark reddish grey or purplish grey. Branches of first order long, slender, spreading horizontally, curved upwards, lower branches descending, drooping at the ends; branches of second order in mature trees extremely long (to 2.5 m), slender, pendulous; crown broad conical, open and irregular in large trees. Branchlets slender, the leading shoots long and flexible, pink-brown or red-brown, turning grey; surface smooth, with ridges and shallow grooves between reddish brown, 2 mm long pulvini. Vegetative buds conical-oblong, with obtuse apex, 5–8 × 2.5–4.5 mm, slightly resinous at first; bud scales triangular, obtuse, appressed, later recurved and papery, yellowish brown or pale brown, persisting several years. Leaves spreading more or less radially on long pendulous shoots, pressed forward against the leading shoots and on short branchlets, curved outward on both sides, 1.5–3(–3.5) cm long, 1.5–2 mm wide, linear, flattened, convex above, weakly keeled below; apex obtuse; epistomatic, stomata in 2 bands of 4–6 lines, separated by a weak midrib; leaf colour dark green above, greenish white stomatal bands below. Pollen cones in leaf axils on pendulous shoots, 2–2.5 cm long, light brown to orange-brown. Seed cones terminal, erect at first, pendulous at maturity, on short branches in top of tree, sessile or very short pedunculate, cylindrical, slightly curved, oblique at base, tapered towards obtuse apex, (7–)8–12(–14) cm long, 3–4 cm

wide with opened scales; colour (immature) green, maturing to purplish brown, ripening to red-brown or dull brown, very resinous. Seed scales obovate-flabellate, convex, thin but rigid, opening very wide when dry, 1.5–2 × 1.3–1.8 cm at mid-cone; surface of abaxial side smooth, slightly striated in some cones, glabrous; upper margin entire, rounded or truncate, slightly incurved; base cuneate. Bracts rudimentary, ligulate, 3 mm, entirely included. Seeds ovoid, 3–4 × 2–3 mm, brown; seed wings ovate, 7–9 × 5–6 mm, orange-brown.

Distribution

USA: NW California, SW Oregon (Siskiyou Mts., Klamath Mts.).
TDWG codes: 73 ORE 76 CAL

Ecology

Picea breweriana is a mountain species of a limited area near the Pacific coast, at elevations between (900–)1200–2300 m a.s.l. It grows in different soil types, mostly associated with former glacial activity. The climate is temperate, with usually warm, dry summers and cool to cold, moist winters with abundant snowfall. It occurs chiefly in the Transition Life Zone, with e.g. *Abies magnifica, A. concolor, Pseudotsuga menziesii, Pinus monticola, P. lambertiana, P. ponderosa, Tsuga mertensiana, Calocedrus decurrens*, and many shrubs (mixed conifer type). This species can compete with e.g. *Pseudotsuga menziesii* and *Pinus monticola* and is well adapted to heavy wet snowfall ('Kammfichte' type of branching).

Conservation

The limited range (extent of occurrence [EOO] 12,000 km²) and rarity, except for larger populations in the western Siskiyou Mountains and in the Marble, Salmon and Trinity Mountains of northern California, put this species potentially at risk from catastrophic damage. The main hazard is forest fires, to which the species is more vulnerable than other conifers that occur within its range. It therefore retreats to N-facing slopes and rocky ridges where fires are less intense or cannot reach. In the face of global warming the frequency and intensity of forest fires are likely to increase, this may move *P. breweriana* within the categories of threat in future. Especially the smaller, isolated sub-populations would be at risk.
IUCN: VU [B2b (ii, iii, v)]

Uses

Brewer spruce is of little or no value as a timber tree. It may occasionally be logged with other conifers and put to use as pulp wood. In horticulture, however, it is considered a very desirable ornamental tree due to its long pendulous foliage branches. It is widely planted especially in European arboreta and parks, and generally performs well, although trees grown from seed are slow to mature to the characteristic habit; grafted trees develop faster. Few cultivars have been selected.

Picea chihuahuana Martínez, Anales Inst. Biol. Univ. Nac. México 13: 31. 1942. Type: Mexico: Chihuahua, Bocoyna, Arroyo de los Talayotes, *R. Dueñas s.n.* (holotype MEXU). Fig. 188

Etymology

The species epithet refers to the Mexican State of Chihuahua, from where it was first described.

Vernacular names

Chihuahua spruce

Description

Trees to 40–45 m tall, d.b.h. to 1–1.2 m; trunk monopodial, straight; bark on trunk rough and scaly, breaking into numerous small plates, dark grey-brown. Branches of first order long, slender, in young trees ascending, in large trees spreading wide, curved; branches of second order dense, spreading, in large trees (partly) pendulous; crown pyramidal in young trees, in mature trees broad conical, open, irregular. Branchlets firm, slender or thick in leading shoots, young shoots pale, later yellowish brown, finally grey; surface smooth, prominently ridged and deeply grooved, glabrous; pulvini strongly developed, dense, 1–1.5 mm, on leading shoots nearly erect. Vegetative buds ovoid conical, with acute apex, 4–8 × 2.5–6 mm, slightly resinous; bud scales triangular-ovate, with ciliate-erose margins,

appressed, light orange-brown, with darker margins, persisting 3–4 years. Leaves on leading shoots dense, radially spreading, more or less assurgent above shoot, parted below, 1.2–2.3(–2.8) cm long, 1–1.8 mm wide, linear, straight or curved, rigid, quadrangular-rhombic in cross-section, acute to acuminate at apex; amphistomatic, 3–5 lines of stomata on each grooved face; leaf colour grey-green or glaucous green. Pollen cones near end of shoots, axillary, 1–1.5 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, solitary or a few together, sessile, cylindrical, with obtuse apex, 10–14(–17) cm long, 4–5 cm wide with opened scales; colour (immature) bright green, ripening to shining (light) brown. Seed scales cuneate-flabellate, convex, opening very wide, 2–2.5 × 1.8–2.1 cm at mid-cone; abaxial surface smooth, glabrous; upper margin entire, rounded; base cuneate. Bracts rudimentary, ligulate, 3–4 mm, entirely included. Seeds ovoid-cuneate, 3–6 mm long, dark red-brown or grey-brown; seed wings ovate-oblong, 10–15 × 5–8 mm, yellowish, tinged with red-brown.

Distribution

Mexico: SW Chihuahua, SW Durango, S Nuevo León.
TDWG codes: 79 MXE-CU MXE-DU MXE-NL

Ecology

Picea chihuahuana occurs in scattered relict populations on N-facing high mountain sides, often in canyons, at elevations between 2150 m and 3200 (–3400) m a.s.l. It grows in poor, barren, but always moist mountain soils of alluvial origin, usually near permanent streams, but in the Sierra Madre Oriental also on calcareous lithosols. The climate is cool and moist, with annual precipitation between 800 mm and 1300 mm, mostly as summer showers, but in the western part of the range also in winter; snow only at the highest elevations. It is mainly associated with *Pinus strobiformis, P. pseudostrobus, P. ayacahuite*. Some other pines, *Pseudotsuga menziesii* var. *glauca, Abies durangensis, A. vejarii* (in Sierra Madre Oriental), *Cupressus lindleyi* (= *C. lusitanica* Mill.), and *C. arizonica* may also occur. Broad-leaved trees are e.g. *Quercus castanea, Q. rugosa* and *Prunus serotina*.

Conservation

The (sub)populations of *P. chihuahuana* are widely scattered and very small, with a total of fewer than 100 to about 350 mature trees in each of the ca. 25 localities known. It is possible that other relict populations are hidden among the pine forests of the Sierra Madres of northern Mexico, yet its total area of occupancy (AOO) is unlikely to exceed 500 km² and is by all accounts much less than this; in addition it is severely fragmented. Unaware of its botanical significance, loggers have exploited this species where they have encountered it, reducing the number of mature individuals. In many stands natural regeneration has been observed to be poor or at best slow. Awareness of its significance for conservation of biodiversity is now increasing, but few subpopulations are as yet under any effective protection.
IUCN: EN [B2ab (ii, iii, v)]

Uses

The rarity of this species renders it economically unimportant as a timber tree. However, its potential size in old-growth stands has made it a valuable resource of good timber when encountered by loggers, and trees have been logged to be processed in local sawmills. Spruces are uncommon to rare in northern Mexico, so there is, or was, an incentive to harvest them for their useful wood properties in construction and carpentry. Introduction to the UK from a population in Nuevo Leon sampled in the early 1980s appears to have been successful, but the species is still rare in cultivation. There are now a few more trees in several arboreta in the USA, the UK and Denmark from collections of seed made in Chihuahua in 1989 and the early 1990s (Grimshaw & Bayton, 2009: 566). It is one of the most attractive species in this genus.

Picea crassifolia Kom., Bot. Mater. Gerb. Glavn. Bot. Sada RSFSR 4: 177. 1923. Types: China, div. loc., *N. M. Przewalski s.n.*, Feb 1800; *P. K. Kozlov s.n.*, May 1895 (syntypes LE).

Etymology

The species epithet means 'with thick leaves'.

Vernacular names

Qinghai spruce; Qinghai yun shan (Chinese)

Description

Trees to 20–25 m tall, d.b.h. to 50–60 cm; trunk monopodial, straight; bark on trunk rough and scaly, red brown. Branches of first order short, spreading horizontally or upturned; branches of second order short, firm, spreading or ascending; crown pyramidal or (narrowly) conical, open in old trees. Branchlets short, firm, leading shoots thick, pale orange-yellow or greenish yellow, often pruinose, later grey, with prominent ridges and deep grooves, glabrous or with some scattered pubescence; pulvini large, 2–2.5 mm, erect or recurved. Vegetative buds ovoid-globose, more conical on leading shoots, up to 8–12 × 6–10 mm, not or slightly resinous; bud scales triangular, acutish, keeled, with erose margins, orange brown, often pruinose, persistent, leaving wide collars of perular scales at base of shoots. Leaves crowded above shoot, upper leaves directed forward and lower leaves curved upward, very rigid, (0.9–)1.2–2.2(–2.5) cm long, 1.5–2.5(–3) mm wide, linear, curved or nearly straight, nearly quadrate-rhombic in cross-section, keeled on two sides; apex obtuse-acutish; amphistomatic, stomata in 4 bands; leaf colour bright green, with two whitish green stomatal bands. Pollen cones axillary, 1–1.5 cm long, yellowish pink. Seed cones terminal, erect at first, pendulous at maturity, sessile, ovoid-oblong or cylindrical, obtuse at apex, (5–)7–11 cm long, 2.5–3.5 cm wide with opened scales; colour (immature) purplish red, maturing to green, with purple margins of seed scales, ripe cones light brown or dark brown. Seed scales broadly obovate-flabellate, slightly convex, flattened when open, 1.5–2 × 1–1.7 cm at mid-cone; surface smooth, usually finely striate, or slightly wrinkled, glabrous; upper margin entire, slightly incurved, rounded; base cuneate. Bracts rudimentary, ligulate, 2 mm, entirely included. Seeds ovoid-oblong, 3–3.5 mm long, brown; seed wings ovate-oblong, 10–13 × 4–5 mm, orange-brown.

Distribution

China: Gansu, Qinghai (Qilian Shan, around Qinghai Hu), Nei Mongol (Daqing Shan), Ningxia (Helan Shan).
TDWG codes: 36 CHI-NM CHI-NX CHN-GS CHQ

Ecology

Picea crassifolia occurs in high mountain ranges of Central Asia, mainly on N-facing slopes, above steppe or desert, at elevations between 1600 m and 3800 m a.s.l. It occurs on calcareous and non-calcareous soils (the first soil type e.g. in Helan Shan). The climate is cold continental and dry, with most of the precipitation falling as snow. It forms mostly pure forests, here and there with *Betula albosinensis* and groves of *Populus tremula*.

Conservation

IUCN: LC

Uses

Qinghai spruce is probably only locally exploited for its timber (firewood?), as it occurs remote from any major urban centres and even major roads. It is not uncommon in cultivation in botanic gardens and arboreta in Beijing, St. Petersburg and Moscow. In the West it is now also appearing, but still very rare; some trees are possibly misidentified, e.g. as *Picea asperata*.

Picea engelmannii Parry *ex* Engelm., Trans. Acad. Sci. St. Louis 2: 212. 1863.

Etymology

W. E. Parry named this species after the botanist George Engelmann (1809–1884), but failed to provide a validating description, an omission made good by Engelmann.

Vernacular names

Engelmann spruce

Description

Trees to 40–45(–50) m tall, d.b.h. to 1–1.5(–2) m; trunk monopodial, straight; bark reddish brown, later grey with light brown and becoming rough and fissured. Branches of first order short, slender, spreading horizontally, curved upward at ends, lower branches more pendant; branches of second order short, dense, spreading or pendulous; crown narrowly conical or narrowly columnar, especially in the N or at high elevations, with branches to the ground or the bole free of branches for a third to half in dense forest stands. Branchlets slender, firm, becoming pendulous, greenish yellow at first, soon yellowish brown, ridged and grooved, finely pubescent when young; pulvini well developed, 2 mm long, standing at nearly 90° to shoot axis. Vegetative buds ovoid-conical, 5–6 mm long, resinous at apex; bud scales obtuse-triangular, appressed, apices later spreading, red brown, persisting several years. Leaves spreading radially, crowded above leading shoots, directed forward, (1.2–)1.5–2.5(–3) cm long, (1–)1.5–2 mm wide, linear, straight or slightly curved, quadrate-rhombic in cross-section; apex acute (not pungent); amphistomatic, 2 narrow bands of 2–3 lines above, 2 bands of 4–6 lines below; leaf colour glaucous green. Pollen cones axillary, 1–1.5 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, sessile, ovoid-cylindric; apex obtuse, (2.5–)3–6(–7.5) cm long, 2–2.5(–3.5) cm wide with opened scales; colour (immature) green tinged with red, maturing to light reddish brown or pale yellowish brown. Seed scales obovate-obtrullate, thin and flexible, 1.2–1.5 × 0.9–1.2 cm at mid-cone; abaxial surface smooth or finely striated, often undulate, glabrous; upper margin rounded or truncate, undulate, entire or erose-denticulate, sometimes lacerate; base cuneate. Bracts broadly ovate, cuspidate, 3–6 mm long, entirely included. Seeds ovoid, 2–3 mm long, greyish brown; seed wings ovate-oblong, 10–12 × 4–5 mm, yellowish brown.

Distribution

W North America: Rocky Mountains from British Columbia to North Mexico.

TDWG codes: 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 76 ARI CAL NEV UTA 77 NWM TEX 79 MXE-CU MXE-NL

Ecology

Picea engelmannii is widespread in the Rocky Mountains, from 600 m to 3700(–4000) m a.s.l., the upper limit progressively higher from N to S. It grows on various mountain soils, both calcareous and non-calcareous. The climate is cold and humid (precipitation above 600 mm annually), with long, snowy winters and short, cool summers. The species forms extensive pure forests or mixed coniferous forests, with *Abies lasiocarpa, Pinus* spp., *Pseudotsuga menziesii, Larix occidentalis*, or *Picea glauca* as most common associated species.

Uses

Engelmann spruce is an important timber tree with a high yield potential especially in managed stands within its native range. Its knotty wood is not of very high grade, but nevertheless increasingly used for home building, carpentry, furniture, plywood, and specialist uses such as musical instruments (pianos, violins). Uses for mining timber, railroad sleepers, and telephone poles have declined and mass production is now directed to the pulp wood industry, especially in western Canada. Here massive clear cut operations still bare whole mountainsides regularly. This species is rarely planted as an ornamental, although it will grow well even on poor soils, and only a few cultivars are known in the trade. Spruces are not much in use as Christmas trees in North America, unlike in Europe where they are the commonest genus for this purpose. The subspecies *mexicana* is rare in cultivation.

2 subspecies are recognized:

Picea engelmannii Parry *ex* Engelm. subsp. ***engelmannii***. *Picea glauca* (Moench) Voss subsp. *engelmannii* (Engelm.) T. M. C. Taylor, Madroño 15: 114. 1959; *Picea glauca* (Moench) Voss var. *engelmannii* (Engelm.) Boivin, Naturaliste Canad. 93: 272. 1966. Type: USA: Wyoming, Wind River Mountains, *F. V. Hayden s.n.* (lectotype MO).

Picea engelmannii Parry *ex* Engelm. var. *glabra* Goodman, Madroño 10: 177. 1950.

Description

Bark reddish brown, later grey with light brown. Leaves 1.5–2 mm wide. Bract scales of seed cones 3–5 mm long.

Distribution

W North America: Rocky Mountains from British Columbia to New Mexico.
TDWG codes: 71 ABT BRC 73 76 77

Conservation

IUCN: LC

Picea engelmannii Parry *ex* Engelm. subsp. ***mexicana*** (Martínez) P. A. Schmidt, Haussknechtia 4: 38. 1988. *Picea mexicana* Martínez, Anales Inst. Biol. Univ. Nac. México 32: 137. 1961; *Picea engelmannii* Parry *ex* Engelm. var. *mexicana* (Martínez) Silba, Phytologia Mem. 7: 44. 1984. Type: Mexico: Nuevo León, El Carmen, *J. Vazquez 500a* (holotype MEXU).

Description

This subspecies differs from the typical subspecies in its lighter (grey) bark, its narrower leaves (1–1.2 mm), and its narrower and slightly longer bract scales (4–6 mm).

Taxonomic notes

This taxon has first been found in the Sierra de la Marta, 75 km SE of Saltillo in NE Mexico, at 3000 m to 3400 m a.s.l. on moist, N-facing, steep slopes of dolomite limestone. Taylor & Patterson (1980) described a Picea "hybrida" population in S Chihuahua (Cerro Mohinora). *D. S. Correll & H. S. Gentry 23183* (MEXU) from that location (3100 m) has cones (7 cm) resembling large cones of *P. engelmannii* and leaves narrower than 1.3 mm, with an acute (not pungent) apex. This material is best treated as *P. engelmannii* subsp. *mexicana*.

Distribution

Mexico: S Chihuahua, Coahuila, Nuevo León; USA: Arizona, Chiricahua Mts.
TDWG codes: 76 ARI 79 MXE-CO MXE-CU MXE-NL

Conservation

The main population in the Sierra de la Marta (the type locality) was nearly exterminated in a forest fire in 1975. Other populations, e.g. on Cerro Mohinora in Chihuahua, are much smaller and declining, and even more susceptible to destructive fires. In addition, trees have been felled while regeneration is poor and slow.
IUCN: EN [A4acd; B2a (ii, iii, v)]

Picea farreri C. N. Page & Rushforth, Notes Roy. Bot. Gard. Edinburgh 38: 130. 1980. Type: Myanmar [Burma]: Kachin, Myitkyina District, Feng Shui Ling (valley), *R. Farrer 1435* (holotype E).

Etymology

This species was named after Reginald Farrer, who first collected it in the 'Valley of the Winds and Water' (Feng-Shui-Ling).

Vernacular names

Farrer's spruce

Description

Trees to 30–35 m tall, d.b.h. to 60–70 cm; trunk monopodial, straight or slightly curved; bark on trunk rough and scaly, with small plates, grey or greyish brown. Branches of first order long, slender, spreading horizontally or curved down, pendant at the ends; branches of second order long, slender, pendulous; crown broadly conical. Branchlets slender, drooping or pendulous, olive brown to pale orange-brown, with flat ridges and shallow grooves, sparsely pubescent at first, soon glabrous; pulvini weakly developed, 0.6–1 mm long, at 40–60° from shoot, pubescent, orange-brown. Vegetative buds ovoid, or ovoid-conical, on leading shoots 4–5 mm, on lateral shoots smaller, slightly resinous; bud

scales obtuse, with erose margins, chestnut brown or purplish brown, persisting several years. Leaves on the upperside of shoots radially spreading forward, more pectinate below, leaves subtending lateral buds longest and at 90°, (1.5–)1.8–2.3(–2.5) cm long, 1–1.1 mm wide, linear, straight or slightly curved, convex above, flattened and keeled below, acute and slightly pungent at apex; epistomatic, stomata in 2 bands of 5–6 lines on lower side; leaf colour green or glaucous green above, two niveous white stomatal bands below. Pollen cones axillary, 1.5–2.5 × 0.3–0.4 cm, yellowish. Seed cones terminal, erect at first, pendulous at maturity; peduncles oblique, 5 mm long; shape ovoid-oblong to ellipsoid-cylindrical, obliquely tapering at base, obtuse at apex, (4–)6–12(–14) cm long, 2.5–4.5 cm wide, colour (immature) green or purplish green, maturing to dark brown. Seed scales obovate-oblong or obovate, slightly convex, lateral margins recurved in opened cones, 1.2–2.2 × 0.8–1.5 cm at mid-cone; surface finely striated or undulate and wrinkled, glabrous; upper margin irregularly rounded, sometimes apically narrowed and recurved, entire; base cuneate. Bracts rudimentary, ligulate, 2–3 mm long, entirely included. Seeds ovoid-oblong with narrowed apex, ca. 4 × 2.5 mm, dark brown; seed wings ovate-oblong, 13–15 × 6 mm, lustrous orange-brown.

Distribution

China, W Yunnan (Salween River); Myanmar [Burma] (Fen Shui Ling [valley & pass]).
TDWG codes: 41 MYA

Ecology

This species occurs in the mountains at elevations between 2400 m and 2700 m a.s.l., on limestone. The climate is cool and wet, with heavy monsoon rains. It forms small stands of pure spruce in usually open forest, with undergrowth of bamboo and juniper. A little higher occur *Larix* sp., *Pinus* cf. *armandii* and *Tsuga dumosa*, but at lower elevations broad-leaved rainforest prevails, adding to the ecological isolation of *Picea farreri* (Page & Rushforth 1980).

Conservation

This very rare and localized spruce was, until quite recently, only known from a high mountain valley in Myanmar [Burma] leading up to a pass crossing into the deep valley of the Salween in Yunnan, China. It was then also found on that side of the border, so now two or perhaps three (sub)populations are known to exist. Forest cutting and clearing for agriculture are expanding into higher elevations, threatening the remaining montane coniferous forest and therewith this rare species. The status of the Burmese population(s) remains poorly known as no foreign botanists have visited this remote valley since the 1930s.
IUCN: VU (D2)

Uses

Farrer's spruce may be used locally for construction timber. Reginald Farrer introduced its seed to England, where it was planted in several arboreta and private parks. The resulting trees were believed to have been lost until a tree at Exbury Gardens in Hampshire, England was identified in 1979 by Chris Page and Keith Rushforth as having grown from seed under Farrer's collection number 1435, the same as the holotype specimen at the Herbarium of the Royal Botanic Garden, Edinburgh (E). Herbarium specimens from this tree were used to illustrate *Picea farreri* in my book Pinaceae (Farjon, 1990: 276) and deposited in the Herbarium at the University of Utrecht (U), now in the National Herbarium of the Netherlands. This tree subsequently died, but cuttings were taken, rooted or grafted, and distributed among arboreta and pineta in England and abroad. New plants were introduced in Scotland from sources in Yunnan, China recently, but this species remains extremely rare in cultivation.

Picea* ×*fennica (Regel) Kom., Fl. S.S.S.R. 1: 145. 1934. *Pinus abies* L. var. *fennica* Regel, Gartenfl. 12: 95, f. b. 1863; *Picea obovata* Ledeb. var. *fennica* (Regel) A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 6: 1360. 1913. Type not designated.

Picea vulgaris Link var. *uralensis* Tepl., Bull. Soc. Imp. Naturalistes Moscou 41: 249, f. 2, 3. 1869; *Picea* ×*fennica* (Regel) Kom. subsp. *uralensis* (Tepl.) P. A. Schmidt, Haussknechtia 4: 38. 1988.

Etymology

The nothospecies epithet refers to Finland (in a wider sense than the present territory of that country).

Vernacular names

Karelian spruce

Description

Trees; habit, bark and foliage similar to *Picea abies* of northern Scandinavia. Seed cones symmetrical, ovoid-oblong, 5–7.5 cm long, 3–4 cm wide when opened; base flattened or tapered to a short peduncle; seed scales spreading widely, obovate, convex; apex more or less rounded to slightly elongated, entire or erose, usually incurved.

Taxonomic notes

The spruces that occur in a broad zone between Norway spruce (*Picea abies*) and Siberian spruce (*P. obovata*) have often been recognized as belonging to the latter species (provided that it was accepted as distinct at the species rank from *P. abies*). The extraordinary variability observed in the cone morphology of *P. abies* in Central and W Europe (see e.g. Schmidt, 1991) appears to be absent in *P. obovata* in Siberia, as well as in the spruces of the 'transition zone', the borders of which are poorly defined. However, certain character states, especially in the shape of the seed scales and their margins, are similar to *P. abies*, while the cones are mostly smaller, as in *P. obovata*. The history of retreats of the forests before the expansion of the Scandinavian ice cap during ice ages, and their subsequent return in interglacials, can have caused an intermingling of these two closely related species in refugia, resulting in a hybrid taxon, as is borne out by isozyme studies (Schmidt, 2002a, b).

Distribution

NE Russia: Archangelsk, Karelia, Kola Peninsula, Komi; Finland?
TDWG codes: 14 RUN

Ecology

The dominant conifer in the northern taiga of European Russia, in drier sites mixed or occasionally replaced by *Pinus sylvestris*, with undergrowth of *Vaccinium* spp. or even lichens, in waterlogged sites by *Sphagnum* bogs. Occurring from near sea level to 600–800 m a.s.l. depending on latitude, dwarfed and becoming scattered at the Arctic tree line. Large parts of its range are underlain by permafrost; the deepest summer frost-free soils here are on river floodplains, where *Picea* attains its largest size. Frequently assosiated with *Populus tremula* and *Salix* spp., especially after fires and slowly replacing these pioneers in undisturbed sites, with natural cycles of forest fires ranging from 40 years to occasionally 400 years. On river floodplains *Alnus glutinosa* characterizes a stadium between pioneer vegetation and returning spruce forest, especially in more sourthern parts of the range of *P.* ×*fennica*.

Conservation

IUCN: NE

Uses

This spruce is an important timber tree; in the Komi region of N Russia it is the mainstay of the economy in a thinly populated region. The production of timber amounted to 6.8 million m^3 in the year 1940, a peak reached just before the Great Patriotic War (WW II) commenced and diverted all manpower to the fronts. Traditional houses there were all built with spruce logs and this use is making a comeback in all of northern Russia. Much of the timber is processed to wood pulp for use in the paper industry. Trees attributed to this hybrid species are in cultivation mainly around the Baltic Sea and in Russia.

Picea glauca (Moench) Voss, Mitt. Deutsch. Dendrol. Ges. 1907 (16): 93. 1907.

Etymology

The species epithet refers to the blue-green (glaucous) foliage.

Vernacular names

White spruce, Canadian spruce

Description

Trees to 40–50 m tall, d.b.h. to 1–1.2 m; trunk monopodial, straight; bark soon flaking, yellowish green, turning grey brown, scaly and rough in large trees. Branches of first order short, slender, spreading or pendant; branches of second order short, dense; crown (narrowly) conical or columnar, branches to the ground, or bole free of (living) branches for one third in dense forest stands; Branchlets short, slender, firm, whitish grey or buff, sometimes yellowish, finally grey; prominently ridged and grooved, glabrous or pubescent; pulvini small, sometimes with minute hairs, at 60–90° from shoot. Vegetative buds ovoid-globose, ca. 6 × 4–5 mm, not resinous; bud scales ovate, obtuse, recurved, light brown, shiny, persisting several years. Leaves spreading radially forward, dense, curved inward or nearly erect above some shoots, parted below, 0.8–1.3(–2) cm long, 1.5 mm wide, linear, straight or curved, quadrangular, nearly equifacial; apex obtuse or acute; amphistomatic, stomata in 4 narrow bands of 2–4 lines; leaf colour glaucous green or bluish green. Pollen cones axillary, numerous, 1–2 cm long, yellow. Seed cones terminal, erect at first, pendulous at maturity, often very numerous in upper part of crown, short pedunculate or sessile, ovoid-oblong or ovoid, often curved, (obliquely) tapering at base; apex narrowed, obtuse, 3–6(–7) cm long, 1.5–2.5 cm wide with opened scales; colour (immature) green or reddish green, maturing to yellowish or orange-brown, old cones light brown or red-brown. Seed scales obovate or obovate-oblong, slightly convex, thin but not papery, spreading at 40°–60° from axis when opened, 1.2–1.5 × 0.8–1.2 cm at mid-cone; surface smooth, finely striated towards apex, often with white resin dots, glabrous; upper margin rounded or truncate, denticulate or entire; base cuneate. Bracts rudimentary, ligulate, 2 mm, entirely included. Seeds ovoid, 2–3 mm long, reddish brown or dark brown; seed wings ovate-oblong, 6–8 × 4–5 mm, light orange-brown.

Distribution

Boreal North America.

TDWG codes: 70 ASK NUN NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 73 MNT 74 MIN SDA 75 MAI MIC NWH NWY

Ecology

This species is the major conifer in the vast boreal forest of North America; it occurs at elevations between 5 m and 1900 m a.s.l. (var. *albertiana* up to 2100 m). The soils are usually of fluvial or glacial origin, neutral or slightly acid and often podzolized. The climate is cold continental in much of its range, but cold maritime in the extreme east, the precipitation varies between 200 mm and 1250 mm, the growing season between 25 and 160 days. It grows in pure stands or mixed with (sparse) *Betula papyrifera*, also with other conifers in various parts of the range; it invades successional stages with various northern broad-leaved trees.

Uses

Stretching accross the northern part of the North American continent White spruce is a major boreal timber resource. Its wood is strong and suitable for general construction timber as well as pulp wood; the latter is probably its major use because in many regions of its range sizes of trees are small in comparison to conifers growing further south. Log cabins in Alaska are often built with White spruce, with the bark left on the outside and moss put between the logs. High grade, straight and even-grained timber is used for indoor finishing and flooring, carpentry and joinery. Small volume uses are the manufacture of boxes, musical instruments (sounding boards) and canoe paddles. White spruce is planted as an amenity tree mainly in northern countries. In horticulture, southern provenances (var. *albertiana*) are more common and most of the dwarfed cultivars come from this source. Some dwarf cultivars originated from witches brooms and are particularly slow growing and suitable for rockeries.

2 varieties are recognized:

Picea glauca (Moench) Voss var. ***glauca***. *Pinus glauca* Moench, Verz. Ausländ. Bäume: 73. 1785. Type not extant.

Picea glauca (Moench) Voss var. *densata* L. H. Bailey, Cult. Conif. N. Amer.: 108. 1933; *Picea albertiana* S. Br. var. *densata* (L. H. Bailey) W. L. Strong & Hills, Canad. J. Bot. 84 (7): 1138. 2006.
Picea glauca (Moench) Voss var. *porsildii* Raup, Sargentia 6: 102, t. 12. 1947; *Picea albertiana* S. Br. var. *porsildii* (Raup) W. L. Strong & Hills, Canad. J. Bot. 84 (7): 1139. 2006.
Picea albertiana S. Br. subsp. *ogilviei* W. L. Strong & Hills, Canad. J. Bot. 84 (7): 1139. 2006.

Description

New shoots glabrous; leaves 0.8–1.3 cm long; apex acute, rarely obtuse. Seed cones ovoid-oblong, (obliquely) tapering at base.

Distribution

Boreal North America: from Newfoundland and New York to NW. Alaska and W. Montana.
TDWG codes: 70 ASK NUN NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 73 MNT 74 MIN SDA WIS 75 MAI MIC NWH NWY

Conservation

IUCN: LC

Picea glauca (Moench) Voss var. ***albertiana*** (S. Br.) Sarg., Bot. Gaz. (Crawfordsville) 67: 208. 1919. *Picea albertiana* S. Br., Torreya 7: 126. 1907; *Picea glauca* (Moench) Voss subsp. *albertiana* (S. Br.) P. A. Schmidt, Haussknechtia 4: 38. 1988. Type not designated.

Description

New shoots pubescent; leaves 1.5–2 cm long; apex obtuse. Seed cones ovoid or ovoid-oblong, abruptly narrowing at base.

Taxonomic notes

This variety has been considered a product of introgressive hybridization with *Picea engelmannii*.

Distribution

Canada: SW Alberta; USA: Montana?
TDWG codes: 71 ABT

Conservation

IUCN: LC

Picea glehnii (F. Schmidt) Mast., Gard. Chron., ser. 2, 13: 300. 1880. *Abies glehnii* F. Schmidt, Mém. Acad. Imp. Sci. Saint-Pétersbourg, sér. 7, 12 (2): 176. 1868. Type: Russia: Russian Far East, Sakhalin, *P. von Glehn s.n.* (holotype LE).

Etymology

This species commemorates Peter von Glehn (1835–1876).

Vernacular names

Sakhalin spruce; aka-matsu (Japanese); el' Glena (Russian)

Description

Trees to 30 m tall, d.b.h. to 60–70 cm; trunk monopodial, straight; bark soon flaking, reddish brown, becoming rough and scaly, breaking into irregular plates, grey-brown to purplish grey or dark grey. Branches of first order long, slender, spreading horizontally, but lower branches bent downward; branches of second order dense, spreading horizontally; crown pyramidal or conical. Branchlets short, slender, firm, orange or reddish brown, becoming purplish brown; surface ridged and grooved, pubescent in the grooves and on well developed, 1 mm long, densely set pulvini. Vegetative buds ovoid or ovoid-conical, 4–6 × 4 mm, (slightly) resinous; bud scales acute-triangular, basal scales long cuspidate, red-brown, shiny, persisting several years. Leaves radially spreading, the leaves above shoot directed

forward, more or less pectinate below, (0.6–)1–1.2 (–1.5) cm long, 1–1.5 mm wide, linear, curved or nearly straight, quadrate-rhombic or transversely broadly rhombic in cross-section; apex obtuse or (shortly) acute; stomata on all sides, in 1–2 lines above and 3–4 lines below on each face; leaf colour green or glaucous green, lower surfaces whitish green. Pollen cones axillary, 1–2 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity; ovoid-oblong to cylindrical-oblong; apex often truncate with opened scales, 3.5–8.5 cm long, 2.5–3.8 cm wide with opened scales; colour (immature) purplish green or dark violet, maturing to purplish brown with greenish bands, old and ripe cones brown, basal part of scales dark purplish brown. Seed scales obovate-oblong to broadly obovate, thin but rigid, 1.1–1.8 × 0.8–1.2 cm at mid-cone; surface striated, usually undulate, glabrous; upper margin undulate or emarginate, erose-denticulate; base cuneate. Bracts rudimentary, ligulate, 2–3 mm long, entirely included. Seeds ovoid-fusiform, 2.5–3 × 1.2–2 mm, light brown or yellowish brown; seed wings ovate-oblong, 7–10 × 4–6 mm, yellowish brown or orange-brown.

Distribution

Japan: Hokkaido, N Honshu; Russian Far East: S Sakhalin, Kunajiri Island (Kurils).
TDWG codes: 31 KUR SAK 38 JAP-HK JAP-HN

Ecology

Picea glehnii occurs from near sea level in the north to 1650 m a.s.l. on Hokkaido, on N Honshu in a restricted area between 1000 m and 1100 m a.s.l. It usually grows on rocky, N- or NW-facing mountain slopes with podzolic soils; it has also been recorded from ultrabasic, heavy metal yielding volcanic soils. The climate is cold, moist maritime, with abundant precipitation all year, increasing sharply with elevation to more than 1500 mm annually. It grows in pure stands, or mixed with *Picea jezoensis* and/or *Abies sachalinensis*; at lower elevations broad-leaved trees, e.g. *Ulmus japonica, Tilia maximowicziana* and *Acer pictum* become important constituents of the forest in many places. Here *Taxus cuspidata* mixes with the Spruces and the broad-leaved trees.

Conservation

IUCN: LC

Uses

Sakhalin spruce is a timber tree of only local importance; its wood is used for construction and general carpentry. It has been introduced into cultivation in Europe and North America, but remains largely confined to a few collections in botanic gardens and arboreta, mostly in cool to cold winter regions.

Picea jezoensis (Siebold & Zucc.) Carrière, Traité Gén. Conif.: 255. 1855.

Etymology

The species epithet refers to Yezo (Jezo), an alternative name for Hokkaido.

Vernacular names

Yezo spruce; ezo-matsu (Japanese); Jel ajanskaja (Russian)

Description

Trees to 40–50 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight; bark on trunk rough and scaly, fissured, blackish brown or dark purplish grey. Branches of first order long, slender, spreading horizontally; branches of second order slender, dense, drooping or pendant; crown pyramidal or broad conical. Branchlets slender, firm, pale yellow at first, later orange-yellow or reddish brown, shiny; ridged and grooved, glabrous or puberulent (form of Kamchatka); pulvini angular, 1 mm long, darker than 2nd year shoot. Vegetative buds ovoid-conical, 5–8 × 4–6 mm, not resinous; bud scales obtuse-triangular, shiny orange-brown, persisting several years. Leaves spreading radially, directed forward above shoot, pectinate below, 1–2(–2.4) cm long, 1.5–2(–2.2) mm wide, linear, straight or slightly curved, shallowly obtriangular in cross-section, acute or mucronate at apex; epistomatic, stomata in 2 bands of 6–7 lines; leaf colour shiny (dark) green above, 2 white stoma-

tal bands below. Pollen cones axillary, clustered on pendulous shoots, 1.5–2 cm long, yellow. Seed cones terminal, erect at first, pendant at maturity, often clustered, numerous, sessile or very short peduncu-late, cylindrical, sometimes slightly curved, obtuse at apex, (3–)4–7(–9) cm long, 2–3.5 cm wide with opened scales; immature cones green, ripening to light or darker yellowish or reddish brown, sometimes pruinose. Seed scales numerous, small, opening wide, obovate-oblong to obtrullate or nearly rhombic, very thin and papery, but rigid, 1–1.2 × 0.6–0.8 cm at mid-cone; surface finely striated, undulate or smooth and flat, glabrous; upper margin thin, undulate, erose-denticulate, flat or incurved; base cuneate. Bracts small, ligulate, with toothed and cuspidate apex, purplish, 4–5 mm long, included. Seeds ovoid-cuneate, 3 × 2 mm, light brown; seed wings ovate-oblong, 6–10 × 4–5 mm, light orange-brown or yellowish brown.

Distribution

NE. China: coastal part of Jilin; Japan: Hokkaido, Honshu; North Korea; Russian Far East.
TDWG codes: 31 KAM KHA KUR MAG PRM SAK 36 CHM-JL 38 JAP-HK JAP-HN KOR-NK

Ecology

Picea jezoensis occurs from near sea level to 2700 m a.s.l. (subsp. *hondoensis* on Honshu: 1100 m to 2700 m), on various (podzolic) soils. The climate is cold temperate, moist or wet (1000 mm to 2500 mm annual precipitation on Honshu). It is usually mixed with other conifers, e.g. *Abies* spp., *Larix* spp., *Pinus* spp. (with *P. pumila* in the north of the range), and *Tsuga diversifolia* on Honshu, while *Betula ermanii* is the most common broad-leaved tree. On Hokkaido it occurs also in mixed coniferous-broad-leaved forests.

Uses

Yezo spruce is an important timber tree in northern Japan and the maritime provinces of NE China, Korea, and Russia. In several forest types it is a co-dominant over large areas where it is logged with other conifers in the forest such as larch and fir. Its wood properties are similar to those of *P. sitchensis*, but this spruce does not attain the great dimensions of that species. Much of its wood is processed to pulp for the paper industry, but more specialized uses are furniture making and (in Japan) musical instruments. The Ainu string instrument *tonkori* has a body made from Yezo Spruce. Log houses are constructed with its wood in northern parts of its range, such as in Kamchatka where a small area of taiga is dominated by this species. This spruce is commonly used in afforestation especially in Japan and Korea; in other parts of the Northern hemisphere it is less often planted, either for forestry or for horticulture. In western Europe, provenances from Honshu are the only ones planted due to 'late' frost damage experienced with trees from more northern sources. Foresters have experimented with hybridization, e.g. with *P. glauca* and *P. mariana* and with its closest relative, *P. sitchensis*. Only a few cultivars are known, usually sporting yellow new foliage.

2 subspecies and 2 varieties are recognized:

Picea jezoensis (Siebold & Zucc.) Carrière subsp. ***jezoensis*** var. ***jezoensis***. *Abies jezoensis* Siebold & Zucc., Fl. Japon. 2 (2): 19, t. 110. 1842. Type: Japan: ["*Abies* No. 2, Coniferae ex insula Jezo"], *P. F. von Siebold s.n.* (lectotype L).

Picea ajanensis Fisch. *ex* Carrière, Traité Gén. Conif.: 259–260. 1855; *Picea jezoensis* (Siebold & Zucc.) Carrière var. *ajanensis* (Fisch. *ex* Carrière) W. C. Cheng & L. K. Fu, Fl. Reipubl. Pop. Sin. 7: 162. 1978.
Picea kamtchatkensis Lacass., Bull. Soc. Hist. Nat. Toulouse 58: 637. 1929; *Picea jezoensis* (Siebold & Zucc.) Carrière f. *kamtchatkensis* (Lacass.) S. L. Tung & Y. L. Chou, in Y. L. Chou, Lign. Fl. Heilongjiang: 46. 1986.
Picea austromandshurica Silba, J. Int. Conifer Preserv. Soc. 6 (2): 35. 1999.

Description

New shoots pale yellow at first, later orange-yellow or yellowish brown; leaves 1.5–2 mm wide, only slightly flattened (obtriangular in cross-section);

stomatal band whitish. Seed cones 4–7(–9) cm long, 2–3.5 cm wide when opened; seed scales obovate-oblong to obtrullate, very thin and papery but rigid; surface undulate; margin erose-denticulate.

Distribution

Japan: Hokkaido; Russian Far East.
TDWG codes: 31 KAM KHA KUR MAG PRM SAK 38 JAP-HK

Conservation

IUCN: LC

Picea jezoensis (Siebold & Zucc.) Carrière subsp. ***jezoensis*** var. ***komarovii*** (V. N. Vassil.) W. C. Cheng & L. K. Fu, Fl. Reipubl. Pop. Sin. 7: 161. 1978. *Picea komarovii* V. N. Vassil., Bot. Zurn. (Moscow & Leningrad) 35: 504. 1950. Type not designated.

Description

Seed cones 3–4 cm long, 2–2.2 cm wide when opened; seed scales nearly rhombic, flat; upper margin strongly erose-denticulate.

Distribution

China: Jilin (near coast); North Korea.
TDWG codes: 36 CHM-JL 38 KOR-NK

Conservation

IUCN: NT

Picea jezoensis (Siebold & Zucc.) Carrière subsp. ***hondoensis*** (Mayr) P. A. Schmidt, Haussknechtia 4: 38. 1988. *Picea hondoensis* Mayr, Monogr. Abiet. Japan. Reich.: 51, t. 4, f. 9. 1890; *Picea jezoensis* (Siebold & Zucc.) Carrière var. *hondoensis* (Mayr) Rehd., Mitt. Deutsch. Dendrol. Ges. 1915 (24): 314. 1915.

Shoots reddish brown in the second year; leaves more or less flattened, 1.8–2.2 mm wide, with 2 niveous white stomatal bands on the inverse-dorsal side. Seed cones dark reddish brown; seed scales (broadly) obovate, nearly flat.

Distribution

Japan: central Honshu, Kansai (Kii Peninsula).
TDWG codes: 38 JAP-HN

Conservation

IUCN: LC

Picea koraiensis Nakai, Bot. Mag. (Tokyo) 33: 195. 1919.

Etymology

This species was named after Korea, from where it was first described.

Vernacular names

Korean spruce; Jel koreiskaya (Russian); hong pi yun shan (Chinese); chongbi namu (Korean)

Description

Trees to 30 m tall, d.b.h. to 60–80 cm; trunk monopodial, straight; bark on trunk rough, scaly, fissured below, dark grey-brown, newly exposed plates brown. Branches of first order long, spreading horizontally, ends slightly assurgent; branches of second order spreading, more pendant in older trees; crown pyramidal or conical. Branchlets slender, firm, (pale) yellowish brown or pale red-brown, turning grey brown, prominently ridged and grooved, glabrous or rarely pubescent; pulvini small (1 mm), at 45°–60° to shoot axis, darker. Vegetative buds ovoid conical, 6–8 × 3.5–5 mm, resinous; bud scales triangular-ovate, reddish brown, persisting several years. Leaves spreading radially, directed slightly forward, parted below shoot, 1.2–2.2(–2.5) cm long, 1.5–1.8 mm wide, linear, straight or curved, transversely broadly rhombic in cross section; apex acute or obtuse; ca. 4 lines of stomata on each face; leaf colour glaucous green or bluish green. Pollen cones axillary, crowded near ends of shoots, 1.5–2.5 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, often numerous, sessile, ovoid-oblong or short cylindrical; apex obtuse, (4–)5–8 cm long, 2.5–4 cm wide with opened scales; colour (immature) green or purplish green, ripening to light orange-brown or dull brown. Seed scales obovate-oblong to ellipsoid,

slightly convex, 1.3–1.9 × 1.1–1.6 cm at mid-cone; surface smooth, slightly striated, exposed part of abaxial surface shining, glabrous; upper margin entire or erose-denticulate, obtuse, rounded or truncate; base cuneate, dark brown. Bracts rudimentary, ligulate, 2–4 mm, entirely included. Seeds ovoid-conical, 3–4 × 2–2.5 mm, dark brown; seed wings ovate-oblong, 12–16 × 6–8 mm, pale yellowish, transparent.

Taxonomic notes

This species is very similar to *Picea koyamai* and also resembles *P. obovata*; with the latter introgressive hybridization is likely to occur. Schmidt-Vogt (1977) recognized three varieties, described by Nakai (*op. cit.*) as species, of these only one is sufficiently different to be treated as a separate taxon.

Distribution

China: S Heilongjiang, Jilin (Changbai Shan), Liaoning, N Nei Mongol [Inner Mongolia]; North Korea; Russian Far East: Primorye (Ussuri River).
TDWG codes: 31 PRM 36 CHI-NM CHM-HJ CHM-JL CHM-LN 38 KOR-NK

Ecology

Picea koraiensis occurs in the mountains near the Sea of Japan, at elevations between 1000 m and 1500 m a.s.l., on mountain slopes or (in the NE of its range) along streams; on various (alluvial) soils. The climate is cool, with snowy winters and annual precipitation above 1000 mm. It is usually mixed with other conifers, e.g. *Abies nephrolepis, Pinus sibirica*, and *Larix gmelinii* var. *olgensis*, merging with *Picea obovata* in the interior and to the north of its range. Along rivers in the NE it is scattered in broad-leaved forest.

Uses

Korean spruce is a valuable timber tree but its limited distribution compared to *P. jezoensis* makes it of minor importance economically. The wood is mainly used for construction and for posts locally, but some of it may end up in the pulp mills together with the much more common Yezo spruce. It has been introduced in arboreta and forestry trials in some northern countries like Finland and Russia, but has not become a common forestry tree. It is in cultivation elsewhere, but uncommon and restricted to arboreta where some may be mis-identified as the similar *P. koyamae* from Japan.

2 varieties are recognized:

Picea koraiensis Nakai var. ***koraiensis***. Types: North Korea: *V. Komarov 82; T. Nakai 1880; T. Nakai s.n.* (syntypes LE, TI).

Picea intercedens Nakai, J. Japan. Bot. 17: 4. 1941; *Picea koraiensis* Nakai var. *intercedens* (Nakai) Y. L. Chou, Lign. Fl. Heilongjiang: 49. 1986.

Description

Seed cones short cylindrical, seed scales more or less thick, obovate-oblong; upper margin entire, rounded or obtuse.

Distribution

China: S Heilongjiang, Jilin (Changbai Shan), Liaoning, N Nei Mongol [Inner Mongolia]; North Korea (Yalu River); Russian Far East: Primorye (Ussuri River).
TDWG codes: 31 PRM 36 CHI-NM CHM-HJ CHM-JL CHM-LN 38 KOR-NK

Conservation

IUCN: LC

Picea koraiensis Nakai var. ***pungsanensis*** (Uyeki *ex* Nakai) Farjon, Pinaceae (Regnum Veg. 121): 231. 1990. *Picea pungsanensis* Uyeki *ex* Nakai, J. Japan. Bot. 17: 3. 1941. Type: North Korea, Mt. Pung-san ["Yotokurei"], *H. Uyeki & T. Kondo s.n.*, 10 Sep 1935 (holotype MATSU? ["H.F.E.S."]).

Description

Seed cones ovoid-oblong; seed scales thin, obovate-ellipsoid or obtrullate; apex obtuse or truncate; upper margin erose-denticulate.

Distribution

North Korea (Mt. Pung-san).
TDWG codes: 38 KOR-NK

Conservation

IUCN: DD

Picea koyamae Shiras., Bot. Mag. (Tokyo) 27: 127. 1913 ["*koyamai*"]. Type: Japan: Honshu, Nagano Pref., Yatsuga-dake, *H. Koyama s.n.* (syntype K).

Etymology

This species has been named after the Japanese botanist Mitsua Koyama, who discovered it in 1911 on Yatsuga-dake (mountain).

Vernacular names

Koyama spruce; Yatsugadake-tohhi (Japanese)

Description

Trees to 25 m tall, d.b.h. to 60 cm; trunk monopodial, straight; bark soon flaking, brown, turning greyish purple, in large trees rough and scaly, dark grey-brown or blackish grey. Branches of first order long, slender, spreading horizontally or assurgent; branches of second order dense, covering the main branches, finally pendant; crown pyramidal or conical, open and irregular in old trees. Branchlets slender, firm, the longest flexible, (pale) yellowish brown, more orange-brown above, becoming darker with age; prominently ridged and deeply grooved, glabrous, or slightly pubescent in grooves on lateral shoots; pulvini well developed, 1–1.5 mm, on the upperside of the leading shoots erect. Vegetative buds ovoid-conical, covered by curved leaves, 4–13 × 3–7 mm, (very) resinous; bud scales triangular-ovate, light brown or red-brown, persisting several years, leaving a thick collar of perular scales at the base of the shoot. Leaves spreading radially, on leading shoots strongly assurgent or nearly erect, with lower leaves spreading and upper leaves hiding the shoot, rigid, (0.6–)0.8–1.5(–2) cm long, the longest leaves near base of shoot, 1.5–2 mm wide, linear, curved, keeled on 4 sides, acutish at apex; with 3–5 lines of stomata on each of 4 faces; leaf colour dark green above, more glaucous green below. Pollen cones axillary, clustered, 1–1.5 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, sessile, ovoid-oblong or cylindric, obtuse or tapering to a narrow apex (3–)4–9(–10?) cm long, 2.5–3.5(–4) cm wide with opened scales; colour (immature) green or purplish green, ripening to dull brown or dark brown. Seed scales obovate to suborbicular, slightly convex, often resinous, 0.6–1.8 × 0.6–1.2 cm at mid-cone; abaxial surface smooth, finely striated, glabrous; upper margin rounded or truncate, denticulate; base cuneate or slightly narrowed. Bracts rudimentary, ligulate, 2–3 mm long, entirely included. Seeds ovoid-conical, 2–4 × 1.5–2 mm, (dark) brown; seed wings ovate-oblong, 5–10 × 3–5 mm, light yellowish brown.

Distribution

Japan: Honshu (Akaishi Mts., Yatsugadake Mts.).
TDWG codes: 38 JAP-HN

Ecology

Picea koyamae occurs in small groves of 10 to 20 trees (total population only a few hundred trees) on the N-facing slopes of mountains, at elevations between 1500 m and 2000 m a.s.l. The rock is volcanic, the soil podzolized and slightly acid. The climate is cool, with cold, snowy winters and abundant precipitation (1000 mm to 2000 mm annually). There are frequent typhoons, which in the 20th century have destroyed a substantial part of the population (Schmidt-Vogt, 1977). There are some pure groves, but it is commonly mixed with *Larix kaempferi, Picea alcoquiana* var. *acicularis, P. maximowiczii* in a few localities, and various broad-leaved trees and shrubs.

Conservation

This species is threatened with extinction under IUCN Red List criteria on the basis of its rarity alone, regardless of whether the population has declined or is declining. However, such decline has now been demonstrated to have occurred and not ceased despite efforts to halt and reverse it. As a result this species has been uplisted since the last assessment.
IUCN: CR [B1ab (ii, iii, v)]

Uses

Due to its rarity and inaccessibility this spruce has no value as a timber tree; it grows slowly and is not useful in plantation forestry. In horticulture it has been

successfully introduced in arboreta in the cooler or colder NE of the USA and in northern Europe, but it has not been grown commercially.

Picea likiangensis (Franch.) E. Pritz., Bot. Jahrb. Syst. 29: 217. 1900.

Etymology

The species epithet refers to the Lijiang Shan in Yunnan, China, from where it was first described.

Vernacular names

Likiang spruce; li jiang yun shan (Chinese)

Description

Trees to 50 m tall, d.b.h. to 2–2.6 m; trunk monopodial, straight; bark rough and scaly, fissured, grey, with orange-brown freshly exposed bark. Branches of first order long, slender, spreading or ascending; branches of second order variable, not pendulous; crown pyramidal or conical. Branchlets thick, rigid or slender, firm, pale yellowish grey or orange-brown to reddish brown; with prominent ridges and fine grooves, pubescent or glabrous; pulvini 1–1.5 mm, at 60–90° to shoot axis. Vegetative buds ovoid-conical or conical, 4–6 × 3–4 mm, (slightly) resinous; bud scales small, triangular, appressed, red-brown or purplish brown, persisting several years. Leaves spreading radially, forward above shoot, parted below, (0.6–)0.8–1.5(–1.7) cm long, 1–1.5(–2) mm wide, linear, straight or curved, rigid, quadrate-rhombic to transversely rhombic in cross-section; apex acute, pungent; amphistomatic, with fewer lines of stomata above than below; leaf colour dark green or glaucous green above, bluish green below. Pollen cones axillary, 2–2.5 cm long, rose-red at first, yellowish at maturity. Seed cones terminal, erect at first, pendulous at maturity, often numerous, sessile or short, obliquely pedunculate, oval-oblong, with oblique base and obtuse apex, (4–)7–12(–15) cm long, (3–)3.5–5 cm wide with opened scales; colour (immature) magenta to red, ripening to yellowish brown, reddish brown, purplish brown or pale brown. Seed scales obovate or broadly obtrullate, 1.5–2.6 × 1–1.7 cm at mid-cone; abaxial surface smooth or striated, glabrous; upper margin rounded obtuse, entire, or undulate, denticulate to repand-lacerate at apex; base cuneate. Bracts rudimentary, ligulate, 2 mm long, entirely included. Seeds ovoid-conical, 2–4 mm long, dark brown; seed wings ovate-oblong, 7–14 mm long, light brown.

Taxonomic notes

This is a highly variable species and several infraspecific taxa have been recognized. Most of these were at one time described as distinct species and there is apparently no strict consensus as to which entities to recognize at what rank [e.g. Farjon, 1990: 287; Flora of China 4: 29–30 (1999)].

Distribution

China: S Qinghai, S & W Sichuan, NW Yunnan, SE Xizang [Tibet]; Bhutan.
TDWG codes: 36 CHC-SC CHC-YN CHQ CHT 40 EHM-BH

Ecology

Both the type (type locality Lijiang Shan, Yunnan) and the varieties are subalpine spruces (2700 m to 4100 m a.s.l.) of the SW Plateau of China. They are usually associated with other conifers, e.g. *Abies* spp., *Picea brachytyla, Larix potaninii*, and *Tsuga* spp. at the lower elevations.

Uses

Likiang spruce is a timber tree used for construction, machines, poles, furniture, and wood pulp for the paper industry. The bark is used to produce tannin, resin is tapped or distilled from the wood, and the needles produce aromatic oils. In Europe and North America this species and its varieties can be found growing in arboreta and botanic gardens, as well as in large private gardens with tree collections. The correct naming to variety of these trees is often problematic.

4 varieties are recognized:

Picea likiangensis (Franch.) E. Pritz. var. ***likiangensis***. *Abies likiangensis* Franch., J. Bot. (Morot) 13 (8): 257. 1899. China: NW Yunnan, *P. J. M. Delavay 1031* (holotype P). Fig. 189, 190, 191

Picea likiangensis (Franch.) E. Pritz. var. *bhutanica* Silba, Phytologia 68: 41. 1990.
Picea likiangensis (Franch.) E. Pritz. var. *forrestii* Silba, Phytologia 68: 41. 1990.

Description

Shoots at first sparsely pubescent or glabrous; leaves 0.8–1.7 cm long, transversely rhombic in cross-section, 1–1.5 mm wide. Seed cones ovoid-oblong with an oblique base, 7–12(–15) cm long, 3.5–5 cm whide when opened; seed scales obovate or broadly obtrullate; upper margin rounded-obtuse, entire, sometimes denticulate and undulate.

Distribution

China: SW Sichuan, NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHT

Conservation

IUCN: VU (A2cd)

Picea likiangensis (Franch.) E. Pritz. var. ***hirtella*** (Rehd. & E. H. Wilson) W. C. Cheng, in Chen, Taxon. Chin. Trees: 40. 1937. *Picea hirtella* Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 32. 1914, *non* Loudon (1838); *Picea purpurea* Mast. var. *hirtella* (Rehd. & E. H. Wilson) Silba, Phytologia 68: 44. 1990. Type: China: Sichuan, Guan Xian, Banlan Shan, ["West of Kuan Hsien, Panlan Shan"], *E. H. Wilson 2084* (holotype A).

Description

Leaves slightly compressed, amphistomatic. Seed cones yellowish brown at maturity; seed scales obtrullate; margins denticulate.

Distribution

China: W Sichuan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHT

Ecology

This variety occurs at high elevations between 3000 m and 4000 m a.s.l. in coniferous forests.

Conservation

The limited range of this variety is exacerbated by forest destruction through logging and subsequent grazing of livestock, which has lead to a decline that is ongoing.
IUCN: EN [B2ab (ii, iii, v)]

Picea likiangensis (Franch.) E. Pritz. var. ***montigena*** (Mast.) W. C. Cheng, in Chen, Taxon. Chin. Trees: 40. 1937. *Picea montigena* Mast., Gard. Chron., ser. 3, 39: 146. 1906. Type: China: Sichuan, Daxue Shan, Kangding, ["China Occ. prope Tatien-lu"], *E. H. Wilson 3027* (holotype BM).

Description

Leaves very short (0.6–1.5 cm), quadrate rhombic.

Distribution

China: SW Sichuan (around Kangding, mainly to the W and S).
TDWG codes: 36 CHC-SC

Ecology

This variety occurs in mountains above 3300 m a.s.l. in coniferous forests.

Conservation

This variety is believed to be of very limited extent of occurrence (EOO) and under threat of deforestation and logging, but no specific data are available.
IUCN: DD

Picea likiangensis (Franch.) E. Pritz. var. ***rubescens*** Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 31. 1914. Type: China: Sichuan, Daxue Shan, Kangding, ["Tachienlu & neighbourhood"], *E. H. Wilson 2057* (holotype A).

Picea balfouriana Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 30. 1914; *Picea likiangensis* (Franch.) E. Pritz. var. *balfouriana* (Rehd. & E. H. Wilson) Hillier, Rep. Conif. Conf. Roy. Hort. Soc. London 1931: 232. 1932; *Picea purpurea* Mast. var. *balfouriana* (Rehd. & E. H. Wilson) Silba, Phytologia 68: 44. 1990; *Picea likiangensis* (Franch.) E. Pritz. subsp. *balfouriana* (Rehd. & E. H. Wilson) Rushforth, Int. Dendrol. Yearb. 1998: 61. 1999.

Description

Shoots pubescent, orange or reddish brown; leaves 1.5–2 mm wide. Seed cones 4–8 × 3–4 cm, often oblique, cleft at one side and purplish brown at maturity; seed scales thin, coriaceous, obtrullate, repand-lacerate.

Distribution

China: S Qinghai, W Sichuan, SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHQ CHT

Conservation

IUCN: VU (A2cd)

Picea linzhiensis (W. C. Cheng & L. K. Fu) Rushforth, Int. Dendrol. Soc. Yearbook 2007: 48. 2008. *Picea likiangensis* (Franch.) E. Pritz. var. *linzhiensis* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975. Type: China: Xizang [Tibet], Zangbo River, Linzhi, *G. X. Fu 676* (holotype PE).

Etymology

The species epithet refers to Linzhi (Linzhi Xian), China, the municipality within which the type specimen was collected.

Vernacular names

lin zhi yun shan (Chinese)

Description

Trees to 50 m tall, d.b.h. to 2–2.2 m; trunk monopodial, straight; bark rough and scaly, silvery grey, with thin, brownish fissures. Branches of first order long, slender, spreading or ascending; branches of second order variable, not pendulous; crown columnar or conical. Branchlets thick, rigid or slender, firm, light brown or slightly orange-brown, becoming greyish in the second to fourth year, with prominent ridges and fine grooves, brown pubescent with glandular hairs in the first year; pulvini 1 mm, at 60–90° to shoot axis. Vegetative buds ovoid-conical, 5–9 × 4–5 mm, resinous only at base; bud scales small, triangular, appressed but later free at apex, red-brown or chestnut brown, persisting several years. Leaves spreading radially, forward above shoot, widely parted below, 0.8–2(–2.5 or rarely 3 cm long at middle part of shoot), 1–1.5 mm wide, linear, straight or curved, rigid, quadrate-rhombic to transversely rhombic in cross-section; apex hard pungent; episto-matic (rarely one or two intermittent lines on abaxial surface); leaf colour glossy green, greyish green below. Pollen cones axillary, 2–2.5 cm long, rose-red at first, yellowish at maturity. Seed cones terminal, erect at first, pendulous at maturity, often numerous, sessile or short, obliquely pedunculate, oval-oblong, with oblique base and obtuse apex, 5–12 cm long, 3–5 cm wide with opened scales; colour (immature) purplish, ripening to brown or reddish brown. Seed scales thin, more or less flexible, obovate or rhombic, 1.5–2.2 × 1–1.5 cm at mid-cone; abaxial surface smooth, glabrous; upper margin obtuse or constricted and incurved, often repand-lacerate at apex; base cuneate. Bracts rudimentary, ligulate, 2 mm long, entirely included. Seeds ovoid-conical, 2–4 mm long, dark brown; seed wings ovate-oblong, 7–14 mm long, light brown.

Taxonomic notes

Recently, Rushforth (2008) reviewed the spruces occurring in the Zangbo [Yarlung Tsangpo] drainage of SE Xizang [Tibet] and found that the spruces growing at high altitudes there differ consistently from *Picea likiangensis* and its varieties known from Sichuan and Yunnan, and have in fact some characteres reminiscent of *Picea spinulosa*. This high altitude taxon was recognized as *Picea likiangensis* var. *linzhiensis* by Chinese botanists, and Rushforth

elevated it to species rank, which is here followed. More collecting in areas outside this drainage in SW Sichuan and NW Yunnan, where it is reported by the Chinese to occur, is needed to establish with more certainty both its distribution and taxonomic status.

Distribution

China: SW Sichuan, NW Yunnan (Dêqên Prefecture), SE Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHT

Ecology

In SE Xizang [Tibet] this species forms almost pure forests between 3000 m and 3800 m a.s.l., usually well above a mixed coniferous forest belt in which *Picea spinulosa* is the dominant spruce. At around 3000 m it occurs also mixed with *Pinus armandii*, while at its upper limit it grows with *Larix* sp. and *Abies* spp., the firs ultimately replacing the spruces above 3600–3800 m a.s.l. Understorey trees include *Betula szechuanica, B. utilis, Acer caudatum, Malus baccata* and *Sorbus* sp. and there may be a well developed shrub layer with e.g. *Rhododendron, Euonymus, Lonicera, Borinda*, and *Enkianthus* (Rushforth, 2008).

Conservation

IUCN: LC

Uses

This species is a timber tree used for construction, machines, poles, furniture and wood pulp for the paper industry. The bark is used to produce tannin, resin is tapped or distilled from the wood and the needles produce aromatic oils. In Europe and North America this species could be found growing in arboreta and botanic gardens from earlier, misidentified introductions. More recently, Keith Rushforth has introduced this species in the UK from several visits to Xizang [Tibet] between 1995 and 2000. The identification given to trees of earlier introduction that belong to this species, which were possibly introduced by Francis Kingdon-Ward from the Zangbo (Tsangpo) Valley, is most likely *Picea likiangensis*.

Picea* ×*lutzii Little, J. Forest. (Washington) 51: 745. 1953. Type not designated.

Etymology

This nothospecies was named after H. J. Lutz of Yale University, who discovered it in 1950–51.

Vernacular names

Lutz's spruce

Description

Trees to 21 m tall; trunk to 50 cm d.b.h. Leaves slightly 4–angled (less so than in *P. glauca*), with whitish stomatal lines on upper surface (similar to *P. sitchensis*). Seed cones (3–)4–7 cm long; seed scales short and more or less rounded, thin, with erose-denticulate upper margin, light brown.

Taxonomic notes

A natural hybrid between *Picea glauca* and *P. sitchensis*, occurring where the parental species are sympatric.

Distribution

USA: Alaska (Kenai Peninsula).
TDWG codes: 70 ASK

Ecology

This taxon occurs in a transition between marine-coastal conifer forest dominated by *Picea sitchensis* and (upland) interior spruce forest dominated by *P. glauca*. Two of the commonest conifers to occur with it are *Tsuga heterophylla* and *T. mertensiana*, the latter more in the interior of the Kenai Peninsula.

Conservation

IUCN: NE

Uses

This hybrid taxon is obviously being logged and used as its parental species as and where it occurs.

It has also attracted some attention from foresters in plantation experimental gardens or plots outside North America, e.g. in the UK and in SW Greenland, where several other northern species in the *Pinaceae* are being tested for plantation forestry. Hybrids between species can grow more vigorously than either of the parents.

Picea mariana (Mill.) Britton *et al.*, Prelim. Cat. Anth. Pter. New York: 71. 1888. *Abies mariana* Mill., Gard. Dict., ed. 8: *Abies* No. 5. 1768. Type not designated.

Etymology

The species epithet means 'belonging to Marius'.

Vernacular names

Black spruce, Bog spruce, Swamp spruce

Description

Trees to 25–30 m tall, but in most of its range only 5–10 m, d.b.h. to 50–60 cm; trunk monopodial, straight or curved; bark on trunk rough and scaly, fissured, grey or blackish grey; inner bark brown. Branches of first order usually short, slender, pendant; branches of second order short, dense, especially in the top; crown variable, mostly narrowly conical or columnar, reaching to the ground, lower branches often layering. Branchlets slender, short, yellowish, or reddish brown, especially in 2nd year, ridged and grooved, densely reddish brown pubescent, glabrous in the 3rd year; pulvini small, densely set in spirals, with light apices. Vegetative buds ovoid-conical; terminal buds 5–6 mm long, lateral buds smaller, not resinous or slightly resinous; bud scales triangular, keeled and acute-cuspidate in terminal buds, pubescent, purplish brown or purple, persisting several years. Leaves spreading radially, directed forward above shoot, parted below, (0.6–)0.8–1.2(–1.5) cm long, 0.7–0.8 mm wide, linear, but slightly tapering towards an acute, pungent (but sometimes nearly obtuse) apex, transversely rhombic in cross section; amphistomatic, with 1–2 lines of stomata on each face above, 3–4 lines below; leaf colour dark green to glaucous green above, green with bluish white stomatal bands below. Pollen cones axillary, often very crowded, 1–1.5 cm long, yellowish brown. Seed cones terminal or subterminal, often in great abundance, clustered in top of tree, short, obliquely pedunculate or sessile, ovoid or (sub)globular; base oblique or curved, (1.5–)2–3.5(–4) cm long, 1.5–2(–2.8) cm wide with opened scales; colour (immature) reddish or (dark) violet, maturing to shiny red-brown or dark purple, old cones dark red-brown, grey-brown or blackish brown, usually persisting several years on the tree, finally deciduous. Seed scales obovate-suborbicular, rigid, brittle at last, 0.7–1.2 × 0.6–1 cm at mid-cone; surface usually quite rough, shining, striated or wrinkled, glabrous; upper margin erose-denticulate, more or less undulate, usually curved inward; base short, broad. Bracts rudimentary, ligulate, 1–2 mm, entirely included. Seeds ovoid-cuneate, 2 mm long, blackish brown; seed wings ovate, 5–8 mm long, orange-brown.

Distribution

Boreal North America: from Newfoundland and New Jersey to interior Alaska.

TDWG codes: 70 ASK NUN NWT YUK 71 ABT BRC MAN SAS 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 74 MIN WIS 75 CNT MAI MAS MIC NWH PEN RHO VER

Ecology

Picea mariana occurs mostly in bogs or swamps and on permafrost sites ('muskeg'), at elevations between <150 m and 800 m a.s.l., occasionally in western mountains to 1500 m or 1800 m a.s.l., on a variety of acid soils, often on peat, in the south predominantly so. The climate is cold subhumid, but with a wide amplitude. Annual precipitation varies from 200 to 1400 mm, the growing season from 25 to 160 days. Pure stands occur mostly on *Sphagnum* peat and on permafrost, elsewhere it is usually mixed with *Picea glauca, Pinus banksiana* and *Abies balsamea; A. lasiocarpa* and *Pinus contorta* in upland regions, and *Populus tremuloides* after fire. In the SE of its range *Picea mariana* occurs in a mixed conifer-angiosperm swamp type with *Chamaecyparis thyoides, Larix laricina, Abies balsamea, Populus balsamifera, Acer rubrum, Ulmus americana, Fraxinus nigra*, and other broad-leaved species.

Conservation

IUCN: LC

Uses

Black spruce is economically very important as a source of pulpwood especially in the eastern parts of its great range. Its wood is light in weight and strong, nearly white in colour, and contains relatively little resin. It is one of the few spruces in North America in use as a Christmas tree, due to its compact shape when taken from natural stands; this use is now in decline. A 'spruce beer' beverage is brewed using the needles, and young twigs and the needle resin are also distilled for their aromatic properties to be used in cosmetics. There is anecdotal evidence that the drinking of spruce beer saved the English inhabitants of 18th century trading posts in Hudson Bay from succumbing to scurvy, caused by a deficiency of vitamin C in sailor's diets. Native Americans used the split roots to bind together birch bark canoes, as their elastic properties tend to pull the seams tight. In horticulture Black spruce is valued for its compact, slow growth and often glaucous leaves and a modest number of cultivars, both dwarf forms and variegated forms, are available in the trade.

Picea martinezii T. F. Patt., Sida 13 (2): 131. 1988. Type: Mexico: Nuevo León, Montemorelos, 6 km SE of La Trinidad, *T. F. Patterson 5629* (holotype MEXU).

Etymology

This species was named after Maximino Martínez (1888–1964), who studied the conifers of Mexico.

Vernacular names

Martinez's spruce

Description

Trees to 30–35 m tall, d.b.h. to 0.8; trunk monopodial, straight; bark on trunk rough and scaly, breaking into numerous small plates, dark grey. Branches of first order long, slender, in young trees ascending, in mature trees spreading wide, curved; branches of second order dense, spreading, becoming (partly) pendulous; crown in large trees broad conical, open, irregular. Branchlets firm, young shoots yellow, later reddish brown, finally grey, prominently ridged and deeply grooved, glabrous; pulvini rounded, 1 mm, on leading shoots nearly erect. Vegetative buds conical, with acute apex, 8–10 × 5–6 mm, slightly resinous; bud scales triangular-ovate, with scarious margins, appressed, reddish brown, persisting 3–4 years. Leaves spreading forward, parted below, 1.6–2.7 cm long, 1–2 mm wide, linear, straight or slightly incurved, flexible, slightly flattened, keeled on one or both surfaces, long acuminate-pungent at apex; amphistomatic, 4–10 lines of stomata on each side; leaf colour glossy green or greyish green. Pollen cones near end of shoots, axillary, 1–1.5 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, solitary or a few together, sessile, cylindrical, with obtuse apex, 8.5–16 cm long, 4–6 cm wide with opened scales; colour (immature) bright green, ripening to shining (light) brown. Seed scales obovate, convex, opening very wide, 2–3 × 1.8–2.5 cm at mid-cone; abaxial surface smooth, glabrous; upper margin denticulate; apex becoming reflexed; base cuneate. Bracts rudimentary, ligulate, 4 mm long, entirely included. Seeds ovoid-oblong, 5–8 mm long, slightly flattened, brown; seed wings ovate-oblong, 16–23 × 6–9 mm, yellowish brown.

Taxonomic notes

Picea martinezii (i.e. the two pupulations in Nuevo León) was at the time of their botanical discovery considered to be conspecific with *P. chihuahuana*, to which the seed cones in particular are very similar (and unique among North American spruces). These disjunct populations were separated as a distinct species based on some minor, but consistent differences in the leaves and seed cone scales. Farjon (1990: 241; 1998, [2001]) considered them conspecific with *P. chihuahuana* in the Sierra Madre Occidental. However, recent analysis using DNA markers (Ledig *et al.*, 2004) showed the two species to be less closely related despite the morphological similarities. *Picea martinezii* is therefore again accepted as a distinct species.

Distribution

Mexico: Nuevo Leon (Sierra Madre Oriental: Montemorelos, Aramberri).

TDWG codes: 79 MXE-NL

Ecology

One locality with this species (near La Trinidad, Montemorelos) is described as on slopes of coarse limestone talus in a sheltered canyon at 2100–2200 m a.s.l. in montane mixed coniferous-deciduous broad-leaved forest. *Picea martinezii* is here associated with *Abies vejarii, Pinus* spp., *Taxus globosa*, and angiosperm broad-leaved trees such as *Quercus* spp., *Tilia, Ostrya, Cornus, Ilex, Juglans*, and *Crataegus*. There is no surface water, but frequent rain and fog provide ample moisture to sustain a lush mesophytic forest type.

Conservation

This extremely rare species is restricted to two populations about 150 km apart. The largest population has suffered some logging in recent years from local lumber companies; the smallest population has fewer than 15 mature trees. However, a considerable amount of regeneration has been observed in the largest population, despite reports of low seed viability. A potential threat is forest fires, which could easily destroy the smallest population in one event. Awareness of the conservation issue is growing and local foresters are monitoring the situation, trying to persuade loggers to leave these trees alone. In the 1980's seed was collected and distributed to several arboreta and the Royal Botanic Gardens, Kew (Rushforth, 1986).
IUCN: EN [B2ab (ii, iii, v)]

Uses

This species has been logged for its timber by local sawmills and the wood has been used for construction purposes and carpentry. This use is now being discouraged for conservation reasons. It has been introduced to arboreta in Europe, Australia (Tasmania) and New Zealand; trees that still survive from this effort can be considered extremely rare. Some may be misidentified as *Picea chihuahuana*, which has more glaucous, shorter leaves and entire, not denticulate seed scales.

Picea maximowiczii Regel *ex* Mast., Gard. Chron., ser. 2, 13: 363. 1880.

Etymology

This species was named after the Russian explorer Carl Johann Maximowicz (1827–1891), who sent numerous seeds and plant specimens back to Europe from Japan.

Vernacular names

Maximowicz's spruce, Japanese bush spruce; himebara-momi (Japanese)

Description

Trees to 20–25 m tall, often a low bush, d.b.h. to 50–60 cm; trunk monopodial, straight, or forked low above the ground; bark on trunk rough and scaly, fissured below, grey-brown or grey. Branches of first order long, slender, ascending or spreading more horizontally; branches of second order short, numerous, spreading or more pendant in old trees; crown (broadly) conical, dense. Branchlets slender, flexible, yellowish brown or orange-brown, darker above, ridged and grooved, glabrous or puberulent; pulvini small, numerous, sometimes darker than shoot. Vegetative buds ovoid-conical or ovoid-globose, 2.5–4.5 mm long, not or slightly resinous; bud scales ovate or rounded, appressed, red-brown or purplish brown, persisting several years. Leaves spreading at 60–70° forward, those above shoot nearly appressed, parted below, on shaded shoots nearly pectinate, (0.6–)1–1.3(–1.6) cm long, 1–1.4 mm wide, linear, straight or slightly curved, transversely rhombic in cross-section, acutish to obtuse at apex; amphistomatic, 2–4 lines of stomata on each face; leaf colour lustrous dark green, with whitish green stomatal lines. Pollen cones axillary, often numerous, 1–1.5 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity; peduncles short, oblique; shape ovoid-oblong or oval-cylindrical; apex obtuse, (2.5–)4–6.5(–9?) cm long, 2.5–3.5 cm wide with opened scales; colour (immature) green, ripening to light red-brown or dull brown. Seed scales broadly obovate-cuneate, near base of the cone suborbicular,

1.3–1.8 × 1–1.5 cm at mid-cone; surface striated or grooved longitudinally, dull or shiny, often resinous, glabrous; upper margin rounded or obtuse, entire or slightly erose; base cuneate. Bracts rudimentary, ligulate, obtuse, 2–3 mm long, entirely included. Seeds ovoid-oblong, (2.5–)3–4.5 × (1.5–)2.5–3 mm, dark brown or grey-brown; seed wings ovate-oblong, 7–10 × 4–5 mm, yellowish brown or orange-brown.

Distribution

Japan: Honshu (Chichibu, Yatsugatake, Akaishi).
TDWG codes: 38 JAP-HN

Ecology

Picea maximowiczii is a rare species of the high mountains in central Honshu, where it occurs at elevations between 1100 m and 2000 m a.s.l. The soils are derived from volcanic rock and usually podzolic. The climate is moist, with cool summers and cold winters, the annual precipitation ranges between 1000 mm and 2000 mm. It occurs in small, scattered groups, usually associated with *Juniperus rigida*, sometimes with *Pinus densiflora* and various broad-leaved trees, mostly in very open, grassy terrain. The variety *senanensis* has been found with *Picea alcoquiana* and *P. koyamae*.

Uses

This small bushy tree has little value for timber and is now protected from further exploitation. In Japan it is commonly planted in gardens, especially in Buddhist temple grounds, where it is valued for its dense habit and slow growth; these traits also make it a good but uncommon species for bonsai growing. Introductions to Europe and North America have mainly been of the var. *senanensis*, or perhaps involved hybrids between the two varieties. In European horticulture it is not a specially valued spruce and is mainly confined to arboreta and similar collections of planted trees. No cultivars are known of this rare species.

2 varieties are recognized:

Picea maximowiczii Regel *ex* Mast. var. ***maximowiczii***. Type: Japan: Honshu, [locality not stated], *Tschonoski (Chônosuka Sugawa) s.n.* (holotype K).

Description

Leaves (0.8–)1–1.3(–1.6) cm long. Seed cones (3.5–)4–6.5(–9?) cm long; seed scales broadly obovate with a cuneate base and a rounded, entire or slightly erose upper margin. Seeds 3–4.5 mm long, 2.5–3 mm wide.

Distribution

Japan: Honshu (Chichibu, Yatsugatake, Akaishi).
TDWG codes: 38 JAP-HN

Conservation

Despite its bushy habit (or is that a result?) this spruce has been over-exploited and present populations are scattered and small. It is a slow grower and regeneration is often hampered by changes of land use that have caused habitat degeneration. Most trees are now situated in State Forests and would therefore enjoy some measure of protection and plantations of *Larix* could be replaced with planted trees of this species raised in forest nurseries.
IUCN: EN (A2a, c, d, e)

Picea maximowiczii Regel *ex* Mast. var. ***senanensis*** Hayashi, Ill. Useful Trees (Forest Trees): sub f. 43. 1969. Type not designated.

Description

This variety differs from var. *maximowiczii* in its shorter needles (0.6–1.3 cm) and smaller cones (2.5–4.5 cm long), which have smaller, slightly pointed (obtuse) seed scales and smaller seeds (2.5–3 × 1.5–2 mm). Some doubt has been raised as to its taxonomic distinction (Yamazaki, 1995).

Distribution

Japan: Honshu (Chichibu).
TDWG codes: 38 JAP-HN

Conservation

IUCN: DD

Picea meyeri Rehd. & E. H. Wilson, in Sargent, Pl. Wilson. 2: 28. 1914. Type: China: Shanxi, Xiao Wutai Shan, Wutai Shan, *F. N. Meyer 22672* (holotype A).

Picea meyeri Rehd. & E. H. Wilson var. *mongolica* H. Q. Wu, Bull. Bot. Res. North-East. Forest. Inst. 7 (2): 153. 1986.
Picea meyeri Rehd. & E. H. Wilson var. *pyramidalis* H. W. Jen & C. G. Bai, J. Beijing Forest. Univ. 17 (1): 95. 1995; *Picea meyeri* Rehd. & E. H. Wilson f. *pyramidalis* (H. W. Jen & C. G. Bai) L. K. Fu & Nan Li, Novon 7 (3): 262. 1997.

Etymology

This species commemorates the Dutch plant collector Frans N. Meijer (1875–1918), who travelled extensively in Asia.

Vernacular names

Meyer's spruce; bai qian (Chinese)

Description

Trees to 30 m tall, d.b.h. to 60 cm; trunk monopodial, straight; bark on trunk rough and scaly, with papery flakes, grey. Branches of first order long, slender, spreading horizontally; branches of second order slender, numerous, thicker and shorter in top of tree; crown (broad) conical, or columnar in forest stands. Branchlets short, firm, colour variable, pale yellow to light brown, with prominent ridges and deep grooves, young shoots variably pubescent or glabrous, all glabrous in the 3rd year; pulvini well developed, 1.5–2 mm long, erect or slightly recurved, darker than shoot. Vegetative buds ovoid-conical to broad conical, more or less acute, 6–10 × 4–8 mm, resinous; bud scales triangular, acute, appressed, recurved near bud apex, light brown, persisting several years. Leaves spreading radially, crowded above shoot, directed forward, parted below, (0.8–)1.3–2.5(–3) cm long, 2 mm wide, linear, curved, on young trees straight, in cross-section transversely rhombic, acutish at apex; amphistomatic, stomata in 2–5 lines on each face above, in 4–5(–8) lines on each face below; leaf colour glaucous green or bluish green, stomatal bands bluish grey. Pollen cones axillary, 2–2.5 cm long, reddish yellow, ripening to orange-yellow. Seed cones terminal, erect at first, pendulous at maturity, (obliquely) short pedunculate or sessile, oval-oblong to cylindrical, usually very symmetrical, sometimes slightly curved, with obtuse apex, (6–)7–10(–12) cm long, 2.5–3.5(–4) cm wide with opened scales; colour (immature) purplish red, maturing to (light) reddish brown or grey-brown. Seed scales obovate or suborbicular, 1.5–2 × 1–1.6 mm at mid-cone; surface finely striated, slightly convex, glabrous; upper margin entire, rounded, convex, in some cones denticulate or truncate; base cuneate. Bracts ligulate-spathulate, 4–6 mm long, entirely included. Seeds ovoid-oblong, pointed at base, 3–4 × 1.5–2.5 mm, brown or blackish brown; seed wings obovate-oblong, 10–15 × 5–6.5 mm, yellowish brown or reddish brown.

Distribution

China: S Gansu?, Hebei, Nei Monggol [Inner Mongolia], Shaanxi, Shanxi (Wutai Shan).
TDWG codes: 36 CHI-NM CHN-HB CHN-SA CHN-SX

Ecology

Picea meyeri is a high montane to subalpine species, occurring at elevations between 1600 m and 2700 m a.s.l., often restricted to the N-facing slopes of the mountains. The soils are partly mountain brown earth, usually podzolized and non calcareous. The climate is cold, continental, especially in the western part of the range, with a moderate annual precipitation (500 to 800 mm). It grows in pure stands or mixed with *Picea wilsonii, Abies nephrolepis*, and *Larix gmelinii* var. *principis-rupprechtii*, the latter at elevations above 2100 m a.s.l. on Wutai Shan.

Conservation

IUCN: NT

Uses

Meyer's spruce is an importan timber tree in northern China, harvested both from natural stands and

from plantations. The wood is used for house building and other construction, foot bridges, poles, furniture making, and also, especially the plantation timber, for wood pulp used in industrial manufacturing. This species is in cultivation for afforestation and as an ornamental tree in arboreta, parks, and large gardens, in China and (as a garden tree only) in Europe and North America.

Picea morrisonicola Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25 (19): 220. 1908. Type: Taiwan: Nantou, Chia-i Pref., Yu-Shan, ["Mt. Morrison"], *T. Kawakami & U. Mori 2108* (lectotype TI). Fig. 192, 193

Etymology

This species is named for Mt. Morrison (Yu-Shan), the highest mountain in Taiwan.

Vernacular names

Taiwan spruce, Mount Morrison spruce; Taiwan yun shan (Chinese)

Description

Trees to 40–50 m tall, d.b.h. to 1.5 m; trunk monopodial, straight; bark on trunk rough and scaly, breaking into small, rounded plates with thin flakes, purplish grey or grey. Branches of first order long, massive, remote, spreading horizontally, curved down at the ends; branches of second order short, numerous and dense; crown broadly conical, in old trees irregular and open. Branchlets slender, flexible, the smallest new shoots only 2 mm thick, pale yellow, underside nearly white, later grey, with small ridges and narrow grooves, glabrous or rarely remote pubescent; pulvini small, reddish. Vegetative buds ovoid-conical, 3–4 mm long, slightly resinous; bud scales triangular-ovate, obtuse, appressed, dark red-brown, persisting several years. Leaves spreading radially, pressed forward above shoot, parted below (leaves with axillary buds longest), perpendicular, (0.8–)1–1.5(–2) cm long, (1–)1.5–2(–2.5) mm wide, linear, usually curved, longest leaves straight, quadrate-rhombic or diamond shaped in cross-section, acute or obtuse at apex; amphistomatic, 2 bands of 2–3 lines above, 2 bands of 4–5 lines below; leaf colour green or dark green, with fine, greenish white lines of stomata. Pollen cones axillary, 1–1.5 cm long, yellow. Seed cones terminal, erect at first, pendulous at maturity; peduncles short, oblique, or cones sessile; shape ovoid-oblong, tapered at base, obtuse at apex, (4–)5–7 cm long, 2.5–3 cm wide with opened scales; colour (immature) (greenish) red or purplish green, light brown or dull brown when ripe. Seed scales obovate or suborbicular, opening wide, 1.2–1.5 × 1–1.2 cm at mid-cone; surface smooth or finely striated, glabrous; upper margin entire, rounded or truncate; base broad cuneate. Bracts rudimentary, ligulate, purplish, 2–3 mm long, entirely included. Seeds ovoid-oblong, 3–3.5 mm long, dark brown; seed wings ovate-oblong, 8–10 × 4–5 mm, light yellowish or orange-brown.

Distribution

Taiwan (central mountains).
TDWG codes: 38 TAI

Ecology

Picea morrisonicola is a high montane species, occurring at elevations between 2300 m and 3000 m a.s.l. on N-facing mountain slopes and in ravines. The soils are acid and podzolized. The climate is cold temperate, with a monsoon character and very wet: annual precipitation exceeds 4000 mm. This spruce occurs in association with *Tsuga chinensis, Pseudotsuga sinensis, Pinus armandii*, and with *Abies kawakamii* and *Juniperus squamata* var. *morrisonicola* to the tree line; at lower elevations also with *Chamaecyparis obtusa* var. *formosana*, which can form pure stands below 2500 m, and broad-leaved trees, e.g. *Quercus variabilis, Acer insulare*, and *Betula* sp. It does not appear to form large pure stands and is in fact often one of the less frequent conifer species in the mixed coniferous forests.

Conservation

Exploitation of indigenous old growth forests for timber has reduced the area of occupancy (AOO) of this species considerably and the best stands of large trees are now largely restricted to protected areas.
IUCN: VU (A2cd)

Uses

Taiwan spruce can attain large size and is a valuable timber tree, but it has been over-exploited in the past and is now relatively rare. The wood is used for construction, carpentry and furniture making. It was introduced to Europe and the USA by Ernest H. Wilson in 1918, but has remained uncommon in cultivation, mostly found only in arboreta, botanic gardens and large private tree collections, and trees still alive today are often dating back to his first introduction.

Picea neoveitchii Mast., Gard. Chron., ser. 3, 33: 116, f. 50, 51. 1903. Type: China: W Hubei, *E. H. Wilson 2601* (holotype BM). Pl. 24

Etymology

The species epithet commemorates James Veitch, a Chelsea nurseryman who sent E. H. Wilson out to China to collect plants; '*neo-*' refers to a new species named after Veitch.

Vernacular names

Veitch's spruce, Hubei spruce; da guo qing qian (Chinese)

Description

Trees to 15–20 m tall, d.b.h. to 50–60 cm; trunk monopodial, straight; bark on trunk rough and scaly, exfoliating in small, thin flakes, grey. Branches of first order spreading, with upper branches ascending, lower ones curved down; branches of second order short, spreading or ascending; crown (broad) conical. Branchlets slender, firm, yellowish brown or pale brown, turning grey, ridged and grooved, glabrous, or rarely sparsely pubescent; pulvini small, directed forward or nearly erect on leading shoots. Vegetative buds conical or ovoid-conical, 5–6 × 3.5–4 mm, not resinous; bud scales triangular, obtuse, brown, appressed, slightly pubescent at base. Leaves spreading radially, curved and directed forward above shoot, parted below, 1.5–2(–2.5) cm long, ca. 2 mm wide, linear, usually curved, transversely rhombic in cross-section, keeled; apex acute to pungent; amphistomatic, with 4–7 lines of stomata on each face; leaf colour dark green, with faint, whitish green stomatal lines. Pollen cones axillary, ca. 2 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, sessile, ovoid-oblong, massive, with obtuse apex, (7–)8–14 cm long, 4.5–6.5 cm wide with opened scales; colour (immature) green, maturing to yellowish brown, ripe cones light brown. Seed scales few, large, very broadly obovate, or broad spathulate near cone apex, convex, with well defined apophysis, opening wide, 2.5–3.2 × 2.5–3 cm at mid-cone; abaxial surface finely striated, smooth when ripe, with basal part more or less frayed; upper margin entire, rounded or slightly obtuse, incurved, often undulate. Bracts rudimentary, ligulate, 4–5 mm long, entirely included. Seeds ovoid-oblong, 5–7 × 4.5 mm, dark brown; seed wings obovate, 15–18 × 8–10 mm, light brown.

Distribution

China: Chongqing (?) (Daba Shan), S Gansu, Henan (Neixiang), NW Hubei, S Shaanxi.
TDWG codes: 36 CHC-HU CHN-GS CHN-SA CHS-HE

Ecology

Picea neoveitchii occurs in medium high mountains, at elevations between 1200 m and 2250 m a.s.l., often on N-facing, steep, rocky slopes. The soils are non-calcareous, podzolic and acidic lithosols, the species even grows in rocky talus. The climate is cold-temperate, more continental in the western part of the range, with annual precipitation between 700–900 mm. In several areas only scattered trees have been found, associated with *Pinus armandii* above 1800 m, with *Abies chensiensis, Tsuga chinensis* or *Picea asperata*, and *Betula, Sorbus* and other angiosmerm trees.

Conservation

Extensive logging has reduced this species dangerously close to extinction in many areas; only a few populations are within forest reserves. The Chinese government has recently announced a policy that intends to halt large scale logging in western China, but the effects on the ground remain uncertain as in

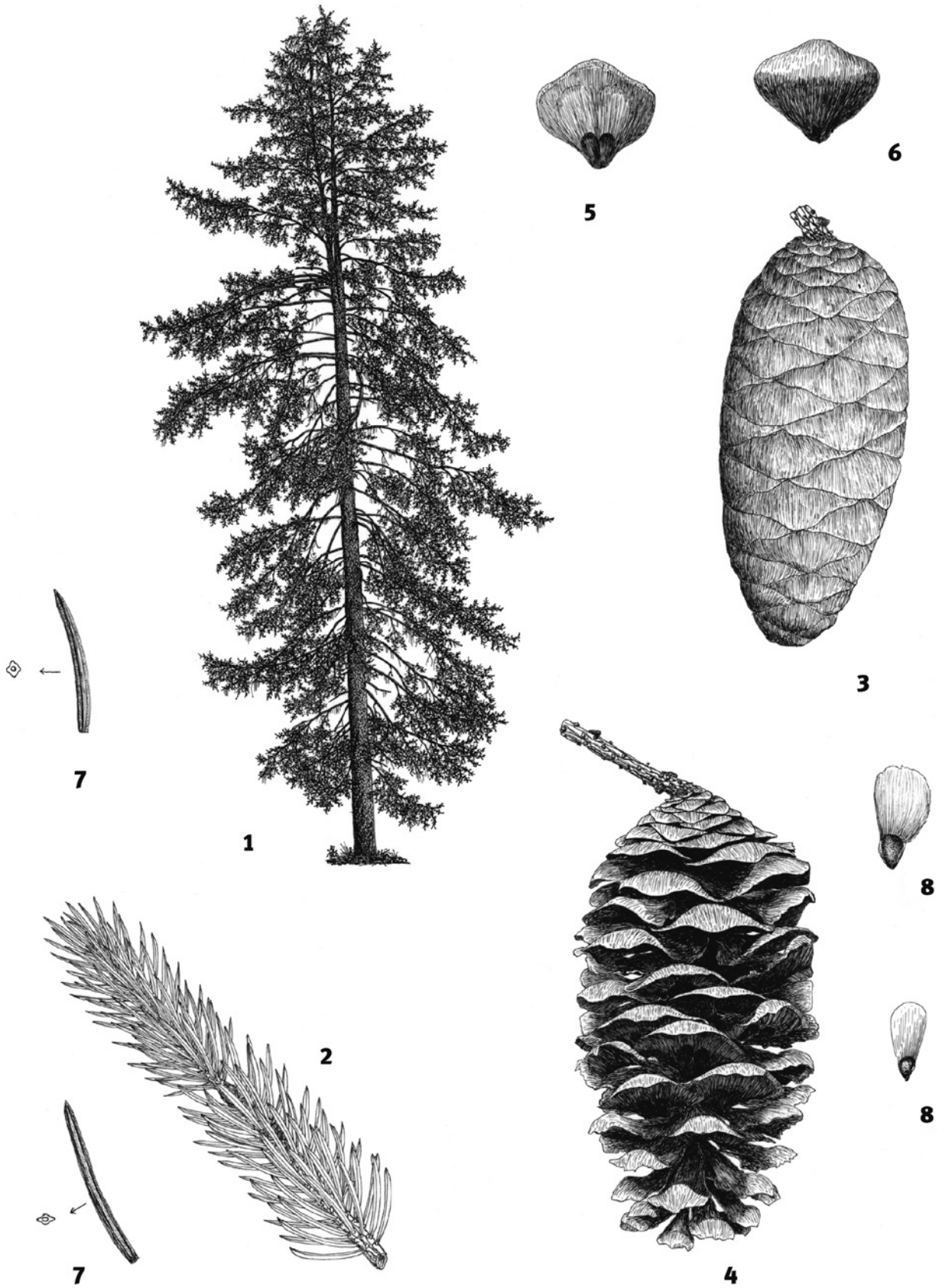

PLATE 24. *Picea neoveitchii*. **1.** Habit of tree. **2.** Branchlet with leaves. **3, 4.** Seed cones. **5.** Seed scale with seeds. **6.** Seed scale. **7.** Leaves. **8.** Seeds.

many areas illegal or unregulated timber extraction is common. Some subpopulations are down to one or a few trees only.
IUCN: CR [B2ab (I, ii, v); C2a (ii)]

Uses

The wood of this timber tree is or was used locally for construction, poles, furniture, and wood pulp in the paper industry. From E. H. Wilson's herbarium specimens, which include ripe cones, no trees seem to have been grown, and its existence in cultivation outside China remains uncertain.

Picea obovata Ledeb., Fl. Altaica 4: 201. 1833. *Picea abies* (L.) H. Karst. var. *obovata* (Ledeb.) Lindq., Acta Horti Berg. 14 (8): 307. 1948; *Picea abies* (L.) H. Karst. subsp. *obovata* (Ledeb.) Hultén, Svensk Bot. Tidskr. 43: 388. 1949. Type: Russia: Altai Mts., *C. F. von Ledebour et al. s.n.* (holotype LE).

Etymology

The species epithet describes the shape of the seed cone scales (obovate = inverse egg-shaped, i.e. with the broadest pole at the apical end).

Vernacular names

Siberian spruce; Jel sibirskaya (Russian)

Description

Trees to 40 m tall, d.b.h. to 1 m; trunk monopodial, straight; Branches of first order slender, long or short, spreading horizontally or curved downward; bark grey at lower part of trunk, rough, scaly, breaking into small plates. Branches of first order slender, long or short, spreading horizontally or curved downward; branches of second order highly variable, spreading horizontally; crown pyramidal or narrowly conical. Branchlets slender, bright orange or red-brown, becoming grey, ridged and grooved, (sparsely) pubescent or glabrous; pulvini 1 mm, oblique. Vegetative buds ovoid-conical, 4–5 × 3–4 mm, not or slightly resinous; bud scales triangular, obtuse, light brown or reddish brown, persisting several years. Leaves spreading radially around shoot, directed forward, parting below, 0.8–2.5 cm long, 1–1.8 mm wide, linear, straight or curved, quadrangular in cross-section, acute at apex; amphistomatic, with 2–4 lines of stomata on each face; leaf colour (dark) green. Pollen cones in leaf axils, near end of shoots, 1–1.5 cm long, yellow. Seed cones terminal, at first erect, pendulous at maturity, sessile, cylindrical, rarely ovoid-oblong, 4–8 cm long, 2.5–4 cm wide with opened scales; colour (immature) green or red, maturing to brown or dark brown. Seed scales obovate-oblong to flabellate, 1.5–2.5 × 1–2 cm at mid-cone; surface smooth, glabrous; upper margin obtuse or rounded, entire; base cuneate. Bracts rudimentary, ligulate, 2–3 mm, entirely included. Seeds ovoid-oblong, 2–4 mm, dark brown or blackish brown; seed wings ovate-oblong or cuneate, (6–)10–15 mm long, light brown.

Taxonomic notes

Picea obovata is considered a distinct species in Russia, but its range meets that of *P. abies* in NW Russia and certainly in Lapland on the Kola Peninsula and in northern Finland. Here it is considered to be either a subspecies of *P. abies*, or the product of hybridization, *Picea ×fennica* (Regel) Kom., between the two taxa. That such hybridization has occurred is more than likely with the repeated retreat of *P. abies* into refuges that were situated in European Russia during the ice ages. The two taxa mixed in their subsequent recolonisation of lost ground when the Scandinavian icecap retreated during warmer interglacial phases. The seed cone morphology of undisputed Siberian populations of *P. obovata* is quite uniform and distinct from the larger but variable cones of *P. abies*; it is where the two have historically been sympatric where identification becomes difficult.

Distribution

Russia: from northern European Russia across Siberia to the Sea of Okhotsk, southward to Mongolia and Xinjiang.
TDWG codes: 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KHA MAG 36 CHX 37 MON

Ecology

Picea obovata is a constituent of the boreal taiga of northern Russia and Siberia, where it tends to dominate on shallow soils over permafrost and occurs to well within the Arctic Circle. In the southern parts of its huge range it is forming almost pure forests or mixed with *Abies sibirica* in the Altai Mountains to ca. 2000 m a.s.l. In water-logged areas it becomes a stunted, narrowly columnar tree and often grows together with *Larix gmelinii* in the eastern part of its range. *Betula* and *Populus* are common associated angiosperm trees in the more or less open conifer forests on slightly deeper and better drained soils. In dryer soil situations *Pinus sylvestris* can grow with the spruces, too. *Picea obovata* is extremely tolerant of low winter temperatures, withstanding extremes below –60° C with a totally frozen soil. Under such extreme conditions, with short but often hot and dry summers, it grows very slowly and trees with a trunk diam. of 10 cm can be a century or more old.

Conservation

IUCN: LC

Uses

Siberian spruce is a major timber tree in Russia and represents the largest resource of standing timber by volume in that country (and perhaps in the world). Much of the wood is processed to pulp, but other uses for which *Picea* wood is traditionally valued also apply to *P. obovata*, including the careful construction of violins. In amenity planting it is less prominent and only used commonly in parts of Russia and rarely in other countries of eastern Europe.

Picea omorika (Pančić) Purk., Oesterr. Monatschr. Forstwesen 27: 446. 1877. *Pinus omorika* Pančić, Neue Conif. Alp.: 4. 1876. [Gard. Chron., ser. 2, 7: 620. 1877]. Type: Serbia: W Serbia, Rastiste, Crvena Stena, *J. Pančić s.n.* (lectotype K, designated here).

Etymology

Omorika is the local name, used as the species epithet by Pančić under *Pinus*.

Vernacular names

Serbian spruce; Morika, Omorika (Serbian)

Description

Trees to 30–40 m tall, d.b.h. to 0.8–1 m; trunk monopodial, straight or curved at base; bark thin, rough and scaly, with papery flakes, (reddish) brown. Branches of first order numerous, short, slender, curved downward or pendant, assurgent at end; branches of second order slender, pendulous, hanging in dense sprays; crown narrowly conical or columnar, branches reaching to the ground. Branchlets short, slender, flexible, orange-brown or dull light brown, later grey-brown, with flat ridges and shallow, faint grooves, pubescent in 1st and 2nd year, then glabrous; pulvini small, to 1.5 mm, nearly glabrous. Vegetative buds ovoid-conical, acute, lateral buds often numerous, 5–8 × 2.5–4.5 mm, not resinous or resinous at base; bud scales ovate, acute, appressed, apices becoming free, red-brown, turning orange-brown, persisting several years. Leaves radially spreading at first, but soon more flat and pectinate, with lower leaves spreading at nearly 90° from shoot, (0.8–)1–2(–2.2) cm long, 1.5–2.2 mm wide, linear, flattened, keeled on both sides; apex obtuse or acutish; epistomatic, stomata in two bands of 4–6 lines on lower surface; upper surface dark glossy green, sometimes glaucous green, two greenish white stomatal bands below. Pollen cones axillary, cylindrical, 2–2.5 cm long, yellowish. Seed cones terminal, often on small lateral shoots, erect at first, pendulous at maturity; peduncles oblique or curved, scaly; cones ovoid-oblong, oblique at base; apex tapering, 4–6.5 cm long, 2–3 cm wide with opened scales; colour (immature) dark purple, maturing to purplish brown, ripe cones red-brown or grey-brown. Seed scales suborbicular, thin, rigid, convex, remaining imbricate for a long time, 1–1.5 × 1–1.3 cm at mid-cone; surface striated, sometimes transversely undulate, often covered with dark resin, glabrous; upper margin erose-denticulate. Bracts rudimentary, ligulate, 2–3 mm long, entirely included. Seeds

ovoid, with acute apex, 3 × 2.5 mm, brown or red-brown; seed wings ovate, 6–8 × 4–5 mm, light red-brown or yellowish brown.

Distribution

Balkan Peninsula: Serbia (Tara Mts., Drina River drainage).
TDWG codes: 13 YUG-SE

Ecology

Picea omorika occurs in the mountains of Serbia, at elevations between 300 m and 1700 m a.s.l., mainly on N-facing slopes. The bedrock is Mesozoic limestone or rarely serpentine, the soils are mesic, humic and calcareous rendzinas, often very rocky. The climate is cool montane, with moderately warm and dry summers and snowy winters, with annual precipitation around 1000 mm. The species is usually mixed with *Picea abies*, but *Abies alba* and *Pinus nigra* also occur, while *Fagus orientalis* and *Castanea sativa* are broad-leaved trees occurring at the lower elevations, where the coniferous forest merges with the more extensive beech forest. It seems to be much less competitive with Fagus than *Abies alba* or *Picea abies*; however, it is capable of layering.

Conservation

This species is a Tertiary relict known from fossil evidence to have occurred in large parts of Europe and to have been reduced to its present refugium on the Balkan Peninsula by successive ice ages. Historically, its natural range has further decreased due to logging and fires, resulting in some 50 small relict stands, which together may not cover more than 60 ha (Schmidt-Vogt, 1977). It is unclear to what extent the planting of *Picea abies* by foresters in the region has contributed to the competition experienced by *P. omorika* from this more agressively growing spruce. The two species do not seem to hybridize, but further planting of *P. abies* should be stopped and introduction of *P. sitchensis*, with which *P. omorika* does hybridize, must be prevented by all means.
IUCN: EN [B1ab (i–v)]

Uses

Serbian spruce is no longer logged for its timber. On a limited scale it has been planted as a forestry (timber) tree in Finland and Sweden. Its economic value however is in horticulture, where it has been widely used due to its characteristic narrow shape with gracefully down-curving branches along the entire stem. It was first introduced in 1880–81 in German and Swiss gardens, from where it rapidly spread to other countries. It grows well on sandy soils and is tolerant to air pollution. It is mainly used as an ornamental tree, but in Denmark it has been planted also as windbreaks. Serbian spruce will layer when planted in open situations and when there is sufficient moisture. A number of cultivars has been selected, especially dwarfed forms suitable for rock and heather gardens, the latter en vogue in the 1960s and 1970s but later going out of fashion.

Picea orientalis (L.) Peterm., Pflanzenreich: 235. 1838–45. *Pinus orientalis* L., Sp. Pl., ed. 2, 2: 1421. 1763. Type: Turkey: Trabzon, *B. Balansa s.n.* (neotype K, designated by Farjon in Jarvis [2007: 745]).
Fig. 194, 195

Etymology

The species epithet refers to its oriental origin (as viewed from western Europe).

Vernacular names

Oriental spruce, Caucasian spruce; Jel kavkasskaja, Jel vostochnaya (Russian)

Description

Trees to 40–50(–60) m tall, d.b.h. to 1.5–2.3 m; trunk monopodial, straight; bark on trunk rough and scaly, breaking into small plates, brown or brown-grey. Branches of first order long, slender, spreading, curved downward, assurgent at end, but variable; branches of second order long, slender, spreading or pendant; crown pyramidal or conical to narrowly conical, dense, branches to the ground in most trees. Branchlets short, slender, flexible, yellowish or pale brown, turning grey, with narrow ridges and grooves,

short pubescent; pulvini small, apices lighter than shoot. Vegetative buds ovoid-conical, acutish; terminal buds acute, 3–5 mm long, not resinous; bud scales triangular, obtuse, appressed, but apices more or less free, reddish brown, persisting several years. Leaves spreading radially, but pressed against shoot above, parted and nearly pectinate below, directed slightly forward, 0.6–0.8(–1) cm long, 0.7–1 mm wide, linear, straight, transversely rhombic in cross-section, obtuse or obliquely acutish at apex; amphistomatic, 1–2 lines of stomata on each face above, 2–5 lines on each face below; leaf colour dark glossy green above, whitish stomatal bands below. Pollen cones axillary, 1–2 cm long, yellowish. Seed cones terminal, erect at first, pendulous at maturity, often very numerous, sessile, narrowly cylindrical, tapering towards apex, (4.5–)5–9(–10) cm long, 2–3.3 cm wide with opened scales; colour (immature) green, purplish green or purple, ripening to red-brown or dark (purplish) brown. Seed scales broadly obovate or suborbicular, thin but rigid, slightly convex, 1.2–1.7 × 1–1.4 cm at mid-cone; surface finely striated, shining, undulate or flat, sometimes resinous, glabrous; upper margin rounded, entire or lacerate; base cuneate. Bracts small, ligulate, serrate at rounded apex, 5–6 mm long, entirely included. Seeds ovoid, pointed at apex, 3–4 × 2–2.5 mm, red-brown or dark brown; seed wings ovate, 6–8 × 4–5 mm, orange-brown or yellowish brown.

Distribution

Caucasus, N Turkey (coastal mountains).
TDWG codes: 33 NCS-KB NCS-KC NCS-SO TCS-AR TCS-GR 34 TUR

Ecology

Picea orientalis occurs in the mountains around the eastern shore of the Black Sea, at elevations between (400–)700–2100 m a.s.l., in Turkey mainly on the northern (seaward) slopes. It has a preference for acid soils. The climate is characterized by cool to cold winters (according to elevation) and relatively warm, dry summers, the annual precipitation varies between 1000 mm and 2000 mm; *Picea* occurs generally on drier sites than *Abies*. It forms extensive pure stands, especially at higher elevations and at the limit of trees, or is mixed with *Abies nordmanniana*. The undergrowth is poor, *Vaccinium* being predominant. At lower elevations it occurs scattered in broad-leaved forests, with *Fagus orientalis, Acer* spp., *Ilex colchica* and *Taxus baccata*.

Conservation

IUCN: LC

Uses

Oriental spruce is an important timber tree in the Caucasus, where it forms extensive pure stands, many of which are managed for forestry. It has also been introduced as a forestry plantation tree in countries in the eastern Mediterranean. The wood of this species is of good quality, comparable to that of Norway spruce, and is put to similar uses. Among these are construction, flooring, carpentry, furniture making, and parts of musical instruments. In horticulture, this spruce is sometimes grown as a Christmas tree, but more commonly as an amenity tree for parks and large gardens in many European countries and in the USA. A good number of cultivars is in the trade, among which are dwarf forms, forms with yellowish flushing leaves and those with 'mounding' habits. The dense foliage with very small leaves, the bright red immature pollen cones, and the pendulous, purple (when still closed) seed cones make this an attractive species for large gardens.

Picea pungens Engelm., Gard. Chron., ser. 2, 11: 334. 1879. Type: USA: Colorado, Clear Creek, *G. Engelmann s.n.* (lectotype MO).

Etymology

The species epithet alludes to the sharp pointed (pungent) needles.

Vernacular names

Blue spruce, Colorado spruce

Description

Trees to 40–50 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight; bark rough and scaly, deeply fissured at lower part of trunk, dark grey-brown.

Branches of first order numerous, moderately long or short, spreading horizontally, more erect or assurgent near top; branches of second order dense, rigid, spreading horizontally; crown conical, in old trees broad columnar below the top, branches commonly to the ground. Branchlets slender, firm, yellowish brown to orange-brown, darkest above, later turning grey, prominently ridged and grooved, glabrous; pulvini small, directed forward, slightly darker than shoot. Vegetative buds ovoid-oblong, obtuse, 5–8 × 3–4 mm, not resinous; bud scales triangular, obtuse, loosely appressed, apices recurved, yellowish brown or pale brown, basal scales keeled, acute, persistent, forming collars at base of shoots. Leaves spreading radially, rigid, directed upward and forward, parted below shoot, 1.5–3 cm long, 1–1.5 mm wide, linear, slightly curved, quadrangular in cross-section, with 4 prominent ribs, with acute to spinescent (pungent), colourless apex; amphistomatic, 3–6 lines of stomata on each (grooved) face; leaf colour green, glaucous green or bluish green. Pollen cones axillary, cylindrical, 2–3 cm long, yellow. Seed cones terminal, erect at first, pendulous at maturity, numerous, concentrated in top of tree, sessile, ovoid-oblong or cylindrical, obtuse or truncate at apex, 5–8(–10) cm long, 3–4.5 cm wide with opened scales; colour (immature) green, ripening to yellowish brown or pale brown. Seed scales obtrullate or broadly rhombic, very thin, papery but tough, undulate, spreading wide, 1.8–2.4 × 1–1.5 cm at mid-cone; surface smooth, finely striated, glabrous; upper margin very erose; apex undulate to emarginate; base cuneate. Bracts rudimentary, ligulate-cuspidate, 3–5 mm long, entirely included. Seeds ovoid, pointed at apex, 3 × 2 mm, brown; seed wings obovate, 6–9 × 5–6 mm, much shorter than the seed scale, yellowish brown.

Distribution

USA: Rocky Mountains, mainly in SE Idaho, Wyoming, Utah and Colorado, with isolated populations in Montana, Arizona and New Mexico.
TDWG codes: 73 COL IDA MNT WYO 76 ARI UTA 77 NWM

Ecology

Picea pungens is a subalpine species occurring in the Rocky Mountains at elevations between 1800 m and 3300 m a.s.l., commonly along mountain streams or on moist, N-facing slopes. The soils are mountain lithosols and streambed gravels of various origin, usually poorly developed. The climate is continental, with long, cold and snowy winters (frost free days 60 or less) and short, but relatively warm summers. Annual precipitation ranges from 600 mm to 900 mm. This species grows in small, scattered groves, especially near perennial streams, or scattered and mixed with *Pinus contorta, Pseudotsuga menziesii* var. *glauca*, or *Populus tremuloides*. It is everywhere a rare constituent of the subalpine forest.

Conservation

IUCN: LC

Uses

Blue spruce is widely planted as an ornamental; perhaps the most famous trees of this species are planted in front of Lenin's mausoleum in the Kremlin in Moscow. Its symmetrical crown and glaucous blue foliage make it an ideal tree for gardening and landscaping. In nature trees with green foliage exist, but these are not much wanted as the stock for horticulture; instead blue forms have been repeatedly selected. A substantial number of cultivars, both tree forms and dwarf forms, have been raised displaying various colours and hues of the needles which tend to change with their age and become less intense. It is also popular as a Christmas tree, especially in the USA. The wood of this species is brittle and knotty because it retains its branches on the bole and is therefore of little commercial value.

Picea purpurea Mast., J. Linn. Soc., Bot. 37: 418. 1906. *Picea likiangensis* (Franch.) E. Pritz. var. *purpurea* (Mast.) Dallim. & A. B. Jacks., Handb. Conif.: 334. 1923. Type: China: Sichuan, Min River, Songpan, ["ad Sung Pan prope Tibetam"], *E. H. Wilson 3026* (holotype BM).

Etymology

The species epithet refers to the purple colour of the seed cones.

Vernacular names

Purple-cone spruce; zi guo yun shan (Chinese)

Description

Trees to 40–50 m tall, d.b.h. to 1–2 m; trunk monopodial, straight; bark on trunk rough and scaly, grey-brown, with freshly exposed parts of bark orange. Branches of first order spreading horizontally, with lower branches curved down; branches of second order short, slender, dense, spreading or more pendant; crown pyramidal or narrowly conical, trees at high elevations making narrow spires. Branchlets slender, flexible, very numerous, pale (pinkish) yellow-grey, finely grooved and ridged, young shoots densely pubescent; pulvini small, directed forward at 30–50° from shoot. Vegetative buds conical, ca. 4 × 3 mm, resinous; bud scales triangular, obtuse, appressed, shiny dark chestnut brown, persisting several years. Leaves above shoot closely appressed, covering it entirely, with lower leaves more or less parting, all directed forward, with leaves on shaded shoots more remote and spreading, 0.7–1.4 cm long, 1.5–1.8 mm wide, linear, straight or curved at base only, more or less dorsiventrally flattened, keeled on both sides, obtuse-mucronate at apex; usually epistomatic, with two bands of densely set stomata below, but sometimes 1–2 intermittent lines of stomata above; leaf colour bright green or glossy dark green above, two greenish white stomatal bands below. Pollen cones axillary, conical, 1.5–2.5 cm long, light red, ripening to rose or yellowish. Seed cones terminal, erect at first, pendulous at maturity, sessile, ovoid to ovoid-oblong, tapering to base, obtuse at apex, 2.5–5(–7) cm long, 1.7–3 cm wide with opened scales; colour violet, purple or bright crimson when immature, ripening to purplish brown or dull (light) brown. Seed scales rhombic, papery at apex, curved, undulate, spreading wide when ripe, 1–1.5 × 0.8–1.2 cm at mid-cone; abaxial surface smooth or finely striated, often resinous, glabrous; upper margin thin, elongated, undulate, incurved in some cones, erose-denticulate; base shortly narrowed. Bracts rudimentary, ligulate, 1–2 mm long, entirely included. Seeds ovate-oblong, pointed at base, 2.5–3 mm long, (dark) purplish brown; seed wings (obliquely) ovate-oblong, 5–7 × 3–4 mm, orange-yellowish.

Taxonomic notes

This species is quite unlike *P. likiangensis* (Franch.) Pritzel, to which it has been linked as a variety in several works describing (Chinese) conifers (e.g. Dallimore & Jackson, 1966; Wright, 1955; Den Ouden & Boom, 1965). It is undoubtedly closely allied to *P. likiangensis* and its varieties and has been placed with that aggregate group in the subsection *Sitchenses* E. Murray. The leaves of the Chinese members of this subsection of spruces vary from nearly equifacial amphistomatic (*P. likiangensis* var. *likiangensis*) to nearly invers-dorsiventral epistomatic (*P. purpurea*).

Distribution

China: Gansu, E Qinghai, Sichuan, NW Yunnan.
TDWG codes: 36 CHC-SC CHC-YN CHN-GS CHQ

Ecology

Picea purpurea is a subalpine species of continental mountains, occurring in a spruce belt at elevations between 2600 m and 3800 m a.s.l., predominantly on N-facing slopes. The soils are either grey-brown mountain soils or lithosols, usually podzolic. The climate is cold continental, with low to moderate precipitation, much of it as winter snow. It grows in pure forests or mixed with several other species of *Pinaceae*, e.g. *Picea asperata, P. wilsonii, Larix potaninii*, and *Abies fargesii*, which prevails above the spruce belt towards the tree line, and with some broad-leaved trees, usually *Populus* spp. and *Betula* spp. in clearings. At lower elevations *Tsuga chinensis* and *Quercus* spp. may occur.

Conservation

IUCN: NT

Uses

This species yields high quality timber used for construction, furniture making, poles, machine and instument making, including musical instruments, and to a limited extent for pulp in industrial manufacturing, e.g. paper. It was introduced to England early in the 20th century by Ernest Wilson and Joseph Rock and is commonly found growing

in arboreta both in Europe and North America, but sometimes misidentified as *P. likiangensis*, or treated as a variety of it (for the U.K. presumably based on its treatment in Dallimore & Jackson's Handbook, 1966). According to Rushforth (1987) introductions by Wilson from W Sichuan grow to taller, more columnar trees than those from Rock's collections, originating from S Gansu, where the climate is drier and colder in winter.

Picea retroflexa Mast., J. Linn. Soc., Bot. 37: 420. 1906. *Picea asperata* Mast. var. *retroflexa* (Mast.) W. C. Cheng, in Chen, Taxon. Chin. Trees: 38. 1937; *Picea aurantiaca* Mast. var. *retroflexa* (Mast.) C. T. Kuan & L. J. Zhou, Fl. Sichuan. 2: 71. 1983. Type: China: Sichuan, Daxue Shan, near Kangding, ["Tachien-lu"], *E. H. Wilson 3030* (holotype A).

Etymology

The species epithet (Latin *retroflexus* = 'bent back, reflexed') refers to the pulvini on the shoots, which Masters described as being "*patenti-reflexi*".

Vernacular names

Dapao Shan spruce; lin pi yun shan (Chinese)

Description

Trees to40–45 m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight; bark on trunk rough and scaly, breaking into small, flaking plates, grey or brownish grey; inner bark yellowish. Branches of first order short, numerous, spreading horizontally; branches of second order short, rigid, numerous, spreading laterally; crown narrowly conical or columnar, especially in trees at high altitude. Branchlets short, firm, thick, light brown or orange-brown, prominently ridged and deeply grooved, glabrous or often ferruginous pubescent; pulvini strongly developed, 1–2 × 1–1.5 mm, on strong shoots almost erect. Vegetative buds broadly conical, closely surrounded by curved leaves, 5–10 × 5–10 mm, resinous, often pubescent at base; bud scales triangular, keeled, appressed, orange-brown or with purplish apex, persisting several years, leaving broad collars of perular scales at shoot bases. Leaves spreading radially, curved forward, (1–)1.2–1.8(–2.5) cm long, (1.2–)1.5–2 mm wide, linear, curved, quadrangular or transversely rhombic in cross-section, with prominent ribs; apex pungent; amphistomatic, on upper surface 2 bands of 2–3 lines, on lower surface 2 bands of 4–6 lines of stomata; leaf colour light green or glaucous green. Pollen cones axillary, 2 3–5 cm long, reddish, ripening to reddish yellow. Seed cones terminal, erect at first, then pendulous, sessile, oval-oblong to cylindric-conical; apex obtuse, 8–13 cm long, 2.5–4 cm wide with opened scales; immature cones purplish red, maturing to purplish or reddish brown, ripening to lustrous brown. Seed scales obovate-oblong or slightly obtrullate, those near base suborbicular, spreading wide when ripe, 1.5–2 × 1.2–1.5 cm at mid-cone; abaxial surface striated, shining, more or less convex, glabrous; upper margin rounded or obtuse, slightly erose-denticulate, incurved, straight or slightly reflexed when opened base cuneate. Bracts ligulate-lanceolate, 5–6 mm long, entirely included. Seeds ovoid-oblong, 3–4 mm long, dark brown or red-brown; seed wings obovate-oblong, 10–15 × 5–7 mm, pale brown or yellowish brown.

Taxonomic notes

In Flora of China 4: 28 (1999) this species has been made a synonym of *P. asperata* var. *asperata*, while other (Chinese) works (e.g. Ying *et al.*, 2004; Farjon, 1990, 1998, [2001]) have maintained the species rank, or included it as a variety of *P. aurantiaca* (Flora of Sichuan). A re-examination of relevant collections and populations seems desirable; this should include work on DNA sequences.

Distribution

China: W Sichuan, Qinghai (Banma Xian), S Gansu (Jone Xian).
TDWG codes: 36 CHC-SC CHN-GS CHQ

Ecology

Picea retroflexa is a typical subalpine species, which occurs between 3000 m and 4000 m a.s.l. (to 4700 m E of Dawu, Schmidt-Vogt, 1977), mainly on N-facing slopes on acidic soils. The climate is continental alpine with low annual precipitation. At the highest elevations it grows either pure or mixed with *Abies*

squamata, but at lower elevations *Picea likiangensis* var. *rubescens, P. aurantiaca, Abies chensiensis* and *Tsuga chinensis* may occur with it. *Betula albosinensis* is the only common broad-leaved tree species in these forests.

Conservation

The limited range of this taxon, in conjunction with exploitation of timber trees in the subalpine conifer forests in which it occurs, have led the Conifer Specialist Group to infer past and possibly ongoing decline. Due to difficulties with identification it would be hard to quantify this decline accurately, but given the overall decline of spruce forests in the region it is likely to exceed 50%.
IUCN: EN (A2cd)

Uses

Although no uses are specifically reported of this species, its timber has been exploited together with that of other species in the area and put to the same uses. This spruce was introduced to Europe and the USA by Ernest Wilson and is still present in several arboreta, often identified as *P. asperata*. According to Rushforth (1987), trees in cultivation (in the UK) are "noticeably greener than Dragon spruce" (*P. asperata*), which could indicate that Wilson introduced seed from a green-leaved form of this species. As Wilson himself noted (on specimen), glaucous forms also occur in its native habitat. This 'mixture' of green and glaucous forms is common among conifers in all families and has given rise to both valuable horticultural varieties and much taxonomic confusion.

Picea rubens Sarg., Silva N. Amer. 12: 33. 1899. Type: Illustration in A. B. Lambert, Descr. Pinus vol. 1, t. 28 (as *Pinus rubra*). 1803. (lectotype).

Etymology

The species epithet means 'red' and describes the colour of the cones (when young?).

Vernacular names

Red spruce, Eastern spruce; Epinette rouge (French)

Description

Trees to (25–)30–35(–50) m tall, d.b.h. to 1–1.5 m; trunk monopodial, straight; bark soon rough and flaking, reddish brown or purplish grey with brown, in old trees fissured near base of trunk. Branches of first order long, slender, spreading horizontally, sometimes slightly assurgent; branches of second order long, slender, spreading laterally; crown narrowly pyramidal or conical. Branchlets slender, flexible, light yellowish brown at first, later turning orange or reddish brown, ridged and grooved, the young shoots more or less densely pubescent, but soon glabrous; pulvini small, pubescent at base. Vegetative buds ovoid-conical, acute, 5–8 mm long, slightly resinous; bud scales triangular, the outer scales acute and reflexed, red-brown or chestnut brown, persisting several years. Leaves spreading radially but parted below, directed obliquely forward, on strong shoots more or less assurgent above shoot, 1–1.5(–1.7) cm long, ca. 1 mm wide, narrowly linear, usually slightly curved, quadrangular in cross-section, acute or nearly obtuse at apex; amphistomatic, stomata in 2–4 lines on all four faces; leaf colour shiny light green. Pollen cones axillary, 1.5–2.5 cm long, reddish at first, yellowish when ripe. Seed cones terminal, erect at first, pendulous at maturity, short pedunculate or sessile, ovoid, tapering towards base, obtuse at apex, 2.5–5(–6) cm long, 1.8–3.5 cm wide with opened scales; colour (immature) purplish red or green with a purple tinge, maturing to red-brown or purplish brown, old cones lustrous red-brown. Seed scales obovate-cuneate, convex, 0.8–1.5 × 0.9–1.3 cm at mid-cone; surface slightly striated or nearly smooth, often with white resin dots, glabrous; upper margin entire (in old cones erose), rounded or obtuse, incurved; base cuneate. Bracts rudimentary, ligulate, ca. 2 mm long, entirely included. Seeds ovoid-oblong, 2–3 × 1.5 mm, light brown or dark brown; seed wings obovate, 5–9 × 3–5 mm, light brown or orange-brown.

Distribution

E Canada: maritime provinces, extreme SE Ontario, S Quebec; USA: New England States and Appalachian Mountains.
TDWG codes: 72 NBR NFL-SP NSC ONT PEI QUE 75 CNT MAI MAS NWH NWJ NWY PEN VER WVA 78 NCA TEN VRG

Ecology

Picea rubens occurs from near sea level on the coasts of the maritime provinces of Canada, to the higher slopes of the Appalachian Mountains (1100 m to 1850 m a.s.l.). In the NE lowland areas the species grows mainly on acid soils (pH 4–5.5) of alluvial origin, in the mountains also on acidic, peaty or rocky soils generally unfavorable for most of the other tree species of NE North America. It is climatically restricted to areas with a cool, moist oceanic climate, with annual precipitation between 875 mm and 2000 mm (increasing with elevation). It is commonly mixed with *Picea glauca* or *Abies balsamea*, more rarely with *Picea mariana*, which occupies swamps and bogs but may extend to drier sites. Rare or local associated conifers are *Abies fraseri, Tsuga canadensis, Pinus strobus*, and *Chamaecyparis thyoides*. Broad-leaved trees can be common or dominant, especially on better soils.

Conservation

IUCN: LC

Uses

Red spruce is an important timber tree of medium size but with a relatively limited natural range. Its wood is light in weight and cream coloured, strong and straight grained. It has varied applications and, besides the mass use for paper pulp, more specialized uses include construction, boat building, flag poles, cooperage, and especially musical instruments. Spruce wood is ideal for sounding boards and bodies of string instruments, from pianos (the keys hit strings) to guitars and violins. It is not often possible to ascertain which species of spruce has been used, as anatomically the wood of three species growing in this area is indistinguishable. Red spruce is uncommon in cultivation probably because it is not very distinct and few cultivars are known. Locally the resin from trunk wounds has been used as chewing gum, perhaps learned by early settlers in Maine from native tribes. This use has been redundant for nearly a century as other sources of gum replaced it.

Picea schrenkiana Fisch. & C. A. Mey., Bull. Sci. Acad. Imp. Sci. Saint-Pétersbourg 10: 254. 1842.

Etymology

This species was named after Alexander Gustav von Schrenk (1816–1876), a German botanist working in Russia.

Vernacular names

Schrenk's spruce, Asian spruce; Jel Schrenka (Russian); xue ling yun shan (Chinese)

Description

Trees to 40–50(–60) m tall, d.b.h. to 1–2 m; trunk monopodial, straight; bark on trunk scaly, with small plates, blackish grey; inner bark orange. Branches of first order short, numerous, spreading and descending; branches of second order short, numerous, very dense, usually spreading; crown narrowly conical or columnar, dense, branches to the ground in most trees. Branchlets short, thick, rigid, pale yellowish or yellowish grey, prominently ridged and deeply grooved, variously pubescent or glabrous; pulvini prominent, assurgent, 1.5–2 mm long. Vegetative buds conical, broad, sometimes ovoid, acute, with crowded pulvini at base, 5–10 × 4–7 mm, not resinous; bud scales triangular, appressed, shiny yellowish brown, persisting several years. Leaves spreading radially, directed forward, (1–)2–3(–3.5) cm long, 1–1.5(–2) mm wide, linear, curved, transversely rhombic in cross-section, with 2 ribs on opposite sides; apex pungent; amphistomatic, with 2–4 lines of stomata in each of 4 grooved faces; leaf colour green, with whitish stomatal lines. Pollen cones axillary, 1.5–2.5 cm long, yellowish red, yellow when ripe. Seed cones terminal, erect at first, pendulous at maturity, shortly pedunculate or sessile, cylindrical-oblong, sometimes slightly tapering towards the obtuse-truncate apex, (6–)8–10(–12) cm long, 2.5–3.5(–4) cm wide with opened scales; colour (immature) purplish or greenish, ripening to purplish black or dull brown. Seed scales obovate, broad, opening at 90°, 1.3–1.8 × 1.2–1.5 cm at mid-cone; abaxial surface striated or wrinkled, glabrous; upper margin rounded or truncate, slightly incurved, entire or erose. Bracts rudimentary, ligulate, 2–3 mm long,

entirely included. Seeds ovoid, pointed at base, 4–5 × 3 mm, dark brown with whitish spots; seed wings ovate, 8–10 × 5–6 mm, orange-brown.

Distribution

China: Xinjiang (Tian Shan); Kazakhstan, Kirgyzstan (mountains around Naryn River and Lake Issyk Kul).
TDWG codes: 32 KAZ KGZ 36 CHX

Ecology

A high montane to subalpine species of Central Asia, occurring between 1300 m and 3000(–3600) m a.s.l., especially on N-facing slopes and in cool ravines. It grows on various mountain soils, usually in rocky places with seepage water from snowmelt (perpetual snow at higher elevations). The climate is cold continental. It forms usually pure forests, but it is sometimes mixed with *Abies sibirica* (*A. sibirica* subsp. *semenovii* with *Picea schrenkiana* subsp. *tianschanica*), at lower elevations with *Ulmus* and *Populus* along streams. *Juniperus pseudosabina* occurs usually on S-facing slopes outside the spruce forest, but may also form a shrub cover in it.

Uses

Schrenk's spruce produces valuable timber in large volumes and quantities, but its exploitation has been hampered by the remoteness of the mountains where it occurs, far from ports and industrial centres. It is a magnificent tree, but it is quite rare in cultivation outside Russia and even there not used very often. A few trees are planted in arboreta in Europe and the USA; this species should also be used more often in parks and large gardens. A few compact 'dwarf' forms are known as cultivars, mostly grown in Central and E Europe.

2 subspecies are recognized:

Picea schrenkiana Fisch. & C. A. Mey. subsp. ***schrenkiana***. Type: Kazakhstan: Dzhungarskiy Alatau, Songaria, Cljekirgo Pass, *A. G. von Schrenk s.n.* (lectotype LE).

Picea prostrata Isakov, Fl. Kirgiz. S.S.R. 10: 374. 1962.

Description

Leaves (1.5–)2–3(–3.5) cm long, 1–1.5 mm wide. Seed cones cylindrical-oblong; seed scales at mid-cone 12–15 mm wide; abaxial surface striated or nearly smooth.

Distribution

Kazakhstan, Kirgyzstan, China (Xinjiang), in the Tien Shan.
TDWG codes: 32 KAZ KGZ 36 CHX

Conservation

IUCN: LC

Picea schrenkiana Fisch. & C. A. Mey. subsp. ***tianschanica*** (Rupr.) Bykov, Izv. Akad. Nauk Kazahsk. S.S.R., ser. Bot. 5: 22. 1950. *Picea tianschanica* Rupr., Mém. Acad. Imp. Sci. Saint-Pétersbourg, sér. 7, 14 (4): 72. 1869; *Picea morinda* Link subsp. *tianschanica* (Rupr.) Berezin, Bot. Zurn. (Moscow & Leningrad) 50: 493. 1970; *Picea schrenkiana* Fisch. & C. A. Mey. var. *tianschanica* (Rupr.) W. C. Cheng & S. H. Fu, Fl. Reipubl. Pop. Sin. 7: 146. 1978. Type not designated. Fig. 196, 197

Description

Leaves (1–)1.5–2(–2.5) cm long, 1.4–2 mm wide. Seed cones elliptical-oblong, with broad, wrinkled seed scales. Schmidt-Vogt (1977) who treated this taxon as a species, reported cones 10–20 cm long (commonly 12 cm), but specimens seen from LE and PE had cones only 9–10 cm long and cones of similar size were seen during a field trip to Kirgyzstan by the author in August 2000.

Distribution

China: Xinjiang (W Tian Shan); Kirgyzstan (mountains around Naryn River)
TDWG codes: 32 KGZ 36 CHX

Conservation

IUCN: LC

Picea sitchensis (Bong.) Carrière, Traité Gén. Conif.: 260. 1855 ["*sitkaensis*"]. *Pinus sitchensis* Bong., Mém. Acad. Imp. Sci. Saint-Petersbourg, sér. 6, Sci. Math. 2: 164. 1832. Type not designated.
Fig. 198

Etymology

The species epithet means 'from Sitka' a small port in Alaska, USA.

Vernacular names

Sitka spruce

Description

Trees to 60–85(–90) m tall, d.b.h. to 4–4.5(–5) m; trunk monopodial, straight, old trees buttressed at base; bark on trunk scaly, breaking into rough plates, dark grey; inner bark brown. Branches of first order long, spreading horizontally; branches of second order long, slender, spreading or pendant; crown pyramidal or broad conical, in old, large trees with abundant reiteration. Branchlets slender, flexible, pale brown to almost white on the underside, turning yellowish or orange-brown, shallowly ridged and grooved, shiny, glabrous; pulvini 1–1.5 mm, at nearly 90° from shoot. Vegetative buds ovoid-conical, acute or obtuse, 4–5 × 2–3 mm, slightly resinous at base or not resinous; bud scales triangular, obtuse, appressed, light brown, persisting several years and becoming dark brown. Leaves spreading radially, stiff, on higher branches pressed forward above shoot, pectinate below the shoot, 1.5–2(–2.5) cm long, ca. 1 mm wide, narrowly linear, usually curved, almost quadrangular in cross-section, keeled, pungent at apex; stomata mainly on two (invers dorsal) faces below, none or a few faint lines above; leaf colour dark or bright green, with two silvery white stomatal bands. Pollen cones axillary, crowded, 2–3.5 cm long, rose-red at first, yellowish at maturity. Seed cones terminal, erect at first, later pendulous; peduncles short, oblique or curved; shape of cones cylindrical-oblong, obtuse at apex, (4.5–)5–9(–10) cm long, (1.5–)2–3(–4) cm wide with opened scales; colour (immature) yellowish green or green, ripening to pale brown or yellowish brown. Seed scales rhombic to obtrullate, sometimes irregular, very thin, papery, 1–1.5 × 0.6–1 cm at mid-cone; surface finely striated, undulate, sometimes with dark spots, glabrous; margins often recurved; apex irregularly dentate or lacerate. Bracts small, ligulate lanceolate, 5–8 mm long (sometimes nearly half as long as seed scale), included, but often visible with wide opened seed scales. Seeds ovoid, 2–3.5 × 1.5–3 mm, light or dark brown; seed wings ovate-oblong, 6–10 × 4–5 mm, light yellowish.

Distribution

Pacific Coast Region of North America: from Alaska to California.
TDWG codes: 70 ASK 71 BRC 73 ORE WAS 76 CAL

Ecology

Picea sitchensis occurs from tidewater up to steep mountain sides in Alaska and British Columbia, generally to ca. 900 m a.s.l. (highest record 1189 m), always in proximity to oceanic weather. The soils are variable, usually with a thick humus layer. The climate is very humid, annual precipitation ranges from 1300 mm to 3750 mm, the winters are moderate (in coastal Alaska snow in winter usually stays only above 200 m). On Vancouver Island and on the Olympic Peninsula in Washington this spruce attains its greatest size. It is usually mixed with *Tsuga heterophylla* (shade tolerant competitor), *Pseudotsuga menziesii* and *Thuja plicata*, other associated conifers are *Chamaecyparis lawsoniana* (locally), *Xanthocyparis nootkatensis*, and *Abies amabilis*, at higher elevations replaced by *Tsuga mertensiana* or *A. lasiocarpa; Alnus rubra* alongside rivers and *Acer macrophyllum* in groves are common broad-leaved trees.

Conservation

IUCN: LC

Uses

Sitka spruce grows to the largest tree of its genus and is abundant in the coastal forests between roughly 43° and 62° N along the Pacific Ocean. It is a highly valuable timber tree with growth rates exceeding those of other species and, in old growth stands, truly magnificent sizes. It is (still) heavily logged in clear cuts

from natural stands including old growth (in this part of the world this means: forest that was never cut before). Smaller sizes go to the paper industry, but big trees are prized for construction and special uses such as small aircraft, masts and spars for sailing ships, oars for rowing boats, ladders, and sounding boards of musical instruments. Sitka spruce has been widely used in plantation forestry on poor acid soils in cool and wet climates such as the hills and moors of Ireland and Scotland; this timber is used for pulp wood. In horticulture it finds less use; most plantings in large parks as specimen trees date from the 19th century, and only a limited number of cultivars has been produced, mostly dwarf forms. It requires a cool and moist climate.

Picea smithiana (Wall.) Boiss., Fl. Orient. 5: 700. 1884. *Pinus smithiana* Wall., Pl. Asiat. Rar. 3: 24, t. 246. 1832. Type: India: Himalaya, *W. S. Webb & [?] Govan 6063* (lectotype C). Fig. 199, 200, 201

Picea smithiana (Wall.) Boiss. var. *nepalensis* Franco, Enum. Fl. Pl. Nepal 1: 26. 1978.

Etymology

This species was named after James Edward Smith (1759–1828), founder and first President of the Linnean Society of London.

Vernacular names

Indian spruce, West Himalayan spruce, Morinda spruce; rai, rewari, salla, ragha, morinda (Himalaya); chang ye yun shan (Chinese)

Description

Trees to 50(–60) m tall, d.b.h. to 1.5–2.5 m; trunk monopodial, straight; bark becoming rough, scaly, greyish brown to grey, breaking into irregular plates. Branches of first order long, slender, spreading horizontally, often assurgent at ends; branches of second order long, slender, dense, strongly pendulous; crown conical, old trees broad columnar. Branchlets long, slender, flexible, pale yellowish brown or greyish brown, prominently ridged and grooved, glabrous; pulvini well developed, 1.5 mm long, directed forward at 45° from shoot, brown. Vegetative buds ovoid conical, (5–)8–12 mm long, resinous; bud scales triangular, obtuse, keeled at base, appressed, slightly recurved at apex, shining chestnut brown, persisting several years. Leaves spreading radially, directed obliquely forward, slightly incurved, esp. on coning shoots, 2.5–4.5(–5) cm long, ca. 1 mm wide, narrowly linear, straight or curved, soft, rhombic to broadly rhombic in cross-section, obliquely acute or acuminate at apex; amphistomatic, with 3–5 lines of stomata on each face; leaf colour dark green. Pollen cones axillary, 2–3 cm long, yellow. Seed cones terminal, erect at first, soon pendulous, obliquely short pedunculate or nearly sessile, cylindro-conical or broad fusiform (when closed) often widest near base when opened, obtuse at apex, (8.5–)10–17(–18) cm long, 4–6 cm wide with opened scales; colour (immature) green or purplish green, maturing to shiny bright green, ripening to lustrous brown, old cones dull grey-brown. Seed scales obovate-flabellate, slightly convex, coriaceous, spreading very wide in opened cones, 2–3 × 1.5–2.4 cm at mid-cone; abaxial surface finely striated, smooth, lustrous, often resinous; upper margin entire, rounded or slightly obtuse, incurved; base cuneate. Bracts rudimentary, ligulate, 4–5 mm long, entirely included. Seeds ovoid-oblong, pointed at apex, 5–7 × 3–4 mm, dark (red-) brown; seed wings ovate-oblong, 13–20 × 7–9 mm, orange-brown.

Distribution

Afghanistan: Hindu Kush; China: Xizang (Tibetan Himalaya); W Himalaya: Himachal Pradesh, Karakoram, Kashmir Himalaya, Uttar Pradesh, Nepal
TDWG codes: 34 AFG 36 CHT 40 NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

Picea smithiana is a high mountain species, occurring in the Himalayas in a belt between (2300–)2500–3600(–3750) m a.s.l. on alpine lithosols. The climate is moist monsoon, with abundant precipitation in two rainy seasons, but becoming gradually drier in the western parts of the range. It usually occurs with *Abies spectabilis, Pinus wallichiana* and *Tsuga dumosa* (eastern part of the range) and with *Abies pindrow* and *Cedrus deodara* in the western part.

It is best developed on northerly exposed slopes in Kashmir. At lower elevations various broad-leaved trees, e.g. *Quercus* spp., *Acer* spp., *Prunus* spp., *Ulmus* spp., and *Aesculus indica* become dominant.

Conservation

IUCN: LC

Uses

Idian or West Himalayan spruce is an important timber tree which can yield excellent construction material of large size. Its wood is used in interior house construction for roofs and floors. Large quantities have been used as railway sleepers after treatment with preservatives to lengthen its durability outdoors. Its relatively light weight combined with strength made it suitable for aircraft, in particular gliders, but wood is no longer the main material for these. Smaller sizes are now being pulped for paper, especially newsprint. Its long needles, drooping branches and bright green seed cones make it an ornamental tree of considerable merit. It is not very common in cultivation, perhaps due to problems with establishment and slow growth; it should be hardy in most countries with a cool temperate climate.

Picea spinulosa (Griff.) Beissn., Mitt. Deutsch. Dendrol. Ges. 15: 83. 1906. *Abies spinulosa* Griff., Itin. Notes: 259, 265, 275. 1848. Type: India: Sikkim, Lachen River, Lachen, *J. D. Hooker s.n.*, 1849 ([orig. mat. lost] neotype K, here designated).

Picea spinulosa (Griff.) Beissn. var. *yatungensis* Silba, Phytologia 68: 45. 1990.

Etymology

The species epithet means 'somewhat thorny' (Latin *spinula* = small thorn), but it is not clear what Griffith had in mind with this.

Vernacular names

Sikkim spruce, East Himalayan spruce; Xizang yun shan, xu mi yun shan (Chinese)

Description

Trees to 50–60 m tall, d.b.h. to 1.5–2.5 m; trunk monopodial, straight; bark rough and scaly, on large trunks fissured below, brownish grey or grey. Branches of first order long, spreading horizontally, curved downward below, drooping at ends; branches of second order long, slender, pendulous; crown pyramidal, in old trees broad columnar, domed, or open and irregular. Branchlets slender, flexible, soon pendulous, pale yellowish grey or pale brown, prominently ridged and deeply grooved, glabrous; pulvini 1–1.5 mm, narrow, at 60–80° from shoot. Vegetative buds ovoid, obtuse, 5–7 mm long, not or only slightly resinous; bud scales ovate, obtuse, orange-brown or red-brown, persisting several years. Leaves radially spreading on pendulous shoots, on more horizontal branches crowded above shoot, directed forward, parted below, 1.5–3.5 cm long, (0.7–)1–1.8(–2) mm wide, narrowly linear, straight or slightly curved, transversely rhombic to quadrangular in cross-section, keeled on both sides, pungent at apex; usually epistomatic, but sometimes 1–2 lines of stomata on the upperside, 2 bands of 4–5 lines below (invers-dorsal side); leaf colour lustrous dark green on the upperside, bluish white stomatal bands below. Pollen cones axillary, 2–2.5 cm long, yellow when ripe. Seed cones terminal, erect at first, pendulous at maturity, short pedunculate or sessile, cylindrical, narrowed at base, obtuse at apex, (4–)6–9(–12) cm long, (2.5–)3–4.5 cm wide with opened scales; colour (immature) green or reddish green, ripening to light reddish brown. Seed scales obovate or obtrullate, often irregular, 1.5–2 × 0.8–1.4 cm at mid-cone; abaxial surface finely striated, lustrous, undulate or with irregular, longitudinal grooves, glabrous; upper margin entire or denticulate; apex elongated, slightly incurved, dentate; base cuneate. Bracts rudimentary, ligulate, 3–4 mm long, entirely included. Seeds ovoid-oblong, 3–5 mm, grey or brown; seed wings obovate-oblong, 8–14 × 4–6 mm, orange-brown.

Distribution

Eastern Himalaya: Bhutan and Sikkim (between the Manas River and the Tista River); S Xizang [Tibet].
TDWG codes: 36 CHT 40 EHM-BH EHM-DJ EHM-SI

Ecology

This species occurs in the 'cloud belt' zone of the E Himalayas, at elevations between 2400 m and 3700 m a.s.l. (in S Xizang [Tibet] 2900 m to 3600 m). It grows on alpine lithosols. The climate is moist monsoon, with moderate to high annual precipitation (1000 mm to 2000 mm), decreasing from south to north. It is usually associated with *Pinus wallichiana, Larix griffithii, Abies densa, Tsuga dumosa, Taxus wallichiana*, and *Juniperus indica*; at the upper forest limit dense growth of *Rhododendron* spp. replaces the conifers. At lower elevations various broad-leaved trees become more abundant: *Acer* spp., *Juglans regia, Fraxinus* spp., *Sorbus* spp., *Quercus pachyphylla, Prunus* spp., and tree-like species of *Rhododendron* are the most common.

Conservation

IUCN: LC

Uses

No local uses have been recorded of this species, although it is likely that its timber is being used for building houses. It is quite rare in cultivation despite considerable garden merit; it was introduced to England from Sikkim in 1878. It seems to have failed from earlier sendings of seed via the botanic garden in Calcutta and is apparently not growing in Central Europe, where the winters may be too cold.

Picea torano (Siebold *ex* K. Koch) Koehne, Deutsche Dendrol.: 22. 1893. *Abies torano* Siebold *ex* K. Koch, Dendrol. 2 (2): 233. 1873. Type: Japan: ["Owari pr., Abies No. 1 torano ki"], *P. F. von Siebold s.n. sub Abies polita* (lectotype L). Pl. 25

Abies polita Siebold & Zucc., Fl. Japon. 2 (2): 20, t. 111. 1842 (*nom. illeg.*, Art. 52.1); *Picea polita* (Siebold & Zucc.) Carrière, Traité Gén. Conif.: 256. 1855.

Etymology

The species epithet repeats one of the vernacular Japanese names of this species.

Vernacular names

Tigertail spruce; Torano momi, Tora momi (Japanese)

Description

Trees to 30–40 m tall, d.b.h. to 1–1.3 m; trunk monopodial, straight; bark on trunk rough and scaly, flaking, fissured, pale grey, with pale brown inner bark. Branches of first order long, spreading horizontally or slightly ascending; branches of second order relatively short, dense, spreading or assurgent; crown broad pyramidal, domed or flat topped in old trees. Branchlets thick, very stout, shining yellowish brown, later grey, prominently ridged and deeply grooved, glabrous; pulvini strongly developed, 2–3 mm long, thickened at base, spreading at 70–90° from shoot. Vegetative buds ovoid or ovoid-oblong, obtuse or acute, 8–12 × 4–8 mm, not or only slightly resinous; bud scales ovate, obtuse, smooth, shining chestnut brown, appressed, persisting several years, leaving thick collars of imbricate perular scales around shoot bases. Leaves spreading radially, curved, assurgent above shoot, very rigid, (1–)1.5–2(–2.5) cm long, 1.8–2(–2.5) mm wide, linear, curved or twisted, quadrate-rhombic in cross-section, very pungent to spinescent at apex; amphistomatic, with 4–6 lines of stomata on each face; leaf colour dark, lustrous green. Pollen cones axillary, 3–3.5 cm long, reddish at first, yellow at maturity. Seed cones terminal, erect at first, pendulous at maturity, sessile, ovoid or ovoid-oblong, obtuse or tapering to a point (when closed) at apex, (5–)8–10(–12) cm long, 4–7 cm wide with opened scales; colour (immature) green or yellowish green, ripening to cinnamon brown or reddish brown. Seed scales cuneate-obovate to semi-orbicular (near base of cone), opening very wide, 2–2.8 × 1.5–2.5 cm at mid-cone; surface finely striated, lustrous, glabrous; upper margin entire or denticulate, rounded, convex, sometimes lacerate; base cuneate. Bracts small, ligulate-linear, 6–7 mm long, entirely included. Seeds ovoid, 5–7 × 3–4 mm, brown or grey-brown; seed wings obovate-oblong, 15–18 × 7–10 mm, orange-brown.

Distribution

Japan: Honshu, Kyushu, Shikoku.

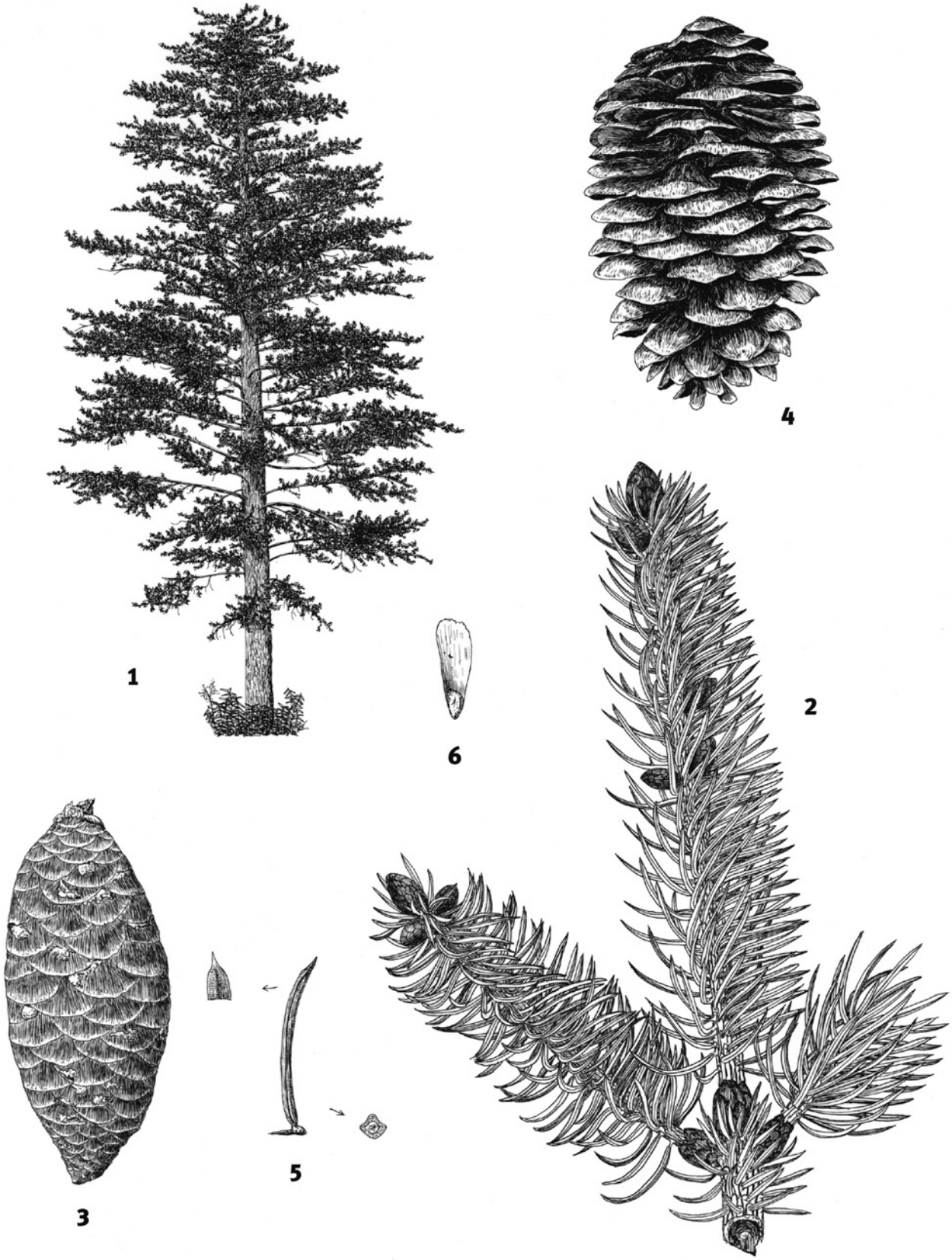

PLATE 25. *Picea torano*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Green seed cone. **4.** Ripe seed cone. **5.** Leaf. **6.** Seed.

TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Ecology

Picea torano occurs in (low) mountains at elevations between 400 m and 1500(–1850?) m a.s.l., almost invariably on podzolic soils of young volcanic rocks such as lava flows and tuffs. The climate is cool, moist maritime, with annual precipitation exceeding 1000 mm, the winters are cold and snowy, especially at the higher elevations. There are some small remnants of pure stands left, e.g. at the northern end of Lake Yamanaka, elsewhere it is mixed with *Abies homolepis, Larix kaempferi, Pinus densiflora* and/or broad-leaved trees, e.g. *Betula, Fagus, Acer, Quercus mongolica* var. *grosseserrata, Prunus maximowiczii*, and *Zelkova serrata*.

Conservation

The more accessible and large trees have been cut in the past and were replaced by afforestation with different species, e.g. *Cryptomeria japonica* and *Larix kaempferi*.
IUCN: VU (A2ce, 3ce)

Uses

Tigertail spruce is uncommon and grows in inaccessible places, therefore it is not an important timber tree. In Japan it is a popular amenity tree, used in gardens and parks. Despite its striking foliage and cones and conical habit in cultivation, it remains an uncommon tree in gardens and arboreta in Europe and is even less common elsewhere outside Japan. Despite its praise sung in earlier conifer handbooks (e.g. Dallimore & Jackson, 1966), a recent book on cultivated conifers in the USA (Bitner, 2007) does not even mention it. It is perfectly adapted to most climate zones in the temperate parts of the world and should be grown much more often; it is there where commercial conservatism and angst to try something off the well beaten track seems to demonstrate itself most clearly.

Picea wilsonii Mast., Gard. Chron., ser. 3, 33: 133. 1903. Type: China: W Hubei, *E. H. Wilson 1897* (holotype BM). Fig. 202

Picea watsoniana Mast., J. Linn. Soc., Bot. 37: 419. 1906; *Picea wilsonii* Mast. var. *watsoniana* (Mast.) Silba, Phytologia 68: 46. 1990.
Picea wilsonii Mast. var. *shanxiensis* Silba, Phytologia 68: 46. 1990.

Etymology

This species was named after Ernest H. Wilson (1876–1930), the famous plant hunter who travelled in China, Korea and Japan.

Vernacular names

Wilson spruce; qing qian (Chinese)

Description

Trees to 40–50 m tall, d.b.h. to 1.3–1.5 m; trunk monopodial, straight; bark on trunk rough and scaly, greyish brown or dark grey. Branches of first order slender, spreading horizontally; branches of second order short, slender, spreading, in some trees becoming pendant; crown pyramidal and dense in young trees, columnar in old trees. Branchlets slender, thin, flexible, pale (yellowish) grey or buff grey, finely ridged and grooved, glabrous; pulvini very small, at 50–70° from shoot. Vegetative buds ovoid, obtuse, 6–8 mm long, not resinous; bud scales ovate, obtuse, appressed, shining, dark brown or purplish brown, persisting several years. Leaves spreading radially, above shoot more or less imbricate, directed forward, parted below, (0.8–)1–1.8(–2.2) cm long, 1–1.7 mm wide, linear, straight or slightly curved, mostly transversely rhombic in cross-section, obtuse or acute at apex; stomata on all sides, 1–2 lines on each face above, 2–4 lines below; leaf colour glossy dark green. Pollen cones axillary, 2–3 cm long, yellowish when ripe. Seed cones terminal, erect at first, later pendulous, very numerous, sessile or obliquely short pedunculate, ovoid-oblong or cylindrical, with obtuse apex, (4–)5–8 cm long, 2.5–3.5(–4) cm wide with opened scales; colour (immature) light green or purplish green, ripening to pale brown or dull reddish brown. Seed scales obovate-cuneate, slightly

convex, opening wide, 1.4–1.7 × 0.9–1.4 cm at mid-cone; surface finely striated, in old cones nearly smooth, glabrous; upper margin entire or erose-denticulate, rounded or truncate, sometimes obtuse; base cuneate. Bracts rudimentary, ligulate, 3–4 mm long, entirely included. Seeds ovoid, pointed at apex, 3–4.5 × 2.5–3 mm, dark brown; seed wings obovate-oblong, 12–15 × 5–7 mm, yellowish or light brown.

Distribution

China: Gansu, Hebei, Hubei, Shanxi, Shaanxi, W Sichuan.
TDWG codes: 36 CHC-HU CHC-SC CHN-GS CHN-HB CHN-SA CHN-SX

Ecology

Picea wilsonii is a high mountain species occurring at elevations between 1400 m and 3000 m a.s.l. (max. 2100 m in the north of its range). The soils are mostly non-calcareous, podzolic mountain soils. The climate is continental, montane to subalpine, with low precipitation and cold, long winters. In the montane boreal coniferous forests of N Sichuan and S Gansu it is usually growing with *Picea asperata* and *P. purpurea*, in the NE of its range also with *P. meyeri*. It is as a rule much rarer than these. *Betula albosinensis* is the most common broad-leaved tree in these spruce forests.

Conservation

IUCN: LC

Uses

Wilson spruce is an important timber tree in China yielding wood for construction, railway sleepers, mining props, carpentry, and furniture making, as well as for pulp used in the paper (newsprint) industry. In horticulture, it is commonly planted as an amenity tree in northern China and Russia and grows well in regions with long, steady winters, but suffers from 'late' frosts in more maritime climates, especially in western Europe. In Europe and the USA it is seldom seen outside arboreta and botanic gardens.

Pilgerodendron Florin, Svensk Bot. Tidskr. 24: 132. 1930. Type: *Pilgerodendron uviferum* (D. Don) Florin [*Juniperus uvifera* D. Don] (*Cupressaceae*).

Named after Robert Pilger (1876–1953), German botanist at the Berlin Botanic Garden; Greek: *dendron* = tree.

Description

See the species description.

Distribution

As for the species.

Taxonomic notes

An overview of the taxonomic history and characters of this monotypic genus has been given in A Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a). Reasons to retain the genus and not re-unite it with *Libocedrus* Endl., as suggested by a phylogenetic analysis based (mainly) on cpDNA data (Gadek *et al.*, 2000) were also outlined in that book, to which the interested reader is referred.

Pilgerodendron uviferum (D. Don) Florin, Svensk Bot. Tidskr. 24: 133. 1930. *Juniperus uvifera* D. Don, in Lambert, Descr. *Pinus*, ed. 2, 2: 116. 1828; *Libocedrus uvifera* (D. Don) Pilg., in Engler & Prantl, Nat. Pflanzenfam., ed. 2, 13: 389. 1926. Type: Chile: Magallanes, Isla Madre de Dios, Puerto Molyneux, *L. Savatier 140* (neotype K). Fig. 203, 204

Etymology

The species epithet means 'bearing grapes' (Latin *uva* = grape(s) or bunch of grapes).

Vernacular names

Guaitecas Cypress; Ciprès de las Guaitecas (Chile), Ten (Argentina), Ciprès (Spanish)

Description

Trees to 20 m tall, evergreen, dioecious; trunk monopodial, erect, to 1.5 m d.b.h. Bark brown, becoming fibrous and fissured, exfoliating in long strips, weathering grey-brown. Branches spreading horizontally and assurgent at ends, higher order branches slender, forming a narrowly conical to pyramidal, in old trees broad rounded or even flat-topped crown. Foliage branches numerous, crowded, spreading or assurgent, ultimate branchlets short, slender but rigid, densely covered by scale leaves and thereby quadrangular, semi-deciduous. Leaves scale-like, decussate, occasionally in whorls of 3, short decurrent at base, covering shoot, imbricate, forming 4(6) rows, monomorphic, (broad) lanceolate, the free part reflexed, narrowly triangular, carinate abaxially, 2.5–6 × 1–2.2 mm on ultimate branchlets, on older branchlets up to twice that size; margins entire; apex obtuse; epistomatic, adaxial leaf face with numerous conspicuous stomata, leaf colour dark green, with a whitish stomatal band. Pollen cones terminal, solitary, cylindrical, 5–10 × 2–2.5 mm; microsporophylls 12–20, decussate, triangular to nearly rhombic, more or less rostrate, subpeltate, bearing 4–8(–10) abaxial, small, globose pollen sacs. Seed cones terminal on foliage branchlets, subtended by 4 decussate, narrower and longer leaves, maturing within one year to cones 8–12 × 4–6 mm, with distally spreading scales. Bract-scale complexes in 2 decussate pairs, elliptic to obtrullate, with upper (fertile) pair 7–11 × 3–5 mm and lower pair lanceolate and half that size, concavo-convex, with a large portion of the bract protruding subapically near the widest portion of the scale; margins papillose, colour reddish brown or brown, the inner surface smooth, grooved or ribbed towards base, lustrous light brown or whitish. Columella conspicuous, a small spike 2–3 mm long. Seeds 3–4 per cone, conical or triangular, with a basal hilum, 3 × 1.5–2 mm, pale yellowish brown; wings 2, marginal, of very unequal size; largest wing 6–7 × 3–3.5 mm, obovate-elliptic; smallest wing a narrow strip.

Distribution

S Argentina: Chubut, Neuquén, Rio Negro, Santa Cruz; S Chile: Aisén, BioBio, Los Lagos, Magellanes.
TDWG codes: 85 AGS-CB AGS-NE AGS-RN AGS-SC CLC-BI CLS-AI CLS-LL CLS-MG

Ecology

This species is a codominant tree along the edges of bogs and swamps of the coastal mountains, at altitudes between 20 m and 750 m a.s.l. and growing with *Fitzroya cupressoides* and the coniferous shrub *Lepidothamnus fonkii*. It occurs also in large and dense stands on wet mountain slopes of islands in shallow, water-logged acidic soil over metamorphic rocks with *Fitzroya, Podocarpus nubigenus, Nothofagus nitida, Desfontainia spinosa*, and the shrub *Tepualia stipularis*, and with *Nothofagus betuloides* and *Drimys winteri* in the southernmost parts of its range. In more continental locations E of the crest of the Andes it grows near mountain lakes. Resistance to light fires assists the regeneration of this shade intolerant species, but intense fires will and have killed many trees. The climate is cool maritime with extremely high precipitation in the coastal ranges.

Conservation

During the period of colonization by Europeans, when agriculture was introduced on a large scale in many lowland and colline regions of Chile, widespread clearance of the forests caused a considerable decline in this and other conifer species. Its value as a timber source, although less than that of *Fitzroya*, was still a sufficient factor to increase the pressure on this tree, causing its virtual extinction in several areas. Continuing pressure until recently has caused this species to be listed in the Appendix I of CITES, effectively prohibiting the export of its wood.
IUCN: VU (A1cd+2cd)

Uses

The timber of this species has been used for building and construction of local farmsteads and other buildings in the past. The wood is decay resistant. There is still local use and trade but, due to deminished resources, much less than in the past and export is now prohibited. Introduced to England by William Lobb in 1849, it is still uncommon in cultivation and almost restricted to arboreta and botanic gardens, which is unfortunate because it grows into a handsome, conical shrub and is perfectly hardy and suitable on acidic soils in all countries with a relatively mild winter.

Pinus L., Sp. Pl. 2: 1000. 1753. Type: *Pinus sylvestris* L. (*Pinaceae*).

Pinea Wolf, Gen. Pl.: 156. 1776. Type: *Pinus pinea* L. *Strobus* Opiz, Lotos 4: 94. 1854. Type: *Strobus weymouthiana* Opiz [*Pinus strobus* L.]. *Caryopitys* Small, Fl. S.E. United States: 29. 1903. Type: *Caryopitys edulis* (Engelm.) Small [*Pinus edulis* Engelm.]. *Apinus* Neck. *ex* Rydb., Bull. Torrey Bot. Club 32: 597. 1905. Type: *Apinus cembra* Neck. *ex* Rydb. [*Pinus cembra* L.]. *Leucopitys* Nieuwl., Amer. Midl. Naturalist 3: 69. 1913 (nom. illeg.). Type: *Leucopitys strobus* (L.) Nieuwl. [*Pinus strobus* L.]. *Ducampopinus* A. Chev., Rev. Bot. Appliq. 24: 30. 1944. Type: *Ducampopinus krempfii* (Lecomte) A. Chev. [*Pinus krempfii* Lecomte]

Pinus is the classical Latin name for pines.

Description

Evergreen monoecious trees, less commonly shrubs; resin canals in wood, bark, leaves and often cones. Trunk of trees monopodial, branching in pseudowhorls, branches assurgent and repeating primary branching arrangement (Rauh's model). Bark furrowed or plated, to thin and scaly or thin and smooth. Shoots dimorphic, with long shoots and dwarf shoots. Primary leaves (cataphylls) scale-like, enclosing "winter buds" (primordial long shoots or ovuliferous strobili), subtending dwarf shoot buds or pollen strobili, early deciduous or persistent. Secondary leaves (needles) borne in fascicles of (1–)2–5(–8) on dwarf shoots; fascicles surrounded at base by an early deciduous or persistent sheath of bud scales or their remnants, persisting 2–30 years and falling as fascicles; length of needles 2.5–50 cm, width 0.5–2.5(–7) mm, acicular (one species lanceolate), plano-convex or triangular (rarely terete or flat) in cross-section, entire or serrulate, epistomatic or amphistomatic (one species occasionally hypostomatic). Pollen cones spirally arranged near proximal end of new long shoots, ovoid-oblong to cylindrical; consisting of a thin axis with numerous spirally arranged, (sub-)peltate microsporophylls, each bearing two pollen sacs containing bisaccate pollen. Seed cones subterminal, borne singly or more commonly clustered, pedunculate, maturing in second year, or rarely in third year, shed early or variously persistent, initially erect; mature cones pendulous or spreading, opening soon or variously serotinous, (obliquely) ovoid to cylindrical, 2–60 cm long. Bracts conspicuous at pollination stage, not growing with seed scales. Seed scales persistent, obovate to oblong, thin or thick woody, attached spirally to a slender or thick rachis; exposed portion (apophysis) variously thickened and/or elongated, with a terminal or dorsal umbo, which may be armed with a spine or prickle. Seeds usually slightly flattened, with an adnate or articulate membranous wing derived from adaxial part of seed scale and several times larger than seed or reduced. Seedlings with 3–24 cotyledons.

113 species.

Distribution

North America: from Yukon to Newfoundland and from SE Alaska and British Columbia south into Mexico and Central America as far as Nicaragua; in E and SE USA to Florida; Bahamas, Carribean (Cuba, Hispaniola). Eurasia (N Africa): Atlas Mountains of Morocco and Algeria; from the Iberian Peninsula through S and Central Europe to E Europe and Turkey, Caucasus, Syria and Lebanon; Scotland (disjunct); from Scandinavia through Russia and Siberia to Kamchatka and Sachalin; Sino-Himalayan mountain system, China, Japan, Taiwan, Indochina to N Sumatera; Philippines.

Synopsis

The genus *Pinus* is the only conifer genus for which several comprehensive studies investigating phylogenetic relationships, based on a number of different gene sequences, have been published. There is also comprehensive work available on comparative morphology, including some cladistic analyses. Consequently, it is possible to set up a classification that is informed by (if not entirely based on) a hypothesis of phylogenetic relationships. The most important and consistent result of these phylogenetic analyses is the confirmation that the genus naturally divides into two subgenera. This leaves all earlier classifications that recognized more than two primary divisions as essentially artificial; the result of a choice of characters rather than a reflection of evolutionary relationships. The first comprehensive formal classification informed primarily by phylogeny was published by Price *et al.* in Richardson (1998). The second was given in my book Pines (Farjon, 2005b),

with a review of the more recent results of molecular phylogenetic analyses. The latter classification, with a few minor amendments, is adopted here.

Genus *Pinus* L.

Subgenus *Strobus* Lemmon
- Section *Parrya* Mayr
  - Subsection *Nelsoniae* Van der Burgh
    - Species: *Pinus nelsonii*
  - Subsection *Balfourianae* Engelm.
    - Species: *Pinus balfouriana, P. aristata, P. longaeva*
  - Subsection *Rzedowskianae* Carvajal
    - Species: *Pinus rzedowskii, P. maximartinezii, P. pinceana*
  - Subsection *Cembroides* Engelm.
    - Species: *Pinus cembroides, P. culminicola, P. edulis, P. remota, P. monophylla, P. quadrifolia*
- Section *Quinquefolius* Duhamel
  - Subsection *Gerardianae* Loudon
    - Species: *Pinus gerardiana, P. bungeana, P. squamata*
  - Subsection *Krempfianae* Little et Critchfield
    - Species: *Pinus krempfii*
  - Subsection *Strobi* Loudon
    - Species: *Pinus strobus, P. albicaulis, P. flexilis, P. strobiformis, P. ayacahuite, P. monticola, P. lambertiana, P. cembra, P. sibirica, P. peuce, P. wallichiana, P. bhutanica, P. armandii, P. amamiana, P. koraiensis, P. pumila, P. parviflora, P. morrisonicola, P. fenzeliana, P. wangii, P. dalatensis*

Subgenus ***Pinus***
- Section *Pinus*
  - Subsection *Pinaster* Mayr *ex* Koehne
    - Species: *Pinus pinaster, P. heldreichii, P. brutia, P. halepensis, P. pinea, P. canariensis, P. roxburghii, P. latteri, P. merkusii*
  - Subsection *Pinus* (syn. Subsection *Sylvestres* Loudon)
    - Species: *Pinus densata, P. yunnanensis, P. kesiya, P. thunbergii, P. tabuliformis, P. henryi, P. hwangshanensis, P. luchuensis, P. taiwanensis, P. densiflora, P. sylvestris, P. resinosa, P. mugo, P. uncinata, P. massoniana, P. tropicalis, P. nigra*
- Section *Trifolius* Duhamel
  - Subsection *Contortae* Little et Critchfield
    - Species: *Pinus contorta, P. banksiana, P. virginiana, P. clausa*
  - Subsection *Ponderosae* Loudon
    - Species: *Pinus ponderosa, P. arizonica, P. jeffreyi, P. engelmannii, P. coulteri, P. sabiniana, P. torreyana, P. hartwegii, P. montezumae, P. devoniana, P. pseudostrobus, P. douglasiana, P. maximinoi, P. durangensis*
  - Subsection *Australes* Loudon
    - Species: *Pinus palustris, P. caribaea, P. elliottii, P. glabra, P. cubensis, P. occidentalis, P. pungens, P. rigida, P. serotina, P. taeda, P. leiophylla, P. lumholtzii, P. herrerae, P. echinata, P. lawsonii, P. pringlei, P. teocote, P. patula, P. greggii, P. attenuata, P. muricata, P. radiata, P. jaliscana, P. tecunumanii, P. oocarpa, P. luzmariae, P. praetermissa*

Keys for the genus *Pinus*

The keys for the genus *Pinus* follow the taxonomic classification presented above. Keys based on taxonomic classifications as opposed to those based on geographic groupings have the advantage that an individual plant growing outside its native range can still be identified with them when the provenance of that plant is unknown. The genus *Pinus* has probably more species planted outside their natural ranges than any other genus in conifers. Excluded from the keys are the four hybrid species *Pinus* ×*densithunbergii*, *P.* ×*hakkodensis*, *P.*× *neilreichiana* and *P.* ×*rhaetica*.

Key to the subgenera of *Pinus*

1a. Pulvini decurrent. Leaves with 2 vascular bundles and variously positioned resin ducts, with a persistent (rarely deciduous) fascicle sheath. Seeds with an articulate, rarely adnate, wing **Subgen. *Pinus***

1b. Pulvini not decurrent. Leaves with a single vascular bundle and external (marginal) resin ducts, with a deciduous (rarely persistent) fascicle sheath. Seeds with an adnate, rarely articulate, wing or wingless when free from the seed scale **Subgen. *Strobus***

Key to the subsections of Subgenus *Pinus*

1a. Shoots uni-nodal; buds not resinous. Leaves in fascicles of only 2 or only 3 (rarely 2 plus some 3 in *P. brutia*). Seed cones 6–20(–25) cm long; seed scales thick woody, rigid (except in *P. heldreichii*); apophyses of seed scales lustrous brown (except in *P. heldreichii*); umbo unarmed or at most with a minute, deciduous prickle (except spinaceous in *P. pinaster*). All Old World species ***Subsect. Pinaster***

1b. Not this *combination* of character states **2**

2a. Buds (slightly) resinous or rarely not resinous. Leaves in fascicles of only 2 or 2 and 3 (only 3 in *P. kesiya*). Seed cones deciduous or persistent for a few years but always opening soon, 2–10 (–12) cm long; seed scales thin woody, rigid; umbo unarmed or with a minute, deciduous or sometimes persistent prickle. All but 2 Old World species ***Subsect. Pinus***

2b. Not this *combibation* of character states **3**

3a. Bark on lower trunk of trees with small plates or flakes. Shoots uni-nodal. Fascicle sheaths shorter than 10 mm; leaves in fascicles of only 2, 2–8(–10) cm long, rigid, curved or twisted; resin ducts in leaves medial. Seed cones (semi-) persistent, (2–)3–8 cm long, more or less serotinous or sometimes opening soon in warm sunshine; seed scales thin woody, rigid. All New World species ***Subsect. Contortae***

3b. Not this *combination* of character states **4**

4a. Leaves in fascicles of 3 or 5, less commonly on the same tree 2, 4 or 6(–8), rarely only 2 (*P. ponderosa* of northern populations), straight (not rigidly curved, contorted or twisted); fascicle sheaths of new leaf fascicles at least 15 mm long, usually 20–35(–40) mm long; resin ducts in leaves medial and sometimes 1–2 internal. Seed cone scales opening soon or sometimes more slowly (cones not serotinous). All New World species ***Subsect. Ponderosae***

4b. Not this *combination* of character states **5**

5. Leaves in fascicles of 2–3, 3 only, or 3, 4 and 5, not of 5 only (or more than 5) and only *P. glabra* and *P. muricata* with fascicles of 2 only; leaf resin ducts usually or predominantly internal, sometimes medial or septal but very rarely 1–2 ducts external. All New World species ***Subsect. Australes***

Note: There is in fact much similarity (and variation) among the species of the latter two subsections and many species cannot be reliably assigned to their respective subsections on the basis of their morphology. These subsections, while supported by phylogenetic analyses based on DNA sequence data, apparently contain much homoplasy (parallel evolution or convergence) in their morphological character states. It is therefore advised to try both keys to identify a species that belongs to any one of these two subsections.

Key to the species of *Pinus* Subsection *Australes*

1a. Scales of leaf fascicles deciduous, leaving the fascicles without a sheath before falling **2**

1b. Scales of leaf fascicles persistent, retaining a sheath at the base of the fascicles when falling **3**

2a. Leaves in fascicles of 3 (exceptionally 2 or 4), (15–)20–30(–40+) cm long, pendulous ***P. lumholtzii***

2b. Leaves in fascicles of (2–)3–5(–6), (4–)6–15 (–17) cm long, rigid or pliant, not pendulous ***P. leiophylla***

3a. New foliage shoots multi-nodal (producing more than 1 whorl of branches or buds in a single growing season) **4**

3b. New foliage shoots uni-nodal **10**

4a. Seed cones deciduous or semi-persistent, opening soon **5**

4b. Seed cones persistent, serotinous **7**

5a. Leaves in fascicles of 2, some times of 3; fascicle sheaths of new leaves 9–12 mm long ***P. cubensis***

5b. Leaves in fascicles of (2–)3–4(–5); fascicle sheaths of new leaves 15–30 mm long **6**

6a. Buds resinous. Leaves rigid, (1.2–)1.4–1.8 mm wide ***P. caribaea***

6b. Buds not resinous. Leaves lax, drooping, 0.7–0.9(–1) mm wide ***P. patula***

7a. Leaves in fascicles of only 2, thick and rigid, 1.3–2 mm wide. Seed cones 5–7(–8) cm long; umbos of seed scales with a curved spine or sharp, persistent prickle ***P. muricata***

7b. Leaves in fascicles of 2 and 3, only 3, or rarely 4 or 5, rigid, 1–1.6 mm wide. Seed cones (5–)7–15 cm long; umbos of seed scales unarmed or with a minute, deciduous prickle **8**

8a. Apophyses of seed scales flat or slightly raised, more or less equally on all sides of the cone; umbo with a minute, deciduous prickle ***P. greggii***

8b. Apophyses of seed scales prominently to extremely raised at least on one side of the cone (in most cones); umbo unarmed **9**

9a. Buds resinous. Pollen cones yellowish before anthesis. Seed cones ovoid-oblong to ovoid-attenuate ***P. attenuata***

9b. Buds not resinous. Pollen cones pink to reddish before anthesis. Seed cones ovoid, asymmetrical in most cones, or nearly symmetrical if the apophyses are only slightly raised ***P. radiata***

10a. Leaves (3–)4–12(–15) cm long, in fascicles of only 2 or 2 and 3. Buds (slightly) resinous **11**

10b. Leaves (7–)10–25(–45) cm long, in fascicles of 2 and 3, sometimes 4 or 5, or only 3 (if 2 and 3 or only 3, usually longer than 12 cm). Buds not resinous or resinous (if resinous, leaves usually longer than 12 cm) **14**

11a. Leaves in fascicles of only 2, slender, 0.7–1.2 mm wide. Seed cones solitary or in pairs ***P. glabra***

11b. Leaves in fascicles of 2, 3 or sometimes 4, robust, 1–1.5(–2) mm wide. Seed cones solitary or more commonly in whorls of 2–6 **12**

12a. Seed cones serotinous; seed scales with prominently raised apophyses ending in a hard, sharp spine ***P. pungens***

12b. Seed cones opening soon or serotinous; seed scales with slightly raised apophyses ending in a small but persistent prickle **13**

13a. Seed cones persistent, opening soon or serotinous, ovoid-conical when closed; umbos of seed scales with a slender, curved prickle. Seed wings 3–4 times longer than the seeds ***P. rigida***

13b. Seed cones semi-persistent, opening soon, narrowly ovoid or ovoid-oblong when closed; umbos of seed scales with a short, stout prickle. Seed wings 2–3 times longer than the seeds ***P. echinata***

14a. Leaves only in fascicles of 3. Seed cones small (2–)3–3.5(–4) cm long, deciduous ***P. herrerae***

14b. Leaves in fascicles of (2–)3, 4 or 5. Seed cones usually longer than 4 cm, deciduous or persistent **15**

15a. Seed cones broadly ovoid to subglobose when closed, with a (15–)20–35 mm long peduncle; umbo of seed scales unarmed or with a minute, deciduous prickle **16**

15b. Seed cones ovoid-conical, ovoid-attenuate, narrowly conical or oblong when closed, with a short (maximum 20 mm long) peduncle or nearly sessile; umbo of seed scales with a minute, deciduous or strong and sharp prickle or spine **19**

16a. Leaves in fascicles of 3, rarely of 4, rigid, 1.2–1.6 mm wide ***P. luzmariae***

16b. Leaves in fascicles of 3, 4 or 5, pliant, lax and/or drooping (sometimes more rigid), 0.5–1.6 mm wide **17**

17a. Seed cones deciduous, leaving basal scales on the peduncle not falling with the cone ***P. praetermissa***

17b. Seed cones persistent or deciduous, if deciduous, falling intact with the peduncle attached to the cone base **18**

18a. Seed cones deciduous, opening soon; apophyses of the seed scales raised ***P. tecunumanii***

18b. Seed cones persistent, semi-serotinous, apophyses of seed scales nearly flat or slightly raised ***P. oocarpa***

19a. Leaves lax and drooping, very slender, (0.5–)0.6–0.8 mm wide ***P. jaliscana***

19b. Leaves rigid or pliant, 1–1.7 mm wide **20**

20a. Buds (slightly) resinous. Seed cone scales thin; umbo of scales armed with a prickle or spine **21**

20b. Buds not resinous. Seed cone scales thick; umbo of scales unarmed or with a minute, deciduous prickle **23**

21a. Leaves in fascicles of 3–5; fascicle sheaths of new leaves (8–)10–15 mm long. Seed cones (lustrous) dark brown ***P. occidentalis***

21b. Leaves in fascicles of (2–)3, occasionally 4; fascicle sheaths of new leaves 15–25 mm long. Seed cones light brown **22**

22a. Leaves in fascicles of 2 and (more numerous) 3. Seed cones deciduous, opening soon ***P. taeda***

22b. Leaves in fascicles of 3, occasionally 4. Seed cones persistent, opening soon or serotinous ***P. serotina***

23a. Leaves 20–45 cm long, in fascicles of 3, rarely 2 or 5. Pollen cones 4–7(–8) cm long. Seed cones (15–)20–25 cm long ***P. palustris***

23b. Leaves (7–)10–25(–30) cm long, in fascicles of 2, 3, 4 or 5. Pollen cones 1–4 cm long. Seed cones (3–)4–15(–18) cm long **24**

24a. Leaves in fascicles of 2 and 3. Pollen cones purplish red before anthesis. Seed cones (7–)9–15(–18) cm long; apophyses of seed scales raised. Seeds 6–7 mm long, with a 20–30 mm long wing ***P. elliottii***

24b. Leaves in fascicles of 3–5 (very rarely 2). Pollen cones yellowish green or yellow before anthesis. Seed cones (3–)4–8(–10) cm long; apophyses of seed scales nearly flat to slightly raised. Seeds 3–6 mm long, with a 12–18 mm long wing **25**

25a. Bark on the trunk breaking into small plates. Seed cones persistent, semi-serotinous; apophyses of seed scales lustrous brown ***P. pringlei***

25b. Bark on the trunk deeply fissured. Seed cones deciduous, opening soon; apophyses of seed scales light brown **26**

26a. Leaves (7–)10–15(–18) cm long, mostly in fascicles of 3, but some of 2, 4 or 5, straight or curved. Seed cones (3–)4–6(–7) cm long; umbos of seed scales with a minute, deciduous prickle ***P. teocote***

26b. Leaves 12–20(–25) cm long, mostly in fascicles of 3 and 4, sometimes of 5 (very rarely of 2), straight. Seed cones 5–8(–9) cm long; umbos of seed scales unarmed ***P. lawsonii***

Key to the species of *Pinus* Subsection *Contortae*

1a. Leaves curved, (0.7–)1.5–2.5(–3) mm wide. Seed cones solitary or in whorls of 2–5. Seed wings 10–12 mm long **2**

1b. Leaves straight but twisted, 1–1.5 mm wide. Seed cones solitary or in pairs. Seed wings 15–20 mm long **3**

2a. Pollen cones orange-red before anthesis. Seed cones ovoid but asymmetrical at base when closed, opening slowly; umbos of seed scales with a variable, persistent prickle ***P. contorta***

2b. Pollen cones yellow before anthesis. Seed cones asymmetric, curved when closed, serotinous; umbos of seed scales unarmed ***P. banksiana***

3a. Seed cones conical, slightly oblique when closed; apophyses of seed scales prominently raised; umbos with a strong, slender prickle to 5 mm long ***P. virginiana***

3b. Seed cones narrowly ovoid when closed; apophyses of seed scales slightly raised; umbos unarmed or with a small prickle ***P. clausa***

Key to the species of *Pinus* Subsection *Pinaster*

The species in this subsection are naturally occurring in the Canary Islands, the Mediterranean, the western Himalaya and tropical Southeast Asia. They are likely the remnant species of a past distribution of numerous pines that bordered the northern coasts of the Thetis Ocean from the (early?) Cretaceous to the Miocene (Klaus, 1988). With one exception, they have seed cones with hard, rigid scales of which the apophyses are lustrous brown with unarmed umbos. The exception, *Pinus heldreichii*, was formerly classified as closely related to *Pinus nigra* and producing hybrids with it (see e.g. Vidaković, 1991), but phylogentic analyses using DNA sequence data have demonstrated that these two species end up in different clades, with *P. heldreichii* closely related (sister to) the species here classified in subsection *Pinaster* and *P. nigra* positioned within the clade forming subsection *Pinus* (Wang *et al.*, 1999; Geada López *et al.*, 2002). For this reason, *P. heldreichii* is here classified in subsection *Pinaster*.

1a. Leaves in fascicles of only 3, 20–30(–35) cm long, pliant and drooping **2**

1b. Leaves in fascicles of only 2 or 2 and sometimes 3, 6–25(–27) cm long, rigid or in one species pliant but not drooping **3**

2a. Fascicle sheaths of new leaves 25–30 mm long. Seed cones persistent, opening slowly; apophyses of scales very strongly developed, conical and often recurved ***P. roxburghii***

2b. Fascicle sheaths of new leaves 15–20 mm long. Seed cones deciduous, opening soon; apophyses of scales prominently raised but not conical (except sometimes in some basal scales) ***P. canariensis***

3a. Fascicle sheaths of new leaves 20–30 mm long; leaves thick, 1.5–2 mm wide. Seed cones 10–20(–22) cm long, persistent, opening slowly; umbo on scales forming a central, rigid spine ***P. pinaster***

3b. Fascicle sheaths of new leaves shorter than 20 mm; leaves 0.7–1.5(–1.8) mm wide. Seed

cones shorter than 13(–15) cm, deciduous or persistent; umbos unarmed or with a minute prickle **4**

4a. Seed scales of cones thin and flexible; apophyses of scales dull brown; umbos with a minute prickle. Leaves usually curved ***P. heldreichii***

4b. Seed scales of cones thick and rigid; apophyses of scales lustrous brown; umbos unarmed. Leaves straight and/or twisted **5**

5a. Bark on trunk breaking into large plates. Fascicle sheaths of new leaves short, to ca. 10 mm long. Seed cones broadly ovoid to subglobose when closed. Seeds 15–20(–22) mm long, thick, with a rudimentary wing much shorter than the seed ***P. pinea***

5b. Bark on trunk breaking into small or elongated plates. Fascicle sheaths of new leaves (9–)10–20 mm long. Seed cones ovoid-conical or oblong-conical when closed. Seeds less than 10 mm long, with a wing at least 2 × the length of the seed **6**

6a. Seed cones persistent, serotinous; apophyses of scales nearly flat or slightly raised. Resin ducts in leaves external (marginal). Seedlings without a 'grass stage' **7**

6b. Seed cones deciduous, opening soon; apophyses of scales prominently raised. Resin ducts in leaves medial. Seedlings commonly developing a 'grass stage' **8**

7a. Leaves in fascicles of only 2, (6–)7–10(–12) cm long, 0.7–0.8 mm wide ***P. halepensis***

7b. Leaves in fascicles of 2 or sometimes 3, (5–)10–18(–29) cm long, 1–1.5 mm wide ***P. brutia***

8a. Leaves 15–20 cm long, 1 mm wide, pliant. Seed wings ca. 4 × as long as the seeds… ***P. merkusii***

8b. Leaves 15–25(–27) cm long, 1.5 mm wide, rigid. Seed wings not more than 3 × as long as the seeds ***P. latteri***

Key to the species of *Pinus* Subsection *Pinus*

Counting leaves in fascicles requires a few guidelines to make sure one gets the correct information from it. The adult type needle leaves of pines grow from dwarf shoots and are held in a fascicle sheath formed of bud scales. In the subgenus *Pinus* these sheaths are mostly persistent (two exceptions) and in the subgenus *Strobus* they are mostly deciduous (one exception). Leaves may fall off singularly from older fascicles with deciduous sheaths; for that reason it is necessary to count leaves only on recent cohorts of leaves with more or less intact fascicle sheaths. Needle leaves of pines are grouped in fascicles of 1–8. There is only one species with consistently single leaves (*P. monophylla*); common numbers are 2, 3 and 5. However, there are numerous species in which the numbers vary on a single tree, especially those native to Mexico, but also from elsewhere. Fascicles with 2–3 are common, as are 3–5, either with predominance at the lower number, or at the higher, or sometimes more equally distributed. Rarely does the number exceed 5, but in a few species in Mexico this sometimes occurs and it can run up to 8. Several species never have more than 2 and several others always have 5, but those with 3 are often more likely to have some variation, either downward or upward. It is therefore necessary to count more than a few fascicles in many cases, if possible from different parts of the tree or, in a population, from a few trees. The number of leaves in a fascicle is not a sufficient diagnostic character of species and needs to be supplemented with other information.

1a. Leaves in fascicles of only 2 **2**

1b. Leaves in fascicles of 2 or 3, or only 3 **12**

2a. Shrubs or small trees. Leaves (2.3–)3–7(–8) cm long, rigid and curved. Seed cones semi-persistent, obliquely ovoid when closed; apophyses of scales on one side of the cone (prominently) raised **3**

2b. Trees. Leaves usually longer than 7 cm, straight or when curved often pliant. Seed cones either deciduous or long persistent (rarely semi-persistent), more or less symmetrical when closed; apophyses of scales flat or raised on all sides of the cone **4**

3a. Shrubs, rarely small trees. Apophyses of seed scales nearly flat to prominently raised ***P. mugo***

3b. Small, monopodial trees. Apophyses of seed scales all raised, most prominently on one side of the cone, curving backward ***P. uncinata***

4a. Bark on trunk with deep, longitudinal fissures. Umbo of seed cone scales unarmed (without a spine or prickle) ***P. thunbergii***

4b. Bark on trunk breaking into large and/or irregular plates. Umbo of seed cone scales with

at least a minute (but possibly deciduous) prickle **5**

5a. Fascicle sheaths of new leaves 15–20 mm long; leaves brittle (breaking easily). Pollen cones red or purple before anthesis ***P. resinosa***

5b. Fascicle sheaths of new leaves 5–15 mm long; leaves rigid or pliant (not breaking easily). Pollen cones yellow or at most tinged red **6**

6a. Leaves thick, robust, 1–2 mm wide **7**

6b. Leaves thin, slender, 0.6–1 mm wide **8**

7a. Leaves 4–7(–12) cm long; resin ducts in leaves external (marginal). Seed cones (2–)3–7 cm long, dull light brown. Seeds 3–5 mm long with a 10–15 mm long wing ***P. sylvestris***

7b. Leaves (4–)8–16(–18) cm long; resin ducts in leaves medial. Seed cones (3.5–)5–10(–12) cm long, slightly lustrous light brown. Seeds (4–)6–8 mm long with a 15–25 mm long wing ***P. nigra***

8a. Leaves ca. 1 mm wide, rigid, straight. Seed cones deciduous; apophyses of seed scales dull brown ***P. densiflora***

8b. Leaves 0.6–1 mm wide, pliant, straight or curved. Seed cones persistent; apophyses of seed scales lustrous brown **9**

9a. Seed cones 2.5–5 cm long, ovoid when closed. Wings of seeds 9–12 mm long. Leaves 7–12 cm long ***P. henryi***

9b. Seed cones 3–6(–8) cm long, narrowly ovoid when closed. Wings of seeds 10–20 mm long. Leaves (5–)10–17 cm long **10**

10a. Fascicle sheaths of new leaves 5–10 mm long. Apophyses of seed scales nearly flat; umbo depressed with a short, persistent prickle ***P. hwangshanensis***

10b. Fascicle sheaths of new leaves 10–14 mm long. Apophyses of seed scales mostly slightly raised; umbo flat or pyramidal, with a minute, deciduous prickle or unarmed **11**

11a. Pollen cones yellow. Umbo of seed scales nearly flat, with a minute, deciduous prickle or unarmed. Seed wings 15–20 mm long ***P. taiwanensis***

11b. Pollen cones tinged red. Umbo of seed scales slightly raised, armed with a sharp, persistent prickle. Seed wings 10–15 mm long ***P. luchuensis***

12a. New foliage shoots multi-nodal (producing more than 1 whorl of branches or buds in a single growing season). Leaves in fascicles of only 3, long and thin, lax and drooping ***P. kesiya***

12b. New foliage shoots uni-nodal. Leaves in fascicles of 2 or 3, short or long but not lax and drooping **13**

13a. Buds slightly resinous. Leaves 6–15 cm long, rigid **14**

13b. Buds not resinous. Leaves 7–30 cm long, rigid or pliant **15**

14a. Bark on trunk breaking into large plates. Seed cones when closed ovoid, 5–8.5 cm long. Seeds 6–8 mm long ***P. tabuliformis***

14b. Bark on trunk with irregular fissures. Seed cones when closed narrowly ovoid, 4–6 cm long. Seeds 4–6 mm long ***P. densata***

15a. Leaves (15–)20–30 cm long, 1.5 mm wide, straight and rigid. Umbo of cone scales unarmed ***P. tropicalis***

15b. Leaves 7–20(–30) cm long, 1–1.2 mm wide, straight, contorted or drooping, pliant. Umbo of cone scales mucronate, or at least with a short prickle **16**

16a. Bark on trunk with long, vertical fissures. Fascicle sheath of new leaves 15–20 mm long. Seed cones deciduous ***P. massoniana***

16b. Bark on trunk with irregular plates. Fascicle sheath of new leaves 10–15 mm long. Seed cones persistent ***P. yunnanensis***

Key to the species of *Pinus* Subsection *Ponderosae*

The species in this subsection range from western North America into Mexico and Central America. The group consists of a very widespread species, *P. ponderosa*, some Tertiary relicts now confined to the two Californias, and taxa that become increasingly diverse genetically and morphologically in Mexico and Central America, where they are most likely still evolving. The relicts are most distinct, while the evolving species are mostly variable and can be difficult to separate on the characters used in this key. Reference to the full descriptions is here most necessary to arrive at a determination with confidence. For counting numbers of leaves per fascicle see comments under the key to the species of *Pinus* Subsect. *Pinus*.

1a. Leaves in fascicles of not more than 3, either 2–3 or only 3 **2**

1b. Leaves in fascicles of 3, 4, or 5, rarely 2 or more than 5 **5**

2a. Seed cones deciduous, opening soon; scales thin woody; apophyses raised but not elongated into a strongly curved spine **3**

2b. Seed cones persistent, opening slowly; scales thick woody; apophyses extremely raised and elongated into a strongly curved spine **4**

3a. Buds resinous. Pollen cones red or magenta before anthesis. Seed cones 5–12 cm long ***P. ponderosa***

3b. Buds not resinous. Pollen cones yellow or with a purplish tinge. Seed cones (10–)12–25(–30) cm long ***P. jeffreyi***

4a. New foliage shoots multi-nodal (producing more than 1 whorl of branches or buds in a single growing season). Leaves thick and rigid, 1.9–2.2 mm wide. Seed cones solitary or in whorls of 2–5 ***P. coulteri***

4b. New foliage shoots uni-nodal. Leaves slender, pliant, 1.5 mm wide. Seed cones solitary, rarely in pairs ***P. sabiniana***

5a. Leaves in fascicles of 3–5, rarely 2 **6**

5b. Leaves in fascicles of 5, rarely 3, 4, or 6, very rarely 8 **7**

6a. Leaves in fascicles of (2–)3(–4), rarely 5, 20–35 cm long, 1.5–2 mm wide ***P. engelmannii***

6b. Leaves in fascicles of 3–5, 10–20(–25) cm long, 0.9–1.8 mm wide ***P. arizonica***

7a. Leaves thick, rigid, ca. 2 mm wide. Pollen cones before anthesis yellow, not tinged pink, purplish or brown. Seed cones persistent, opening slowly, broadly ovoid when closed ***P. torreyana***

7b. Leaves slender, rigid or pliant, 0.6–1.6 mm wide. Pollen cones before anthesis usually tinged pink, purplish or brown. Seed cones deciduous, opening soon, ovoid-oblong or ovoid-attenuate when closed **8**

8a. Leaves (6–)10–20(–24) cm long **9**

8b. Leaves (15–)20–40(–45) cm long **10**

9a. Leaves relatively thick, rigid, (1–)1.2–1.5 mm wide ***P. hartwegii***

9b. Leaves slender, rigid or pliant, 0.7–1.1 mm wide ***P. durangensis***

10a. Bark on trunk reddish brown to dark brown, divided by very deep, longitudinal, black fissures. Seed cones massive, 15–35 cm long. Seeds 8–10 mm long, with a 25–35 mm long wing ***P. devoniana***

10b. Bark grey-brown or brown, with plates or fissures less deep relative to the trunk diam. Seed cones smaller (maximum 20 cm long). Seeds 4–7 mm long, with a 13–28 mm long wing **11**

11a. Seed cones solitary or in pairs, on distinct, curved peduncles; seed scales thin and flexible. Leaves very slender, pliant, 0.6–1(–1.1) mm wide ***P. maximinoi***

11b. Seed cones solitary or more often in whorls of 2–6, on short peduncles or appearing sessile; seed scales thin or thick but rigid. Leaves rigid or pliant, 0.8–1.3 mm wide **12**

12a. Seed cones 7–10 cm long; umbo unarmed. Seeds 4–5 mm long ***P. douglasiana***

12b. Seed cones 7–20 cm long; umbo obtuse but strongly developed, or with a small, persistent prickle. Seeds 5–7 mm long **13**

13a. Bark on trunk breaking into small plates, not with deep longitudinal fissures. Seed cones solitary or more often in whorls of 3–6; apophyses flat or moderately raised ***P. montezumae***

13b. Bark on trunk breaking into elongated plates and deep, longitudinal fissures. Seed cones solitary or in whorls of 2–3; apohyses very variable, from nearly flat to extremely raised or conical, especially towards the base of the cone ***P. pseudostrobus***

Key to the subsections (and some species) of *Pinus* Subgenus *Strobus*

The morphological characters of species in this subgenus are highly diverse but also demonstrate convergent evolution of certain traits, which means that similar character states do appear in phylogenetically not closely related species. In the classification adopted here (see Farjon, 2005b: 218–224) some weight has been given to certain autapomorphies (characters unique in a species or lineage that do not inform us about their relationships). In a few cases the subsections therefore may diverge slightly from those that would only recognize (DNA based) phylogenetic characters. This approach makes it somewhat easier to use morphological characters in this key to the amended subsections of the subgenus *Strobus*.

1a. Fascicle sheaths of leaves persistent, not recoiling; leaves connate, appearing as 1 but actually with 3 (rarely 4) in a fascicle. Seed cones on relatively very long, curved peduncles
Subsect. Nelsoniae: a single species ***P. nelsonii***

1b. Fascicle sheaths of leaves deciduous, scales first recoiling or not; leaves free (sometimes more or less connate from the base but always distally free). Peduncles of seed cones much shorter than the cones **2**

2a. Leaves in fascicles of only 5, these persisting on the branches for more than 10 and up to 30 years, forming long 'foxtail' tufts; fascicle sheaths not recoiling and already absent in second year fascicles ***Subsect. Balfourianae***

2b. Leaves in fascicles of 1–5 (very rarely 6 or 7), these persisting 2–5 years (rarely as long as 8 years), with recoiling or early deciduous fascicle sheaths **3**

3a. Leaves flat, 1.5–5 mm wide, in fascicles of only 2. Seeds with a long wing attached ***Subsect. Krempfiae:*** **a single species** ***P. krempfii***

3b. Leaves not flat, 0.5–2(–2.5) mm wide, in fascicles of 1–5 (very rarely 6 or 7); if with 2 leaves then seeds without a wing attached **4**

4a. Bark on trunk (and branches) remaining smooth even in large trees, exfoliating with thin flakes creating a multi-coloured pattern somewhat similar to bark of planes (*Platanus*)
Subsect. Gerardianae

4b. Bark on trunk becoming rough and scaly at least in large trees, exfoliating irregularly, forming multi-layered small or large plates, or becoming fissured **5**

5a. Umbos of seed cone scales terminal (at apex of scale). Leaves in fascicles of 5 (rarely 6 or 7)
Subsect. Strobi

5b. Umbos of seed scales dorsal (above apex of scale). Leaves in fascicles of 1–5 (rarely 6) **6**

6a. Leaves 5–12(–14) cm long. Seed cones 5–25 (–27) cm long, if shorter than 8 cm only partly opening with thick but flexible seed scales
Subsect. Rzedowskianae

6b. Leaves (1.5–)2–6(–8) cm long. Seed cones (2–)2.5–6(–7.5) cm long, always opening widely with thin, flexible seed scales
Subsect. Cembroides

Key to the species of *Pinus* Subsection *Balfourianae*

1a. Leaves with small resin droplets drying as white specks. Umbos on seed cone scales with a strong, 4–10 mm long prickle ***P. aristata***

1b. Leaves without small resin droplets. Umbos with a weak, 1–6 mm long prickle or unarmed **2**

2a. Bark on the trunk breaking into small, irregular plates, creating a tessellate pattern, cinnamon or orange-brown. Seeds 8–10 mm long
P. balfouriana

2b. Bark on the trunk breaking into irregular, scaly ridges, shallowly to deeply fissured, reddish brown. Seeds 5–8 mm long ***P. longaeva***

Key to the species of *Pinus* Subsection *Cembroides*

1a. Usually decumbent shrubs, multi-stemmed. Leaves predominantly in fascicles of 5 (very rarely of 4 or 6), persisting 2–3 years. Seeds 5–7 mm long ***P. culminicola***

1b. (Small) trees with at least a short single trunk before branching. Leaves in fascicles of 1–5 (rarely 6), persisting (3–)4–8 years. Seeds 10–18 mm long **2**

2a. Leaves in fascicles of only 1 (rarely 2), 1.2–2.2 (–2.5) mm diam., terete unless with 2 in a fascicle; fascicle sheaths not recoiling
P. monophylla

2b. Leaves in fascicles of (1–)2–5(rarely 6), (0.6–)0.7–1.5(–1.7) mm wide, not terete unless with 1 in a fascicle; fascicle sheaths recoiling or not **3**

3a. Scales of fascicle sheaths recoiling before falling. Integument of seeds thick and hard **4**

3b. Scales of fascicle sheaths deciduous without recoiling. Integument of seeds thin, crushed easily **5**

4a. Leaves 2–4 cm long, predominantly in fascicles of 2, sometimes in fascicles of 1 or 3 ***P. edulis***

4b. Leaves (2–)3–6(–8) cm long, predominantly in fascicles of 3, but commonly of 2 or 4 (rarely of 5) ***P. cembroides***

5a. Leaves in fascicles of 2, sometimes in fascicles of 3, 0.8–1.1 mm wide. Seed cones (2–)2.5–4 cm long ***P. remota***

5b. Leaves in fascicles of (3–)4(–5), rarely in fascicles of 2 or 6, (0.8–)1–1.5(–1.7) mm wide. Seed cones 4–6 cm long ***P. quadrifolia***

Key to the species of *Pinus* Subsection *Gerardianae*

1a. Leaves in fascicles of 4–5; 9–17 cm long; buds resinous. Seed cones on 1.5–2 cm long peduncles; seeds with a ca. 15 mm long wing ***P. squamata***

1b. Leaves in fascicles of only 3; 5–10 cm long; buds not resinous. Seed cones nearly sessile; seeds without a wing or wing rudimentary **2**

2a. Seed cones 5–7 cm long; umbos of seed scales with a rigid prickle or spine; seeds 8–10 mm long. Leaves up to 2 mm wide ***P. bungeana***

2b. Seed cones 12–20(–23) cm long; umbos of seed scales unarmed; seeds 20–25 mm long. Leaves 1 mm wide ***P. gerardiana***

Key to the species of *Pinus* Subsection *Rzedowskianae*

1a. Leaves in fascicles of 3, rarely of 4, rigid, 0.8–1.2 mm wide; scales of fascicle sheaths early deciduous, not recoiling ***P. pinceana***

1b. Leaves in fascicles of (3–)4–5, lax, 0.5–0.8 mm wide; scales of fascicle sheaths recoiling before dropping off **2**

2a. Bark on the trunk thick, deeply fissured, dark brown. Pollen cones small, 5 × 3 mm, purplish before anthesis. Seed cones 10–15 cm long, with thin scales; seeds with a long wing attached ***P. rzedowskii***

2b. Bark on the trunk breaking into square plates, not fissured, outer bark grey. Pollen cones 8–10 mm long, yellowish before anthesis. Seed cones massive, (15–)17–25(–27) cm long, with very thick scales; seeds without a wing attached ***P. maximartinezii***

Key to the species of *Pinus* Subsection *Strobi*

The foliage characters in this subsection of pines are very similar and, however desirable in the situation where there are no cones, as in young trees, they cannot be used reliably as first characters in the leads in most cases. Seed cones and sometimes pollen cones are necessary and even these can be very similar; see the note at the end of this key.

1a. Seed cones nearly sessile, persistent, serotinous. Pollen cones reddish or red-purple **2**

1b. Seed cones pedunculate, deciduous or sometimes semi-persistent, opening soon or more slowly. Pollen cones yellow, greenish white or sometimes tinged reddish at the apex **5**

2a. Shrubs, spreading with layering stems. Buds resinous. Seed cones 3–5 cm long ***P. pumila***

2b. Trees. Buds not resinous. Seed cones 5–10 (–12) cm long **3**

3a. Leaves persisting on the branches for up to 8 years, 3–6.5 cm long ***P. albicaulis***

3b. Leaves persisting on the branches 2–4 years, 6–11(–13) cm long **4**

4a. Seed cones broadly ovoid, 5–8 cm long ***P. cembra***

4b. Seed cones ovoid-conical, (5–)7–10(–12) cm long ***P. sibirica***

5a. Seed cones opening slowly and only slightly, late deciduous to semi-persistent; seed scales thick and rigid; seeds without a wing or wing rudimentary **6**

5b. Seed cones opening soon and fully, deciduous; seed scales thin or thick; seeds with a wing at least half the length of the seed, usually much longer **9**

6a. Leaves persisting on the branches (3–)5–6 years. Pollen cones 6–10 mm long ***P. flexilis***

6b. Leaves persisting on the branches 2–3 years. Pollen cones at least 15 mm long **7**

7a. Seed cones 5–7 cm long, ovoid to ovoid-elliptic when closed. Leaves (3–)5–8(–9) cm long, 0.8–1 mm wide ***P. amamiana***

7b. Seed cones 8–14 cm long, ovoid-oblong or conical-cylindric when closed. Leaves (5–)6–14 cm long, 1–1.5 mm wide **8**

8a. Margins of seed scales recurved. Pollen cones yellow. Young shoots occasionally pubescent ***P. koraiensis***

8b. Margins of seed scales not recurved. Pollen cones greenish white with a reddish apex. Young shoots always glabrous ***P. armandii***

9a. Leaves drooping or pendulous, straight but often with a sharp bend near the base. Bark on the trunk of large trees fissured longitudinally **10**

9b. Leaves lax, pliant or rigid, spreading, straight or (slightly) curved. Bark on the trunk of large trees not fissured longitudinally **11**

10a. Young shoots glandular pubescent; leaves soon deciduous, remaining only 1.5–2 years, pendulous, 15–24 cm long ***P. bhutanica***

10b. Young shoots glabrous; leaves remaining on the shoots 2–3 years, drooping or sometimes pendulous, (6–)10–18(–20) cm long ***P. wallichiana***

11a. Seed cones in clusters of 4–8(–10), nearly sessile, persistent, ovoid or sub-globose when closed, 4–7 cm long ***P. parviflora***

11b. Seed cones solitary or in whorls of 2–4, pedunculate, deciduous, ovoid to long cylindrical, variable but usually longer than 7 cm **12**

12a. Seed cones with thick, rigid scales and these with thick, woody apophyses, large (but variable in one species) to 55–60 cm long **13**

12b. Seed cones with thin, flexible or more rigid scales and these with thin or only partly thickened apophyses, (3–)5–40(–50) cm long **14**

13a. Seed cones when mature at least 30 cm long, with 5–12 cm long peduncles. Bark on large trunks breaking into large plates ***P. lambertiana***

13b. Seed cones when mature 12–30(–60) cm long, on 1.5–2.5 cm long peduncles. Bark on large trunks breaking into small plates ***P. strobiformis***

14a. Seed scales near base (but well above the peduncle) upturned or reflexed **15**

14b. Seed scales near base (but well above the peduncle) incurved or more or less straight and flat **17**

15a. Seed cones 10–25(–30) cm long; seeds with a 20–25 mm long wing ***P. monticola***

15b. Seed cones (3–)4–15(–17) cm long; seeds with a rudimentary or short wing to 16 mm long **16**

16a. Leaves 2.5–6 cm long; resin ducts in leaves medial ***P. wangii***

16b. Leaves 4–18 cm long; resin ducts in leaves external, sometimes a few medial ***P. fenzeliana***

17a. Seed cones with short, curved or obliquely inserted peduncles, or more or less curved at base. Leaves remaining on the shoots 3–4 years **18**

17b. Seed cones with up to 4 cm long, straight peduncles and more or less straight at base. Leaves remaining on the shoots 2–3 years **19**

18a. Pollen cones 15–25 mm long. Seed cones 6–11 cm long. Leaves 4–9 cm long, 0.6–1 mm wide ***P. morrisonicola***

18b. Pollen cones 10–15 mm long. Seed cones (7–)8–15(–20) cm long. Leaves 7–10(–12) cm long, 0.5–0.7 mm wide ***P. peuce***

19a. Seed cones (10–)15–40(–50) cm long, 7–15 cm wide when open. Leaves (8–)10–15(–18) cm long ***P. ayacahuite***

19b. Seed cones (5–)6–20(–25) cm long, 4–9 cm wide when open. Leaves (3–)5–12 (–14) cm long **20**

20a* Buds slightly resinous [American species] ***P. strobus***

20b* Buds not resinous [Vietnamese species] ***P. dalatensis***

* Both leaf lengths and seed cone lengths are extremely variable in these two species, ranging from (3–)5–12(–14) cm in the leaves and (5–)6–23(–25) cm in the cones. These species, with disjunct ranges in eastern North America, southern Mexico and parts of Guatemala (*P. strobus*), and Viet Nam (*P. dalatensis*), are remarkably similar and probably closely related. The Mexican-Guatemalan populations are by some accepted as a third species, *Pinus chiapensis*, but are here maintained as a variety of *P. strobus*, which during the Ice Ages occupied refugia far to the south of its current range and extended probably into Mexico.

Pinus albicaulis Engelm., Trans. Acad. Sci. St. Louis 2: 209. 1863. Type: USA: Colorado, *J. S. Newberry s.n.* (US No. 61140) (holotype US). Fig. 205

Etymology

The Latin epithet *albicaulis* means 'with a white stem', referring to the light grey bark.

Vernacular names

Whitebark pine, Scrub pine

Description

Trees to 10–15(–21) m tall, d.b.h. to 1–1.5 m. Trunk monopodial or with 2–several stems, straight or contorted, branching very low and much reduced in size at tree line. Bark thin, rough and scaly, breaking into small, scaly plates, yellowish brown, weathering pale grey, on young trees and branches smooth and greyish white. Branches of first order contorted, usually short, ascending or spreading, persistent, of higher orders flexible, assurgent. Shoots often puberulent, with short, non-decurrent pulvini, pale red-brown, ageing to pale grey-brown. Cataphylls 5–7 mm long, subulate, scarious, brown, with entire margins, soon deciduous. Vegetative buds ovoid and acute; terminal bud 8–10 mm long; lateral buds smaller, with imbricate, appressed, subulate, red-brown scales. Fascicle sheaths 8–12 mm long, with 6–7 loosely imbricate, orange-brown scales, deciduous and absent in second year's fascicles. Leaves in fascicles of 5, in dense tufts towards ends of branchlets, persisting up to 8 years, mostly connivent, curved forward against shoot, 3–6.5 cm long, 1–1.5 mm wide, with serrulate margins distally, acute, yellow-green on abaxial face, white stomatal lines on both adaxial faces. Stomata: leaves epistomatic or weakly amphistomatic, with 0–1 lines of stomata in grooves on abaxial face and 2–3 (intermittent) lines on each adaxial face. Pollen cones crowded at the proximal end of a new shoot, spreading, subtended by light brown bracts, ovoid-oblong, 10–15 mm long, red, maturing to brown. Microsporophylls peltate, the distal part cordate to rounded, smooth, ca. 1 mm wide. Seed cones subterminal, solitary, in pairs or in whorls of 3, on very short peduncles, persistent. Immature cones erect, ovoid, dark grey or purplish, maturing in two seasons. Mature cones broadly ovoid to subglobose, 5–8 × 4–7 cm. Seed scales ca. 50, remaining closed, concavo-convex, with seed cavities near base on adaxial side, dark grey or purple, maturing to light brown. Apophysis thick, triangular to rhombic, transversely keeled, straight or recurved but not reflexed at mid-cone, light brown, resinous. Umbo terminal, transverse-triangular, acute, 5–6 mm wide, grey-brown, very resinous. Seeds obovoid, 7–11 × 4–7 mm, chestnut brown. Seed wings absent when the seed is free from the scale.

Distribution

W North America: Rocky Mountains, Cascade Range, Sierra Nevada.

TDWG codes: 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 76 CAL NEV

Ecology

Pinus albicaulis is a high altitude pine growing in subalpine conifer forests up to the timberline. It occurs at altitudes up to 1350 m a.s.l. in the north and 3650 m a.s.l. in the south of its range. It is a very slow growing and long-lived tree, with often contorted stems and branches on exposed mountain ridges. Whitebark pine occurs in a cold, moist, and snowy climatic zone exposed to high winds, where few trees can compete. Most commonly it is associated with *Abies lasiocarpa, Tsuga mertensiana*, and in regions with less abundant precipitation, *Pinus contorta*. Rain only occurs in the short summer period (June-September), during the remainder of the year sleet and snow prevail, and the snow pack can cover small trees entirely except on windswept ridges. The strong, flexible branches of *P. albicaulis* can withstand winds of hurricane force. *Pinus albicaulis* co-evolved with a mountain bird, Clark's Nutcracker (*Nucifraga columbiana, Corvidae*; see also under *P. cembra*) in a mutualism concerning seed dispersal. The bird removes the seeds from the closed cones without damaging them and puts them away for later use in caches. Those that are forgotten may germinate, often two to five trees thus grow close together. No germination occurs without help from the bird and the bird even feeds its young with the pine seeds. Red squirrels play a similar but lesser role in seed planting.

Conservation

The most severe threat to this species at present is infestation by the introduced rust *Cronartium ribicola*, which has led to reductions of 80–90% in some northern areas of its range, where there is a wetter climate. Additional threats are predation by the beetle *Dendrococtonus ponderosae* (attacking especially weakened pines infested by the rust) and fire suppression in National Parks leading to a successional change in vegetation. Attempts are being made to

select rust-resistant genetic variants and to adjust the fire regimes in National Parks to a more natural frequency. This species has a very wide distribution and not all populations are similarly effected.
IUCN: EN (A4a, c, e)

Uses

Whitebark pine's main value is providing habitat for wildlife. The wood is used locally to build log cabins and for firewood. The edible seeds are difficult to harvest due to the serotinous and resinous cones; they were used by Native Americans only as an emergency food source. Its aesthetic value is best appreciated *in situ* in the high mountains; the horticultural merits of this pine are low because of extremely slow growth and vulnerability to pathogens such as white pine blister rust (*Cronartium ribicola, Basidiomycota*) and 'late frost' in parks and gardens. It is therefore scarcely known in cultivation.

Pinus amamiana Koidz., Bot. Mag. (Tokyo) 38: 113. 1924. *Pinus armandii* Franch. var. *amamiana* (Koidz.) Hatus., Mem. Fac. Agric. Kugos Univ. 1: 37. 1974. Type not designated.

Etymology

This species was named after the Amami people, who inhabit the Ryukyu Islands.

Vernacular names

Amami pine; amami-goyo, yaku-tane-goyo (Japanese)

Description

Trees to 20(–30) m tall; trunk to 2 m d.b.h. Bark smooth in young trees, greyish brown, becoming fissured and breaking into large and flaking plates on lower trunk, grey or blackish grey. Branches in pseudo-whorls in young trees, forming a conical crown; in older trees crown widening and becoming rounded and open. Foliage branches smooth, young shoots puberulent, soon glabrous, grey-green, turning grey-brown. Buds cylindrical, slightly resinous; terminal bud 10–15 mm long; lateral buds smaller; cataphylls ovate-linear, reddish brown. Leaves in remote fascicles of 5, held by a soon deciduous sheath of flimsy scales, persisting 2–3 years, slender and spreading, (3–)5–8(–9) cm long, straight or slightly curved, triangular in cross-section, 0.8–1 mm wide; stomata in lines on the two adaxial faces only. Pollen cones in long clusters, spirally arranged at base of new shoots, cylindrical or ovoid-ellipsoid, 1.5–2.5(–3) cm long, slender or stout, greenish white with a slightly reddish apex. Seed cones solitary or in pairs, initially erect and green, becoming more or less pendulous on stout, curved, 1–2 cm long peduncles, opening only slightly, ovoid to ovoid-elliptic, 5–7 cm long, 3–4 cm wide when opened, often resinous, turning dark purplish brown. Seed scales woody, rigid, 1.5–2 cm long, 2–3 cm wide, curved slightly inward; basal scales scarcely or not recurved, on the adaxial side with two marked depressions holding the seeds. Apophysis rhombic or more or less rounded distally, thick woody, with a straight or slightly recurved edge terminating in an inconspicuous, obtuse umbo, light yellowish brown or darker red-brown. Seeds ellipsoid, 10–12 mm long, 5–6 mm wide, ca. 4 mm thick, grey to nearly black, wingless or with a small ridge on abaxial margin, rarely with a rudimentary wing.

Taxonomic notes

The relationship of this species with the very similar species *P. armandii*, *P. fenzeliana* and *P. morrisonicola* and the infraspecific taxa in this group of East Asian pines belonging to subsection *Strobus* is in need of further investigation using DNA sequence data. *Pinus amamiana* may be most distinct in its cones and seeds, which seem to be more morphologically adapted to seed dispersal by birds, with small cones and relatively large, virtually wingless seeds. However, as we have learned from DNA analysis of other pines with such cones (e.g. *P. albicaulis* and *P. cembra*) strong selective pressure has determined the evolution of these adaptations and they are not necessarily good indicators of phylogenetic relationships.

Distribution

Japan, Kyushu (Yakushima, Tanegashima).
TDWG codes: 38 JAP-KY

Ecology

Pinus amamiana occurs in exposed, open stands in often sparsely vegetated localities on rocky slopes at between 50 m and 900 m a.s.l. on two smaller islands in the south of Japan.

Conservation

This rare species has an area of occupancy (AOO) of less than 100 km²; the total population size amounts to fewer than 3000 trees (ca. 2000 on Yakushima) and is declining. These trees were formerly exploited for timber and regeneration is slow due to exposed conditions. Nematodes accidentally introduced from the USA have caused increased mortality among seedlings and saplings according to information obtained by Tetsukazu Yahara of the Japanese Plant Specialist Group (IUCN-SSC) in 1999.
IUCN: EN [A3c, e; B1ab (iii, v), B2ab (iii, v)]

Uses

No recent uses have been recorded of this species; in the past its timber was exploited and used locally for construction, carpentry and wooden canoes for fishermen. It is reported to be very rare in cultivation, but since it has frequently been referred to as *P. armandii* var. *amamiana* or even equated with that species (as it was considered by E. H. Wilson, 1916), there may be trees in collections (arboreta etc.) that are misidentified. It may be somewhat more common in Japanese gardens.

Pinus aristata Engelm., Amer. J. Sci. Arts, ser. 2, 34: 331. 1862. *Pinus balfouriana* Balf. var. *aristata* (Engelm.) Engelm., in Rothrock, Rep. U.S. Geogr. Surv., Wheeler, 6, Bot.: 375. 1878; *Pinus balfouriana* Balf. subsp. *aristata* (Engelm.) Engelm., Trans. St. Louis Acad. Sci. 4: 176. 1880. Type: USA: Colorado, *C. C. Parry s.n.* (lectotype MO). Fig. 206

Etymology

The species epithet is from Latin *arista* = ear (of corn); it refers to the long, slender prickles or bristles on the cone scales causing the resemblance.

Vernacular names

Rocky Mountain bristlecone pine, Colorado bristlecone pine, Hickory pine

Description

Trees, small to medium, height to 10–15 m, d.b.h. to 1–1.2 m. Trunk monopodial, straight or contorted, often strongly tapering in old trees, branching very low and much reduced in size at tree line. Bark thin, shallowly fissured, breaking into flat, irregular ridges, reddish brown, weathering grey. Branches of first order contorted, usually short, ascending or spreading, persistent, of higher orders flexible. Shoots puberulent, with short, non-decurrent pulvini, pale red-brown, ageing to grey. Cataphylls 5–7 mm long, subulate, scarious, brown, with entire margins, soon deciduous. Vegetative buds ovoid and acute, resinous; terminal bud 8–10 mm long, lateral buds smaller; with imbricate, appressed, subulate, red-brown scales. Fascicle sheaths deciduous and absent in second year's fascicles. Leaves in fascicles of 5, in dense tufts persisting up to 17 years, mostly connivent, curved forward against shoot, 3–4.5 cm long, 0.8–1 mm wide, with white resin droplets that dry into small white specks or scales; margins entire or distally serrulate; apex acute or subulate, leaf colour glaucous green on the deeply grooved abaxial face, many white stomatal lines on both adaxial faces. Pollen cones crowded at the proximal end of a new shoot, spreading, subtended by light brown bracts, ellipsoid or ovoid, ca. 10 mm long, mostly yellow (a few red or bluish purple), maturing to brown. Microsporophylls peltate, the distal part cordate to rounded, smooth, ca. 1 mm wide. Seed cones subterminal, solitary or in pairs, nearly sessile, falling after seed dispersal. Immature cones erect, ovoid, dark purple, maturing in two seasons. Mature cones narrowly ovoid becoming ovoid-cylindric when open, 6–11 × 4–6 cm. Apophysis on seed scales thick, triangular to rhombic, transversely keeled, recurved, brown. Umbo dorsal, transverse-triangular at base, terminating in a slender, brittle, recurved and 4–10 mm long prickle. Seeds obliquely obovoid, 5–6 × 3–4 mm, grey-brown to near black. Seed wings 10–14 mm long.

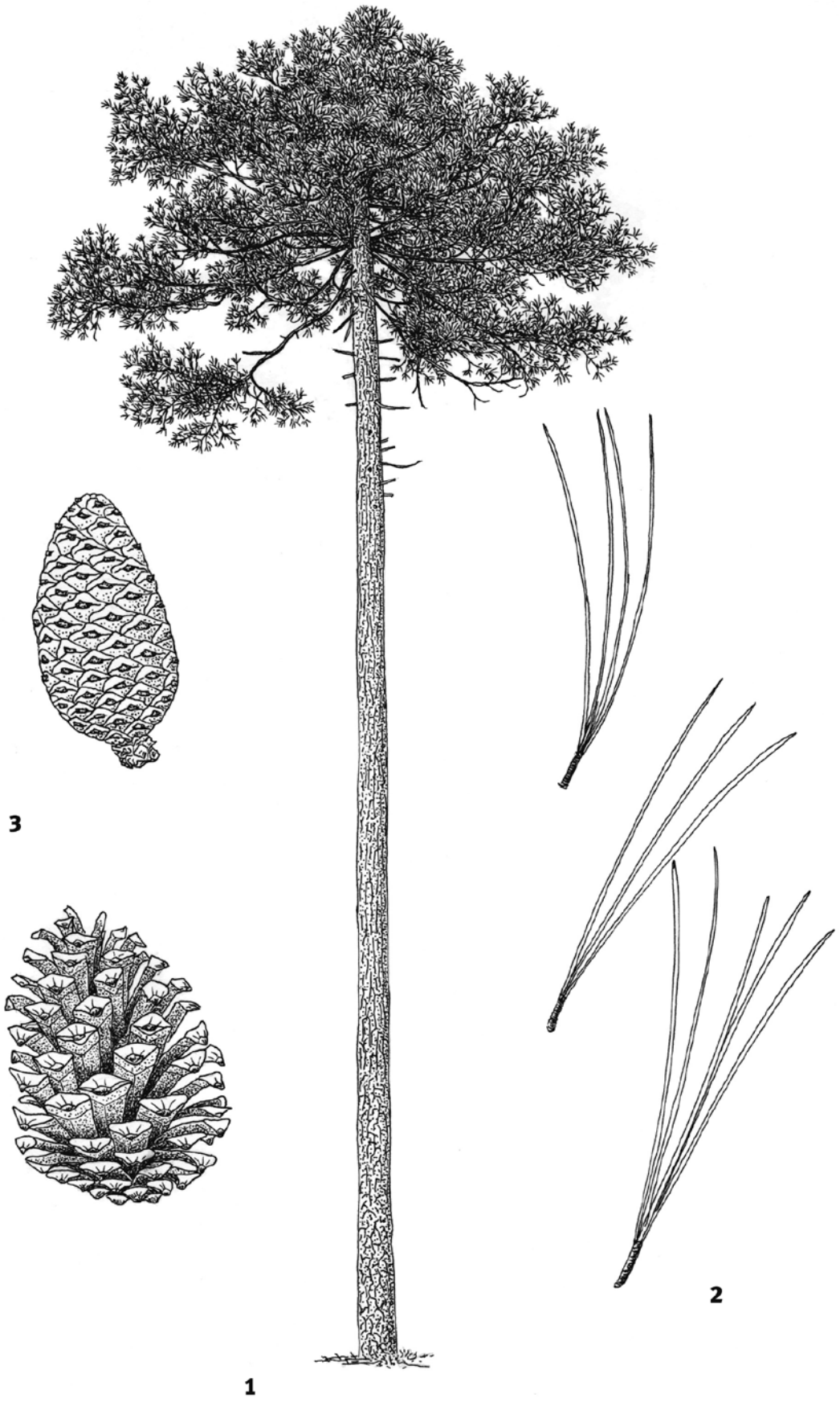

PLATE 26. *Pinus arizonica var. arizonica*. **1.** Habit of tree. **2.** Leaves. **3.** Seed cones, one green, one ripe.

Distribution

USA: N Arizona, Colorado, N New Mexico.
TDWG codes: 73 COL 76 ARI 77 NWM

Ecology

Pinus aristata occurs in the subalpine and alpine zones of the central Rocky Mountains; its altitudinal range is between 2500 m and 3400 m a.s.l. It is often found on extremely exposed slopes and ridges that can be battered by severe snow and ice storms. It may occur in pure, scattered stands or together with *Pinus albicaulis* or *Picea engelmannii*. It is extremely slow growing and, although no trees have been found that quite match the maximum ages observed in *P. longaeva* to the west, some individual trees are estimated to be in excess of 3000 years old.

Conservation

IUCN: LC

Uses

Rocky Mountain bristlecone pine is not a timber tree due to unfit shape and extremely slow growth. It is in cultivation and grown as an ornamental in rock gardens and other suitable settings, especially in the USA, and is commonly present in arboreta of the NE and NW USA, Canada and northern Europe. Although tolerant of poor, rocky soil and dry conditions, this species is often difficult to keep alive for long due to susceptibility to pathogens under moist air conditions. As a species of high alpine habitats in mid-continental climate, once warm weather sets in it will flush and not expect frost again, as often occurs in more maritime climates of the northern hemisphere. A few cultivars have been named, mostlly based on compact growth forms.

Pinus arizonica Engelm., in Rothrock, Rep. U.S. Geogr. Surv., Wheeler, 6, Bot.: 260. 1879.

Etymology

The species epithet refers to Arizona, from where it was first described.

Vernacular names

Arizona pine

Description

Trees to 30–35 m tall, d.b.h. to 1–1.2 m. Trunk monopodial, erect, straight. Bark thick, rough, scaly, breaking into large plates divided by broad, shallow or deep fissures, reddish brown to dark brown; outer bark grey. Branches spreading or ascending, lower branches subpendulous, slender. Crown in old trees rounded or flat-topped, open or dense. Shoots at first orange-brown or glaucous, rough with persistent, decurrent pulvini. Cataphylls up to 15 × 3–4 mm, subulate, scarious, soon reflexed, with erose-ciliate margins and caudate apex, dark brown. Vegetative buds ovoid to ovoid-acute; terminal bud 15–30 × 10–15 mm; lateral buds smaller, not resinous, brown; the scales spreading or recurved at apex, with long-ciliate, white or brown margins. Fascicle sheaths initially long, 15–30 mm, reduced to ca. 10 mm. Leaves in fascicles of 3–5, persisting 2–3 years, rigid or pliant, straight or slightly curved and twisted, (8–)10–20(–25) cm long, 0.9–1.8 mm wide; margins serrulate; apex acute to pungent; leaf colour light yellowish green or glaucous green. Stomata on all faces of leaves, in (3–)4–8(–12) lines on the convex abaxial face and in (3–)4(–5) lines on each adaxial face. Pollen cones ovoid-oblong to cylindrical, 1.5–2 cm × 5 mm, yellowish to yellowish brown. Seed cones solitary, in pairs or whorls of 3–5, on short, curved, persistent peduncles retaining a few scales on the branches. Mature cones seemingly sessile, ovoid or broadly ovoid with parted scales, asymmetrical at obliquely flattened base, often slightly curved, (4.5–)5–10(–14) × 3.5–6(–8) cm when open. Seed scales thick, rigid, broadly oblong, nearly straight or recurved especially near base, dark purplish- to blackish brown on abaxial side, light brown with faint marks of seed wings on adaxial side. Apophysis rhombic to pentagonal in outline, mostly symmetrical around cone, transversely keeled, ochraceous to light reddish brown. Umbo dorsal, raised and slightly recurved or nearly flat, rhombic, transversely keeled, 4–8 mm wide, grey, with a minute, deciduous prickle. Seeds obliquely ovoid, slightly flattened, 4–7 × 3–5 mm, light brown with black spots; wings obliquely ovate,

12–20 × 4–8 mm, semi-transparent, greyish brown with black tinge.

Distribution

SW USA: Arizona, New Mexico; in Mexico mainly in the Sierra Madre Occidental, southwards to S Durango, scattered in Coahuila, NE Zacatecas and Nuevo León.

TDWG codes: 76 ARI 77 NWM TEX 79 MXE-CO MXE-CU MXE-DU MXE-NL MXE-ZA MXN-SI MXN-SO

Ecology

Pinus arizonica is forming pure stands or is more commonly mixed with *Quercus* spp., other pines, e.g. *Pinus engelmannii, P. strobiformis*, and occasionally *Juniperus flaccida* at lower or *J. deppeana* at higher altitudes. It grows on various substrates, but the best stands are in valleys and on mesas with deep soil, in moderately dry to mesic forest with light winter frost occurring, at altitudes from (1300–)2000–2700 (–3000) m a.s.l. Annual precipitation is low to moderate, from 700 mm to 900 mm, mostly falling during the winter months.

Conservation

Pinus arizonica is an important constituent of the pine and pine-oak forests of northern Mexico, especially in the Sierra Madre Occidental. As such it is heavily exploited as a timber tree in much of its range, especially in the more accessible regions, and stands with large trees in these localities are now rare (Perry, 1991). While the species as a whole is widespread and still abundant, two of its varieties with limited distributions are now assessed as Vulnerable.

Uses

In Mexico, *Pinus arizonica* is a major timber tree, often compared (or equated) with *P. ponderosa* in the USA. The uses of its wood are similar. Timber of large sizes and high grade is sawn for light construction like window frames, doors, stairs, flooring, sidings, panelling, and veneers and for furniture, cabinetwork, boxes, and woodware. There are many local or regional sawmills where the logs are sawn and relatively little is exported. The resource has become much reduced by overexploitation and it is difficult to implement more sustainable forestry methods in the short run that would reverse the downward trend. This pine is not known to be in cultivation outside a few trial plantations, but perhaps an occasional tree from southern Arizona identified as *P. ponderosa* planted in parks or gardens belongs to this species.

3 varieties are recognized:

Pinus arizonica Engelm. var. ***arizonica***. *Pinus ponderosa* Douglas *ex* C. Lawson var. *arizonica* (Engelm.) Shaw, [Pines Mexico] Publ. Arnold Arbor. 1: 24. 1909; *Pinus ponderosa* Douglas *ex* C. Lawson subsp. *arizonica* (Engelm.) E. Murray, Kalmia 12: 23. 1982. Type: USA: Arizona, Pima Co., Santa Rita Mts., *J. T. Rothrock 652* (holotype MO). Pl. 26

Description

Trees, usually tall, height to 30–35 m. Leaves in fascicles of 3–5 (predominantly 3–4), rigid to slightly lax, straight or slightly curved and twisted, (8–)10–20(–23) cm long, 0.9–1.4(–1.6) mm wide. Stomata on all faces of leaves, in (3–)4–8 lines on the convex abaxial face and in (3–)4(–5) lines on each adaxial face (abaxial number of lines correlated with width of leaf). Seed cones ovoid to broadly ovoid, often slightly curved, (4.5–)5–7 × 3.5–6 cm when open. Seeds obliquely ovoid, slightly flattened, 4–6 × 3–3.5 mm. Seed wings obliquely ovate, 12–15 × 4–6 mm.

Distribution

SW USA (Arizona, New Mexico); mainly in the Sierra Madre Occidental of Mexico southwards to S Durango, scattered in Coahuila, NE Zacatecas and Nuevo León.

TDWG codes: 76 ARI 77 NWM 79 MXE-CO MXE-CU MXE-DU MXE-NL MXE-ZA MXN-SI MXN-SO

FIGURE 177. *Nothotsuga longibracteata in Nan Ling Mts. Hunan, China*

FIGURE 178. *Nothotsuga longibracteata seed* cones (photo Y. Liu)

FIGURE 179. *Papuacedrus papuana var. papuana* pollen cones (photo D. White)

FIGURE 182. *Parasitaxus usta* foliage and seed cones (photo W. Baker)

FIGURE 184. *Phyllocladus aspleniifolius* foliage and pollen cones

FIGURE 181. *Parasitaxus usta* in New Caledonia (photo W. Baker)

FIGURE 180. *Papuacedrus papuana* leaves and seed cones (photo D. White)

FIGURE 183. *Pherosphaera hookeriana* in Tasmania, Australia

FIGURE 185. *Phyllocladus hypophyllus* canopy on Mt Kinabalu, Borneo

FIGURE 187. *Phyllocladus trichomanoides* var. *alpinus* foliage

FIGURE 186. *Phyllocladus hypophyllus* glaucous foliage on Mt. Kinabalu 3100 m

FIGURE 188. *Picea chihuahuana* green and ripe seed cones

FIGURE 190. *Picea likiangensis* var. *likiangensis* seed cones (photo P. de Spoelberch)

FIGURE 189. *Picea likiangensis* var. *likiangensis* young seed cones

FIGURE 192. *Picea morrisonicola* tree in Taroko N.P., Taiwan

FIGURE 193. *Picea morrisonicola* trunk with bark

FIGURE 191. *Picea likiangensis* var. *likiangensis* seed cones

FIGURE 194. *Picea orientalis* foliage and pollen cones

FIGURE 195. *Picea orientalis* seed cones

FIGURE 196. *Picea schrenkiana* subsp. *tianschanica* in Kirgyzstan

FIGURE 197. *Picea schrenkiana* subsp *tianschanica* tree in Kirgyzstan

FIGURE 198. *Picea sitchensis* tree in Olympic N.P., Washington, USA

FIGURE 199. *Picea smithiana* pollen cones.

FIGURE 200. *Picea smithiana* seed cone from bud

FIGURE 201. *Picea smithiana* seed cone

FIGURE 203. *Pilgerodendron uviferum* pollen cones

FIGURE 204. *Pilgerodendron uviferum* foliage and seed cones

FIGURE 202. *Picea wilsonii* pollen cones

FIGURE 205. *Pinus albicaulis* foliage and pollen cones

FIGURE 206. *Pinus aristata* foliage

FIGURE 207. *Pinus armandii* var. *armandii* seed cone

FIGURE 209. *Pinus ayacahuite* var. *veitchii* foliage and seed cones

FIGURE 208. *Pinus attenuata* seed cones

FIGURE 210. *Pinus balfouriana* in the Sierra Nevada, California, USA

FIGURE 211. *Pinus bungeana* trunk with bark

FIGURE 212. *Pinus bungeana* seed cone

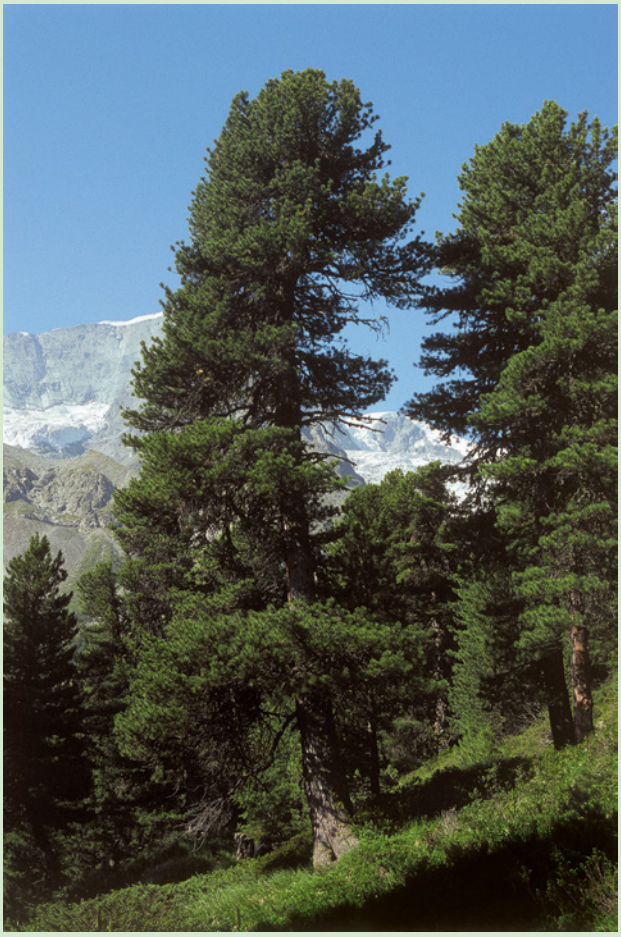

FIGURE 213. *Pinus cembra* in the Alps, Switzerland

FIGURE 214. *Pinus cembra* foliage and seed cones

FIGURE 216. Pinus cembroides var. cembroides bark

FIGURE 215. *Pinus cembroides* var *cembroides* in Hidalgo, Mexico

FIGURE 217. *Pinus cembroides* subsp. *orizabensis* seed cones

FIGURE 218. *Pinus contorta* var *murrayana* in the Sierra Nevada, California, USA

FIGURE 219. *Pinus coulteri* pollen cones

FIGURE 220. *Pinus coulteri* foliage and seed cones

FIGURE 221. Pinus culminicola foliage

FIGURE 222. Pinus devoniana foliage

FIGURE 223. *Pinus durangensis* in Durango, Mexico (photo C. Hughes)

FIGURE 224. *Pinus engelmannii* foliage

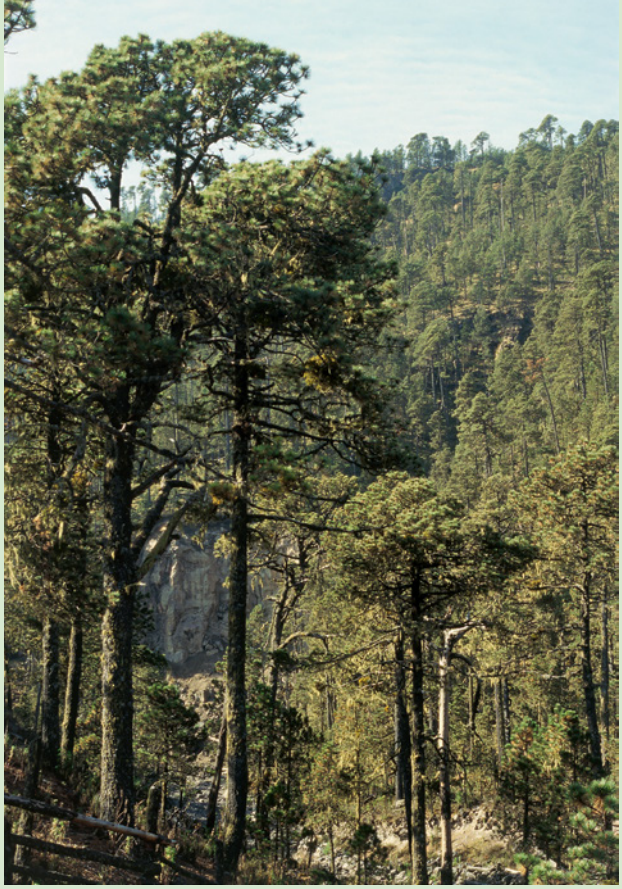

FIGURE 228. *Pinus longaeva* on Telescope Peak, Death Valley N.P., California

FIGURE 225. *Pinus hartwegii* on Pico de Orizaba, Veracruz, Mexico

FIGURE 226. *Pinus heldreichii* seed cones.

FIGURE 230. *Pinus maximartinezii* seed cone and seedling

FIGURE 231. *Pinus monophylla* foliage and seed cones

FIGURE 229. *Pinus maximartinezii* in Zacatecas, Mexico

FIGURE 227. *Pinus latteri* forest in Thailand (photo H. Hazebroek)

FIGURE 232. *Pinus monophylla* leaves

FIGURE 233. *Pinus muricata* pollen cones

FIGURE 234. *Pinus muricata* seed cones

FIGURE 235. *Pinus nelsonii* seed cone

FIGURE 236. Pinus nigra subsp. *laricio* trunk with bark

FIGURE 239. *Pinus patula* var. *patula* leaves

FIGURE 238. *Pinus patula* var. *patula* tree in Oaxaca, Mexico

FIGURE 237. *Pinus nigra* subsp. *salzmannii* seed cones

Conservation

IUCN: LC

Pinus arizonica Engelm. var. ***cooperi*** (C. E. Blanco) Farjon, Flora Neotropica 75: 107. 1997. *Pinus cooperi* C. E. Blanco, Anales Inst. Biol. Univ. Nac. México 20: 185. 1950. Type: Mexico: Durango, El Salto, (coll. C. E. Blanco) *M. Martínez 3442* (lectotype A).

Trees, usually tall, height to 30–35 m. Leaves in fascicles of (3–)4–5, predominantly 5, rigid to slightly lax, usually curved, (5–)6–10(–12) cm long, 1.0–1.3 mm wide. Stomata on all faces of leaves, in 4–7 lines on the convex abaxial face and in (3–)4 lines on each adaxial face (abaxial number of lines correlated with width of leaf). Seed cones ovoid to broadly ovoid, often slightly curved, 5–10(–12) × 4–6 cm when open. Seeds obliquely ovoid, slightly flattened, 5–7 × 4–5 mm. Seed wings obliquely ovate, 15–20 × 6–8 mm.

Distribution

Mexico: mainly in Durango, but scattered northward in the Sierra Madre Occidental into Chihuahua and Sonora, also S Sinaloa, Nayarit (?) and N Jalisco (?).
TDWG codes: 79 MXE-CO MXE-CU MXE-DU MXN-SI MXN-SO

Conservation

IUCN: VU [B2ab (iii, v)]

Pinus arizonica Engelm. var. ***stormiae*** Martínez, Pinos Mexic., ed. 2: 295. 1948. *Pinus ponderosa* Douglas *ex* C. Lawson var. *stormiae* (Martínez) Silba, Phytologia 68: 59. 1990. Type: Mexico: Coahuila, General Cepeda, Sierra la Cocordia, *M. Martínez 3455* (lectotype MEXU).

Description

Trees of medium size, height to 15–20 m. Leaves in fascicles of 3–4(–5), thick, coarse, rigid, usually curved and twisted, 14–25 cm long, 1.4–1.8 mm wide. Stomata on all faces of leaves, in 8–12 lines on the convex abaxial face and in (3–)4 lines on each adaxial face (abaxial number of lines correlated with width of leaf). Seed cones ovoid to ovoid-oblong, often curved, (4.5–)5–10(–14) × 3.5–6(–8) cm when open. Seeds obliquely ovoid, slightly flattened, 5–6 × 3.5–4 mm. Seed wings obliquely ovate, 12–16 × 6–8 mm.

Distribution

Mexico: mainly in S Nuevo León, a few localities in S Coahuila, Zacatecas and possibly San Luís Potosí.
TDWG codes: 79 MXE-CO MXE-NL MXE-SL MXE-ZA

Conservation

IUCN: VU [B2ab (ii, v)]

Pinus armandii Franch., Nouv. Arch. Mus. Hist. Nat., sér. 2, 7: 95. 1884.

Etymology

This species was named after the French missionary and naturalist Armand David (1826–1900), an avid explorer of China.

Vernacular names

Armand's pine; hua shan song (Chinese)

Description

Trees to 30–35 m tall; trunk to 1 m d.b.h. Bark smooth in young trees, becoming fissured and breaking into large and more or less rectangular plates on the lower trunk, grey or purplish grey. Branches in pseudo-whorls in young trees, forming a conical crown, in older trees crown widening and becoming rounded and open. Foliage branches smooth, young shoots glabrous, green, grey-green, or grey-brown, sometimes glaucous, turning brown. Buds cylindrical, slightly resinous; terminal bud 10–15 mm long; lateral buds smaller. Leaves in remote fascicles of 5, sometimes 6–7, held by a soon deciduous sheath of flimsy scales, persisting 2–3 years, slender and spreading or drooping, (5–)8–14 cm long, often curved near base, triangular in cross-section, 1–1.5 mm wide; stomata

in lines on the two adaxial faces only. Pollen cones in long clusters, spirally arranged at base of new shoots, cylindrical or ovoid-ellipsoid, 1.5–2.5(–3) cm long, slender or stout, greenish white with a slightly reddish apex. Seed cones solitary or in pairs, initially erect and green, becoming more or less pendulous on stout, curved, 2–3 cm long peduncles, falling late after seed dispersal, conical-cylindric, 8–14 cm long, 5–8 cm wide when opened, often resinous, turning variously brown. Seed scales woody, rigid, 3–4 × 2.5–3 cm, curved slightly inward,basal scales scarcely or not recurved, on the adaxial side with two marked depressions holding the seeds. Apophysis rhombic or triangular, often thick woody, with a straight or slightly recurved edge terminating in an inconspicuous, obtuse umbo, light yellowish brown or darker red-brown. Seeds obovoid, 10–15 mm long, 6–10 mm wide, light or dark brown to nearly black, wingless or with a small ridge on abaxial margin, rarely with a rudimentary wing.

Distribution

China, Anhui, Chongqing, S Gansu, Guizhou, Guangxi, Hainan, Henan, Hubei, S Shaanxi, Sichuan, Yunnan, extreme SE Xizang [Tibet]; N Myanmar [Burma]; Taiwan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHH CHN-GS CHN-SA CHN-SX CHS-AH CHS-HE CHT 38 TAI 41 MYA

Ecology

Pinus armandii occurs in mountains at altitudes from 900 m to 3500 m a.s.l.; usually in association with other conifers and seldom in pure stands. Common conifer genera in these mixed forests are *Abies, Picea, Pseudotsuga*, and in SW China also *Larix*. More often than these conifers, the pines tend to occupy rocky areas with thin soils where other trees, among them angiosperms, are less competitive.

Uses

This pine is a notable ornamental tree in China and it was introduced to France by Armand David in 1895. It remains an uncommon tree in gardens and parks outside China, but has spread to arboreta in many parts of the world. As a timber tree it is of limited value and exploited only for local use.

3 varieties are recognized:

Pinus armandii Franch. var. ***armandii***. Type not designated. Fig. 207

Description

New shoots green or grey-green. Pollen cones stout, 1.5–2 cm long, ovoid-ellipsoid. Apophyses in mature cones thick woody, rhombic, not recurved or only the umbo slightly recurved, yellowish brown or light brown. Seeds dark brown to nearly black.

Distribution

China: Chongqing, S Gansu, Guizhou, Hainan, Henan, Hubei, Shaanxi, Sichuan, Yunnan, extreme SE Xizang [Tibet]; N Myanmar [Burma].
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHH CHN-GS CHN-SA CHN-SX CHS-HE CHT 41 MYA

Conservation

IUCN: LC

Pinus armandii Franch. var. ***dabeshanensis*** (W. C. Cheng & Y. W. Law) Silba, Phytologia 68: 47. 1990. *Pinus dabeshanensis* W. C. Cheng & Y. W. Law, Acta Phytotax. Sin. 13 (4): 85. 1975; *Pinus fenzeliana* Hand.-Mazz. var. *dabeshanensis* (W. C. Cheng & Y. W. Law) L. K. Fu & Nan Li, Novon 7 (3): 262. 1997. Type: China: Anhui, Yuexi, Laibangmen, *C. Q. Zhang 1* (holotype PE).

Description

Leaves 5–14 cm long. Apophysis of seed scales thick woody. Seeds light brown, with a rudimentary wing.

Taxonomic notes

In Flora of China 4: 24 (1999) this taxon is treated as a variety of *Pinus fenzeliana* Hand.-Mazz. Farjon

(1998, [2001], 2005b) has maintained it under *P. armandii*. Although the thicker seed scales and rudimentary seed wings are most similar to *P. armandii*, we also know that these are adaptive traits that may evolve independently in species with zoochorous seed dispersal. Careful DNA analysis may be the only solution to the problem of relationship of this taxon; it has so far not been included in a comprehensive analysis of *Pinus* section *Strobus*.

Distribution

China: Anhui (Jingzhai, Yuexi), Henan (Shangcheng), Hubei (Luotian, Yingshan).
TDWG codes: 36 CHC-HU CHS-AH CHS-HE

Conservation

This variety is known from disjunct localities in a limited area where three provinces meet and where deforestation is known to occur and has occurred for a long time. In Flora of China it is called "an endangered plant" but it is not clear whether this is based on IUCN criteria.
IUCN: VU [A2acd; B1ab (iii, v)]

Pinus armandii Franch. var. ***mastersiana*** (Hayata) Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25 (19): 217, f. 8. 1908. *Pinus mastersiana* Hayata, Gard. Chron., ser. 3, 43: 194. 1908; *Pinus armandii* Franch. subsp. *mastersiana* (Hayata) Businský, Acta Pruhoniciana 68: 13. 1999. Type: Taiwan: Nantou, Chia-i Pref., Yu-Shan, ["Mt. Morrison"], *G. Nakahara s.n.*, 3 Oct 1905 (holotype TI).

Description

New shoots grey-brown. Pollen cones when fully grown slender, cylindrical, 2–3 cm long. Apophyses usually slightly recurved towards apex, brown or red-brown when mature. Seed colour not recorded.

Distribution

Taiwan (Mt. Alishan, Mt. Yushan).
TDWG codes: 38 TAI

Conservation

This variety of 'soft pine' is the only representative of *Pinus* subsection *Strobi* native to Taiwan and the timber of pines in this subsection is very much superior for high grade carpentry and furniture making. As a result, the resource has been overexploited and the population has dwindled. At present, several remaining stands are protected within Yushan National Park.
IUCN: EN [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Uses

An important timber tree, but a very limited resource.

Pinus attenuata Lemmon, Mining Sci. Press 64: 45. 1892. Type: USA: California, Berkeley, California, *J. G. Lemmon s.n.* (lectotype UC). Fig. 208

Etymology

The species epithet refers to the tapering (attenuate) shape of the closed seed cone.

Vernacular names

Knobcone pine, Narrowcone pine

Description

Trees to 15–20(–25) m tall, d.b.h. to 40–50 cm. Trunk monopodial, straight or sometimes curved. Bark thin, rough, scaly, breaking in small, rectangular plates, greyish brown to grey. Branches spreading to assurging, forming an irregular or rounded, open crown. Shoots often multi-nodal, with short decurrent, persistent pulvini. Cataphylls subulate, scarious, tapering into a caudate apex; margins erose-ciliate, dark brown. Vegetative buds ovoid-acute; terminal bud 15–30 × 10–15 mm; lateral buds smaller, resinous, brown; the scales appressed, subulate, scarious, with erose, hyaline margins. Fascicle sheaths initially 10–18 mm long, reduced to 3–6 mm. Leaves in fascicles of 3, rarely 2, persisting 2–3 years, rigid, straight, (8–)10–12(–14) cm long, 1.0–1.5 mm

wide; margins serrulate; apex acute; leaf colour light green or slightly glaucous green. Stomata on all faces of leaves, in 8–12 lines on the convex abaxial face and in 3–5 lines on each adaxial face. Pollen cones ovoid-oblong to cylindrical, 1.5–2 cm × 5–7 mm, yellowish to yellowish brown. Seed cones subterminal, solitary or more often in pairs or whorls of 3–5, on short, stout, recurved peduncles, very persistent on main stem and branches. Mature cones seemingly sessile, reflexed, extremely serotinous, ovoid-oblong to ovoid-attenuate, slightly curved, asymmetrical, 8–15 × 3.5–6 cm when closed (up to 8 cm wide when open). Seed scales thick, rigid, oblong, straight or slightly curved when parted, purplish to reddish brown. Apophysis rhombic to pentagonal in outline, transversely keeled, from slightly raised on lower side of the cone to conical and curved on upperside, especially towards base of cone (there more than 10 mm long), ochraceous or yellowish brown, slightly lustrous, weathering grey. Umbo dorsal, rhombic, from almost flat to pyramidal or unciform in conjunction with development of the apophysis, curved towards cone apex, up to 5 × 5 mm, darker than apophysis; prickle absent. Seeds obliquely ovoid, flattened; apex slightly acute, 5–7 × 3.5–4.5 mm, blackish grey. Seed wings oblong, with one side curved, 12–18 × 5–7 mm, yellowish to grey-brown.

Distribution

Mexico: Baja California Norte; USA: California, S. Oregon.
TDWG codes: 73 ORE 76 CAL 79 MXN-BC

Ecology

This species is a fire successional tree with extremely persistent and serotinous seed cones on dry slopes in chaparral or similar vegetation, also on rocky outcrops of serpentine with little other plant growth. In the northern part of its range, where trees grow somewhat taller, it is often mixed with several species of oak (*Quercus* spp.) and with *Cupressus* sp. In the USA its altitudinal range is from 300–1200 (–1700) m a.s.l. In Mexico it is found mainly from 250–600 m a.s.l. and close to the coast.

Conservation

IUCN: LC

Uses

Knobcone pine has little or no value as a timber tree. Its erratic growth habit and generally small size do not yield quality timber; its dry habitat ensures slow growth to any useful size, although on establishment after fire its initial growth rate is quite rapid. Cross sections of stems with inclosed whorls of cones have sometimes been polished and offered as curios in local woodcraft shops. Its horticultural merits are likewise not esteemed and it is therefore restricted to a few arboreta and pineta, mainly in regions with a suitable, Mediterranean type climate, or at least one with warm, dry summers and mild winters. In California, hybridization experiments have resulted in hybrids with *P. radiata* (known as *P.* ×*attenuradiata* Stockwell & Righter) and with *P. muricata*. All three species belong to a group of pines informally known as the 'California closed-cone pines' and are indeed closely related.

Pinus ayacahuite Ehrenb. *ex* Schltdl., Linnaea 12: 492. 1838.

Etymology

The species epithet takes up one of the indigenous vernacular names for this pine.

Vernacular names

Mexican white pine; acalote, ayacahuite, ocote gretado, pinabete, pino gretado (Mexico, Guatemala)

Description

Trees to 40–45(–50?) m tall, d.b.h. to 1.5–2 m. Trunk monopodial, straight. Bark rough, scaly, divided into small, rectangular scales, exfoliating with small flakes, grey-brown, weathering grey. Branches spreading horizontally, but lower branches somewhat drooping; crown pyramidal to broad conical. Shoots mostly glabrous or current year's shoots brownish puberulent, grooved; pulvini prominent, short decurrent. Cataphylls small, 5–10 mm long, subulate, with erose margins, dark brown, soon deciduous. Vegetative buds small; terminal bud 8–15 × 5–8 mm, ovoid-oblong; lateral buds smaller, ovoid, not or only slightly resinous; the scales subulate-linear,

acute, free, dark purplish brown. Fascicle sheaths 15–20(–25) mm long, deciduous. Leaves in fascicles of 5, very rarely 6, persisting 2–3 years, straight or slightly curved or twisted, not drooping, (8–)10–15(–18) cm long, 0.7–1.0 mm wide; margins (weakly) serrulate; apex acute; leaf colour green or grey-green with two whitish stomatal bands. Stomata on the two adaxial faces only, in two dense bands of 3–6 intermittent lines. Pollen cones ovoid to short cylindrical, 7–10 mm long, yellow, turning orange-brown. Seed cones towards end of main branches, subterminal, solitary or more often in pairs or whorls of 3–4 on short (–25 mm) peduncles which usually fall with the cone. Mature cones pendulous, cylindrical, curved, tapering towards apex, (10–)15–40(–50) cm × 7–15 cm when open. Seed scales spreading, thin, flexible or more rigid, straight, the proximal scales recurved, transversely nearly flat or concavo-convex, 5–7 cm long, rugose or grooved, dull brown or dark reddish brown. Apophysis irregularly trullate, recurved or reflexed towards apex, or apex curved up below umbo, longitudinally grooved, dull light brown, very resinous. Umbo terminal, broadly triangular, obtuse, 5–10 mm wide. Seeds in two cup-like depressions at base of scale, obovoid, laterally flattened, 8–15 × 6–9 mm, dull brown with black spots. Seed wings oblique, with a curved side or broad truncate, 20–35 × 8–12 mm, light brown with dark striations or dark brown.

Distribution

Mexico: from Central Mexico southwards to Chiapas; Guatemala; Honduras; El Salvador.
TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-GU MXE-HI MXE-QU MXG-VC MXS MXT-CI 80 ELS GUA HON

Ecology

Pinus ayacahuite forms emergent trees in mixed montane conifer forest on mesic sites, or grows in groups or small groves; reaching its greatest extent in Chiapas and W Guatemala. The best stands are on loamy, well drained soils. Its altitudinal range is (1500–)1900–3200(–3600) m a.s.l.

Uses

Pinus ayacahuite and its variety *P. ayacahuite* var. *veitchii* are both very important and highly sought after timber trees as they are the tallest growing and most regular shaped representatives of the so-called soft pines in Mexico and Mesoamerica. The wood is used for construction, carpentry, furniture and utilities such as containers, pallets and crates as well as wood pulp. This Mexican pine with its large, pendent cones is uncommon in cultivation and restricted to a few arboreta and private parks or gardens with rare trees. Hybrids have been produced by bringing this species together with its close relatives in the subsection *Strobi*, e.g. *P. flexilis, P. monticola, P. strobus* and *P. wallichiana*, the hybrid with the latter is known as *P.* ×*holfordiana* A. B. Jacks. and can also be found planted in some tree collections. Forestry plantations with these trees outside their native ranges, e.g. in western Europe, have been unsuccessful due to the risk of infestation with White pine blister rust (*Cronartium ribicola, Basidiomycota*), which particularly affects introduced pine species of this subsection. The fungus resides in alternative hosts; in this case species of *Ribes*, native shrubs in much of Europe, which do not suffer damage. Eradication of native flora in forestry is no longer acceptable practice in the EU and foresters have to look for other tree species to grow.

2 varieties are recognized:

Pinus ayacahuite Ehrenb. *ex* Schltdl. var. ***ayacahuite***. Type: Mexico: Hidalgo, Omitlan de Juarez, Montes del Lucero, near Hacienda de Guerrero, *C. A. Ehrenberg 647* (lectotype MO).

Description

Seed cones pendulous, cylindrical, curved, tapering towards apex, (10–)15–40 cm long, 7–15 cm wide when opened. Seed scales ca. 100–120, thin, flexible; apophysis thin, trullate, usually recurved, rarely reflexed at apex. Seeds 8–10 × 6–8 mm. Seed wings 20–35 × 8–12 mm, tapering towards apex.

Distribution

Central America: El Salvador, Guatemala, Honduras; S Mexico: northwards to Hidalgo.
TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-HI MXG-VC MXS-GR MXS-MI MXS-OA MXT-CI 80 ELS GUA HON

Conservation

IUCN: LC

Pinus ayacahuite Ehrenb. *ex* Schltdl. var. ***veitchii*** (Roezl) Shaw, [Pines Mexico] Publ. Arnold Arbor. 1: 10. 1909. *Pinus veitchii* Roezl, Cat. Grain. Conif. Mexic.: 32. 1857. *Pinus strobiformis* Engelm. subsp. *veitchii* (Roezl) Frankis, Int. Dendrol. Soc. Yearb. 2008. 2009. Type: Mexico: México, Valle de México, Volcán Popocatepetl, ["ridge between Mts. Popocatepetl and Iztaccihuatl"], *C. G. Pringle s.n.* (neotype A). Fig. 209

Description

Seed cones pendulous, broadly cylindrical, curved, often very large, 15–50 cm long, 10–15 cm wide when opened. Seed scales ca. 100–150, not flexible; apophysis thick, trullate, with an extremely elongated, abruptly narrowed, reflexed distal part and sometimes an upturned apex. Seeds 10–15 × 7–9 mm. Seed wings up to 2 × as long as the seed, oblique, broad truncate or tapering to a rounded apex.

Distribution

Mexico: in Guanajuato, Querétaro, Hidalgo, Veracruz, México, Puebla, Tlaxcala, Morelos, and Michoacán.
TDWG codes: 79 MXC-ME MXC-MO MXC-PU MXC-TL MXE-GU MXE-HI MXE-QU MXG-VC MXS-MI

Conservation

IUCN: LC

Pinus balfouriana Balf., in Murray, Bot. Exped. Oregon 8: 1. 1853. Type: USA: California, Shasta Co., Mt. Shasta, ["On a range of mountains between Chastey (Castey) and Scotts Valley (River) lat. 41° 50"], *J. Jeffrey 618* (holotype E). Fig. 210

Pinus balfouriana Balf. subsp. *austrina* Bruijn & J. Mastrog., Syst. Bot. 5 (1): 102. 1980; *Pinus balfouriana* Balf. var. *austrina* (Bruijn & J. Mastrog.) Silba, Phytologia Mem. 7: 48. 1984.

Etymology

This species was named after (but not by) John Hutton Balfour (1808–1884), who for bibliographic reasons is to be credited with the authorship.

Vernacular names

Foxtail pine

Description

Trees to 22 m tall, d.b.h. to 2.5 m. Trunk monopodial, straight or slightly contorted, massive. Bark breaking into irregular, small plates forming tesselated patterns, or becoming deeply fissured, cinnamon or orange-brown, weathering grey in the northern population. Branches of first order short and contorted, ascending or spreading, persistent; branches of higher orders flexible and often pendent. Shoots glabrous or puberulent, with short, non-decurrent pulvini, red-brown, ageing to yellowish grey or grey. Cataphylls 5–7 mm long, subulate, scarious, brown, with entire margins, soon deciduous. Vegetative buds ovoid and acute, resinous; terminal bud 8–10 mm long; lateral buds smaller; with imbricate, appressed, subulate, red-brown scales. Fascicle sheaths deciduous and absent in second year's fascicles. Leaves in fascicles of 5, in dense tufts persisting up to 30 years, mostly connivent and spreading outward or curved forward along shoot, (1.5–)2–4 cm long, 1–1.4 mm wide; margins entire; apex acute or short acuminate; leaf colour deep green or blue-green on the smooth abaxial face, white stomatal lines on both adaxial faces. Pollen cones crowded at the proximal end of a new shoot, spreading, subtended by light brown bracts, ellipsoid, 6–10 mm long, yellow (rarely red), maturing

to brown. Microsporophylls peltate, the distal part cordate to rounded, smooth, ca. 1 mm wide. Seed cones subterminal, solitary or frequently in pairs, nearly sessile, falling after seed dispersal. Immature cones erect, ovoid, dark purple, maturing in two seasons. Mature cones ovoid-cylindric becoming more ovoid when open, 6–10 × 4–6 cm. Apophysis on seed scales thick, triangular to rhombic, transversely keeled, recurved, red-brown. Umbo dorsal, transverse-triangular at base, unarmed or terminating in a weak prickle 1 mm long. Seeds ellipsoid or narrowly obovoid, 8–10 × 4–6 mm, light brown with darker red-brown specks. Seed wings 10–12 mm long.

Taxonomic notes

The two disjunct populations have been treated as distinct subspecies or varieties, with the southern population named *P. balfouriana* subsp. *austrina*. The differences are very small and include chemical characters (terpene compounds), which are of doubtful significance in taxonomy. The populations being disjunct, it is likely that some differences can be found, e.g. in leaf colour, and that these may be partly genetic in origin. Mostly the differences involve character gradients and would appear to be not truly distinct if wide sampling was done before analysing the data. *Pinus balfouriana* appears to be closely related to *P. longaeva*, a species which occurs to the east, also in isolated populations on high mountains. There are at least some consistent differences in the morphology between these two species, but it could as well be defended that there is only a single species with two or three subspecies or varieties.

Distribution

USA: mainly California, in two disjunct populations in northern (Klamath Mts.) and in southern (Sierra Nevada) California. One locality (metapopulation) of the northern population is just across the state border in Oregon (Lanner, 2007).
TDWG codes: 73 ORE 76 CAL

Ecology

Pinus balfouriana occurs in the subalpine to alpine zones of the Klamath Mountains (the northern population) and of the southern Sierra Nevada (the southern populations). In the north it is found at altitudes of between 1600 m and 2400 m a.s.l., in the south between 2900 m and 3700 m. Stands of this pine are very open and occur on dry, rocky, exposed high slopes and ridges, usually devoid of other significant vegetation. Stands may be pure or mixed with *P. albicaulis*, sometimes *Juniperus occidentalis* grows with it, too. Regeneration and growth are extremely slow and stands commonly look as if entirely composed of veteran trees of great age. Regeneration is probably episodal and may be linked with climatic cycles. Unlike its even longer lived 'cousin' *P. longaeva*, growing only 35–40 km to the east of the Sierra Nevada, little is known about the exact ages of some of the oldest trees, but they are likely to be more than 2000 years old.

Conservation

This species may be at risk in the long term from climate change if this is continuing to accelerate, possibly bringing in competitors and/or pathogens it may not be able to cope with. At present, both disjunct populations are well protected within National Parks and National Forest Wilderness Areas and unaffected by long-term effects of fire suppression in forests as the trees usually occur in remote subalpine locations where such measures have not been undertaken. It would be profitable to study the (aut-) ecology of this species in more detail in order to be able to estimate risks under various climate change scenarios.
IUCN: NT

Uses

Foxtail pine is not a timber tree due to extremely slow growth and general inaccessibility of the stands of relatively small trees. The dense and hard wood is obviously of value for special uses like wood craft and some dead and down wood may be used for this purpose. Almost all stands of this pine are now within protected areas and felling as well as dead wood collecting are there strictly prohibited. This species was introduced to Britain in the early 1850s by the Scottish 'Oregon Association' through the services of John Jeffrey, who collected seeds of western American trees for the gentlemen who instituted

the association for this purpose. It is still in cultivation for gardens, but rare and virtually restricted to collections of trees and shrubs. Only two cultivars have been named, both in the USA

Pinus banksiana Lamb., Descr. Pinus 1: 7, t. 3. 1803. Type: Illustration in Lambert, Descr. Pinus 1: t. 3. 1803. (lectotype).

Etymology

This species has been named after Joseph Banks (1743–1820), the famous English naturalist-explorer and President of the Royal Society, who collected this species in Newfoundland in 1766.

Vernacular names

Jack pine, Black pine, Hudson Bay pine

Description

Trees to 27 m tall, but usually smaller and sometimes a shrub; trunk to 60 cm d.b.h. Bark scaly, with shallow fissures, orange- to red-brown, weathering dark grey-brown. Branches spreading or descending, with higher order branches often pendulous, forming a pyramidal or irregular to bushy crown. Shoots smooth and glabrous, slender, orange-brown or reddish brown; terminal bud ovoid, red-brown, resinous, 0.5–1 cm long; lateral buds smaller. Cataphylls with nearly entire margins. Leaves in remote fascicles of 2 held by a 3–6 mm long, persistent sheath of perular scale remnants, spreading or ascending, persisting 2–3 years, often curved and twisted and stiff, 2–4.5(–5) cm long, 1.5–2(–2.5) mm wide, light green or sometimes dark green; margins minutely serrulate; apex acute; stomata in fine lines on all surfaces. Pollen cones in small clusters, spirally arranged, cylindric, 10–15 mm long, yellow turning orange-brown. Seed cones in pairs or whorls of 2–4 (sometimes solitary) at intervals on branches, long persistent, opening soon or more often serotinous, sessile or on short stalks, oblong, 3–5.5 cm long, asymmetric, when closed strongly curved inwards towards the branch, with a tapering apex. Seed scales with generally flat or depressed, but in some cones on the exposed side nearest base more or less gibbous, light brown to tan apophyses; umbo central, small, depressed or sunken, unarmed or with a minute, reflexed prickle. Seeds obovoid, flattened, 4–5 mm long, brown to blackish, with a 10–12 mm long wing.

Distribution

N North America, from Nova Scotia and Pennsylvania to Northwest Territories and Alberta.
TDWG codes: 70 NWT 71 ABT MAN SAS 72 NBR NSC ONT QUE 74 MIN WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY PEN VER

Ecology

Pinus banksiana is a boreal to subarctic pine with a wide distribution in the lowlands of the North (max. alt. 800 m a.s.l.), where it reaches the Arctic tree line and merges with the tundra. Except for a small part of its range in Nova Scotia, it occurs in continental climate conditions with short, warm summers, and long, very cold winters and low precipitation, about half of it as snow. It grows mostly on dry, sandy soils but is also found on thin soils over granite or metamorphosed rock and on peat. This pine is highly adapted to fires, which are frequent in the taiga forests and can destroy vast areas of forest cover. Its serotinous cones rarely open without the heat of fire and remain for many years on the branches. Jack pine is the most successful coniferous pioneer after fire, producing seeds at an early age. It is often accompanied by *Betula papyrifera* or *Populus tremuloides*. Later successional phases may bring in *Picea mariana* especially in boggy situations, and *Larix laricina, Picea glauca* and *Abies balsamifera*. On the southern line of its distribution *Pinus banksiana* can be a component of a more diverse mixed forest with *Pinus resinosa* and broadleaved trees such as *Quercus* spp. and *Acer rubrum*.

Conservation

IUCN: LC

Uses

Despite its relatively small size, Jack pine is an important timber tree for pulpwood, lumber and round timber, mainly because it is the most widely distributed species of pine in Canada and its pioneer ecology guarantees even-aged stands with high

yields per ha even under natural conditions. Its wood is also used in carpentry and joinery, for containers, pallets and crates as well as particle-board. It was introduced to Europe in 1785, but has limited value in horticulture and is present only as specimen trees in most arboreta in countries or regions with a cool to cold climate. A few mutants, some from witches brooms, are grown as cultivars. Extensive planting in forestry has usually been associated with afforestation of poor sandy soils in northern regions; there it remained a small tree of irregular shape in most instances.

Pinus bhutanica Grierson *et al.*, Notes Roy. Bot. Gard. Edinburgh 38: 299. 1980. *Pinus wallichiana* A. B. Jacks. subsp. *bhutanica* (Grierson *et al.*) Businský, Acta Pruhoniciana 68: 10. 1999. Type: Bhutan: Mongar District, Tashiyangsi, 4 km N of Tschilingor, *A. J. C. Grierson & D. G. Long 2282* (holotype E).

Etymology

The species epithet refers to Bhutan, from where it was first described.

Vernacular names

Bhutan pine, Bhutan white pine

Description

Trees to 25 m tall or more; trunk to 80 cm d.b.h., bole straight and columnar. Bark smooth on young trees and on branches of large trees, becoming fissured and breaking into small scales that flake off in small chips, dark greyish brown. Branches whorled, spreading wide and sinuous, those of higher orders drooping but with upturned ends, forming a somewhat open crown. Foliage branches slender or stout, new shoots glandular pubescent, whitish pruinose, becoming pale green and then grey. Buds ovoid-conical; terminal bud 10–15 mm long; lateral buds smaller and more ovoid, slightly resinous; cataphylls grey with an orange tinge or light reddish brown. Leaves in fascicles of 5, held in deciduous, basal fascicle sheaths of orange-brown flimsy scales, persisting 1.5–2 years, very slender and flexible, 15–24 cm long, pendulous, often with a bend near the base but otherwise straight, 1 mm wide, triangular in cross-section; margins minutely serrulate; leaf colour bright green abaxially, glaucous white adaxially; stomata in fine lines on the two adaxial faces. Pollen cones in small clusters at base of new shoots, spirally arranged, with 8–12 basal perular scales remaining and partly covering the short cylindrical, yellow cones. Seed cones solitary or in whorls of 2–6, initially erect on stout, (1–)4–6 cm long peduncles, becoming pendulous when growing, cylindrical, usually slightly curved, 12–20 cm long, 3–4 cm wide when closed and 5–7 cm wide when mature and opened, usually resinous, soon falling with peduncle after seeds have been released. Seed scales cuneate-oblong, widest just below the apophysis, thin woody, only slightly flexible, with two seed cavities near adaxial base, dull red-brown with lighter marks of seed wings. Apophysis rhombic, slightly raised, obtusely keeled, light brown with darker terminal umbo. Seeds obovoid, 6–8 mm long, 4–5 mm wide, slightly flattened, brown; wing persistent, 15–22 mm long, 7–10 mm wide, grey-brown.

Taxonomic notes

This species was formerly not recognized as distinct from *Pinus wallichiana* and herbarium specimens belonging to *P. bhutanica* may remain unrecognized as the distinction is more in the habit (strongly pendulous leaves) and young shoots (not always collected). Some botanists regard it as a subspecies or variety of *Pinus wallichiana*. The identification of a seedling in China is therefore dubious, as seedling characters were not originally described from this species and no comparative study growing both species has been published.

Distribution

Bhutan; NE India: Arunachal Pradesh (Kameng district); SW China: NW Yunnan, SE Xizang [Tibet].
TDWG codes: 36 CHC-YN CHT 40 EHM-AP EHM-BH

Ecology

The species occurs in a (warm) temperate zone, from ca. 1700 m to 3050 m in Bhutan, at 2100 m in SE Xizang [Tibet], and at 1800–2200 m a.s.l. in NW Yunnan, with reports down to 1000 m in Arunachal

Pradesh. Associated species can include *Pinus wallichiana, Pinus roxburghii* (dry inner valleys) and various broadleaved trees. It has been reported from a variety of forest types, including secondary forest where logging has occurred.

Conservation

The known range of this species (extent of occurrence or EOO) does not meet the threshold for a threatened category. It is also thought to occur more widely eastwards, but botanical collecting has been virtually absent in this region since this species was first described in 1980. It is reported to be harvested as part of a mixed timber resource, but there is no evidence of decline and new localities have been found. New collections have recently been made in China (Yunnan, Gaoligong Mts.) and an assessment of the species in this area is required.
IUCN: LC

Uses

The uses as a timber tree are unknown. In horticulture, Bhutan pine has been introduced in the UK in 1979 and it now grows well in S England, as well as in Ireland (Grimshaw & Bayton, 2009: 590–591). However, it is still restricted to botanic gardens and arboreta despite its appealing habit and gracefully pendulous foliage.

Pinus brutia Ten., Fl. Napol. 1, Prodr.: lxxii. 1811–15.

Etymology

The species epithet is presumably derived from Brutium, a Roman district, now Calabria in southern Italy.

Vernacular names

Calabrian pine, Brutia pine; Kızılçam (Turkey)

Description

Trees to 30(–35?) m tall; trunk to 1.5(–2.1) m d.b.h., usually a straight bole, or slightly sinuous, sometimes forked. Bark thin, orange-brown, becoming thick only on lower trunk of large trees, then deeply fissured longitudinally, scaly, breaking into elongated plates, pale brown to red-brown. Branches long, spreading and ascending, forming a broad pyramidal or rounded, open crown. Foliage branches slender, 3–5 mm thick (to 10 mm on cone-bearing shoots), becoming rough with pulvini from fallen leaf fascicles, glabrous, new shoots glaucous green, yellowish brown and finally grey. Buds ovoid-conical, acute, 10–15 mm long, not resinous; cataphylls with recurved apices, reddish brown fringed with white hairs. Leaves in fascicles of 2 (sometimes 3), held by a 10–16 mm long, persistent sheath, retained on branchlet 2–3 years, straight and rigid, spreading, rarely lax and pendulous, (5–)10–18(–29) cm long, 1–1.5 mm wide; margins minutely serrulate; leaf colour bright or dark green; stomata in fine lines on all surfaces. Pollen cones spirally arranged, short cylindrical, 1–2 cm long, yellow. Seed cones solitary or in whorls of 2–3(–4), short pedunculate to nearly sessile, persistent, spreading forward or at right angle to shoot when full grown, narrowly or broadly ovoid-conical or ovoid to rarely subglobose when closed, (4–)6–11(–13) cm long, variously serotinous, 3–5 cm wide when closed, 5–8 cm wide when opened. Seed scales thick woody, rigid, straight, oblong; apopyses nearly flat or slightly raised, (sharply) transversely keeled and with thin rays radiating from the centre, more or less rhombic or often with a rounded upper margin, to 20 mm wide at mid-cone, lustrous red-brown weathering grey; umbo flat or depressed, 4–7 mm wide, broadly rhombic in outline, tan or grey-brown, unarmed. Seeds obovoid, slightly flattened, 6–7(–8) mm long, grey-brown, sometimes dark mottled; wing 14–20 mm long, 8–11 mm wide, oblique, grey-brown with darker streaks.

Distribution

E Mediterranean Region; around the Black Sea; Caucasus; Turkey; NW Iran; N Iraq.
TDWG codes: 13 GRC KRI TUE 14 KRY 33 NCS-KR TCS-AZ 34 CYP EAI IRN IRQ LBS-LB LBS-SY TUR

Ecology

Pinus brutia can form extensive, relatively open pine forests, either pure or mixed with *Cupressus semper-*

virens and *Juniperus excelsa*, or mixed open woodland with *Quercus coccifera* or *Q. calliprinos, Pistacio lentiscus* and other drought tolerant trees. It regenerates after fire by seed dispersal and can successfully invade maquis vegetation when this does not burn for several years. The near-coastal natural distribution of this pine coincides with the Mediterranean climate characterized by cool, wet winters and hot, dry summers. In contrast with planted forests, natural forests of *Pinus brutia* have a diverse undergrowth of shrubs and herbs and form important habitat for wildlife. The altitudinal range of this species is from near sea level to 1500 m.

Uses

Pinus brutia has been planted extensively in countries around the eastern Mediterranean and Black Sea as it is the easiest pine to grow (with *P. halepensis*) in the Mediterranean climate. It was originally described from Calabria in Italy, which is probably a planted source. Frequent use of *P. halepensis* sources from the western Mediterranean threaten to destroy the genetic distinctions between the two species, possibly also in natural stands of *P. brutia*. The latter species has a 'better' stem shape and growth from a forestry point of view and should therefore be protected. Its timber is used for fencing posts, telephone posts, building timbers, railway sleepers, carpentry, boxes and crates, hardboard and pulp. The resin of both pines has been used from ancient times to flavour white wines known as retsina and is still tapped especially in Turkey, now mainly for the production of turpentine. In horticulture its use is less common, mainly as an occasional amenity tree in villages and towns around the Mediterranean Sea; this species was also tried as a forestry plantation tree in SE Australia.

4 varieties are recognized:

Pinus brutia Ten. var. ***brutia***. *Pinus halepensis* Mill. var. *brutia* (Ten.) A. Henry, Trees Great Brit. Ireland 5: 1100. 1910; *Pinus halepensis* Mill. subsp. *brutia* (Ten.) Holmboe, [Stud. Veg. Cyprus] Bergens Mus. Skr., ser. 2, 1 (2): 29. 1914. Type not designated.

Pinus brutia Ten. var. *densifolia* F. Yaltirik & M. Boydak, Karaca Arbor. Mag. 5 (4): 175. 2000.

Description

Leaves 10–18 cm long, spreading. Seed cones ovoid-conical; apophyses red-brown.

Distribution

E Mediterranean Region; Turkey.
TDWG codes: 13 BUL GRC KRI TUE 34 CYP EAI LBS-LB LBS-SY TUR

Conservation

IUCN: LC

Pinus brutia Ten. var. ***eldarica*** (Medw.) Silba, Phytologia 58: 367. 1985. *Pinus eldarica* Medw., Trudy Tiflissk. Bot. Sada 6 (2): 21. 1903. Type: Illustration in Trudy Tiflissk. Bot. Sada 6 (2): 21. 1903 (lectotype).

Description

Seed cones ovoid-globose; apophyses slightly raised, whitish grey.

Taxonomic notes

Caucasian and Russian botanists usually refer to this taxon as a distinct species, *Pinus eldarica*; however, its distinctive characters are minor and may not warrant taxonomic recognition at all. A critical taxonomic revision involving the species pair *P. brutia – P. halepensis* is overdue and should include this taxon. The use of DNA sequence analysis in such a study is paramount, as morphology is not very informative in these species.

Distribution

Afghanistan?; Azerbaijan (near border with Georgia); Georgia; NW Iran; N Iraq.
TDWG codes: 33 TCS 34 IRN IRQ

Ecology

Semi-dry pine forests, usually mixed with sclerophyllous angiosperms in an open canopy.

Conservation

The range of this variety of *P. brutia* remains imperfectly known and an assessment of its conservation status is also made difficult for lack of information about trends at (sub)population level.
IUCN: DD

Pinus brutia Ten. var. ***pendulifolia*** Frankis, in Taskin (ed.), Papers Int. Symp. *Pinus brutia* Ten.: 14. 1993. Type: Turkey, Mugla, near Kayadibi, *M. P. Frankis 63* (holotype E).

Description

Leaves 18–29 cm long, pendulous. Seed cones ovoid-conical; apophyses red-brown.

Distribution

Turkey, Mugla Prov.
TDWG codes: 34 TUR

Conservation

IUCN: LC

Pinus brutia Ten. var. ***pityusa*** (Steven) Silba, Phytologia 58: 367. 1985. *Pinus pityusa* Steven, Bull. Soc. Imp. Naturalistes Moscou 11: 49. 1838. Type not designated.

Pinus pityusa Steven var. *stankewiczii* Sukaczev, Bot. Zurn. (St. Petersburg) 1: 37. 1906; *Pinus brutia* Ten. var. *stankewiczii* (Sukaczev) Frankis, in Taskin (ed.), Papers Int. Symp. Pinus brutia Ten.: 14. 1993.

Description

Leaves 5–8 cm long, rigid and spreading. Seed cones ovoid-conical; apophyses red-brown.

Distribution

Caucasus: Krasnodar, Transcaucasia (Abkhazia); Georgia; Ukraine: Krym [Crimea].
TDWG codes: 14 KRY 33 NCS-KR TCS-AB TCS-GR

Conservation

IUCN: VU [B2ab (ii, iii, v)]

Pinus bungeana Zucc. *ex* Endl., Syn. Conif.: 166. 1847. Type not designated. Fig. 211, 212

Etymology

This species was named after the Russian botanist Alexander Andrejewitsch von Bunge (1803–1890).

Vernacular names

Lace-bark pine; bai pi song (Chinese)

Description

Trees to 25–30 m tall; trunk monopodial or multi-stemmed from a short length above base, to 3 m d.b.h. Bark smooth, hard, irregularly exfoliating with thin flakes, exposing light patches, which later turn from yellow-green to purplish brown, creating a multi-coloured pattern on trunk and large branches. Branching ascending or assurgent, forming a broadly domed or flat-topped crown in older trees. Foliage branches slender, smooth, glabrous, grey-green. Buds ovoid, to 10 mm long, not resinous; cataphylls imbricate, red-brown. Leaves in remote fascicles of 3, held by a deciduous basal sheath, spreading, straight, rigid, 6–10 cm long, smooth, up to 2 mm wide, broadly triangular in cross-section; apex acute, leaf colour light green or slightly glaucous; stomata on all surfaces. Pollen cones in elongated clusters on new shoots, spirally arranged, axillary to broad cataphylls, ovoid-cylindrical, 10–15 mm long. Seed cones solitary on short peduncles or nearly sessile, erect or spreading, broadly ovoid to subglobose when open, 5–7 cm long, 4–5(–6) cm wide, turning from pale green to light brown. Seed scales relatively few, broadly cuneate-oblong, woody and rigid. Apophysis much thickened, more or less rhombic in outline, strongly transversely keeled; umbo dorsal, more or less central, broadly triangular, armed with a rigid, curved and sharp prickle or spine. Seeds obovoid, 8–10 × 5–6 mm, dull brown, with a reduced wing of only 4–5 mm which easily detaches from the seed.

Distribution

China: Beijing (Xi Shan), SE Gansu, S Hebei, W Henan, Hubei (Badong Xian, Wudang Shan), Shaanxi, Shandong (Lao Shan), Shanxi, N Sichuan.
TDWG codes: 36 CHC-HU CHC-SC CHN-BJ CHN-GS CHN-HB CHN-SA CHN-SD CHN-SX CHS-HE

The geographic range given above is based on the mapping of herbarium specimens, mostly in Beijing (PE)*, which we believe have been collected from trees growing in the wild. This map is roughly in agreement with that given by Ying *et al.* (2003). Other sources mention a wider distribution but seem to include planted specimens as well. This species is highly ornamental and has been planted in temple grounds etc. for many centuries.

* courtesy Dr. Qiaoping Xiang, Institute of Botany, Chinese Academy of Sciences, Beijing.

Ecology

Pinus bungeana occurs in mountains, often on limestone rocks and on S-facing slopes, scattered and mixed with *P. tabuliformis* and angiosperms. In the northern part of its range it is also common on acid soils. Its altitudinal range is probably between 500 m and 2150 m a.s.l.; records from lower elevations are probably not from natural occurrences, but from planted trees. It is a light demanding species and therefore is usually restricted to sites less suitable for other trees, especially angiosperms.

Conservation

IUCN: LC

Uses

Lace-bark pine is a decorative tree because of its patterned bark reminiscent of plane (*Platanus*), but more colourful (although in old trees becoming nearly white) and it is commonly cultivated in China as an amenity tree. It has traditionally been planted around temples and in cemeteries in northern China and Korea, from where some of the earlier records of the species originate, including that by Alexander von Bunge in Beijing in 1831. It was introduced to England in 1843 but is still not very common in gardens and parks of Europe. Of lesser importance is the use of its timber, but in NE China it is locally a source for roundwood such as poles as well as construction timber, fences and gates, and utilities such as boxes, crates and pallets, while more refined applications are in furniture and veneers. The seeds are edible and are used in traditional Chinese medicine to alleviate respiratory ailments.

Pinus canariensis C. Sm., in Buch, Phys. Beschr. Canar. Ins.: 159. 1825. Type: Macaronesia: Canary Islands, *C. Smith (1) s.n.* (lectotype C). Pl. 27

Etymology

The species epithet refers to the Canary Islands, where this pine is native.

Vernacular names

Canary pine, Canary Islands pine; pino canario (Spanish)

Description

Trees to 45 m tall; trunk to 2.5 m d.b.h., straight or slightly curved. Bark becoming thick on trunk, breaking into large, irregular plates divided by deep fissures, exfoliating in smaller chips exposing patterns of grey, white, purplish and red-brown colours. Branches spreading and assurgent, lower branches curving down, sometimes slowly or poorly self-pruning, forming rounded or in old trees domed to flat-topped crowns. Foliage branches slender or stout, glabrous, rough with pulvini from fallen leaf fascicles, yellowish green becoming brown-grey. Buds large, the terminal bud to 3.5 cm long, ovoid-conical, acute, scarcely resinous; cataphylls lanceolate, orange-brown, with white fringed margins and reflexed apex. Primary leaves on seedlings short, lax, bluish, long retained and often re-appearing on epicormic shoots in mature trees. Leaves in fascicles of 3, held in persistent, 15–20 mm long sheaths, retained for 2 years, forming short but dense tufts at ends of upturned branches, spreading or slightly drooping, 20–30 cm long, pliant, 1.5–2 mm wide, bright green; margins serrulate; apex acute; stomata in fine lines

on all faces, more conspicuous on the two adaxial sides. Pollen cones numerous in long clusters along lower part of new shoots, spirally arranged, subtended by fringed cataphylls, ovoid-cylindrical, yellow. Seed cones solitary or with 2–3 in a whorl on stout peduncles, erect but soon becoming reflexed or pendant, 10–20(–25) cm long, narrowly ovoid when closed, broadly conical with a flat base when opened, when falling a few basal scales may be left on the branch. Seed scales spreading wide, oblong, thick woody, rigid, dark brown with lighter seed wing marks. Apophysis prominently raised, more or less rhombic, strongly transversely keeled, sometimes with additional radial ridges, lustrous red-brown or buff; umbo prominent, obtuse, darker coloured. Seeds obovoid, 12–15 mm long, brown; wing adnate (persistent), oblique, 30–35 mm long, dark grey or grey-brown with dark streaks.

Distribution

Macaronesia, Canary Islands (La Palma, Tenerife, Gran Canaria, El Hierro).
TDWG codes: 21 CNY

Ecology

In the Canary Islands this species occupies fairly extensive forest areas above an altitude of 1200 m to ca. 2200 m a.s.l. It grows well on exposed mountain slopes of volcanic origin amidst or on old lava flows and on scoria. Winter snow and frost limit its altitudinal range upwards (Pico del Teide is 3718 m); at lower elevations a thermophile woodland and/or xerophytic scrub vegetation, interspersed with rare evergreen lauraceous woodland on N-facing slopes and in moist gullies, dominates. *Pinus canariensis* is dominant within this pine belt where it exists, but spring-flowering leguminose and other herbs and shrubs may be common. Some common shrubs are *Adenocarpus foliolosus, Chamaecytisus proliferus*, and *Cistus symphytifolius*. The pine woods are characteristically very open and sunny and often there is nothing else on the ground than rocks, pine needles and great numbers of the large seed cones rolled into hollows.

Conservation

Extensive logging in the past combined with destructive forest fires at one time reduced the area of occupancy (AOO) very substantially. However, extensive replanting since the 1950s and regrowth and better management, as well as cessation of exploitation, have restored most of the pine forests, even if large trees are now very rare. The fire hazard still remains and may become more acute with the ever increasing tourism and its ramifications, and with climate change if this tends to lengthen periods of drought on the islands where this species is indigenous. Development, especially on Tenerife, is encroaching into the pine belt ("corona forestal"), which once encircled the volcano and mountain spur to the NE, but is no longer contiguous.
IUCN: LC

Uses

Pinus canariensis was heavily exploited for its timber in the 19th and early parts of the 20th century; the wood was exported. Reforestation with this species has been sucessful, but today the timber is considered less important than the water retaining capacity of the belt of pine forest especially on Tenerife and Gran Canaria. The ever increasing tourism and development of built areas put a great demand on limited resources of drinking quality water, which even with ample precipitation on the western islands would be quickly lost downhill and into the sea through the extensive areas of scoria and cavernous lava flows, if it were not for the water retaining capacity of the pine forest belt. This species has been introduced to Italy and South Africa as a forestry plantation tree. Its wood is suitable for building timbers because of its good strength, and is widely used in light construction, carpentry, wall panelling, turnery, and marquetry. Mass uses as for pit props in mining and chipboard are now discontinued, as forests are required to regrow to former extent and capacity after a period of overexploitation. In horticulture it is uncommon, but present in gardens and parks in the Mediterranean region and in some arboreta elsewhere in countries with a similar climate. Growing this and other pines from warm climates under glass in cooler countries will not succeed; pines need the movement of wind to

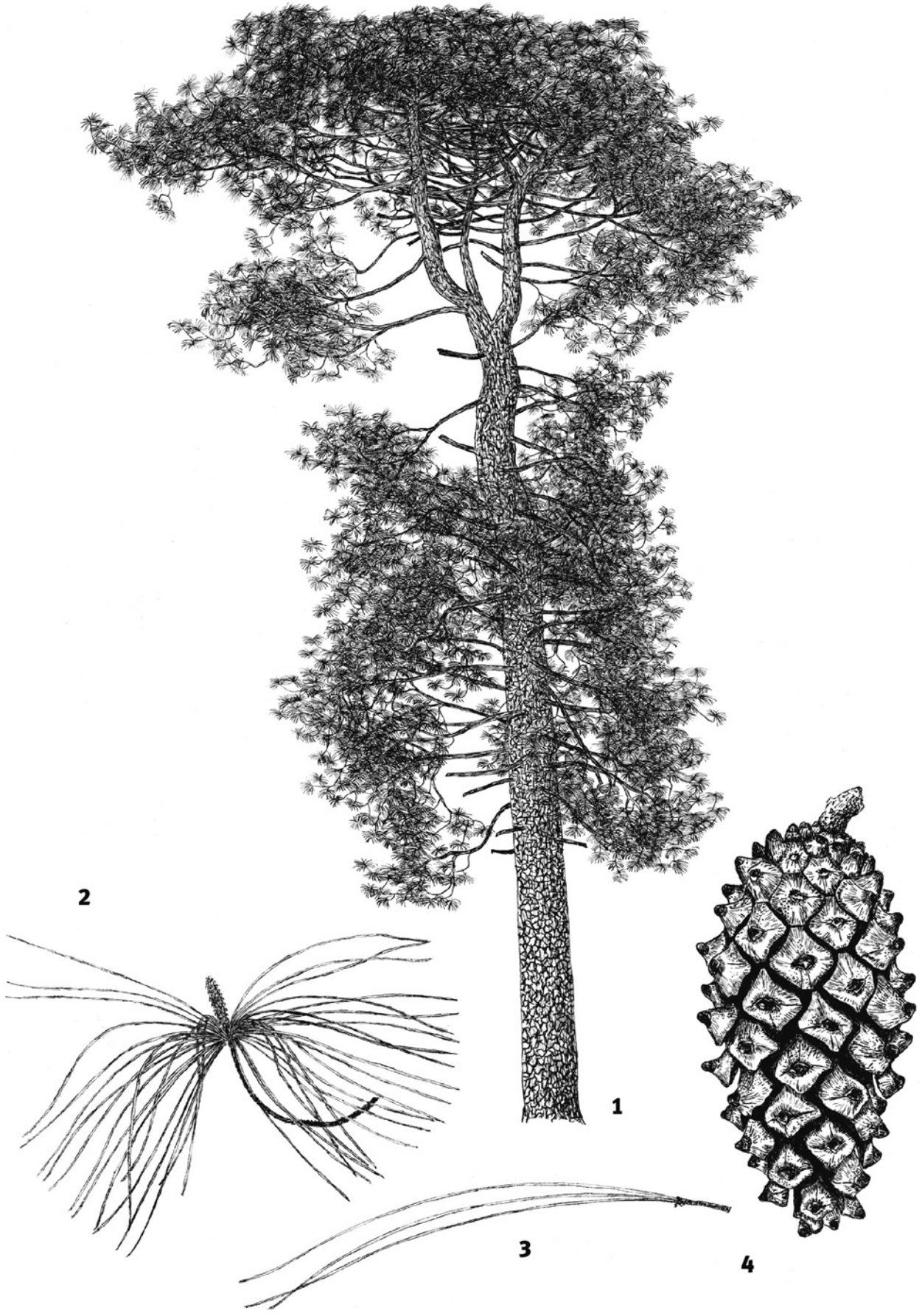

PLATE 27. *Pinus canariensis*. **1.** Habit of tree. **2.** Branchlet with leaves. **3.** Leaves. **4.** Seed cone.

build stems that can support a crown. Specimens I have seen in glasshouses beyond sapling size had to be hung from the ceiling by a steel wire.

Pinus caribaea Morelet, Rev. Hort. Côte d'Or 1: 107. 1851.

Etymology

The species epithet refers to its occurrence in the Caribbean; the species was originally described from Isla de la Juventud [Isla de Pinos] in Cuba.

Vernacular names

Caribbean pine; pino de la costa, pino colorado, pino macho (Spanish)

Description

Trees to 20–35(–45) m tall, d.b.h. to 50–100 cm; trunk monopodial, erect. Bark rough, scaly, breaking into irregularly square plates, grey-brown. Branches spreading or ascending, of higher orders similar, or drooping. Crown broad conical, open or irregular. Shoots multi-nodal, very rough, resinous; with large, short decurrent and persistent pulvini. Cataphylls 15–20 mm long, subulate, strongly recurved, scarious, with hyaline-ciliate margins, dark brown. Vegetative buds ovoid-oblong to cylindrical; terminal bud 20–25 mm long, but lateral buds smaller, ovoid-acute, (slightly) resinous. Fascicle sheaths 15–20 mm long, retaining their length or reduced to ca. 10 mm at maturity. Leaves in fascicles of (2–)3(–4), very rarely 5, persisting 3 years, straight, (slightly) twisted, rigid, (12–)15–26(–28) cm long, (1.2–)1.4–1.8 mm wide; margins serrulate; apex acute-pungent; leaf colour light or dark green (occasionally glaucous green), more or less lustrous. Stomata conspicuous on all faces of leaves, in 8–11(–14) lines on the convex abaxial face and 4–6 lines on each adaxial face. Pollen cones cylindrical, often curved when mature, 2–3 cm × 5–6 mm, pink or yellow, turning yellowish or reddish brown. Seed cones subterminal, mostly in pairs or whorls of 3–5(–8), on 2–2.5 cm long peduncles, ovoid-conical or ovoid when opened, more or less symmetrical but base obliquely flattened, (4–)5–12(–13) × (3–)4–6(–7) cm when open. Seed scales oblong, straight or recurved, dark (purplish) brown or blackish brown. Apophysis raised or nearly flat on basal scales, rhombic to pentagonal in outline, transversely keeled, up to 15 mm wide, ochraceous, light or dark brown, lustrous. Umbo dorsal, flat or slightly raised or pyramidal and curved upward, with a minute, persistent prickle. Seeds obovoid, slightly flattened, 5–7 × 2.5–3.5 mm, light grey-brown with dark spots, or dark brown to blackish. Seed wings articulate or adnate, obliquely ovate or oblong, 10–20 × 5–8 mm, thin, semi-transparent, yellowish grey or light brown with dark stripes.

Distribution

West Indies: Bahamas, Turks-Caicos Islands, W Cuba (including Isla de la Juventud [Isla de Pinos]); Mexico (S Quintana Roo); N Guatemala; Belize; Honduras (including Islas de la Bahía); Nicaragua.
TDWG codes: 79 MXT-QR 80 BLZ GUA HON NIC 81 BAH CUB TCI

Ecology

See under varieties.

Uses

Pinus caribaea, and especially the Mesoamerican variety *hondurensis*, is an important timber tree forming easily accessible, extensive stands in level to moderately hilly terrain. As such it is heavily exploited and although not in danger of extinction in any of its major areas, many local and especially outlying populations which are likely to be genetically distinct are now severely degraded (Dvorak & Donahue, 1992). One of these is Ejido Caobas, Quintana Roo, Mexico, which is the northernmost occurrence of *P. caribaea* var. *hondurensis*. *Pinus caribaea* has been widely planted as a timber tree in tropical and subtropical lowland areas around the world. The heavily resinous wood is used for building, crates, pallets, boat decks, poles and posts, plywood, and particleboard, as well as for pulp manufacture. The latter use comes primarily from plantations outside its natural range. In Honduras, trees have been widely tapped for resin, but this activity has become less common recently. This species is scarcely known in horticulture and can only be grown successfully in the subtropics and tropics.

3 varieties are recognized:

Pinus caribaea Morelet var. ***caribaea***. Type: Cuba: Isla de la Juventud [Isla de Pinos], Santa Barbara, *H. A. Lückhoff 11608* (neotype PRF).

Description

Fascicle sheaths 15–20 mm long, retaining their length at maturity. Leaves in fascicles of 3(–4), very rarely 2 or 5, (13–)15–26 cm long, (1.2–)1.4–1.8 mm wide, light or dark green. Seed cones (4–)5–10(–12) × (3–)4–6(–7) cm when open; apophysis rhombic to pentagonal in outline, ochraceous or light brown, lustrous. Cotyledons (4–)6–7(–9), 12–25 mm long. Seedlings with an elongated stem; primary leaves green, more or less ascending, soon replaced by secondary leaves.

Distribution

West Indies: W Cuba, Pinar del Río; Isla de la Juventud [Isla de Pinos].
TDWG codes: 81 CUB

Ecology

Forming pure, open, dry fire-climax forest or open woodland with undergrowth of grasses or scattered shrubs on sandy or gravelly, well-drained, acidic soils. Altitudinal range from 1–700 m a.s.l., with most extensive stands below 400 m. The growing is season continuous in a warm tropical climate with long dry spells. Annual precipitation varies mainly with altitude, between ca. 1000–1800 mm, with a winter dry season. Frost does not occur.

Conservation

IUCN: EN [B2ab (ii, iii, v)]

Pinus caribaea Morelet var. ***bahamensis*** (Griseb.) W. H. Barrett & Golfari, Rev. Hort. Côte d'Or 1: 107. 1851. *Pinus bahamensis* Griseb., Fl. Brit. W.I.: 503. 1864. Type: Bahamas: New Providence, *L. Golfari 77571* (neotype BAB).

Description

Fascicle sheaths 15–20 mm long, reduced to ca. 10 cm at maturity. Leaves in fascicles of 3(–2), on Grand Bahama 2–3, (13–)15–26 cm long, (1.2–)1.4–1.8 mm wide, light or dark green. Seed cones (4–)5–10(–12) × (3–)4–6(–7) cm when open; apophysis rhombic to pentagonal in outline, ochraceous or light brown, lustrous. Cotyledons (4–)6–7(–9), 12–25 mm long. Seedlings with an elongated stem; primary leaves green, more or less ascending, soon replaced by secondary leaves.

Distribution

Bahamas: on Grand Bahama, Great Abaco, New Providence and North and South Andros Islands in the north; on Great Inagua Island in the south. Also on the Turks and Caicos Islands in three distinct subpopulations at Pine Cay, North Caicos and Middle Caicos.
TDWG codes: 81 BAH TCI

Ecology

On flat to rolling, eroded limestone rock with pockets of sandy alkaline soil, or on sandy spits and old beaches, forming pure, open fire-climax stands, usually with scattered or dense undergrowth of shrubs (often *Sabal palmetto*); also invading open scrubland forming secondary forest. Altitudinal range 1–10 m a.s.l. Annual precipitation decreases from ca. 1500 mm on Grand Bahama to ca. 1000 mm on South Andros in the northern Bahamas (750 mm on TCI); mean annual temperature is ca. 25° C and frost does not occur. Hurricanes are a recurring destructive factor.

Conservation

In the Turks-Caicos Islands an epidemic of an accidentally introduced scale insect (*Toumeyella parvicornis*) has in recent years led to serious dieback affecting 90% or more of the three subpopulations on these islands (Martin Hamilton, RBG Kew, pers. comm. 2006). In 2007, a conservation programme has been started, using apparently resistant individual trees that have been found growing among infested and dead trees. The infestation has not yet occurred in the Bahamas and was probably caused by importing infested young cut pines from the USA as Christmas trees in the late 1990s.
IUCN: VU [B2ab (ii–v)]

Pinus caribaea Morelet var. ***hondurensis*** (Sénécl.) W. H. Barrett & Golfari, Caribbean Forest. 23: 65. 1962. *Pinus hondurensis* Sénécl., Conif.: 126. 1868. Type: Belize: El Cayo, San Pastor Pine Ridge, Chiquibul F.R., Angel's Drive, *W. H. Barrett 77582* (neotype BAB).

Description

Fascicle sheaths 15–20 mm long, retaining their length at maturity. Leaves in fascicles of 3 (rarely 2, 4, very rarely 5), (12–)16–28 cm long, (1.2–)1.4–1.8 mm wide, light green, occasionally glaucous green. Seed cones (4–)5–12(–13) × 3.5–7 cm when open; apophysis rhombic to pentagonal in outline with upper margin irregularly undulate, chestnut-brown, lustrous. Cotyledons 5–8, 20–35 mm long. Seedlings with an elongated stem; primary leaves glaucous, more or less spreading, development of secondary leaves delayed.

Distribution

Mexico (S Quintana Roo); Belize; N & E Guatemala; Honduras (including the Islas de la Bahía); Nicaragua.
TDWG codes: 79 MXT-QR 80 BLZ GUA HON NIC

Ecology

Mainly distributed on the lowland coastal plains within the Atlantic climatic influence, from the edges of mangrove swamps to lower upland "bunch-grass/pine savannas". It occurs on well-drained, sandy or gravelly, acidic soils, forming pure (or sometimes mixed with *P. oocarpa* and/or *P. tecunumanii*) fire-climax forest, or pine-oak forest, with undergrowth of grasses, *Pteridium aquilinum*, or *Sabal palmetto* nearer the coast, possibly replacing broad-leaved rainforest under human influence in many areas. The altitudinal range is 1–700(–1000?) m a.s.l. Annual precipitation varies greatly, from the highest measurement at Laguna del Pinar in Nicaragua (ca. 4000 mm) to the lowest at Los Limones in the interior of Honduras (ca. 660 mm). Mean annual temperature is from 21–27° C and no frosts occur.

Conservation

IUCN: LC

Pinus cembra L., Sp. Pl. 2: 1000. 1753. Type: Illustration: "*Larix sempervirens, foliis quinis, nucleis edulibus*" in Breyn in Acad. Caes.-Leop. Carol. Nat. Cur. Ephem. 7: 8, t. 1. (1719). (lectotype). Fig. 213, 214

Etymology

The species epithet is from the Italian vernacular name cembro for this pine.

Vernacular names

Arolla pine, Swiss stone pine; Arve, Zirbel (German); auvier, pin arôle (French); cembro (Italian); limba (Polish); borovice limby (Slovak)

Description

Trees to 25 m tall; trunk to 1.5 m d.b.h., often crooked and stunted at high altitude. Bark smooth and orange-brown on young trees and on branches, becoming scaly and deeply fissured on trunks of large trees, turning grey with red-brown fissures. Branches spreading and assurging, forming a broadly conical crown, often flat-topped in exposed trees. Foliage branches slender to stout, initially with a dense, brown pubescence, then glabrous, smooth, light brown. Buds small, ovoid-conical, without resin; cataphylls reddish brown. Leaves in dense tufts towards end of shoots, persiting 2–4 years, in fascicles of 5 held by deciduous basal sheaths of thin, orange-brown scales that fall away in the second year, spreading wide or forward, straight or slightly curved, more or less rigid to flexible but not lax, (6–)7–9 cm long, triangular in cross-section, not twisted, 1–1.5 mm wide; margins minutely serrulate; leaf colour green; stomata in white lines predominantly on the two adaxial faces, a few stomata may occur on abaxial side. Pollen cones clustered, spirally arranged, short cylindrical, initially reddish turning red-brown. Seed cones intitially erect, becoming patent, single or in 2–3 in whorls on very short peduncles, remaining closed or opening only slightly at maturity, from green or glaucous green to purplish when growing, resinous, broadly ovoid, 5–8 cm long, 4–6 cm wide, dark brown when ripe. Seed scales imbricate, widely cuneate proximally, with 2 deep seed cavities adaxially, soft woody. Apophysis broadly rhombic or widely triangular to semi-orbicular,

thickened; margins free or slightly reflexed; umbo terminal, triangular, obtuse, pale brown. Seeds oblong-obovoid, 10–16 × 6–8 mm, without a wing or wing rudimentary.

Distribution

Europe: Alps, Carpathians.
TDWG codes: 11 AUT-AU CZE-CZ CZE-SL GER POL SWI 12 FRA-FR 13 ITA-IT ROM YUG-BH 14 UKR-MO UKR-UK

Ecology

In the inner valleys of the Alps *Pinus cembra*, together with *Larix decidua*, forms open conifer forest and woodland up to the tree line at between 2200 and 2600 m altitude. Arolla pine may descend down to 1200 m, where it is usually a rare component of conifer forest dominated by *Picea abies*. Centuries of intensive grazing mainly with cattle have brought the tree line in the Alps down and turned much of the ancient forest into pasture woodland. This vegetation is in places dominated by *Ericaceae* such as *Vaccinium myrtillus* and *Rhododendron ferrugineum*, grasses and herbs. However, more recently alpine grazing has been substantially reduced and the forest is making a come-back on many slopes. Arolla pine is dependent on the European Nutcracker (*Nucifraga caryocatactes, Corvidae*) for its effective seed dispersal and the birds carry the seeds and therewith the pines up slope. *Pinus cembra* is most probably a Siberian element in the European flora and is resistant to –40° frost; unlike accompanying the larches, *P. cembra* has evergreen foliage and it reduces the water content in the needles during winter to a minimum. *Pinus cembra* is slow growing and can live to great age (>1000 years in the Swiss Aletschwald) having rot-resistant wood.

Conservation

IUCN: LC

Uses

Arolla pine is not a significant timber tree due to its slow growth and commonly curved or contorted shape, although the tree can grow quite straight and to considerable size in protected localities. As it grows with European larch and the latter is much more valued for timber, forestry practises tend to favour the latter, which in succesional terms is the pioneer species. The wood has been used for the building of traditional houses and is valued for special uses such as joinery, panelling, cabinet making, tools, and wood turning. The seeds, though edible, are difficult to harvest due to the soft, resinous and closed cone scales and are consequently mostly left to the birds. As an ornamental tree it is quite valuable, but it is sensible to 'late frosts' as are other conifers from very cold regions where spring means spring and is not interrupted by a brief return to winter. Despite this, a number of cultivars are known, both with distinct habit and with divergent needle colours; they are particularly well grown in northern and eastern Europe.

Pinus cembroides Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 1: 392. 1832.

Etymology

The species epithet means 'similar but not equal to *cembra*', i.e. *Pinus cembra* L.

Vernacular names

Pinyon pine, Mexican nut pine; piñón (Spanish)

Description

Shrubs or trees 3–15(–25) m tall, d.b.h. to 10–80 (–120) cm. Trunk monopodial, very short (shrubs) to medium size, branching low. Bark thick, rough and scaly, breaking into small, irregular, shaggy plates, grey or greyish brown. Branches spreading or trailing on the ground, or ascending. Crown an open or dense shrub or broad, open, irregular. Shoots orange-brown or slightly glaucous at first, soon grey. Cataphylls small, 2–4 mm long, subulate or triangular, acute-acuminate, with erose margins, light brown, caducous. Vegetative buds ovoid-oblong to oval-cylindrical; terminal bud 5–8(–10) ×x 3–5 mm; lateral buds smaller, not or slightly resinous, light brown or ochraceous. Fascicle sheaths short, 4–6 mm long, loosely imbricate, the scales (pale) brown, soon recoiling, then pale straw-coloured to grey, forming a small rosette at base of fascicle but

deciduous before the leaves fall. Leaves in fascicles of (2–)3(–4, rarely 5), persisting (3–)4–5(–7) years, curved or less often straight, lax or sometimes rigid, (2–)3–6(–8) cm long, (0.6–)0.7–1(–1.2) mm wide; margins entire; apex acute-acuminate or pungent; leaf colour variable, dull green to glaucous green, with or without white adaxial faces; leaves sometimes producing a few resin drops. Stomata: leaves amphistomatic, or epistomatic in one variety, in 2–3(–4) lines on the convex abaxial face (or none), in 2–3(–4) lines on each adaxial face. Pollen cones small, ca. 5 × 3 mm, yellowish. Seed cones solitary, paired or more rarely in whorls of 3, on very short, 3–5(–8) mm long peduncles remaining with fallen cones. Mature cones seemingly sessile, irregularly globose or ovoid-globose when closed, spreading often wider than long when opened, with a flattened base, irregular in size and shape, often resinous, (2–)3–5(–7.5) × 3–6(–7) cm when open. Seed scales parting easily and widely, more or less weakly attached to the rachis and hence moveable, up to 15–20 mm wide, concavo-convex, with 1–2 deep seed cavities. Apophysis raised, transversely keeled or radially keeled, rhombic to pentagonal in outline but irregular, in all shades from yellowish green or ochraceous to reddish brown, sometimes lustrous. Umbo dorsal, flat or raised and curved, with a minute prickle. Seeds obovoid-oblique, 10–16 × 6–10 mm, greyish brown to blackish grey, or light brown; integument thick, 0.5–1(–1.1) mm; megagametophyte ('endosperm') pinkish or white when fresh. Seed wings absent.

Distribution

SW USA: SE Arizona, SW New Mexico, SW Texas; Mexico: from the Sierra Madres to South-Central Mexico and in Baja California (Sierra de la Laguna). **TDWG codes:** 76 ARI 77 NWM TEX 79 MXC-DF MXC-ME MXC-PU MXC-TL MXE-AG MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-BS MXN-SO MXS-JA

Ecology

In much of its range, *Pinus cembroides* occupies a transition zone between (semi-)desert plateaux and valleys and more mesic coniferous montane forests. The altitudinal range is extensive: (800–)1500–2600(–2800) m a.s.l., with highest occurrences in the SE of its range. It grows on a variety of substrates, ranging from alluvial bajadas to volcanic rock, usually on scarcely developed soils. It forms open woodland alone or mixed with *Juniperus* spp., *Pinus nelsonii, P. pinceana, Quercus, Yucca, Agave, Cactaceae* (e.g. *Opuntia*), *Arctostaphylos, Ceanothus, Arbutus* and other shrubs of dry, hot areas; at higher and/or moister sites it forms part of a mixed pine-oak woodland or forest including, e.g. *Pinus arizonica, P. engelmannii, P. leiophylla* var. *chihuahuana*, and *P. pseudostrobus* in the southeastern part of its range. The climate is warm and dry, with annual precipitation varying from 380–650 mm and a dry season of 7–8 months. Frost may occur at higher elevations in the interior, but is infrequent. There is an important mutualist relationship with the corvid birds *Aphelocoma coerulescens* and *Gymnorhinus cyanocephalus* (Tomback & Linhart, 1990), which feed on the seeds and cache them, thereby providing an effective dispersal mechanism.

Uses

Although not a timber tree in most areas due to its low stature and low and heavy branching, *Pinus cembroides* is nevertheless an economically important species of pine in Mexico. Its principal value for local economies lies in the edible seeds (piñones), which are regularly harvested and marketed. Further use is made of its wood for carpentry, or sometimes for timber where there is no other pine species available, as in Baja California Sur. Due to its adaptation to semi-arid environments and extensive range it is also an important shrub or tree for aspects of land management, such as watershed protection, prevention of erosion, and as a shade tree in agroforestry. Pinyon pines are uncommon in cultivation and mostly seen in arboreta and botanic gardens and in some urban landscaping schemes mainly in SW USA

3 subspecies and 2 varieties are recognized:

Pinus cembroides Zucc. subsp. ***cembroides*** var. ***cembroides***. Type: Mexico: México, Sultepec, Santa Cruz, *F. Karwinski s.n.* (holotype M). Fig. 215, 216

Description

Small tree to 10–15 m tall. Leaves in fascicles of 2–3, lax or sometimes rigid, (2–)3–5(–6.5) cm × (0.6–) 0.7–1 mm; leaf colour variable, dull green to glaucous green especially on adaxial faces. Seeds 10–13 × 6–10 mm; integument thick, 0.6–1 mm; megagametophyte pinkish when fresh.

Distribution

SW USA: SE Arizona, SW New Mexico, SW Texas; Mexico: NE Sonora, Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León, W Tamaulipas, San Luís Potosí, Aguascalientes, NE Jalisco, N Guanajuato, Querétaro, Hidalgo, México, Distrito Federal, Tlaxcala, Veracruz and Puebla.
TDWG codes: 76 ARI 77 NWM TEX 79 MXC-DF MXC-ME MXC-PU MXC-TL MXE-AG MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXN-SO MXS-JA

Conservation

IUCN: LC

Pinus cembroides Zucc. subsp. ***cembroides*** Little var. ***bicolor*** Little, Phytologia 17: 331. 1968. *Pinus discolor* D. K. Bailey & Hawksw., Phytologia 44: 130. 1979; *Pinus culminicola* Andresen & Beaman var. *discolor* (D. K. Bailey & Hawksw.) Silba, Phytologia 56: 490. 1985. Type: USA: Arizona, Santa Cruz Co., Madera Canyon, Coronado National Forest, Santa Rita Mountains, Madera Canyon, *E. L. Little 23011* (holotype US).

Pinus johannis Rob.-Pass., Adansonia, sér. 2, 18: 366. 1978; *Pinus culminicola* Andresen & Beaman var. *johannis* (Rob.-Pass.) Silba, Phytologia 56: 491. 1985. Type: Mexico: Zacatecas, Concepción del Oro, Puerto el Dique, *M. F. Robert & J. Passini 5936B* (holotype P).

Description

Shrubs or small trees to 3–12 m tall. Leaves in fascicles of 3, rarely 2, 4 or 5, more or less rigid, 2.5–5(–6) cm × 0.8–1.2 mm, dull green to grey-green on abaxial face, usually glaucous white on adaxial faces, divided by a green midrib. Seeds 10–12 × 6–9 mm, integument thick, 0.5–1 mm; megagametophyte white when fresh.

Distribution

SW USA: SE Arizona, SW New Mexico; Mexico: NE Sonora, Chihuahua, Coahuila, Nuevo León, W Tamaulipas, Durango, Zacatecas, N & W San Luís Potosí.
TDWG codes: 76 ARI 77 NWM 79 MXE-CO MXE-CU MXE-DU MXE-NL MXE-SL MXE-TA MXE-ZA MXN-SO

Conservation

IUCN: LC

Pinus cembroides Zucc. subsp. ***lagunae*** (Rob.-Pass.) D. K. Bailey, Phytologia 54: 98. 1983. *Pinus cembroides* Zucc. var. *lagunae* Rob.-Pass., Bull. Mus. Hist. Nat. (Paris), ser. B, Adansonia 1: 64. 1981; *Pinus lagunae* (Rob.-Pass.) Passini, Phytologia 63: 337. 1987. Type: Mexico: Baja California Sur, Sierra de la Laguna, La Laguna, *M. F. Robert 10021* (holotype P).

Description

Trees to 20–25 m tall. Leaves in fascicles of (2–)3, very rarely 4, lax, (2.5)4–7(–8) cm × (0.7–)0.8–0.9 mm, dull green to greyish green. Seeds 10–16 × 6–10 mm; integument thick, 0.5–0.8 mm; megagametophyte pinkish when fresh.

Distribution

Mexico: Baja California Sur (Sierra de la Laguna).
TDWG codes: 79 MXN-BS

Conservation

The extent of occurrence (EOO) of this subspecies is estimated to be 20,000 ha; it is endemic in the Sierra de La Laguna. The trees now enjoy some form of protection, but have been exploited for local use, which is estimated to have led to a decline. As a small population it is prone to destruction by fires if these were extensive or frequent. To what extent, if any, the pines are dependent on fire in order to compete with oaks is not known. Access roads on the mountain are few and primitive.
IUCN: VU (D2)

Pinus cembroides Zucc. subsp. ***orizabensis*** D. K. Bailey, Phytologia 54: 89. 1983. *Pinus cembroides* Zucc. var. *orizabensis* (D. K. Bailey) Silba, Phytologia 68: 48. 1990; *Pinus orizabensis* (D. K. Bailey) D. K. Bailey & Hawksw., Novon 2: 306. 1992. Type: Mexico: Puebla, Soltepec, along Hwy. 140, ca. 10 km SW of San Salvador el Seco, *D. K. Bailey 83–01* (holotype MEXU). Fig. 217

Description

Small trees to 8–10 m tall. Leaves in fascicles of 3(–4, rarely 2 or 5), more or less rigid, (2–)3–5(–6) cm × 0.7–1.1 mm, dull green to greyish green. Seeds 10–14 × 6–10 mm; integument thick, 0.7–1.1 mm; megagametophyte pinkish when fresh.

Distribution

Mexico: Puebla, Tlaxcala, Veracruz.
TDWG codes: 79 MXC-PU MXC-TL MXG-VC

Conservation

This subspecies occurs in areas where agriculture is expanding and woods are cleared. There is for this reason a continuous decline of area of occupancy (AOO) and likely of mature trees.
IUCN: EN [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Pinus clausa (Chapm. *ex* Engelm.) Sarg., [Rep. Forests N. America] U.S. 10th Census 1880, vol. 9: 199. 1884. *Pinus inops* Aiton var. *clausa* Chapm. *ex* Engelm., Bot. Gaz. 2: 125. 1877. Type not designated (possibly a collection from near Apalachicola, Florida, USA by A. W. Chapman).

Pinus clausa (Chapm. *ex* Engelm.) Sarg. var. *immuginata* D. B. Ward, Castanea 28: 4. 1963; *Pinus clausa* (Chapm. *ex* Engelm.) Sarg. subsp. *immuginata* (D. B. Ward) E. Murray, Kalmia 13: 22. 1983.

Etymology

The species epithet means 'closed' and refers to the seed cones.

Vernacular names

Sand pine, Florida spruce pine

Description

Trees to 21 m tall; trunk to 50 cm d.b.h., often stunted and crooked, branching low or sometimes multi-stemmed; crown open and irregular or flattened. Bark scaly, breaking into narrow ridges and furrows, grey-brown, in the crown thin and flaking, red-brown. Shoots slender, purplish to reddish brown, often glaucous, glabrous, rough with persistent pulvini after leaf fascicles have fallen. Buds ovoid to cylindrical, 0.5–1 cm long, with or without resin, red-brown; cataphylls with white, fringed margins. Leaves in fascicles of 2, held in 4–8 mm long sheaths, persisting 3–4 years, spreading, (2–)5–8(–10) cm long, nearly straight or contorted, 1–1.5 mm wide, rigid, dark green or light green; margins minutely serrulate; apex acute; stomata in inconspicuous lines on all surfaces. Pollen cones in small clusters, spirally arranged, short cylindric, 10–15 mm long, yellow maturing to red-brown. Seed cones solitary or in pairs, persistent, nearly sessile or short peduncculate, serotinous or opening soon in warm sunshine, symmetrical, 4–8 cm long, narrowly ovoid when closed, broadly ovoid when open. Seed scales thin woody, rigid, often purple on the border below the apophysis on adaxial surface, turning brown when old. Apophysis slightly raised, keeled, angular in outline, with a small, low pyramidal umbo terminating in a small prickle or unarmed, colour dull reddish

brown when cones are ripened. Seeds obovoid, slightly flattened, 4–6 mm long, pale brown with darker spots or dark brown, with a narrow wing 15–20 mm long.

Taxonomic notes

Trees with serotinous cones in central Florida have been described as *P. clausa* var. *immuginata*. Although there appears to be some geographical separation of the two forms, serotiny of cones has been found among trees with opening cones and this character alone seems insufficiently distinct to give it taxonomic separation as a variety or subspecies. Cone serotiny is clearly an adaptive trait related to fire and trees with these cones are probably strongly selected for in areas with frequent fires. The phenomenon occurs in a good number of phylogenetically distant (not closely related) species in the subgenus *Pinus*.

Distribution

USA: Alabama (Baldwin Co., Escambia Co.), Florida.
TDWG codes: 78 ALA FLA

Ecology

This lowland pine from the sandy interior and coasts of Florida occupies the drier areas away from swamps and eutrophic rivers. It is a fire-successional species, in particular on infertile white sand dunes and flats of marine origin and low elevations between 5 and 60 m a.s.l. or up to 90 m on the west coast. There are abundant summer rains while winters are generally dry, but much of the precipitation drains away quickly into the sandy soil. There are two ecotypes or 'races' of this species, one with mostly serotinous cones and another of which the cones open more readily; these were recognized previously as botanical varieties. *Pinus clausa* is characteristic of 'sand pine scrub' a distinctive plant community of north-central Florida. The tree layer is dominated by *P. clausa*, with an understorey composed of evergreen shrubs to 3 m tall and in almost total absence of a herb layer. Several species of oak (*Quercus*) and small palms (*Sabal etonia, Serenoa repens*) are most abundant. The ground is often covered by lichens (*Cladina evansii, Cladonia* spp.).

Conservation

IUCN: LC

Uses

Sand pine is of some value as a timber tree only in plantations, where it can give a reasonably high yield for the pulp wood industry. The 'Chocktawhatchee' form of western Florida with short branches and dark green needles is grown as a Christmas tree. The species is thought to be of use in 'biomass plantations' for fuelwood from trials conducted by the USDA Forest Service in the 1980's. Such use may become more important in the current political drive to reduce dependence on oil in the USA and to increase the contribution of 'renewables' to the fuel for motorcars. This species has no significance in horticulture.

Pinus contorta Douglas *ex* Loudon, Arbor. Frut. Brit. 4: 2292. 1838.

Etymology

The species epithet *contorta* means twisted (contorted) and probably refers to the often twisted needles.

Vernacular names

Lodgepole pine, Tamarack pine, Shore pine

Description

Shrubs or trees to 50 m tall; trunk to 1–2 m d.b.h., very straight to contorted. Bark scaly, breaking into small plates or longitudinal ridges and furrows, light brown, reddish brown to grey. Branching variable, dependent on environment and to some extent genetically determined, in dense stands short, self-pruning, usually spreading and contorted, lower branches descending. Foliage branches slender, shoots green, turning orange-brown, rough with pulvini after leaf fascicles have fallen. Buds ovoid, the terminal ones narrow, 10–15 mm long, the lateral ones much smaller, slightly resinous; cataphylls dark red-brown, with entire or scarious margins. Leaves in more or less remote fascicles of 2 held

by short sheaths, persisting 4–8 years, spreading, (2–)3–7(–8) cm long, rigid, usually curved and twisted, 0.7–2(–3) mm wide; margins minutely serrulate; leaf colour light yellow-green to dark green; apex obtuse, acute or acuminate; stomata in lines on all surfaces. Pollen cones in small clusters, spirally arranged, ellipsoid to cylindric, 5–15 mm long, orange-red turning red-brown. Seed cones solitary or in whorls of 2–5, nearly sessile to short pedunculate, spreading or reflexed, variably persistent and variably serotinous, sometimes remaining on branches and closed for many years, ovoid but often with an asymmetrical base, (2–)3–5(–6) cm long, broadly ovoid to nearly globose when open. Seed scales thin woody, rigid, brown. Apophysis more or less rhombic in outline, variously raised, sometimes gibbous on the sun-exposed side near base of cone, transversely keeled, with a central, depressed, triangular umbo armed with a variable, thin or blunt prickle up to 6 mm long. Seeds obovoid, slightly flattened, ca. 5 mm long, red-brown with blackish spots or nearly black; wing 10–12 mm long.

Distribution

Western North America, from Yukon to Baja California and S Colorado.
TDWG codes: 70 ASK NWT-MK YUK 71 ABT BRC 73 74 SDA 76 79 MXN-BC

Ecology

Pinus contorta occupies a large part of the North American West with in particular a vast latitudinal range. It consequently has a wide ecological amplitude and grows form near sea level to 3350 m or perhaps higher and from the relatively mild but cool and rainy Pacific coast to the cold and continental interior of the northern Rocky Mountains. Precipitation consequently ranges from only 250 mm at low elevations in the interior to 5000 mm along the northern coast. In the interior, Lodgepole pine forms pioneer stands of great density after forest fires and can form monotypic stands of great extent, especially on infertile soils. In other sites it is associated with many western conifers, most commonly in the north with *Picea glauca* and mixed with *Betula papyrifera* or *Populus tremula*; at higher altitudes with *Tsuga mertensiana, Picea engelmannii* and *Abies lasiocarpa*. Further south, the species diversity increases and in California it is a component of the mixed conifer forest as well as subalpine conifer woodland and meadows with numerous conifer species. Here soils are more nutrient rich and fires are less frequent, so *Pinus contorta* does not attain dominance. As a component of the mixed conifer forest it can attain 50 m in height, with 1 m d.b.h., and live to a considerable age. In other areas, such as large tracts of Yellowstone Park in Wyoming, Lodgepole pine appears to be self-perpetuating as the only tree species capable of growing in a more dynamic environment characterized by frequent fires.

Uses

Lodgepole pine is a major timber tree in western North America. Its geographical varieties differ apart from minor botanical characters also in growth performance and maximum size, which is at least in part due to environmental factors. As other conifers, it attains greatest size in Oregon and California (var. *murrayana*) with trees over 50 m tall and 2 m diam. In the interior, the tall, thin stems of densely grown pines provided the 'lodgepoles', i.e. tent poles for the bison-hide covered conical tents of the Plains Indians with such famous tribes or 'nations' as the Dakota ('Sioux') and Blackfeet. Today Lodgepole pine is put to all traditional (European) uses common to pine wood, but mass production is for the pulp industry or increasingly the manufacture of so-called structural particleboard, where chips are glued into boards for interior construction. *Pinus contorta* is sometimes planted as a shelter tree on barren sites, but otherwise uncommon in cultivation; only a limited number of cultivars are known. Hybrids between *P. contorta* and *P. banksiana* have been generated by foresters in the USA in attempts to produce trees suitable for plantations.

3 varieties are recognized:

Pinus contorta Douglas *ex* Loudon var. ***contorta***.
Type: USA: Washington, *D. Douglas s.n.* (lectotype K).

Description

Leaves 2–5 cm long, rarely longer, slender, 0.7–1.2(–1.5) mm wide. Seed cones solitary or in whorls of 2–5,

asymmetrical near base, persistent and variously serotinous; umbos armed with a slender prickle to 6 mm long.

Distribution

NW coast of North America, from S Alaska to N California.
TDWG codes: 70 ASK 71 BRC 73 ORE WAS 76 CAL

Conservation

IUCN: LC

Pinus contorta Douglas *ex* Loudon var. ***latifolia*** Engelm., in Watson, Botany (Fortieth Parallel): 331. 1871. *Pinus contorta* Douglas *ex* Loudon subsp. *latifolia* (Engelm.) Critchf., Publ. Maria Moors Cabot Found. Bot. Res. 3: 107. 1957; *Pinus divaricata* (Aiton) Dum.-Cours. var. *latifolia* (Engelm.) Boivin, Naturaliste Canad. 93: 272. 1966. Type: USA: Utah, Uintah Mts., *S. Watson ["Clarence King's Exped. 40th Parallel"] 1110* (holotype A).

Description

Leaves (4–)5–8 cm long, 1–2(–3) mm wide. Seed cones solitary or in pairs, 4–6 cm long, strongly asymmetric and recurved on branches, persistent and variously serotinous; apophyses near base of cone often gibbous; umbo with a small, blunt prickle.

Distribution

NW North America, from Yukon to Colorado.
TDWG codes: 70 ASK NWT-MK YUK 71 ABT BRC SAS 73 COL IDA MNT ORE WAS WYO 74 SDA 76 UTA

Conservation

IUCN: LC

Pinus contorta Douglas *ex* Loudon var. ***murrayana*** (Balf.) Engelm., in Watson, Bot. California 2: 126. 1880. *Pinus murrayana* Balf., in Murray, Bot. Exped. Oregon 8: 2. 1853; *Pinus contorta* Douglas *ex* Loudon subsp. *murrayana* (Balf.) Engelm., Trans. St. Louis Acad. Sci. 4: 177. 1880. Type: USA: California, Siskiyou Mts, *J. Jeffrey 740* (holotype E). Fig. 218

Description

Trees to 50 m tall; trunk to 1–2 m d.b.h. Leaves 5–8 cm long, 1–2 mm wide. Seed cones solitary or in pairs, mostly symmetrical or nearly so, opening soon and falling soon after seed dispersal; apohyses transversely keeled but not gibbous; umbo with a small prickle.

Distribution

USA: California, Nevada, Oregon, S Washington; NW Mexico: Baja California Norte.
TDWG codes: 73 ORE WAS 76 CAL NEV 79 MXN-BC

Conservation

IUCN: LC

Pinus coulteri D. Don, Trans. Linn. Soc. London 17: 440. 1836. *Pinus ponderosa* Douglas *ex* C. Lawson subsp. *coulteri* (D. Don) E. Murray, Kalmia 12: 23. 1982. Type: USA: California, Monterey Co., Santa Lucia Mts., Cone Peak, *T. Coulter s.n.* (holotype TCD). Fig. 219, 220

Etymology

This species was named after Thomas Coulter (1793–1843), an Irishman who collected the type specimen, a large cone now kept in Trinity College, Dublin.

Vernacular names

Coulter pine, Bigcone pine

Description

Trees to 15–25 m tall, d.b.h. to 1 m. Trunk monopodial, straight or curved at base. Bark on trunk rough,

scaly, divided into irregular, longitudinal plates, dark brown with black fissures. Branches spreading horizontally to more or less ascending, ultimate branches upturned, forming a broad, irregular pyramidal and open crown. Shoots multinodal, thick, rigid, rough with prominent, decurrent pulvini, light orange-brown or purplish brown, often glaucous. Cataphylls 15–20 mm long, subulate, recurved, with caudate apex and erose-ciliate margins. Vegetative buds large; terminal bud 15–30 mm long, ovoid-acute; lateral buds ovoid, smaller, resinous, reddish brown. Fascicle sheaths thick, remaining ca. 20 mm long. Leaves in fascicles of 3, persisting 3–4 years, very rigid, straight or curved, slightly twisted, 15–25(–30) cm long, 1.9–2.2 mm wide; margins serrulate; apex acute-pungent to subulate; leaf colour light green to grey-green. Stomata on all faces of leaves, with (10–)12–14 lines on the convex abaxial face and (4–)5–7 lines on each adaxial face. Pollen cones ovoid to cylindric, 2–2.5 cm long, light purplish brown, maturing to orange-brown. Seed cones solitary or occasionally in pairs, or in whorls of 3–4(–5) on bole of young trees; borne on thick, short, persistent peduncles, holding cone to branch for as long as 25 years and retaining a few basal scales when it falls. Mature cones ovoid, massive, heavy, usually slightly oblique or curved, moderately serotinous, 20–35 × 15–20 cm when open, extremely resinous. Seed scales flat, thick woody with thin, curved margins, widest towards the apophysis. Apophysis very strongly developed, on one side of cone larger than on the other, thick woody, sharply transversely keeled, merging into a long, uncinate umbo, up to 30 mm wide, light yellowish brown or light caramel coloured. Umbo dorsal, elongate, curved, with keeled sides, 25–35 mm long, 10–15 mm wide at base, ending in a sharp uncinate claw. Seeds obliquely obovoid, slightly flattened, 10–18 × 7–10 mm, smooth, lustrous dark brown, turning blackish. Seed wings dolabriform to semi-ovate, 18–30 × 12–16 mm, orange-brown to dark reddish brown.

Distribution

USA: California (Coast Ranges); Mexico: Baja California Norte.
TDWG codes: 76 CAL 79 MXN-BC

Ecology

In California, Coulter pine is prominent in the southern California Mixed Conifer Forest, especially at the lower limit of this forest type, where it merges into fire-prone chaparral. In Baja California it is also a tree of mixed chaparral, together with *Quercus chrysolepis*, or growing on granite boulder formations around Laguna Juárez. Its altitudinal range is from 300 m to 2100 m a.s.l. (in Mexico 1200–2150 m). It is most commonly found on dry, rocky slopes and ridges, where competition from other trees is minimized. The climate is of a Mediterranean type with winter rain and long, hot and dry summers.

Conservation

IUCN: NT

Uses

Coulter pine has no particular commercial value as a timber tree and its seeds, although edible, are not harvested for consumption. It is quite frequently represented in parks and arboreta in southern Europe and the milder parts of the British Isles, and this pine has also been introduced as an amenity tree in Australia and New Zealand. In California it is also planted in parks and large gardens, often in small groups. No cultivars are known of this pine and it is apparently rarely grown and sold by horticultural nurseries. The impressive cones are often collected and displayed as curiosities in private houses as well as schools and other public buildings.

Pinus cubensis Griseb., [Pl. Wright.] Mem. Amer. Acad. Arts, ser. 2, 8: 530. 1862. Pinus occidentalis Sw. var. cubensis (Griseb.) Silba, Phytologia Mem. 7: 55. 1984. Type: Cuba: E Cuba, C. Wright 598 (lectotype GOET).

Pinus maestrensis Bisse, Ciencias (Havana), ser. 10, 2: 2. 1975; *Pinus occidentalis* Sw. var. *maestrensis* (Bisse) Silba, Phytologia 68: 57. 1990.

Etymology

The species epithet *cubensis* refers to Cuba, where it is endemic.

Vernacular names

Cuban pine

Description

Trees to 25–30 m tall, d.b.h. to ca. 1 m; trunk monopodial, erect. Bark thick, rough, scaly, breaking into irregular, squarish plates divided by deep fissures, or forming vertical ridges between fissures, grey-brown, weathering grey. Branches spreading irregularly, forming a small, irregular, broadly domed and open crown. Shoots more or less multi-nodal, glaucous to pruinose in the first and second years. Cataphylls small, subulate, scarious, early recurving, with ciliate margins, brown. Vegetative buds ovoid-oblong; terminal bud 10–15 mm long and lateral buds smaller, acute, not resinous or sometimes slightly resinous. Leaf fascicles initially 9–12 mm long, on adult leaves reduced to 7–9 mm, persistent. Leaves in fascicles of 2(–3), persisting 2–3 years, more or less rigid, or flexible, straight or slightly curved, (6–)10–15(–18) cm long, 0.8–1.3 mm wide; margins serrulate, acute; leaf colour light green, occasionally glaucous green. Stomata on all faces of leaves, with 5–10 lines on the convex abaxial face and 4–5(–7) on adaxial face(s). Pollen cones cylindrical, often recurved when mature, 1.5–2 cm × 5 mm. Seed cones sub-terminal, solitary or in pairs, less commonly in whorls of 3–4, on 1–2 cm long, recurved or straight peduncles, deciduous. Mature cones (narrowly) ovoid to ovoid-attenuate when closed, (broadly) ovoid when opened, (3.5–)4–7 × (2–)3.5–5 cm when open. Seed scales parting readily except basal ones, oblong, straight or slightly recurved, thin woody. Apophyses more or less symmetrical around cone, slightly raised, transversely keeled, transverse-rhombic to pentagonal in outline, with curved or irregular upper margin, up to 11 mm wide, radially striate, dark ochraceous to dull brown. Umbo dorsal, depressed or slightly raised, the minute prickle early deciduous. Seeds obliquely ovoid, flattened, 5–6 × 3–3.5 mm, mottled grey-brown. Seed wings obliquely ovate-oblong, 12–16 × 5–6 mm, grey-brown, with a graphite-like tinge.

Distribution

E Cuba: From the Sierra Maestra and the Sierra de Nipe E into the highlands terminating the eastern part of the island.
TDWG codes: 81 CUB

Ecology

This species occurs in foothills and highlands as well as in 'pine barrens' along the coast. Its altitudinal range is from 100–900(–1200) m a.s.l. *Pinus cubensis* forms mostly pure but open stands or is invasive in disturbed sites on serpentine or serpentine-derived, often ferruginous soils ('Nipe latosol' or 'Nipe clay'), or on alluvial sediment near the coast. In the highlands there is abundant rainfall (1800 mm or more annually), but a dry winter season is a typical aspect of the tropical to subtropical climate.

Conservation

IUCN: LC

Uses

Pinus cubensis is the only pine occurring in the eastern part of Cuba; no pines occur naturally in Cuba between eastern Cuba and Pinar del Río in the extreme west of the island, and as such the pines are of importance economically as a timber source to this part of Cuba. This species is not known to be in cultivation.

Pinus culminicola Andresen & Beaman, J. Arnold Arbor. 42: 437. 1961 Type: Mexico: Nuevo León, Galeana, Cerro Potosí, *J. H. Beaman 2675* (holotype MSC). Fig. 221

Etymology

The species epithet means: 'growing on the summit' (of mountains).

Vernacular names

Potosi pinyon pine; Potosí piñon (Spanish)

Description

Shrubs 1–5 m tall, diam. of stems to 15–25 cm; multistemmed, or very low branched, individuals forming a spreading, in places dense vegetation. Bark thin, scaly, exfoliating in small, irregular plates, grey-brown, soon weathering grey. Branches often prostrate to assurgent, the higher order branches assurgent to erect. Shoots short, thick, light brown turning grey. Cataphylls small, narrowly triangular to subulate; apex caudate; margins erose, light brown, weathering blackish grey. Vegetative buds broadly ovoid; terminal bud 6–10 mm long; lateral buds smaller, slightly resinous. Fascicle sheaths initially 6–8 mm long, in mature fascicles the scales separate and recoil, forming a rosette at the base of fascicle, straw-coloured to grey, semi-persistent but mainly falling before the leaf fascicles. Leaves in fascicles of 5 (very rarely 4–6), erect to assurgent, persisting 2–3 years, curved, rigid, 3–5 cm long, 0.9–1.3 mm wide, very remotely serrulate to entire, obtuse, greyish green, whitish or glaucous adaxially. Stomata restricted to both adaxial faces, with 4–5 lines on each face. Pollen cones ovoid-oblong when mature, 5–8 mm long, yellowish, turning yellowish brown. Seed cones subterminal, solitary or in pairs on short, stout peduncles which are covered with subulate-caudate cataphylls. Mature cones subglobose when still closed, opening with a flattened base and remote, spreading fertile seed scales, then 3–4.5 × 3–5 cm. Seed scales parting and spreading wide except the smaller, infertile proximal scales, irregular, often curved, thin, concavo-convex, with 1–2 deep, cup-like depressions holding the seeds. Apophysis slightly raised, transversely keeled, rhomboid to pentagonal in outline, radially rugose when dry; margins crenate or angular, colour yellowish brown, often resinous. Umbo dorsal, slightly raised, rhombic in outline, with or without a minute prickle. Seeds obliquely obovoid, 5–7 × 4–5 mm, with a 1 mm thick integument, brown. Seed wings absent on seeds parted from the scales.

Distribution

Mexico: Coahuila, Nuevo León.
TDWG codes: 79 MXE-CO MXE-NL

Ecology

The altitudinal range of *P. culminicola* is 3000–3700 m a.s.l., which includes the highest ridges of these mountains. Its habit is very similar to other mountain 'dwarf pines', e.g. *P. mugo* in Europe and *P. pumila* in NE Asia. Adaptation to blasting, ice- or sand-laden winds and a short growing season is responsible for this habit. Soils are mostly rocky and calcareous. Climatic conditions are not well known due to a lack of weather stations at these summits, but precipitation, some of it as snow, is probably abundant. On Cerro Potosí, the species forms extensive monocultures of close-packed individuals. It occurs there with scattered, stunted *P. hartwegii*, which indicates that the climatic tree line is not reached there at around 3700 m. Somewhat lower, on the Sierra La Marta, Coahuila, *P. culminicola* has been found in a scrub-community with *Quercus* spp., *Arctostaphylos, Ceanothus, Agave* and grasses; on the Cerro La Viega and the Sierra de Arteaga, Coahuila, a similar vegetation, but also with *Abies* and *Pseudotsuga*, are reported growing scattered with *P. culminicula*. Pollen dispersal has been reported on Cerro Potosí to occur in late July, at 3690 m, which indicates a late fertilization and short growing season.

Conservation

This species is vulnerable to fire during long dry periods. In recent years devastating fires have destroyed large parts of the population on Cerro Potosí and regeneration, if it occurs, will be very slow.
IUCN: EN [B1ab (ii–v), B2ab (ii–v)]

Uses

This species is not used commercially, although locally it may be used for firewood. It should be suitable as a low bushy pine for large rockeries, has attractive foliage, and deserves to be taken into cultivation for horticulture. It has established itself well in the rock garden of the Royal Botanic Garden in Edinburgh, Scotland, from seed collected by Michael Frankis in 1991 and another, slightly later gathering. It remains very rare in cultivation; it seems that the trade is often very slow in recognizing potentially good, albeit perhaps slow growing, conifers for the garden.

Pinus dalatensis Ferré, Bull. Soc. Hist. Nat. Toulouse 95: 178. 1960. Pl. 28

Etymology

This species is named after Dalat in Viet Nam, a city near which it was discovered.

Vernacular names

Dalat pine; Thông Đà Lạt (Vietnamese).

Description

Trees to 30(–40) m tall; trunk to 2(–2.5) m d.b.h., straight and columnar. Bark smooth in young trees and on branches, becoming rough and scaly on trunk, breaking into small, grey-brown plates. Branches wide spreading, self-pruning, forming domed or umbrella-shaped, broad crowns in older trees. Foliage branches slender, smooth, new shoots glabrous or pubescent, often glaucous or pruinose, becoming pale brown or reddish brown. Buds small, conical or ovoid, acute, not resinous; cataphylls appressed, orange-brown. Leaves in fascicles of 5, with deciduous basal sheaths, straight, spreading, (3–)5–10(–14) cm long, slender, lax or pliant, 0.6–1(–1.2) mm wide; margins mostly minutely serrulate; leaf colour green or glaucous green (often a combination, with abaxial face green); apex acute; stomata in fine lines on the two adaxial faces. Pollen cones in small clusters at base of new shoots, spirally arranged, ovoid to short cylindrical, yellow. Seed cones solitary or in whorls of 2–3 on stout, 1–4 cm long, scaly peduncles, persisting some time after seed dispersal, initially erect but pendulous when grown to full size, extremely variable in size, 6–23 cm long, straight or curved ellipsoidal or cylindrical, opening to 5–9 cm wide, resinous, green ripening to dull or lustrous brown. Seed scales few or numerous depending on cone size, flat or boat-shaped, thin woody, flexible; basal scales appressed, rarely some recurved. Apophysis large, thin or slightly thickened, more or less rhombic or with rounded distal margin, straight or slightly incurved, striated or grooved towards a terminal, 4–10 mm wide, sunken, flat or obtuse umbo. Seeds varying in size with the seed scales (especially the wings), with maximal lengths of 8–10 mm and wings to 20–30 mm long and 10 mm wide, the latter often with dark longitudinal streaks.

Taxonomic notes

Pinus dalatensis is considered by Vietnamese botanist to be a variable species (Nguyen Tien Hiep *et al.*, 2004). This species was studied in the field by Businský (1999, 2004), who not only discovered several new populations in formerly unknown localities, but described them under two subspecies, one with a new variety. The discriminating characters given in his papers are largely continuous and overlapping, but it seems probable that some of the variation is sufficiently consistent within the disjunct populations to merit recognition as varieties. I have retained them here, more or less provisionally, under the ranking given by Businský, and listed only those few chracter states that appear to more or less separate them. It has to be emphasized (again) that geographical disjunction is not a taxonomic character. Some genetic research seems appropriate here.

Distribution

Viet Nam: Binh Tri Thiên, Dac Lac, Gia Lai-Công Tum, Lâm Dông; Lao PDR: Nakai Nam Theun NPA.
TDWG codes: 41 LAO VIE

Ecology

Pinus dalatensis is a montane pine occurring at altitudes between 1400 m and 2300 m a.s.l. in tropical evergreen forest. This species forms small stands of a few to about 30 trees surrounded by evergreen angiosperm forest, dominated by members of the *Fagaceae* and *Lauraceae*. In most localities, the pines occupy rocky outcrops or steep ridges and adjacent slopes where competition from broad-leaved trees is less intense. In more favourable sites on flat mountain ridges or in foothills near streams, often on yellow ferralitic soils, it becomes a large, emergent tree. Associated conifers found are *Pinus krempfii*, also an emergent, *Fokienia hodginsii*, and *Dacrydium elatum* in the southernmost part of the Central Highlands. In most cases, this pine can grow rapidly up to reach the canopy, so it is semi-shade tolerant, but seedlings are intolerant of shade, so some form of canopy disturbance has to precede regeneration, e.g. periodic fires.

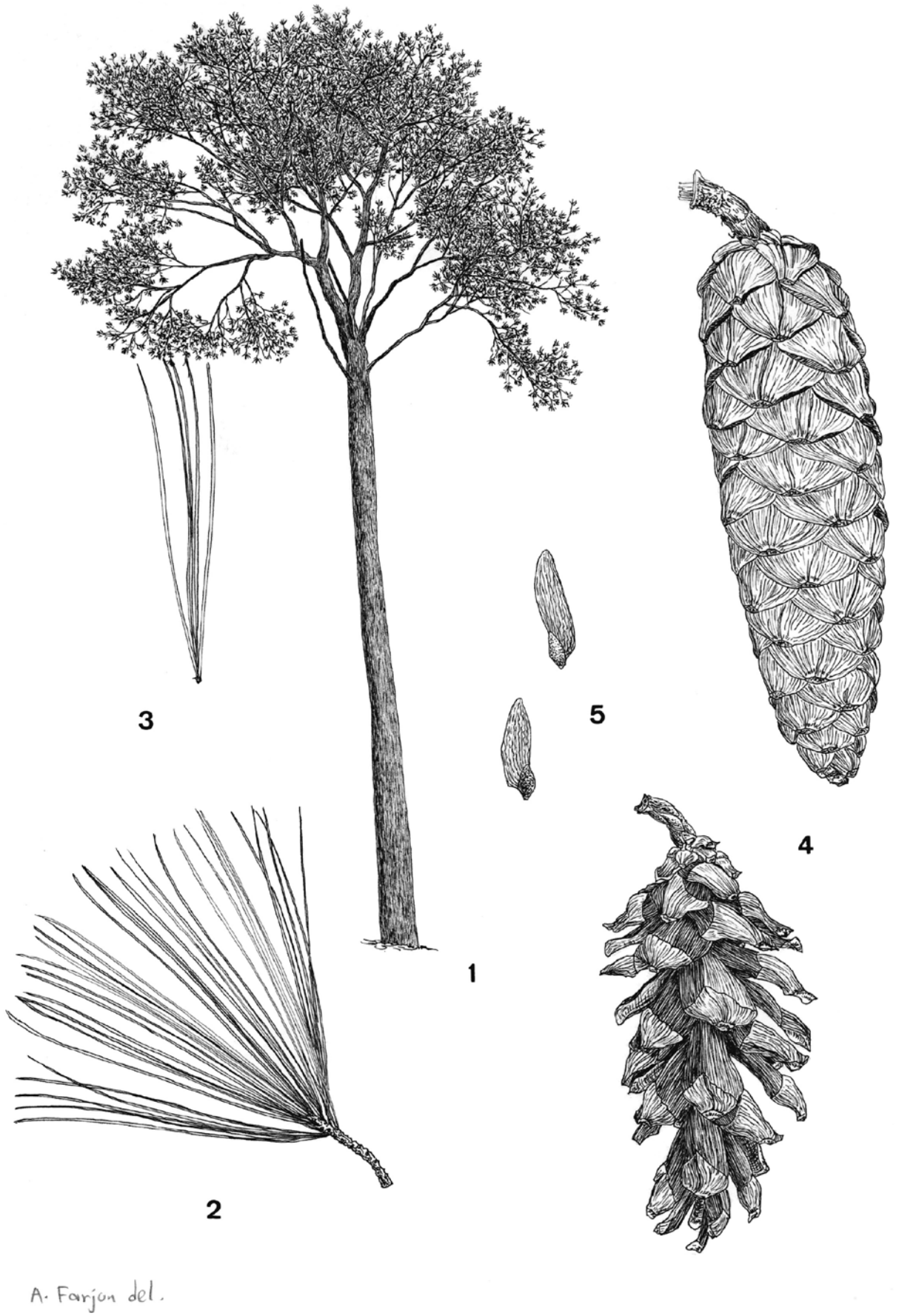

PLATE 28. *Pinus dalatensis.* **1.** Habit of tree. **2.** Branchlet with leaves. **3.** Leaves. **4.** Seed cones, one green, one ripe. **5.** Seeds.

Conservation

This species has recently been conservation assessed (Nguyen Tien Hiep *et al.*, 2004) and is considered to be Vulnerable. Populations are few and small, and several have been in continuous decline; on the other hand, given recent discoveries and their disjunct occurrence, new populations are likely to be found. Some of these are in as yet undisturbed forests. The main threat in the past was logging, often as an adjunct to the much sought after large trees of *Fokienia hodginsii*; today it is mostly conversion to managed pine forest with planted *Pinus kesiya*, or conversion of primary forest to other land uses via slash-and-burn agriculture. Several populations are within recently declared national parks and nature reserves.

IUCN: VU [B2ab (ii, iii, iv)]

Uses

A valuable timber tree, but very rare and logged only incidentally. Its wood properties are similar to those of *Pinus wallichiana*, a native of the Himalayas, and other so-called white pines. It is not known in cultivation.

2 subspecies and 2 varieties are recognized:

Pinus dalatensis Ferré subsp. ***dalatensis*** var. ***dalatensis***. Type: Viet Nam: Lâm Dông, Da Lat, Trai Mat, *H. Gaussen s.n.* (holotype TLF).

Description

New shoots variably pubescent. Seed cones 6–16 cm long.

Distribution

Viet Nam: Binh Tri Thiên, Dac Lac, Lâm Dông (Chu Yang Sinh Massif, Da Lat environs); Lao PDR: Nakai Nam Theun NPA.
TDWG codes: 41 LAO VIE

Conservation

IUCN: NE

Pinus dalatensis Ferré subsp. ***dalatensis*** Businský var. ***bidoupensis***, Candollea 54: 127. 1999. Type: Viet Nam: Lâm Dông, Dong Nai, Mt. Bi Doup, W slopes of massif 6 km SE of Bi Doup, *R. Businský 39160* (holotype G).

Description

New shoots glabrous. Seed cones 10–16 cm long.

Distribution

Viet Nam: Lâm Dông (Bi Doup Mountain).
TDWG codes: 41 VIE

Conservation

IUCN: NE

Pinus dalatensis Ferré subsp. ***procera*** Businský, Candollea 54: 133. 1999. Type: Viet Nam: Gia Lai Prov., Ngoc Linh Mountains, Mt. Ngok Niay, *R. Businský 44114* (holotype G).

Description

New shoots (mostly densely) pubescent. Seed cones 9–23 cm long.

Distribution

Viet Nam: Gia Lai-Công Tum (Ngoc Linh, Ngok Niay Mountain, Kon Plong); perhaps across the border in Lao PDR.
TDWG codes: 41 VIE

Conservation

IUCN: NE
Note on conservation status: Although the species as a whole has been assessed as VU, the status of the separate infraspecific taxa, although logically meeting the criteria for at least VU, has not been evaluated.

Pinus densata Mast., J. Linn. Soc., Bot. 37: 416. 1906. *Pinus tabuliformis* Carrière var. *densata* (Mast.) Rehd., J. Arnold Arbor. 7: 23. 1926. Type: China: Sichuan, Yalong River, *E. H. Wilson 3015* (holotype BM).

Etymology

The species epithet is perhaps from Latin *densatio* = thickening (condensation) and may refer to the apophyses; if so it is not used in its original sense.

Vernacular names

Gaoshan pine; gao shan song (Chinese)

Description

Trees to 30 m tall; trunk to 1.3 m d.b.h. Bark scaly, forming irregular plates and longitudinal fissures, dark grey-brown. Branches spreading, forming a broadly domed or open crown in older trees. Foliage branches stout, new shoots glabrous, rough with pulvini from fallen leaf fascicles, lustrous yellowish brown, turning reddish brown. Buds ovoid-conical, acute, the terminal bud ca. 15 mm long, slightly resinous; cataphylls with white fringed margins, acuminate. Leaves in fascicles of 2(–3), held by a persistent, 10–15 mm long but shortening basal sheath, straight, 8–14 cm long, rigid, slightly twisted, 1–1.5 mm wide, dull green; margins minutely serrulate; apex acute; stomata in fine lines on all faces. Pollen cones in clusters at base of new shoots, spirally arranged, short cylindrical, ca. 2 cm long, yellow. Seed cones solitary or in pairs, sessile or very short pedunculate, persistent but opening widely, spreading or curved down, narrowly ovoid when closed, 4–6 cm long, when opened 4–7 cm wide. Seed scales oblong, thin woody, rigid, brown; apophyses prominently raised, more or less rhombic, strongly transversely keeled, lustrous chocolate brown; umbo dorsal and central, armed with a short prickle. Seeds ovoid to ellipsoid, 4–6 mm long, light brown to grey-brown; wing 15–20 mm long.

Taxonomic notes

Maxwell Masters (*op. cit.*) described this pine as a new species and compared it with *Pinus densiflora* and to some extent (via E. H. Wilson's field observations) with *P. sylvestris*. Both species occur far to the NE from the known range of *P. densata*. The hybrid status of this species has later been inferred from morphological intermediacy of character states in comparison with *P. yunnanensis*, with which it is partially sympatric, and *P. tabuliformis*, which occurs also further north in China. Some molecular evidence (DNA sequence data) supports this hypothesis, possibly with the involvement of an unknown, third species from the Tertiary. Due to ecological as well as geographical separation, there is no indication that these species form new hybrids at present in their natural habitats. It seems to me that it is appropriate to treat this taxon not as a nothospecies but as a species. Its hybrid status has not been demonstrated beyond doubt, and given that hybridization is probably a major cause of speciation in plants generally, we would not gain much relevant information if we did prove it.

Distribution

China: S Qinghai, W Sichuan, NW Yunnan, E Xizang [Tibet].
TDWG codes: 36 CHC-SC CHC-YN CHQ CHT

Ecology

Pinus densata occurs in high mountains at altitudes from 2600 m to 4000 m a.s.l. or even above this line to 4200 m. It forms open pure stands at the highest elevations, but becomes mixed with other pines, e.g. *P. armandii* and *P. yunnanensis*, below 3000 m a.s.l. It is presumed that its hybrid characters include a greater tolerance to frost than either of its putative parents, *P. tabuliformis* and *P. yunnanensis*, enabling it to colonize right up to the present tree line in western China's great mountain system.

Conservation

IUCN: LC

Uses

There is presently little economic use of this species, primarily because it occurs in high mountains in often inaccessible places. A traditional use at least

a century ago seems to have been making torches, using wood and resin. It has been suggested that it would be suitable for afforestation (presumably forest restoration) in the alpine regions of western China. It was introduced in Europe (UK) about 100 years ago, but this species remains rare in botanic gardens and arboreta.

Pinus* ×*densithunbergii Uyeki, [Not. Pl. Lign. Sikoku 2] Sci. Rep. Matsuyama Agric. Coll. 10: 6. 1953. *Pinus densi-thunbergii* Uyeki, Corean Timber Trees 1: 65 (Chôsen 4). 1926. Type: Illustration in Uyeki, Corean Timber Trees 1: photograph opp. p. 66, No. 1–6. 1926 (lectotype designated here).

Etymology

The nothospecific epithet combines the names of the parental species.

Vernacular names

aiguro-matsu, akakuro-matsu (Japanese)

Description

A natural natural hybrid between *Pinus densiflora* Siebold et Zucc. and *P. thunbergii* Parl, first described by Mayr (1890) and named first as a species and then as a nothospecies by Uyeki. Its morphological characters are described as intermediate between the two species. The resin ducts are external (marginal) in *Pinus densiflora* and medial in *P. thunbergii*; in the leaves of the hybrid taxon both positions were found. The thickness of the leaf hypodermis is described as intermediate between those of the parent species.

Distribution

Japan: Honshu, Shikoku, Kyushu; South Korea.
TDWG codes: 38 JAP-HN JAP-SH JAP-KY KOR-SK

Ecology

Apparently widespread among populations of both putative parents.

Conservation

IUCN: NE

Uses

Controlled crossings of *Pinus densiflora* with *P. thunbergii* have been undertaken in Japan and the USA.

Pinus densiflora Siebold & Zucc., Fl. Japon. 2 (3): 22, t. 112. 1842. Type: Japan: ["in Japonia"], *P. F. von Siebold s.n.* comm. 1842 ex herb. Zuccarini No. 438 (lectotype M).

Pinus funebris Kom., Trudy Imp. S.-Peterburgsk. Bot. Sada 20: 177. 1901; *Pinus densiflora* Siebold & Zucc. var. *funebris* (Kom.) T. N. Liou & Q. L. Wang *ex* Silba, Phytologia Mem. 7: 50. 1984.
Pinus densiflora Siebold & Zucc. f. *sylvestriformis* Taken., J. Japan. Forest. Soc. 24: 120, f. 1. 1942; *Pinus sylvestris* L. var. *sylvestriformis* (Taken.) W. C. Cheng & C. D. Chu, Fl. Reipubl. Pop. Sin. 7: 246. 1978; *Pinus densiflora* Siebold & Zucc. var. *sylvestriformis* (Taken.) Q. L. Wang, Changbai Shan zhi-wu min-lu [Checklist of plants in Changbai Mt.]: 49. 1982.
Pinus densiflora Siebold & Zucc. var. *zhangwuensis* S. J. Zhang *et al.*, Bull. Bot. Res. North-East. Forest. Inst. 15 (3): 338. 1995.

Etymology

The species epithet means 'with compact inflorescence' and may refer to the closely set pollen cones.

Vernacular names

Japanese red pine; akamatsu (Japanese); chi song (Chinese); sonamoo (Korean)

Description

Trees to 30–35 m tall, in coastal areas smaller, to 20 m tall; trunk to 1–1.5 m d.b.h., bole straight and columnar, self-pruning. Bark of young trees and in crown of old trees thin, with papery flakes, orange-red; on large trunks becoming thick and breaking into large, irregular plates, turning grey-brown

or red-brown. Branches spreading, higher order branches assurgent, forming an umbrella-shaped or flat-topped crown. Foliage branches slender, young shoots smooth, glabrous, yellowish, sometimes slightly glaucous, becoming rough with persistent pulvini from fallen leaf fascicles, turning dark grey-brown to grey. Buds ovoid-oblong, slightly resinous; cataphylls dark red-brown. Leaves in fascicles of 2, persisting 2–3 years, held by a short basal sheath, straight and rigid, 6–12(–15) cm long, often slightly twisted, ca. 1 mm wide; margins minutely serrulate; apex acute-acuminate; leaf colour green or glaucous green; stomata in fine lines on all surfaces. Pollen cones in small clusters at base of new shoots, spirally arranged, short cylindrical, 1.5–2.5 cm long, yellow. Seed cones mostly solitary, erect or reflexed on short peduncles or nearly sessile, falling after seed dispersal, symmetrical or nearly so, 3–6 cm long, ovoid-conical when closed, broadly ovoid when opened. Seed scales thin woody, rigid, oblong, spreading moderately wide; apophyses flat or slightly raised, transversely keeled, more or less rhombic in outline or with upper margin rounded, dull brown; umbo broadly triangular or irregular, depressed or slightly protruding, unarmed or with a weak, minute prickle. Seeds obovoid or ellipsoid, slightly flattened, 4–7 mm long, dull brown or tan; wing firmly attached, 12–20 mm long, 5–7 mm wide.

Taxonomic notes

Pinus funebris has been described by Komarov (*op. cit.*) as a separate species from North Korea and the adjacent Russian border area; some later authors considered it to be a variety of *P. densiflora*. Quite a number of other forms or varieties were subsequently described and named, all from NE China. None of these are recognized here, but Flora of China 4 (1999) still recognizes two; one of these, *P. densiflora* var. *ussuriensis* T. N. Liou et Q. L. Wang is a synonym of *P. sylvestris* (Farjon, 1998, [2001]). The other variety, var. *zhangwuensis* S. J. Zhang *et al.*, lacking "white powdery" (glaucous?) branchlets, is described with longer (13–15 cm) needles than var. *densiflora* (6–12 cm), but unless (and until) such descriptions are based on wide sampling, enabling morphometric studies, they remain unconvincing.

Distribution

China: Heilongjiang, Jilin, Liaoning, Shandong, Anhui, Jiangsu, Henan; Japan: Honshu, Kyushu, Shikoku; North & South Korea; Russian Far East: Primorye.

TDWG codes: 31 PRM 36 CHM-HJ CHM-JL CHM-LN CHN-SD CHS-AH CHS-HE CHS-JS 38 JAP-HN JAP-KY JAP-SH KOR-NK KOR-SK

Ecology

Pinus densiflora occurs in extensive pure stands in many parts of its range and is one of the most dominant conifers in Japan and Korea. It grows in a variety of acidic soils, from dry sandy or rocky sites to peaty soils. In Japan it reaches from near sea level (and close to the shore) up to 2300 m in the mountains, but on mainland Asia its altitudinal range is more restricted and extends upward to only 900 m a.s.l. in NE China and 1300 m in Korea. In areas where broad-leaved forest dominates, *P. densiflora* is restricted to poorer sites such as rock outcrops on S-facing slopes and edges of moors or mountain lakes. Here it mixes with the angiosperms and can quickly recolonise ahead of them after forest fires.

Conservation

IUCN: LC

Uses

Japanese red pine is very similar (and closely related) to Scots pine and has consequently similar wood properties; it is an important timber tree in NE Asia. The wood is today mainly used in the paper industry, but also still provides timbers for underground mining and for railway sleepers, as well as construction timber. Foresters in Japan and the USA have produced hybrids with *P. thunbergii* and *P. massoniana* and with *P. nigra* as well as with *P. sylvestris*. In Japan, this species is extensively planted for forestry as well as for amenity; in Japanese horticulture perhaps as many as 100 cultivars are known. This pine and its cultivars are often used in Japanese landscape gardens of larger size, traditionally around shrines and in palace grounds. Relatively few of these cultivars,

and indeed the species itself, have made their way to Europe, probably because there *P. sylvestris* offers similar opportunities for horticultural experimentation. The Japanese horticultural art 'bonsai' also makes use of this species. Needles and extracts from them are used in traditional medicine such as aromatherapy. The pollen is edible and also used as medicine.

Pinus devoniana Lindl., Edwards's Bot. Reg. 25: 62. Aug 1839. [Allg. Gartenzeitung 7: 324. 1839] Type: Mexico: Hidalgo, Mineral del Monte, Cerro Ocotillo, *C. T. Hartweg s.n.* (lectotype W). Fig. 222

Pinus michoacana Martínez, Anales Inst. Biol. Univ. Nac. México 15: 1. 1944.

Etymology

This species was named in honour of William Spencer Cavendish, sixth Duke of Devonshire (1790–1858), who had a great interest in gardening.

Vernacular names

Michoacan pine; pino blanco, pino lacio, ocote gretado (Mexico)

Description

Trees to 20–30 m tall, d.b.h. to 0.8–1 m. Trunk monopodial, usually erect; bark thick, scaly, very rough, with elongated plates divided by deep longitudinal black fissures, reddish brown to dark brown. Branches spreading and assurging, or ascending near the top, forming an open, broad pyramidal or domed crown. Shoots 15–20 mm thick, rigid, curved, very rough and scaly. Cataphylls up to 20–25 mm long, subulate, scarious, recurved or reflexed, dark brown to blackish grey, with erose-ciliate margins. Vegetative buds large; terminal bud 20–40 mm long, but lateral buds smaller, ovoid-acute, not resinous. Fascicle sheaths to 30–40 mm long, often very resinous. Leaves in fascicles of 5, rarely 4 or 6, persisting 2–3 years, rigid, straight, or flexible and drooping, (17–)25–40(–45) cm long, 1.1–1.6 mm wide, with serrulate margins, acute-pungent, lustrous green. Stomata on all faces of leaves. Pollen cones cylindrical, 20–40 mm long, pink-purplish, turning light brown. Seed cones subterminal, solitary or in pairs or whorls of 3–4. Mature cones on short, persistent peduncles, leaving a few scales on the branch when falling, variable in size and shape, typically ovoid-oblong, with an oblique base, or curvate to cornute (often by insect-damage), 15–35 × 8–15 cm when open. Seed scales parting when the seeds are mature, spreading wide, straight or slightly recurved, thick woody, rigid or flexible with some force. Apophyses mostly raised, transversely keeled, rhombic in outline, with irregular sides, up to 25 mm wide, often radially striated, in various shades of brown. Umbo dorsal, raised, flat or depressed, terminating in a small, usually deciduous prickle, grey-brown. Seeds obliquely broad ovoid, flattened, 8–10 × 5–7 mm, light brown, often with dark spots. Seed wings obliquely ovate to oblong, with a straight side, 25–35 × 10–15 mm, light brown with darker stripes. Many seedlings developing a 'grass stage' with delayed apical growth of stem.

Taxonomic notes

This species is still known in many books on conifers by its name given by Maximino Martínez, *Pinus michoacana*. Martínez (1945, 1948), who worked on the pines of Mexico during the difficult years of World War II, considered it likely that his new species would correspond with some of John Lindley's names, among which *P. devoniana* was mentioned, but at the time he had no access to these original publications. The complexity of forms and many of the names that were given to these have been united by Farjon & Styles (1997) in a comprehensive monograph on Latin American pines under the earliest available name *Pinus devoniana* Lindley. Hopefully, the results of thorough taxonomic work published in specialized literature that strictly follows the rules of botanical nomenclature will eventually filter through to become established in the literature aiming at a more general audience.

Distribution

Mexico: Sinaloa, Nayarit, Jalisco, Zacatecas, Aguascalientes, San Luís Potosí, Querétaro, Hidalgo, Michoacán, México, Distrito Federal, Morelos, Tlaxcala, Puebla, Veracruz, Guerrero, Oaxaca and Chiapas; in Guatemala in the southern highlands.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-AG MXE-HI MXE-QU MXE-SL MXE-ZA MXG-VC MXN-SI MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 GUA

Ecology

This species is a constituent of relatively open, often secondary pine-oak forests, or it occurs with *Pinus oocarpa* invading burned mountainsides. It is well adapted to withstand fires by its juvenile "grass stage" similar to that of *P. palustris* of the SE USA. The pines most commonly associated with it vary somewhat from north to south and include *P. oocarpa, P. montezumae, P. pseudostrobus*, and *P. maximinoi* and less frequently *P. cembroides* at lower altitudes and *P. hartwegii* at higher altitudes. Common are also *Quercus*, *Liquidambar*, and in the understorey *Calliandra, Leucaena, Acacia, Dodonaea*, *Gaultheria*, and *Mimosa*. Its altitudinal range is (700–)900–2500(–3000) m a.s.l. *Pinus devoniana* grows on a variety of soils, often of volcanic origin. The climate is warm-temperate to subtropical, with annual precipitation 1000–1500 mm and a dry season from November to May.

Conservation

IUCN: LC

Uses

Pinus devoniana is a common tree throughout the mountainous parts of S Mexico and Guatemala, often encountered in open, degraded pine-oak or pine forest. As it is not a very tall, straight-boled tree and has branches low on the trunk, it is not often selected as a timber tree. On the other hand, it is locally used and, like other pines, increasingly for firewood by the growing rural population. Uses of timber are put to fence posts, boxes, furniture, toll handles, and other woodware and, mixed with other pine wood, wood chips glued and compressed to particleboard. It is virtually unknown in horticulture despite the fact that it is one of the most strikingly beautiful pines, with perhaps the longest needles in the entire genus and large cones and a deep red-brown bark. Provenance is crucial to establish whether some trees could turn out to be hardy, but otherwise it would do fine in much of California, the Mediterranean, Australia, and New Zealand, to mention just a few regions where gardening and tree planting are a major enjoyment for many.

Pinus douglasiana Martínez, Madroño 7: 4. 1943. Type: Mexico: Nayarit, Jalá, Cerro Juanacata, *M. Martínez 3429* (holotype MEXU).

Etymology

This species was named after the plant collector David Douglas (1798–1834), who, however, never visited Mexico.

Vernacular names

Douglas pine; ocote, pino hayarín (Mexico)

Description

Trees to 20–45 m tall, d.b.h. to 0.8–1 m. Trunk monopodial, straight; bark rough, scaly, divided into large, irregular plates and deep fissures, dark reddish brown, weathering grey-brown. Branches long, slender, spreading, or ascending in upper part of crown. Shoots uni-nodal, dark brown, not glaucous. Cataphylls subulate-caudate, spreading or recurved, with erose-ciliate margins, brown. Vegetative buds ovoid-conical; terminal bud 15–25 × 10–15 mm, but lateral buds smaller, not resinous. Fascicle sheaths persistent, remaining long, (15–)20–35 mm, weathering greyish brown. Leaves in fascicles of 5, rarely 4 or 6, persisting 2–2.5 years, slender, lax or sometimes more rigid, 22–35 cm long, 0.7–1.2 mm wide; margins serrulate; apex acute; leaf colour light yellowish green to glaucous green. Stomata on all faces of leaves. Pollen cones numerous, forming long, spiculate clusters, cylindrical, 20–25 × 4–5 mm, pinkish brown at maturity. Seed cones solitary, in pairs or whorls of 3–4 on stout, recurved, 10–15 mm long peduncles which fall with the cone. Mature cones ovoid to ovoid-attenuate when closed, often slightly curved, more broadly ovoid with a flattened base when opened, then 7–10 × 5–7 cm. Seed scales parting to release the seeds except at base, (thin) woody, oblong, straight or slightly curved. Apophyses nearly flat or raised and transversely keeled, radially striate

or grooved, rhombic or pentagonal in outline, nearly symmetrical around cone, 11–17 mm wide, light brown, reddish brown or dark brown. Umbo dorsal, raised, transversely rhombic, darker than the apophysis, prickle absent. Seeds obliquely obovoid, slightly flattened, 4–5 × 3–3.5 mm, light grey or brown, often with dark spots. Seed wings oblong, with a straight and a curved side, 18–24 × 7–9 mm, light yellowish brown, translucent, sometimes with a darker brown tinge.

Distribution

Mexico: mainly in Jalisco, Michoacán, México and N Morelos, but extending northward into Nayarit and the crest of the Sierra Madre Occidental on the border line of Sinaloa and Durango, southwards it occurs locally in Guerrero and Oaxaca.

TDWG codes: 79 MXC-ME MXC-MO MXC-PU MXE-DU MXN-SI MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA

Ecology

This species is a constituent of mostly mixed pine or pine-oak forests at elevations ranging from (1100–)1400–2500(–2700) m a.s.l. in warm to temperate climatic zones. The annual precipitation differs with altitude but is roughly around 1000 mm in most areas. Common associated pines are *Pinus pseudostrobus, P. herrerae, P. leiophylla, P. lawsonii, P. ayacahuite* in the southern part of its range, sometimes *P. oocarpa* and *P. devoniana* at lower elevation and drier sites respectively. At the highest and wettest sites *P. douglasiana* can occur with *Abies, Picea* (in Durango) or *Cupressus lusitanica*. In many areas *Quercus* spp. are codominant; a shift in forest composition towards broad-leaved trees may occur also by selective cutting of pines.

Conservation

IUCN: LC

Uses

Pinus douglasiana is, along with other species with which it often occurs, an important timber tree in most of its range. It is, however, not especially sought out for tree-breeding purposes, perhaps due to the fact that it is relatively unknown to foresters. It is perhaps present in a few arboreta or pineta in regions with a mild climate, but not generally cultivated for horticulture. It has been tried in forestry plantations, but is not in common use.

Pinus durangensis Martínez, Anales Inst. Biol. Univ. Nac. México 13: 23, f. 1–4. 1942. Type: Mexico: Durango, El Salto, Las Adjuntas, *M. Martínez 3477* (holotype MEXU). Fig. 223

Pinus martinezii E. Larsen, Madroño 17: 217. 1964; *Pinus douglasiana* Martínez var. *martinezii* (E. Larsen) Silba, Phytologia 68: 49. 1990.

Etymology

The species epithet *durangensis* refers to the Mexican State of Durango, from where it was first described.

Vernacular names

Durango pine; ocote, pino blanco, pino real (Mexico)

Description

Trees to 35–40 m tall, d.b.h. to 0.8–1 m; trunk monopodial, erect, straight. Bark rough, scaly, breaking into large, irregular, elongated plates divided by longitudinal, shallow fissures, dark brown, weathering grey. Branches long, slender, with lower branches usually curved downward, ultimately more or less pendant. Shoots uni-nodal, orange-brown or reddish brown, usually glaucous. Cataphylls ca. 15 mm long, 3–4 mm wide at base, subulate, soon reflexed, scarious, with erose-ciliate margins and caudate apex, dark brown. Vegetative buds ovoid; terminal bud 15–20(–25) × 10–15 mm, but lateral buds smaller, not resinous. Fascicle sheaths 20–30 mm long, persistent but reduced to 10–15 mm. Leaves in fascicles of (4–)5–6(–7, rarely 8), persisting 2–2.5 (–3?) years, straight or slightly curved, 14–24 cm long, 0.7–1.1 mm wide; margins serrulate, acute to pungent; leaf colour yellowish green to glaucous green. Stomata on all faces of leaves. Pollen cones ovoid-oblong to cylindrical, yellowish brown when mature. Seed cones subterminal, solitary, in pairs

or in whorls of 3–4 on short, stout, usually persistent peduncles, eventually deciduous. Mature cones ovoid or broadly ovoid when opened, slightly flattened or obtuse-conical at base, often slightly curved, 5–9(–11) × 4–6(–7) cm when open. Seed scales parting readily to release seeds except those at base of cone, thick woody, broadly oblong, straight or recurved near base of cone. Apophysis raised, sometimes flat on basal scales, prominently transversely keeled, rhombic to pentagonal in outline, more or less symmetrical around cone, ochraceous to light (reddish) brown. Umbo dorsal, raised, slightly recurved, transversely keeled, with a small, persistent (or deciduous) prickle. Seeds obliquely ovoid, slightly flattened, 5–6 × 4–4.5 mm, light brown to grey, with small, dark spots. Seed wings oblique, 14–20 × 6–9 mm, light greyish brown, translucent, with a blackish tinge.

Distribution

Mainly in the southern Sierra Madre Occidental of Mexico, rare in E Sonora and Chihuahua, common in Durango, Zacatecas and N Jalisco, more scattered further south in Jalisco and N Michoacán.
TDWG codes: 79 MXE-CU MXE-DU MXE-ZA MXN-SI MXN-SO MXS-JA MXS-MI

Ecology

In the Sierra Madre this species is an important constituent of the 'yellow pine' forest, where it occurs in pure stands or mixed with several other species of pine, e.g. *P. arizonica, P. leiophylla*, and *P. engelmannii*, or in pine-oak forests. Its altitudinal range is extensive: (1400–)1600–2800(–3000?) m, but it is most common at 2000–2800 m a.s.l. Climatically, the Sierra Madre is warm-temperate, but with cold spells during the short winter at the higher elevations. Annual precipitation varies between 700–1200 mm, most of which occurs in the summer. This pine is adapted to grow on shallow, rocky soils, but its better stands are found on deeper soils, where it can successfully compete with most other pines. The soils are mostly derived from volcanic rock. At the highest elevation *P. durangensis* occurs with *Abies* and/or *Cupressus lusitanica*, at the lowest with *Juniperus deppeana* and *Pinus oocarpa*. Other pines are *P. montezumae, P. teocote* and in the southern part of its range *P. ayacahuite* can occur with it.

Conservation

Pinus durangensis, as a pine tree with a tall, straight bole, has been much sought after as a timber tree and exploitation has been severe, especially in Durango (Perry, 1991), where extensive, more or less pure stands are now rare. In mixed forest and remote areas mature to aged trees still occur abundantly, but in the near future protection may become necessary to avoid over-exploitation.
IUCN: NT

Uses

Durango pine is an important timber tree. It grows straight and tall and is (or was) abundant and widespread in many areas within its range. Logging from natural stands at the current rate is unsustainable and plantations are now being attempted in the state of Durango. The timber is used for construction such as roof beams, general carpentry, furniture, floors, and plywood. This species is virtually unknown in horticulture.

Pinus echinata Mill., Gard. Dict., ed. 8: Pinus No. 12. 1768. Type not designated.

Etymology

The species epithet means 'spiny' or 'prickly', but it is not clear what Philip Miller found so spiny in this pine.

Vernacular names

Shortleaf pine

Description

Trees to 35–40 m tall; trunk to 1.6 m d.b.h. Bark breaking into irregularly rectangular or square, scaly plates, dark brown, slightly resinous. Branches spreading, sometimes heavy but more slender and shorter in trees growing in closed canopy stands. Foliage branches slender, often more or less pendulous, new shoots purplish green, often glaucous, turning red-brown to grey, rough with persistent pulvini after leaf fascicles have fallen. Buds ovoid to ovoid-cylindric, 5–10 mm long, strongly resinous. Leaves in fascicles of 2 or 3, held in a 10–15 mm

long fascicle sheath, persisting 3–5 years, spreading, (5–)6–11(–12) cm long, straight or slightly curved and flexible, ca. 1 mm wide, yellowish green, greyish green or dark green; margins minutely serrulate; apex short acute; stomata in fine lines on all surfaces. Pollen cones in small clusters, spirally arranged, cylindrical, 1.5–2 cm long, pale purplish green to yellow, turning light brown. Seed cones solitary or in whorls of 2–4, short pedunculate or nearly sessile, semi-persistent but opening soon, spreading, 4–7 cm long, narrowly ovoid or ovoid-oblong when closed, broadly ovoid or ovoid-conical with a nearly flat base when open. Seed scales thin woody, rigid, uniformily dull brown below the apophysis without a dark band; apophysis slightly raised, sharply keeled transversally; umbo dorsal and central, armed with a short, stout prickle. Seeds ellipsoid, ca. 6 mm long, grey mottled black, with a similarly patterned wing 12–15 mm long.

Distribution

E and SE USA, from New York to E Texas across 22 states.

TDWG codes: 74 ILL MSO OKL 75 CNT NWJ NWY OHI PEN WVA 77 TEX 78 ALA ARK DEL FLA GEO KTY LOU MRY MSI NCA SCA TEN VRG WDC

Ecology

Pinus echinata is a lowland pine with an extensive range across the SE United States, mostly growing from ca. 150 m up to the foothills of the Appalachian Mountains at ca. 600 m a.s.l. It is absent in the Mississippi Valley and its delta as well as in a narrow to fairly wide coastal strip along the Gulf of Mexico and Atlantic Ocean, and it does not extend into most of Florida. This indicates that it is primarily limited by climatic factors, such as the 10° C average annual temperature isoline at its northern limit and an average annual precipitation above 1000 mm distributed more or less evenly over a year as its southern limit. It grows on a great variety of soils, but most have a capacity for moist retention with a sandy loam or silty loam texture and good drainage. Although this species can form nearly pure stands, in most sites it will be succeeded by broadleaved trees especially oaks (*Quercus* spp.) except where thin soil overlies rock. There *P. echinata* forms a minor component of various angiosperm-dominated forest and woodland types. It can also be associated with *P. taeda*, which has a very similar distribution, but at least in parts of its range occurs in a wetter habitat.

Conservation

IUCN: LC

Uses

Shortleaf pine is an important commercial conifer species in the SE United States and both natural stands and plantations are exploited for timber. The wood is of excellent quality, with orange or yellowish brown heartwood and creamy yellow sapwood; it is used for railway sleepers, construction lumber, indoor finishing like panelling, plywood, furniture, and kraft pulp and dissolving pulp; the latter product feeds the paper industry. Most of the plantation timber goes to pulping. There is a limited use for amenity planting and in urban areas this pine is planted to screen off residential areas from motorways (major highways) or industrial areas. This species has little significance in horticulture and is rarely planted in gardens.

Pinus edulis Engelm., in Wislizenus, Mem. Tour N. Mexico: 88. 1848. *Pinus cembroides* Zucc. var. *edulis* (Engelm.) Voss, Mitt. Deutsch. Dendrol. Ges. 1907 (16): 95. 1907; *Pinus cembroides* Zucc. subsp. *edulis* (Engelm.) E. Murray, Kalmia 12: 22. 1982. Type not designated.

Etymology

The species epithet means 'edible' and refers to the seeds.

Vernacular names

Pinyon pine, Two-needle pinyon pine, Colorado pinyon

Description

Shrubs or trees to 15(–21) m tall, d.b.h. to 60 cm. Trunk monopodial, short to medium size, strongly tapering, branching low. Bark thick, rough and scaly, breaking into small, irregular plates, divided by

irregular, shallow fissures, not easily exfoliating, red-brown weathering grey-brown. Branches spreading or ascending, irregularly disposed in most trees. Crown broad conical or rounded, dense. Shoots pale red-brown or tan, rarely slightly glaucous at first, soon grey, glabrous or minutely puberulent. Vegetative buds ovoid-oblong to ellipsoid; terminal bud 5–10 × 3–5 mm, but lateral buds smaller, resinous, red-brown. Fascicle sheaths 5–7 mm long, loosely imbricate, soon recoiling, then pale straw-coloured to grey, forming a small rosette at base of fascicle but deciduous before the leaves fall. Leaves in fascicles of (1–)2(–3), spreading, persisting 4–6 years, upcurved, connivent, rigid, 2–4 cm long, 0.9–1.5 mm wide; margins entire or minutely serrulate; leaf colour variable, dull green to glaucous green. Stomata: leaves amphistomatic, with 2–4 lines on each face. Pollen cones in more or less elongated, spiculate clusters, ca. 7 × 3.5 mm, yellowish to red-brown. Seed cones solitary, paired or more rarely in whorls of 3, on very short, 3–5 mm long peduncles remaining with fallen cones. Mature cones seemingly sessile, irregularly globose or ovoid-globose when closed, spreading often wider than long when opened, with a flattened base, irregular in size and shape, often resinous, 3–5 × 3–6 cm when open. Seed scales parting easily and widely, narrowly and more or less weakly attached to the rachis and hence moveable, concavo-convex, with 1–2 deep seed cavities. Apophysis prominently raised, transversely keeled or radially keeled or ribbed, rhombic to pentagonal in outline but irregular, often angular or curved, variously brown. Umbo dorsal, flat or slightly raised, with a minute prickle. Seeds obovoid or ellipsoid, 10–15 × 6–9 mm, greyish brown or light brown; integument thick, 0.5–1(–1.1) mm; megagametophyte ('endosperm') pinkish or white when fresh. Seed wings absent when the seed is detached from the scale.

Distribution

SW USA: Arizona, S California, Colorado, New Mexico, W Oklahoma, NW Texas, Utah, S Wyoming.
TDWG codes: 73 COL WYO 74 OKL 76 ARI CAL UTA 77 NWM TEX

Ecology

Pinus edulis is widely distributed in the interior basins, plateaus, mesas and mountains of the 'Four Corner' States of the USA. It forms extensive, open stands commonly with one or more species of *Juniperus* known as Pinyon-Juniper woodland, which is one of the most widespread semi-arid vegetation types in North America. Summers are hot and winters cold, but climatic conditions are varying with altitude and latitude. Soils are commonly thin to sceletal or may be absent altogether, with the trees growing from fissures in the sandstone, limestone, or shale. Recent sedimentation accumulates in the basins and valley bottoms, where grasses and 'sagebrush' (*Seriphidium tridentatum*) dominate, while at higher elevations in the mountains the Pinyon-Juniper woodland gives way to open pine forest with *Pinus ponderosa* and *Pseudotsuga menziesii*. The altitudinal range of *P. edulis* is 910–3200 m a.s.l. *Juniperus monosperma* and *J. osteosperma* are the most commonly associated junipers with *P. edulis*. The appearance is of a stunted forest as the free standing trees branch low and form wide spreading crowns while only attaining modest height. Depending on openess, there is an understorey dominated by shrubs of which *Seriphidium* (*Artimisia*) is most common and widespread, supplemented by scrubby oaks (*Quercus* spp.), *Chrysothamus*, *Cercocarpus, Ephedra, Yucca*, and several others depending on geographical area, as well as grasses and other herbs.

Conservation

Although the species is too widespread and abundant to be threatened with extinction, the Pinyon-Juniper woodland as an ecosystem is under threat in many places due to 'range improvement' for the grazing of cattle and sheep, causing the removal or degradation of the woodland over large areas. There is growing awareness that these practices must stop, as the habitat itself is increasingly found to be more important than the production of more beef and wool and much of the Pinyon-Juniper woodland occurs on public lands.
IUCN: LC

Uses

Firewood from the Pinyon-Juniper woodland is the most common use both past and present. Pinyon pine wood has a higher than average heat value and burns with a distinctive aroma (as does the juniper wood, which I prefer for my campfires when trav-

eling in the area). Large quantities were logged and its rough timbers used as props in the mining boom of the late 19th century. Poor growth form from the forester's perspective renders the wood unsuitable for sawn timber, even though its quality matches that of Ponderosa pine. The edible seeds are easy to harvest and in great demand as a delicacy; they may constitute the economically most valuable product of the species. Crops can vary greatly from one year to the next and the slow growing pines do not perform well in plantations. Horticultural value is limited, although locally young trees are harvested as Christmas trees.

Pinus elliottii Engelm., Trans. Acad. Sci. St. Louis 4: 186, t. 1–3. 1880.

Etymology

This species was named after the botanist Stephen Elliott (1771–1830).

Vernacular names

Slash pine

Description

Trees to 30 m tall; trunk to 80 cm d.b.h., straight or contorted. Bark breaking into large, irregularly rectangular, thin papery or scaly plates separated by irregular furrows, orange-brown or purplish brown. Branches spreading, forming a wide, dome-shaped, open crown. Foliage branches stout, often to ca. 1 cm thick, orange-brown, turning red-brown to dark brown, rough with persistent pulvini after leaf fascicles have fallen. Buds ovoid-cylindric to cylindric, 1.5–2 cm long, not resinous; cataphylls with white or silvery fringed margins. Leaves in fascicles of 2 or 3, held in a 15–20 mm long fascicle sheath, persisting 2 (rarely 3) years, spreading, (15–)18–25(–30) cm long, straight and flexible, slightly twisted, 1.2–1.5 mm wide, yellowish green or glaucous green; margins minutely serrulate; apex short acute to acuminate; stomata in fine lines on all surfaces. Pollen cones in clusters, spirally arranged, cylindrical, 3–4 cm long, purplish, turning dark or dull brown. Seed cones solitary or in pairs, pedunculate to 3 cm or almost sessile, soon falling after seed dispersal, spreading, (7–)9–15(–18) cm long, narrowly ovoid or ovoid-oblong when closed, broadly ovoid or ovoid-cylindric with a more or less flattened base when open. Seed scales thin woody, rigid, light brown proximally; apophysis lustrous brown, raised and sharply keeled transversally; umbo dorsal and depressed-pyramidal, armed with a short, stout prickle. Seeds ellipsoid, 6–7 mm long, dark brown, with a wing 20–30 mm long. Seedlings with or without a 'grass' stage.

Distribution

SE USA, from North Carolina to Mississippi, S to Florida Keys.
TDWG codes: 78 ALA FLA GEO LOU MSI NCA SCA

Ecology

Pinus elliottii is a subtropical pine growing in a warm and humid climate at low elevations. Most rain falls in summer as short cloudbursts to a total average of 1270 mm per year; winters are mild to warm and dry although frosts do occur especially on clear nights. It especially thrives in wetlands, where it is abundant on the sandy islands of extensive swamps such as Okefenokee and the Everglades and on pond margins and along drainages. Its roots need aerated soil, so it avoids the swamps proper. In the Florida Keys, the variety *densa* occurs on karst limestone, an extremely nutrient poor rock type derived from ancient coral reefs. *Pinus elliottii* can form pure stands, or mixed pine forest with *P. taeda* and *P. serotina*. Other conifers that can occur with *P. elliottii* are *Chamaecyparis thyoides* and *Taxodium distichum*; broadleaf trees are e.g. *Nyssa sylvatica* and *N. aquatica, Magnolia virginiana*, and *Persea borbonia*. The understorey is often dominated by shrubby palms or palmettos (*Sabal palmetto, Serenoa repens*). The southernmost populations (var. *densa*) develop a 'grass stage' as an adaptation to frequent ground fires. Initially, seedlings produce very little apical growth and develop an extensive root system; after fire damage new buds are formed at the apex of a very short stem near the ground. Photosynthesis is with juvenile 'grass' leaves only. After some years, a sudden apical growth elongates the stem rapidly without branching, lifting the growing points above the heat of fires. At this stage normal subapical branching begins and fascicles with adult needle leaves are formed.

Uses

Slash pine is a main source for naval stores, a term used first by the English for course resin products used in the navy to make wooden ships waterproof and tar the rigging. This industry is one of the oldest in the United States and has supplied huge quantities of resin and turpentine since colonial times. In the past, resin was virtually the only product harvested from Slash pine (the method of tapping gave the tree its vernacular name), reaching a production peak in the 1930s. After that date production sharply declined due to labour costs and other market forces, but plantation trees are still tapped for this purpose up to 20 years of age, after which the timber is harvested for the pulp industry, yielding sulfate turpentine as a by-product. Selection of high resin yielding trees has produced commercially available seedlings for this purpose and such seedlings have been exported to many tropical countries. Detailed information on this industry is found in the book Plant Resins (Langenheim, 2003). The other uses of the wood are mainly as roundwood for poles and posts, often after treatment for conservation. Bark and needles are used as a mulch in horticulture, but the tree itself is rarely planted in gardens.

2 varieties are recognized:

Pinus elliottii Engelm. var. ***elliottii***. Type: USA: South Carolina, *J. H. Mellichamp s.n.* [MO No. 3941460], 20 Mar 1873 (lectotype MO).

Description

Leaves mostly in fascicles of 3; hypodermis with 2–3 cell layers; resin ducts 3–5. Seedlings developing normally, with regular internodes and branching whorls.

Distribution

SE USA, from North Carolina to Mississippi (coastal plain) including Florida to the Everglades.
TDWG codes: 78 ALA FLA GEO LOU MSI NCA SCA

Conservation

IUCN: LC

Pinus elliottii Engelm. var. ***densa*** Little & K. W. Dorman, J. Forest. (Washington) 50: 921, f. 1, 2. 1952. *Pinus elliottii* Engelm. subsp. *densa* (Little & K. W. Dorman) E. Murray, Kalmia 12: 23. 1982; *Pinus densa* (Little & K. W. Dorman) Silba, Phytologia Mem. 7: 50. 1984. Type: USA: Florida, Henry Co., La Belle, 20 mi. (30 km) SE of La Belle, *E. L. Little & K. W. Dorman 14033* (holotype US).

Pinus densa (Little & K. W. Dorman) Silba var. *austrokeysensis* Silba, Phytologia 68: 49. 1990, ["*austro-keysensis*"].

Description

Leaves more frequently in fascicles of 2 than in 3's; hypodermis with (2–)3–4(–5) cell layers; resin ducts up to 9 per leaf. Seedlings usually developing a grass stage, with shortened stems and crowded subterminal buds; growing stem mostly without branches initially.

Distribution

SE USA: in S Florida and north along the coasts to Central Florida; also on eight of the Lower Florida Keys.
TDWG codes: 78 FLA

Conservation

IUCN: NT

Pinus engelmannii Carrière, Rev. Hort., sér. 4, 3: 227. 1854. Type: Mexico: Chihuahua, Cosiquiriachi, *F. A. Wislizenus 233* (lectotype MO). Fig. 224

Pinus macrophylla Engelm. var. *blancoi* Martínez, Anales Inst. Biol. Univ. Nac. México 15: 345. 1944; *Pinus engelmannii* Carrière var. *blancoi* (Martínez) Martínez, Pinos Mexic., ed. 2: 288. 1948.

Etymology

This pine species was named after the German/American botanist Georg(e) Engelmann (1809–1884), who became Director of the Missouri Botanical Garden.

Vernacular names

Apache pine; pino real, pino prieto (Mexico)

Description

Trees to 20–25(–27) m takk, d.b.h. to 70–90 cm. Trunk monopodial, straight; bark thick, rough, scaly, divided into long, irregular plates by wide, shallow fissures, dark brown, weathering grey. Branches long, spreading or assurging, forming a broad, rounded, open crown. Shoots stout, very rough with large, decurrent, persistent pulvini. Cataphylls large, 15–20 mm long, subulate, recurved, with scarious lamina and erose-ciliate margins, dark brown to blackish. Vegetative buds large; terminal bud 20–30 × 15–20 mm, ovoid-conical; lateral buds smaller, not resinous. Fascicle sheaths persistent and remaining long, (15–)25–35(–40) mm, reddish brown weathering brown to blackish. Leaves in fascicles of (2–)3(–4), rarely 5, persisting 2–3 years, rigid or pliant, straight or slightly drooping, (18–)20–35 cm long, 1.5–2 mm wide; margins serrulate; apex acute-pungent; leaf colour light green or glaucous. Stomata on all faces of leaves, in (6–)8–15 lines on the convex abaxial face and 4–8 lines on each adaxial face. Pollen cones ovoid-oblong to cylindrical, up to 4 cm long and 12 mm wide, yellowish pink, turning yellowish brown. Seed cones subterminal, in pairs or in whorls of 3–5, on thick, short, curved peduncles, persisting some time, leaving a few scales on branch when falling. Mature cones seemingly sessile, ovoid-oblong, curved, with an oblique base when opened, 8–15 × 6–10 cm when open, often resinous. Seed scales oblong, straight or recurved, thick woody, with thin margins, up to 20 mm wide. Apophysis prominently raised, transversely keeled, rhombic or pentagonal in outline, ochraceous or light brown, often with dark radial lines or fissures. Umbo dorsal, large, rhombic to transverse-rhombic in outline, with a persistent, curved spine up to 3 mm long. Seeds obliquely ovoid, slightly flattened, 5–8 × 4–5.5 mm, light grey-brown, often with dark spots. Seed wings ovate-oblong to obliquely ovate, 18–25 × 7–10 mm, translucent light ochraceous.

Distribution

USA: SE Arizona and extreme SW New Mexico; Mexico: extending south from the populations in the SW USA through the Sierra Madre Occidental in Sonora, Chihuahua, NE Sinaloa, Durango and more scattered in Zacatecas, also in Nuevo León.

TDWG codes: 76 ARI 77 NWM 79 MXE-CO MXE-CU MXE-DU MXE-NL MXE-ZA MXN-SI MXN-SO

Ecology

Pinus engelmannii occurs on moderately dry, summer-warm open mountain slopes or plateaus at altitudes between (1200–)1500–2700(–3000) m a.s.l., most abundantly between 2000–2500 m. It occurs on poor rocky (volcanic) soils as well as on alluvial coarse sand/gravel or loamy sand. The climate is temperate, with annual rainfall from 400–700 mm increasing southward. Above 2000 m frost and snow are common in winter. It is a constituent of open pine and pine-oak woodland, sometimes of mixed pine forest, with e.g. *P. leiophylla, P. lumholtzii* and *P. pseudostrobus*, on drier sites with *P. cembroides* and *Juniperus* sp., and usually with various species of *Quercus* present.

Conservation

IUCN: LC

Uses

Apache pine is commonly logged, but apparently not specifically selected as a timber tree; in most of its range it grows together with other pines. In some areas depletion of larger trees has been observed. Its wood properties are similar to those of Ponderosa pine and Jeffrey pine and the wood is put to similar uses. In recent decades it has been taken more often into cultivation as it apparently grows well in regions with relatively mild winters and (moderately) warm summers. Its very large, light green to glaucous green needles are a striking feature in any good size garden.

Pinus fenzeliana Hand.-Mazz., Oesterr. Bot. Z. 80: 337. 1931. *Pinus parviflora* Siebold & Zucc. var. *fenzeliana* (Hand.-Mazz.) C. L. Wu, Acta Phytotax. Sin. 5 (3): 143. 1956. Type: China: Hainan Island, *[?] Fenzel 55* (holotype WU).

Pinus kwangtungensis Chun & Tsiang, Sunyatsenia 7: 113. 1948; *Pinus wangii* Hu & W. C. Cheng var. *kwangtungensis* (Chun & Tsiang) Silba, Phytologia 68: 64. 1990; *Pinus wangii* Hu & W. C. Cheng subsp. *kwangtungensis* (Chun & Tsiang) Businský, Acta Pruhoniciana 68: 11. 1999.

Pinus kwangtungensis Chun & Tsiang var. *variifolia* Nan Li & Y. C. Zhong, Novon 7 (3): 262. 1997; *Pinus wangii* Hu & W. C. Cheng subsp. *variifolia* (Nan Li & Y. C. Zhong) Businský, Acta Pruhoniciana 68: 11. 1999.

Pinus fenzeliana Hand.-Mazz. var. *annamiensis* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 30. 2000.

Pinus orthophylla Businský, Willdenowia 34 (1): 229. 2004.

Pinus eremitana Businský, Willdenowia 34 (1): 234. 2004.

Etymology

This pine species has been named after "Fenzel" the collector of the type specimen.

Vernacular names

hai nan wu zhen song, hua nan wu zhen song (Chinese names for two species here united into one).

Description

Trees to 50 m tall, in many areas only to 20–30 m tall; trunk to 1 m d.b.h. Bark on young trees and branches smooth, thin, becoming scaly and flaking, brown, dark brown or grey-brown on trunks of larger trees. Branches spreading wide, forming broad, umbrella-shaped or domed crowns. Foliage branches slender; young shoots pale brown, rarely glaucous, glabrous or rarely puberulent in grooves, turning greyish brown. Buds ovoid to cylindrical, slightly resinous; cataphylls dark brown. Leaves in fascicles of 5, held by deciduous sheaths of flimsy, brown scales; some leaves may fall independently before the whole bundle falls off the twig, producing fascicles with seemingly fewer than 5 leaves. Leaf length extremely variable at least between populations, 4–18 cm long, leaves spreading or drooping, slender, flexible, the shorter leaves straight or curved, 1–1.5 mm wide, glaucous green, with stomatal lines on the two adaxial surfaces; margins minutely serrulate. Pollen cones in small clusters, short cylindrical. Seed cones variable in size and shape, from short ovoid to long cylindrical, initially erect on stout peduncles, becoming curved down to pendulous, (3–)5–15(–17) cm long, solitary or with 2–3 together. Seed scales soft woody, more or less flexible at base, cuneate to oblong; apophyses rhombic to oblong (at base and apex of cone), curved or more or less straight, not recurved or more commonly recurved near cone base, becoming longitudinally furrowed in mature cones, ripening to yellowish brown or reddish brown, weathering grey-brown; apex thin or marginally thickened, usually upcurved; umbo terminal, small and obtuse. Seeds obovoid or ellipsoid, 10–15 mm long, wingless when dispersed, or with a variously rudimentary to small wing always shorter than the seed and easily detached.

Taxonomic notes

Using a somewhat broader species circumscription here, I have united *Pinus kwangtungensis* with *P. fenzeliana*, a name which must then be taken up as the earliest one validly published for the broader defined species. The variability of this species, with character states inconsistently distributed within and among populations, has led to the naming of many varieties and the classification of these with more than one species. In Flora of China 4 (1999) *P. fenzeliana, P. kwangtungensis* and *P. wangii* are kept separate, the two former each with two varieties. In this group of pines (section *Quinquefolius*, subsection *Strobus*) the number of leaves per fascicle is five and remarkably constant (very rarely a few fascicles with more than five, but never with fewer). The variety *variifolia* recently described by Nan Li and Y. C. Zhong (*op. cit.*) seems to be based on erroneous observation. Recently, Businský (2004) in a revision of *Pinus* subsection *Strobus* in Asia, described two new species, one from Hainan Island in China (*P. orthophylla*) and one from N Viet Nam (*P. eremitana*) which both appear to belong here. The differences in character states tabulated in this paper are not distinct, but have overlapping values,

which may indicate varieties, but not distinct species. Given the substantial range of measurements found for most of these characters, it is obvious that these character states are variable within populations.

Distribution

S China: Guangdong, Hainan, Guangxi, S Hunan; Viet Nam.
TDWG codes: 36 CHH CHS-GD CHS-GX CHS-HN 41 VIE

Ecology

This species occurs often on steep mountain slopes and rocky ridges, generally above a zone of less steep terrain dominated by evergreen broad-leaved trees. Its altitude range is from (500–)700 m to 1500 (–1800) m a.s.l. It can form nearly pure stands, but is often associated with other conifers and at the lower range of altitude with angiosperms as well.

Conservation

IUCN: NT

Uses

As a 'soft wood' pine, this species will yield excellent timber for construction, carpentry and perhaps furniture making. Uses are presumably local only, as there are no great quantities of it anywhere. Resin is tapped from trees in Viet Nam and used as a glue. Because this species resembles *P. morrisonicola* from Taiwan, it has potential as a garden tree or for bonsai culture. This species is currently not known to be in cultivation.

Pinus flexilis E. James, Account Exped. Pittsburgh 2: 27, 35. 1823.

Etymology

The species epithet refers to the very flexible branches.

Vernacular names

Limber pine, Rocky Mountain White pine

Description

Trees to 10–15(–20) m tall, d.b.h. to 1–1.5 m; trunk straight or contorted, branching very low. Bark thin, rough and scaly, breaking into small, scaly plates, brown, weathering grey. Branches ascending or spreading, of higher orders slender, flexible, assurgent. Shoots initially puberulent, soon glabrous, grey-green to grey. Cataphylls 5–10 mm long, subulate, scarious, brown. Vegetative buds ovoid or subglobose; terminal bud 8–15 mm long; lateral buds smaller, resinous. Fascicle sheaths ca. 15 mm long, deciduous and absent in second year's fascicles. Leaves in fascicles of 5, persisting (3–)5–6 years, straight or slightly curved, sometimes twisted, lax, (5–)6–9 cm long, 0.8–1.2 mm wide, with remotely serrulate to nearly entire margins, acute to acuminate, dark green on abaxial face, glaucous to white stomatal lines on both adaxial faces. Pollen cones ovoid-oblong, 6–10 mm long, yellow. Seed cones subterminal, solitary, in pairs or in whorls of 3(–4), on stout, to 15 mm long peduncles falling with cone. Mature cones subpendulous, cylindrical, straight or slightly curved when closed, ovoid-cylindrical or broad-cylindrical when opened, then 10–15 × 4–6 cm. Seed scales parting but spreading only ca. 50° from the axis, the proximal, infertile scales straight or slightly recurved, the other scales obtrullate, slightly concavo-convex, with seed cavities near base on adaxial side; apex straight or recurved at mid-cone; colour dark (reddish) brown. Apophysis relatively thick woody, triangular to rhombic, with an obtuse apex, straight or recurved but not reflexed at mid-cone, ochraceous to light brown, very resinous. Umbo terminal, transverse-triangular, obtuse, grey-brown, very resinous. Seeds broadly obovoid, flattened, 10–15 × 8–10 mm, dark brown, sometimes with blackish spots. Seed wings vestigial to very small, reduced to a narrow strip around the distal part of the seed up to 5 mm wide, or absent when the seed is free from the scale.

Distribution

W North America: Rocky Mountains from Alberta and British Columbia to New Mexico and Texas and some isolated localities to the east, mountains of SE California, Nevada, N Arizona, Utah; and extending into northern Mexico in scattered localities in Chihuahua, NE Sonora, Coahuila and Nuevo León.

PLATE 29. *Pinus flexilis*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Leaves. **4.** Seed cone.

TDWG codes: 71 ABT BRC 73 COL IDA MNT WYO 74 SDA 76 ARI CAL NEV UTA 77 NWM TEX 79 MXE-CO MXE-CU MXE-NL MXN-SO

Ecology

Pinus flexilis is a conifer tree of the subalpine zone in the Rocky Mountains and the 'Basin and Range' region further west. In many respects its habitat resembles that of *Pinus albicaulis*, which has a more westerly and northerly distribution. Some isolated populations, here recognized as var. *reflexa*, occur on high peaks in northern Mexico. In the Black Hills of North Dakota *P. flexilis* may grow as low as 900 m a.s.l., in the southern Rocky Mountains it can occur at 3800 m. This species is one of several in the genus *Pinus* of western North America that can withstand extreme conditions of climate on bare rock or scree without any other vegetation cover. On these sites it occurs either alone or with *Pinus albicaulis* and *Abies lasiocarpa* in the northern parts of its range and with *Pinus aristata* in the SE and *P. longaeva* in the SW. At lower altitudes it is usually only a minor component of more diverse conifer forest in the south and with *Picea engelmannii, Pinus contorta*, and *Pseudotsuga menziesii* in the north. The seeds, which only have rudimentary wings, are mostly dispersed by rodents and birds, of the latter Clark's Nutcracker (*Nucifraga columbiana, Corvidae*) is the most important vector.

Uses

Although the wood of Limber pine is of high quality, as a timber tree the species is of minor importance due to its occurrence at high altitudes, where it is generally inaccessible and most of the trees do not grow into straight boles. Planted trees have a tendency to become multi-stemmed from a short base and grow rather slowly. Locally, it has been used much for construction in 'pioneer times', but more recently its main uses have been restricted to carpentry and furniture, as well as firewood. The species has been introduced to Britain in 1851, but has remained rare in gardens there and elsewhere in Europe. In the USA it is more common and several cultivars, most of which have glaucous blue needles and more compact habits, are being grown and are in the horticultural trade.

2 varieties are recognized:

Pinus flexilis E. James var. ***flexilis***. Type: USA: Colorado, El Paso Co., eastern flank of Pike's Peak, 0.25 miles north of Ruxton Park, *Andresen J. W. & [?] Barger A2125* (neotype SIU). Pl. 29

Pinus flexilis E. James var. *macrocarpa* Engelm., in Rothrock, Rep. U.S. Geogr. Surv., Wheeler, 6, Bot.: 258. 1879; *Pinus novaemexicana* P. Landry, Phytologia 65: 479. 1989.

Description

Seed scales imbricate but spreading at maturity to release seeds; apophyses straight or slightly incurved, not recurved. Seeds without a wing when detached from the scale.

Distribution

W North America: Rocky Mountains from Alberta to New Mexico, mountains of SE California, Nevada, N Arizona, Utah, isolated localities in North Dakota, South Dakota and Nebraska.
TDWG codes: 71 ABT BRC 73 COL IDA MNT WYO 74 NDA NEB SDA 76 ARI CAL NEV UTA 77 NWM

Conservation

IUCN: LC

Pinus flexilis E. James var. ***reflexa*** Engelm., in Rothrock, Rep. U.S. Geogr. Surv., Wheeler, 6, Bot.: 258. 1879. *Pinus reflexa* (Engelm.) Engelm., Bot. Gaz. 7: 4. 1882; *Pinus flexilis* E. James subsp. *reflexa* (Engelm.) E. Murray, Kalmia 12: 23. 1982. Type: USA: Arizona, Pima Co., Santa Rita Mts., E of Tucson, *J. T. Rothrock 654* (lectotype MO).

Pinus strobiformis Engelm. var. *potosiensis* Silba, Phytologia 68: 62. 1990.
Pinus stylesii Frankis *ex* Businský, Acta Pruhon. 88: 6. 2008.

Seed scales imbricate, spreading when mature; apophyses slightly recurved. Seeds with a wing to 5 mm or wing vestigial.

Taxonomic notes

In a recent publication on the genus *Pinus*, Businský (2008) separated the populations of white pines in the northern part of the Sierra Madre Oriental, Mexico, as well as some outlier populations, as a distinct species *P. stylesii*. This concept includes *P. strobiformis* var. *potosiensis* Silba and *P. flexilis* var. *reflexa*, both from Cerro Potosí in Nuevo León. Chris Earle (www.conifers.org) has considered that it may be of hybrid origin involving (originally) *P. flexilis* and *P. strobiformis* (= *P. flexilis* var. *reflexa*). As *P. flexilis* retreated from the area in post-glacial time, while *P. strobiformis* seems to have increased its range, fewer and fewer 'original' hybrid trees remained and the genes from *P. strobiformis* may eventually subsume those from these earlier hybrid trees. If that scenario is correct, the name *P. flexilis* var. *reflexa* would be the most appropriate for this taxon.

Distribution

USA: Arizona, New Mexico, SW Texas; Mexico: Chihuaha, Coahuila, Nuevo León, NE Sonora.
TDWG codes: 76 ARI 77 NWM TEX 79 MXE-CO MXE-CU MXE-NL MXN-SO

Conservation

IUCN: NT

Pinus gerardiana Wall. *ex* D. Don, in Lambert, Descr. *Pinus*, ed. 8°, 2: p. s.n. inter 144 et 145, t. 79. 1832. Type: India: Uttaranchal, Kumaon, "*Lt.*" *Gerard s.n.* [Wallich Cat. No. 6064] (lectotype K-W, here designated).

Etymology

This pine species was named after its European discoverer Lt. Gerard, who brought it to the attention of Nathaniel Wallich in Calcutta.

Vernacular names

Gerard's pine, Chilgoza pine, Himalayan nut pine; chilghoza (Hindi); chiri, chujin (NW Himalaya)

Description

Trees to 25 m tall, but usually to 15–18 m; trunk to 0.8–1 m d.b.h., usually branching low, sometimes multi-stemmed. Bark smooth, hard, irregularly exfoliating with large thin plates, exposing fresh patches, which later turn from yellow-green or pale green to greyish white and create a multi-coloured pattern on branches and a grey-white trunk; bark on lower portion of trunk can become rough and fissured. Main branches long, spreading and ascending, forming a very wide, open crown. Foliage branches slender or stout, smooth, glabrous, yellowish green to olive-green. Buds ovoid, reddish brown, not resinous. Leaves in fascicles of 3, at first held by a basal sheath, the scales of which are shed in the second year, persistent 2–3 years, straight or curved and rigid, spreading, 5–10 cm long, slender, ca. 1 mm wide, grey-green or dark green; stomata on the two adaxial faces. Pollen cones clustered at the beginning of new shoots, spirally arranged, 7.5–13 mm long, ovoid-cylindrical. Seed cones solitary, lateral on shoot, sessile or short pedunculate, robust, 12–20(–23) cm long, 8–11(–13) cm wide when open, oblong-ovoid, with a more or less level base, falling 2–3 years after maturity. Seed scales thick woody, rigid, 3.5–5 cm long and 2–2.5 cm wide at mid-cone, spreading relatively wide, with two deep cavities on adaxial surface that hold the seeds; apophysis strongly developed, reflexed, longitudinally ridged and grooved, apically strongly curved near base of cone; umbo dorsal, with a recurved or hooked, obtuse apex. Seeds large, 20–25 mm long, ovoid-oblong to more or less cylindric, asymmetrical, 8–12 mm wide; wing rudimentary, remaining attached to the seed scale.

Distribution

E Afghanistan; China, S Xizang (Tibet); India, Jammu-Kashmir; N Pakistan.
TDWG codes: 34 AFG 36 CHT 40 PAK WHM-HP WHM-JK

Ecology

Pinus gerardiana grows in the mountains from about 2000 m to 3350 m above sea level. In the Himalayas this means that this pine is restricted to valley floors between very high mountain ranges, which isolate

different populations to a certain extent. It prefers dry, sunny slopes where the vegetation is more or less open. In Afghanistan this pine is cultivated for its edible seeds. They are evidently dispersed by birds, as is the case with other wingless or nearly wingless pine seeds, but detailed studies to identify the bird(s) and the role they play in the survival of this pine have not been undertaken as far as I know.

Conservation

IUCN: NT

Uses

The main economic use of this pine is of its edible, oil-rich seeds (neoza in Hindi), which are harvested by knocking the cones from the trees in autumn and early winter. Local mountain clans and villages own rights to the seeds and control the harvest, which is exported to markets on the plains of northern India. Trees that do not produce enough cones anymore are cut as firewood and new trees are planted from seeds in some areas to maintain stock. Animal husbandry, grazing the pine stands, conflicts with this use as it thwarts natural regeneration as well as planting efforts. The wood is used locally for light construction and carpentry. This species is comparatively rare in horticultural cultivation (despite good hardiness) and mainly restricted to collections in arboreta. Its bark is reminiscent of that of the Lacebark pine (*P. bungeana*), but somewhat less decorative; the seeds of *P. gerardiana* are much larger and better for comsumption (although the Chinese may of course disagree on this).

Pinus glabra Walter, Fl. Carol.: 237. 1788. Type not designated.

Etymology

The species epithet means 'smooth' (glabrous, i.e. without hairs) and pertains to the shoots.

Vernacular names

Spruce pine, Poor pine

Description

Trees to 30–35 m tall; trunk to 1 m d.b.h., straight, columnar. Bark thick, compact, breaking into elongate, irregular, small plates and longitudinal fissures, exfoliating slowly, grey-brown weathering grey, on branches in crown smooth, not flaking, grey. Branches few, spreading to ascending, forming a rounded to flat-topped crown in older trees. Foliage branches slender, rough with pulvini of fallen leaf fascicles, reddish or purplish brown, new shoots sometimes glaucous, turning grey. Buds ovoid, 5–10 mm long, acute, slightly resinous; cataphylls red-brown, finely fringed. Leaves in fascicles of 2, held together in a short sheath, straight, 4–8 cm long, rigid, slightly twisted, 0.7–1.2 mm wide; margins minutely serrulate; apex acute; leaf colour dark green; stomata in lines on all surfaces. Pollen cones in small clusters, spirally arranged, short cylindrical, 1–1.5 cm long, purplish, turning brown. Seed cones solitary or in pairs, semipersistent, opening soon, spreading on branch from short peduncles, 4–7 cm long, symmetrical or nearly so, ovoid-oblong before opening, becoming more cylindrical when open. Seed scales thin woody, more or less flexible at base, without a contrasting sealing border; apophysis slightly raised, irregularly rhombic in outline or with a rounded upper margin, transversely keeled; umbo central, depressed or obtuse, unarmed or with a weak, deciduous and small prickle. Seeds obovoid or nearly deltoid, 5–6 mm long, seed coat rough, mottled brown, with a wing 12–15 mm long.

Distribution

SE USA, Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina (coastal plain).
TDWG codes: 78 ALA FLA GEO LOU MSI SCA

Ecology

Pinus glabra is a lowland pine of the warm temperate climate in the SE United States, where summers are long, hot and humid and winters mild. This species occurs scattered in river valleys on banks of streams and in hummocks and swamps of the southern Coastal Plain in acidic sandy soils, often with a high water table. It establishes itself in the shade of broad-leaf trees such as *Magnolia, Liriodendron,*

Liquidambar, Nyssa, Carya, Fagus, and *Quercus* and survives by overtopping them. This tolerance to shade is rather unusual for a pine and it is diminished as it grows taller, so it often requires some canopy opening to attain dominance. Unlike many other pines it is susceptible to fire. It may occasionally grow with other pines such as *Pinus echinata, P. elliottii* and *P. taeda* or with *Taxodium distichum*. Numerous other angiosperms are components of these swamp forests, where waterlogging is only intermittent, most are trees and shrubs or woody vines.

Conservation

IUCN: LC

Uses

The quality of its timber is poor, the wood is brittle and not durable while the scattered occurrence of this species also discourages exploitation on a large scale. Locally it may support a small scale forest industry if mixed with other pines. In some parts of its range it is planted and harvested for Christmas trees, but it needs shearing repeatedly to attain the desired density of foliage and shape. Its horticultural merits are deemed to be low and it is rarely grown outside arboreta and botanic gardens.

Pinus greggii Engelm. *ex* Parl., in Candolle, Prodr. 16 (2): 396. 1868.

Etymology

This species was named after J. Gregg, who collected the type specimen in 1848.

Vernacular names

Gregg's pine; pino prieto (Spanish)

Description

Trees to 20–25 m tall, d.b.h. to 70–80 cm. Trunk monopodial, usually straight; bark thick, with deep, longitudinal fissures and rough, elongated plates, greyish brown. Branches long, slender, spreading or curved downward, not pendulous, forming a rounded, dense or more open crown. Shoots often multi-nodal, smooth, reddish brown to grey-brown. Cataphylls lanceolate to subulate, straight, erose-ciliate at margins, dark brown. Vegetative buds ovoid-conical to oval-oblong; terminal bud 10–15 mm long; lateral buds more ovoid and smaller, not resinous. Fascicle sheaths initially ca. 10 mm long, persistent but reduced in mature fascicles to 3–5 mm. Leaves in fascicles of 3, usually rigid, or flexible and drooping, persisting up to 4 years, straight, (7–)9–13(–15) cm long, 1–1.2 mm wide, serrulate along margins, acute-pungent, lustrous green. Stomata in several lines on all faces of the leaves. Pollen cones ovoid-oblong to cylindrical, 1.5–2 cm × 5–6 mm, yellowish. Seed cones appearing on very young trees, subterminal or lateral, in whorls of 3–8, sometimes more, on short, stout, tenacious peduncles, at maturity appearing sessile, long persistent, serotinous. Mature cones serotinous, narrowly and obliquely ovoid to ovoid-attenuate, slightly curved or straight when closed, with an oblique base, (6–)8–13(–15) × (4–)5–7 cm when open (width 3.5–5 cm when closed). Seed scales remaining closed several to many years, parting eventually or not, oblong, straight or recurved when parted. Apophyses flat or slightly raised, rhombic to obtrullate in outline, with an undulate or crenate upper margin, (weakly) transversely keeled, sometimes gibbous on one side towards base of cone, lustrous ochraceous or light brown, weathering grey. Umbo dorsal, depressed or flat, with a minute, deciduous prickle. Seeds obliquely obovoid to ellipsoid, slightly flattened, 5–8 × 3–4 mm, grey-brown to blackish brown. Seed wings oblong, with a straight and a curved side, 15–20 × 5.5–8 mm, yellowish to grey-brown.

Distribution

Mexico: in extreme SE Coahuila, S Nuevo León, SE San Luís Potosí, Querétaro, Hidalgo and N Puebla.

TDWG codes: 79 MXC-PU MXE-CO MXE-HI MXE-NL MXE-QU MXE-SL

Ecology

The altitudinal range of this species is 1300–2600 m, in the northern part of its distribution 2300–2700 m a.s.l. Annual precipitation varies between 600–800 mm in much of its range, except on the eastern escarpment of the mountain ranges along

the Hidalgo-Veracruz borderline, where it is 1000–1600 mm. In the north it is more often found on slightly alkaline soils (pH 7.0–8.0), in the south on acid soils (pH 4.0–5.0) (Dvorak & Donahue, 1992). It is nowhere abundant in its scattered range, and always occurs mixed with e.g. *Quercus, Platanus, Liquidambar*, and *Fraxinus*, other pines, e.g. *Pinus patula, P. pseudostrobus, P. teocote, P. montezumae*, and *P. arizonica* var. *stormiae*, with *P. cembroides* and *Juniperus flaccida* on dry sites, and at higher and more mesic locations with *Abies vejarii, Pseudotsuga menziesii*, or *Cupressus lusitanica*. The serotinous cones indicate adaptation to fire, but no studies on how this affects seed dispersal and germination have been undertaken (or published).

Uses

Although locally exploited with other pines, Gregg's pine is not specifically in demand as a timber tree in Mexico. In many areas it has been severely depleted by general logging and overexploitation of forests. Foresters from abroad are taking an interest in its potential as a forest plantation tree in other countries; it has been introduced for that purpose in (among other countries) India, South Africa, Zimbabwe, Argentina, and Brazil. Like another, and probably related, "closed-cone" pine, *P. radiata*, it seems to grow much faster in trial plots than several other species (Dvorak & Donahue, 1992). Gregg's pine is rare in cultivation and probably restricted to botanical collections (arboreta), although in Italy it is sometimes planted as an amenity tree.

2 varieties are recognized:

Pinus greggii Engelm. *ex* Parl. var. ***greggii***. Type: Mexico: Coahuila, San Antonio de las Alanzanas, near Saltillo, *J. Gregg 402* (lectotype MO).

Description

Leaves 7–12 cm long, rigid, spreading to erect, with all resin ducts medial. Seed wings 5.5–6.4 mm wide.

Distribution

Mexico: Coahuila, Nuevo León, San Luis Potosí.
TDWG codes: 79 MXE-CO MXE-NL MXE-SL

Ecology

This northern variety is mainly found on alkaline soils (pH 7–8) derived from limestone. It is most commonly found scattered in mixed pine-oak forest.

Conservation

According to extent of occurrence (EOO) data this variety rates as Near Threatened, but according to its area of occupancy (AOO = 320 km²) it is possibly Vulnerable. Indications of exploitation and other human impact justify it to be NT. These impacts appear to be less severe than in the area of the southern variety. No collections were recorded from protected areas.
IUCN: NT

Pinus greggii Engelm. *ex* Parl. var. ***australis*** Donahue & Lopez, Sida 18 (4): 1092. 1999. Type: Mexico: Queretaro, Landa de Matamoros, El Madroño, *J. K. Donohue & J. Lopez Upton B30* (holotype MO).

Description

Leaves 10–15 cm long, flexible, frequently drooping, sometimes with 1–2 internal resin ducts. Seed wings 6–8 mm wide.

Distribution

Mexico: Querétaro, Hidalgo, N Puebla.
TDWG codes: 79 MXC-PU MXE-HI MXE-QU

Ecology

This variety is generally growing on acid soils. It is a relatively rare pine that always grows sporadically among other species of pine, or in mixed pine-oak woodland.

Conservation

The range of this variety, based on herbarium collections data, is inside the threshold for VU (EOO = 6980 km²). The AOO is less than 250 km², well inside EN. Change in land use especially conversion to agriculture is widespread in the region and

almost certainly affects both EOO and AOO of this taxon. The subpopulations of this variety are often some distance apart and surrounded by agricultural land. Grazing may have a significant effect on regeneration, because areas that are not grazed showed regeneration as opposed to those where grazing was evident. Some locations are within protected areas: the Sierra Gorda, Los Marmoles and Cuenca Hidrografica del Rio Necaxa Reserves.
IUCN: EN [B2ab (ii, iii, v)]

Pinus* ×*hakkodensis Makino, in Makino & Nemoto, Fl. Japon., ed. 2: 148. 1931. *Pinus pentaphylla* Mayr var. *hakkodensis* (Makino) Kusaka, in Iwata & Kusaka, Conif. Jap. Ill. ed. 2: 151. 1954. Type not designated.

Etymology

The epithet means 'from Hakkoda', which is an orthographic variant of Hokkaido.

Vernacular names

hakkoda-goyo (Japanese)

A natural hybrid between *Pinus parviflora* var. *pentaphylla* and *P. pumila*, with characters more or less intermediate between those of the parent species. It is a shrub with ascendent stems to 3 m tall. The seed cones are ellipsoid-ovoid, ca. 6 cm long and 3.5 cm wide and open at maturity to release the seeds. The seed scales have rounded apophyses terminating in a spiny umbo and the seeds have short wings.

Distribution

Japan: Central and N Honshu, S Hokkaido.
TDWG codes: 38 JAP-HN JAP-HK

Ecology

This nothospecies occurs in subalpine regions of S Hokkaido and Central and N Honshu in scrubby vegetation at altitudes between 1000 m and 1700 m a.s.l.

Conservation

IUCN: NE

Pinus halepensis Mill., Gard. Dict., ed. 8: Pinus No. 8. 1768. Type not designated.

Pinus ceciliae Llorens & L. Llorens, Folia Bot. Misc. 4: 55. 1984; *Pinus halepensis* Mill. var. *ceciliae* (Llorens & L. Llorens) Roselló *et al.*, Candollea 47 (1): 67. 1992.

Etymology

The species epithet is derived from Aleppo [Haleb] on the coast of Syria.

Vernacular names

Aleppo pine; pino de Alepo, pino carrasco (Spanish); pin d'Alep (French); pino d'Aleppo (Italian)

Description

Trees to 20 m tall; trunk to 80 cm d.b.h., straight, curved or sinuous, often forked. Bark thin, grey-brown, becoming thick only on lower trunk of large trees, then fissured longitudinally, scaly, breaking into elongated plates, purplish brown to red-brown, weathering grey. Branches numerous, spreading and ascending, forming a broadly rounded, sometimes flat-topped, dense crown. Foliage branches slender, 2–3 mm thick (to 6 mm on cone-bearing shoots), nearly smooth, glabrous, new shoots glaucous or grey-green, becoming ash-grey. Buds ovoid-conical, acute, 5–10 mm long, not resinous; cataphylls with recurved apices, reddish brown fringed with white hairs. Leaves in fascicles of 2, held by a 9–12 mm long, persistent sheath, falling in the third year, straight and rigid, spreading, (6–)7–10(–12) cm long, 0.7–0.8 mm wide; margins minutely serrulate; leaf colour light green; stomata in fine lines on all surfaces. Pollen cones in clusters at base of new shoots, spirally arranged, short cylindrical, 1–2 cm long, yellow. Seed cones solitary or in whorls of 2–3, short pedunculate, directed backward or more or less spreading when full grown, long persistent, narrowly or broadly ovoid-conical when closed, sometimes slightly asymmetrical, 6–10(–12) cm long,

variously serotinous, 3–5 cm wide when closed, 4–7 cm wide when opened. Seed scales thick woody, rigid, straight, oblong; apopyses nearly flat or slightly raised, weakly transversely keeled and with thin rays radiating from the centre, more or less rhombic or often with a rounded upper margin, to 20 mm wide at mid-cone, lustrous orange-brown or red-brown weathering grey; umbo flat or depressed, 4–7 mm wide, broadly rhombic in outline, tan or grey-brown, unarmed. Seeds obovoid, slightly flattened, (5–)6–7(–8) mm long, grey-brown, dark mottled; wing 15–25 mm long, 8–12 mm wide, more or less straight, grey-brown with darker streaks.

Taxonomic notes

Varieties described of *Pinus halepensis* by some authors are here considered to be varieties of *P. brutia. Pinus brutia* and *P. halepensis* are closely related and the first is sometimes treated as a variety or subspecies of the latter. *Pinus halepensis* has somewhat shorter and certainly thinner needles, not reaching 1 mm diam.; its cones are more elongate when closed and tend to be deflected back on the branch by a curved peduncle, instead of spreading. Unlike *P. brutia, P. halepensis* is remarkably constant in its morphological characters throughout its wide range; this could be an indication, to be tested with research into its DNA, that it originated from a particular population of *P. brutia* in the eastern Mediterranean and quickly spread westward upon the advent of substantial climate change.

Distribution

Mediterranean, from Morocco and Portugal to Greece and the coast of Libya at Jabal al Akhdar, and in Israel, Jordan, Lebanon, SW Syria.

TDWG codes: 12 BAL COR FRA-FR FRA-MO POR SAR SPA-SP 13 ALB GRC ITA-IT SIC-MA SIC-SI YUG-BH YUG-CR YUG-MN 20 ALG LBY MOR-MO MOR-SP TUN 34 LBS-LB LBS-SY PAL-IS PAL-JO

Ecology

Aleppo pine grows in the hotter parts of the Mediterranean coast, where brush and forest fires are frequent. Despite this, its seed cones are only semi-serotinous and do open in the absence of fire in the heat of the sun. Although closed stands exist, it is more commonly scattered in maquis or garrigue vegetation on sunny hills and slopes down to the sea shore, most commonly on limestone and dolomite. In stands where fire has been absent for a longer period, oaks (*Quercus suber, Q. ilex*) invade and will eventually dominate. Presumably increased frequency of fire caused by human activities gives the advantage to *P. halepensis*. Its altitudinal range is from sea level to ca. 1700 m (in Morocco).

Conservation

IUCN: LC

Uses

The wood of Aleppo pine, due to size and shape of most trees and poor quality, is of little value as timber. It is presently used as firewood and for charcoal burning, in the past it served for mine props, railway sleepers, and telephone poles. It is rich in resin and still tapped locally for that product; plantations have been established for this use in Greece. Witches brooms are common in this pine and could be a source of dwarf cultivars in Mediterranean countries; the species is generally not hardy in more northern latitudes. It has been planted as wind breaks and to stop soil erosion on dry slopes. Ill considered plantations established in the southern hemisphere have given rise to invasiveness of this species; in Australia, New Zealand, and South Africa *P. halepensis* is now a serious weed threatening natural and often species-rich vegetation as well as land used for agriculture.

Pinus hartwegii Lindl., Edwards's Bot. Reg. 25: 62. Aug 1839. [Allg. Gartenzeitung 7: 324. 1839]. Type: Mexico: locality unknown, *C. T. Hartweg s.n.* (lectotype P). Fig. 225

Pinus rudis Endl., Syn. Conif.: 151. 1847; *Pinus montezumae* Lamb. var. *rudis* (Endl.) Shaw, [Pines Mexico] Publ. Arnold Arbor. 1: 22. 1909; *Pinus hartwegii* Lindl. var. *rudis* (Endl.) Silba, Phytologia 68: 50. 1990.

Pinus donnell-smithii Mast., Bot. Gaz. 16: 199. 1891.

Etymology

This species was named after the plant collector C. T. Hartweg, who made extensive collections in Mexico in the decade 1838–1848.

Vernacular names

Hartweg's pine; ocote, pino de las alturas (Mexico)

Description

Trees to 25–30 m tall, d.b.h. to 0.0–1 m; trunk monopodial, erect. Bark thick, scaly, deeply fissured, divided into small or large, square or irregular plates; outer bark dark brown, weathering grey. Branches spreading and assurging, often persistent, forming a dense, rounded crown in mature trees. Shoots thick, rigid, purplish brown, sometimes glaucous. Cataphylls 15–20 mm long, subulate, recurved, scarious, brown, weathering blackish grey. Vegetative buds ovoid-conical; terminal bud up to 30 × 15 mm; lateral buds smaller, not resinous. Fascicle sheaths of young leaves 30–40 mm long, reduced in older fascicles to (10–)15–20 mm, resinous. Leaves in fascicles of (3–)4–5(–6), most commonly 5, persisting 2(–3) years, straight or curved, not twisted, rigid, (6–)10–17(–22) cm long, (1–)1.2–1.5 mm wide, with serrulate margins, acute-pungent, dull light green or glaucous green. Stomata on all faces of leaves. Pollen ovoid-oblong to cylindrical, to 20–25 × 6–7 mm, yellowish or pink-purplish, maturing to brown. Seed cones subterminal, in pairs or whorls of 3–6 on short, stout peduncles which are hidden by basal scales. Mature cones ovoid-oblong, with acute, curved apex when closed, (obliquely) ovoid with a flattened base when opened, 8–12(–14) × 5–8 cm. Seed scales spreading wide, often recurved near base, oblong, thin woody, flexible or more rigid. Apophysis more or less flat, (weakly) transversely keeled, sometimes gibbous, rhombic in outline with an angular or irregular upper margin, varying from light brown to purplish brown with a blackish centre. Umbo dorsal, depressed, flat or raised, obtuse or with a deciduous prickle. Seeds broadly ovoid, slightly flattened, 5–6 mm long, light or dark brown with black spots. Seed wings oblong with a straight and a curved side, 12–20 × 7–12 mm, brown tinged with dark stripes.

Distribution

Mexico: in Chihuahua (Cerro Mohinora), S Coahuila, S Nuevo León, Durango, SW Tamaulipas, Jalisco (Nevado de Colima), Michoacán, México, Morelos, Hidalgo, Distrito Federal, Tlaxcala, Puebla, W Veracruz, Guerrero (Cerro Teotepec and vicinity), Oaxaca and Chiapas; in Guatemala in most of the SW highlands; in Honduras on several isolated mountain summits; reported from the extreme N of El Salvador, but not confirmed.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-AG MXE-HI MXE-QU MXE-SL MXE-ZA MXG-VC MXN-SI MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 GUA HON

Ecology

Pinus hartwegii is the typical high altitude pine of Mexico and Guatemala, where it often forms extensive, monotypic pine forests up to the tree line on high, isolated volcanos or summits of mountain ranges. In Honduras it is rare, of limited extent and usually found with *Abies guatemalensis, Cupressus lusitanica, Juniperus standleyi, Quercus* spp., *Dendropanax lempirianus, Drymis granadensis*, a ground cover of *Ericaceae, Lycopodiaceae*, and epiphytic *Bromeliaceae* in a cool cloud forest type usually between 2700–2850 m on the highest mountain summits. Similar forests occur in Guatemala and the southern states of Mexico, but there extensive pine forests predominate, in which *P. hartwegii* increasingly dominates with rising altitude. Its altitudinal range in Guatemala and Mexico is similar: (2300–)2500–4000(–4300) m a.s.l. At lower elevations it is often mixed with *P. montezumae*, with which it is closely related, and with other pines depending on the geographical area. Soils are both from volcanic and granitic rock, of various depths, but often poor in nutrients. Climatically there are considerable differences congruent with latitude/altitude gradients, with heavy frost and snow during several months and often high winds near the tree lines of the high volcanos in Central Mexico.

Conservation

IUCN: LC

Uses

Pinus hartwegii has fairly dense, but resinous wood. It is exploited as a timber tree where stands are extensive and accessible, but due to high altitude and consequent lack of infrastructure (access roads) many forests remain virtually untouched today. Its wood is used as round wood for posts and sawn for construction or railway sleepers, while it is also pulped for the paper industry. Despite its hardiness, originating from very high altitudes, it is very rare in cultivation, in some instances under its taxonomic synonym *P. rudis*.

Pinus heldreichii H. Christ, Verh. Naturf. Ges. Basel 3: 549. 1863. Type not designated. Fig. 226

Pinus leucodermis Antoine, Oesterr. Bot. Z. 14: 366. 1864; *Pinus heldreichii* H. Christ var. *leucodermis* (Antoine) Markgr. *ex* Fitschen, in Beissner, Handb. Nadelholzk., ed. 3: 404. 1930; *Pinus heldreichii* H. Christ subsp. *leucodermis* (Antoine) E. Murray, Kalmia 13: 23. 1983.

Etymology

This pine species was named after the German botanist T. H. H. von Heldreich (1822–1902).

Vernacular names

Heldreich's pine, Bosnian pine

Description

Trees to 25(–30) m tall; trunk to 2 m d.b.h., some old trees with squat boles. Bark thick, dense and hard, breaking into numerous ridges and small angular plates separated by shallow, irregular fissures, grey-brown weathering grey. Branches spreading and ascending, forming a conical crown, in old trees rounded or irregular. Foliage branches stout, slightly rough after leaves have fallen, new shoots glabrous, light brown and glaucous or pruinose, turning brown and finally grey. Buds ovoid-oblong, 10–15 mm long, acute, not resinous; cataphylls papery, fringed white towards apex. Leaves in fascicles of 2, held in a short, persistent basal sheath, spreading in stiff pseudo-whorls, remaining on branches 5–6 years, 6–11 cm long, rigid, straight or more often curved, 1.2–1.5 mm wide, lustrous green or dark green; margins minutely serrulate; apex acute; stomata in fine lines on all surfaces. Pollen cones in large clusters near base of new shoots, spirally arranged, ovoid-oblong becoming cylindrical at anthesis, 2–3 cm long, bright yellow. Seed cones solitary or in whorls of 2–3 on short peduncles, ovoid or narrowly ovoid when closed, dark green or bluish purple, soon opening and turning dull light brown to grey, 6–10 cm long, 4–6 cm wide when open, with a more or less flat and asymmetrical base. Seed scales thin woody, soft and flexible at their base, oblong, spreading wide, light brown; apophyses nearly flat or (slightly) raised, rhombic to broadly rhombic, transversely keeled; umbo depressed or raised, armed with a minute, deciduous prickle. Seeds elliptic, (4–)5–6(–7) mm long, brown; wing 15–25 mm long, 5–7 mm wide, oblique at the distal end.

Taxonomic notes

Pinus leucodermis Ant. is still often treated as either a distinct species, or a variety of *P. heldreichii*, but the stated differences between the two, such as colour of shoots, buds, bark, needles, and cones are not only trivial and rather variable, they are inconsistent, with herbarium specimens and/or trees sometimes displaying character states that 'belong' to the other species. The seed cones, apart from the alledged differences in colour (green versus purple in the growing stage, a trait found in many populations of several species in *Pinaceae* and usually not of taxonomic significance) are so similar and share uniquely soft scales not found in other species in the section *Pinus*, that they must belong to a single species. They are here treated as synonyms, therefore the earlier name *P. heldreichii* H. Christ applies. Molecular data indicate that *P. heldreichii* is not closely related to *P. nigra*, but belongs to a group of Mediterranean pines instead. Putative hybrids with *P. nigra* found in the Balkans (see Vidaković, 1991, citing work by P. Fukarek in Serbo-Croatian) may therefore be somewhat doubtful. These authors also reported successful controlled hybridization between Bosnian pine (*P. heldreichii* var. *leucodermis*) and European black pine (*P. nigra* subsp. *nigra*).

Distribution

Balkan Peninsula, scattered from Bosnia Herzegovina to N Greece, Bulgaria (Rhodope Mts.) and S Italy (Calabria and Basilicata).
TDWG codes: 13 ALB BUL GRC ITA-IT YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE

Ecology

Pinus heldreichii is a montane to subalpine species, in Albania, Bosnia and Serbia usually growing above 2200 m a.s.l. up to 2640 m, but elsewhere down to 1000 m. It is most commonly found on steep mountainsides with very thin soil over limestone, most often in pure, scattered stands. It grows very slowly in this habitat and presumably ancient specimen trees are known, e.g. in Calabria. Although occurring in the Mediterranean region, its altitudinal range subjects it to sometimes quite severe winter frosts.

Conservation

IUCN: LC

Uses

Heldreich's pine is not an important timber tree, although it is planted in some Balkan countries with timber production as an objective. The wood is used for heavy construction or as round timber, e.g. for poles, and to build traditional fences. Its main value is as an ornamental tree and it is fairly widely cultivated for this purpose. It forms as a young tree a dense, conical crown and has attractive glaucous to light grey shoots and dark green needles. In cultivation it grows relatively fast, given better conditions than in its natural habitat. Several cultivars are known, usually under the synonym *P. leucodermis*. Some of these are slow growing 'dwarf' conifers. In the Balkans, a number of botanical varieties has been named under *P. heldreichii*, it is not known if any of these are in cultivation.

Pinus henryi Mast., J. Linn. Soc., Bot. 26: 550. 1902. *Pinus massoniana* Lamb. var. *henryi* (Mast.) C. L. Wu, Acta Phytotax. Sin. 5 (3): 153. 1956; *Pinus tabuliformis* Carrière var. *henryi* (Mast.) C. T. Kuan, Fl. Sichuan. 2: 113. 1983; *Pinus tabuliformis* Carrière subsp. *henryi* (Mast.) Businský, Acta Pruhoniciana 68: 26. 1999. Type: China: Hubei, [locality unknown], *A. Henry 6909* (holotype K).

Pinus massoniana Lamb. var. *wulingensis* C. J. Qi & Q. Z. Lin, Bull. Bot. Res. Harbin 8 (3): 143. 1988.

Etymology

This pine species was named after Augustine Henry (1857–1930), an English dendrologist who was an early botanical visitor to China.

Vernacular names

Henry's pine; ba shan song (Chinese)

Description

Trees to 25 m tall; trunk to 1 m d.b.h., monopodial. Bark scaly, fissured, breaking into large irregular plates, greyish brown weathering grey, flaking in small or large chips. Branches spreading or curving down, contorted, forming a domed or flat-topped crown. Foliage branches stout, becoming rough with pulvini after shedding leaves, glabrous, new shoots reddish brown, usually glaucous, turning light brown to grey-brown or grey. Buds oblong, acute; terminal bud to 20 mm long, slightly resinous; cataphylls appressed, pale brown. Leaves in fascicles of 2, more or less remote, persisting 2–3 years, spreading, held in a 10–15 mm long, persistent basal sheath, 7–12 cm long, straight or curved, pliant, 0.7–1 mm wide, often slightly twisted, green; margins minutely serrulate; apex acute or acuminate; stomata in fine lines on all surfaces. Pollen cones in clusters at base of new shoots, spirally arranged, short cylindrical, ca. 2 cm long, yellow. Seed cones solitary or in pairs, short pedunculate, usually persisting a few years but opening soon, ovoid when closed, near-symmetrical, 2.5–5 cm long and 2.5–5 cm wide when opened. Seed scales thin woody, rigid, oblong to obovate, except basal scales spreading wide, often recurving, brown. Apophyses slighty raised, variously shaped,

transversely keeled or with 4 radial ridges, ripening from green to lustrous brown or reddish brown; umbo depressed with a minute prickle. Seeds ovoid-oblong, 3.5–5 × 2–3 mm, pale brown, often mottled; wing 9–12 mm long, 4–5 mm wide, dark brown.

Taxonomic notes

This species has been treated as a variety of *Pinus tabuliformis* in Flora of China 4 (1999) and is indeed similar in many characters to that species. Its leaves are not wider than 1 mm and its seed cones are smaller, with scales that have only slightly raised apophyses. It was also classified as a variety of *P. massoniana*, from which it differs in its much shorter leaves, its uninodal growth of shoots, smaller, nearly globose-ovoid seed cones, and relatively shorter seed wings.

Distribution

China: Chongqing, Hubei, Hunan, Shaanxi, Sichuan.
TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHN-SA CHS-HN

Ecology

Pinus henryi is most common at middle elevations in the mountains of Central China, and occurs from 1100 m to 2000 m a.s.l. It prefers dry, sunny slopes and hills, where competition from broad-leaved trees is less severe as the woods are more open and lower than in more mesic sites. It is also a pioneer in secondary vegetation, and is there commonly mixed with deciduous shrubs and trees, in later stages of the succession often giving way to these angiosperms.

Conservation

IUCN: NT

Uses

This species is similar in its wood properties to *P. tabuliformis*, but it is less common and widespread, and as a consequence of this less important as a timber tree. *Pinus henryi* is apperently absent or very rare in cultivation; it was not introduced to Europe when the opportunity arose during the early decades of the 20th century.

Pinus herrerae Martínez, Anales Inst. Biol. Univ. Nac. México 11: 76. 1940 ["*herrerai*"]. *Pinus teocote* Schiede *ex* Schltdl. & Cham. var. *herrerae* (Martínez) Silba, Phytologia 68: 63. 1990. Type: Mexico: Jalisco, Tecalitlán, Sierra del Halo, *M. Martínez 3427* (lectotype MEXU).

Etymology

This species was named after "Prof. D. Alfonso L. Herrera", a Mexican naturalist.

Vernacular names

Herrera's pine; Ocote, Pino chino (Spanish)

Description

Trees to 30–35 m tall, d.b.h. to 0.8–1 m; trunk monopodial, straight or sometimes tortuous. Bark thick, rough, with scaly plates and shallow, longitudinal fissures, reddish brown to grey-brown. Branches long, slender, arching or spreading horizontally, the foliage slightly pendulous. Shoots smooth, with well developed, long decurrent pulvini, orange-brown. Cataphylls subulate, scarious, recurving, brown. Vegetative buds ovoid-acute to ovoid-oblong or cylindrical; terminal bud 10–15 mm long; lateral buds smaller, not resinous. Fascicle sheaths up to 20 mm long, torn by elongating and spreading leaves, persistent but reduced to 8–15 mm in mature fascicles. Leaves in fascicles of 3, persisting 3 years, slender, lax, drooping or spreading, (10–)15–20 cm long, 0.7–0.9 mm wide, serrulate at margins, acute, light green to yellowish green. Stomata on all faces of the leaves. Pollen cones spreading, ovoid-oblong to cylindrical, 1.5–1.8 cm × 5 mm, yellowish green, tinged red. Seed cones subterminal, solitary or opposite, rarely in whorls of 3, on 10–15 mm long peduncles, at first erect, soon on recurved peduncles which fall with cones. Mature cones narrowly ovoid when closed, nearly symmetrical or slightly curved, ovoid when opened, (2–)3–3.5(–4) × 2–3.5 cm when open. Seed scales thick woody, oblong, straight or recurved. Apophysis slightly raised, mostly so on a

few proximal scales on one side of cone, transversely keeled; apical margin entire or crenate, radially striate, light brown. Umbo dorsal, pyramidal, with a minute, deciduous prickle. Seeds (ob)ovoid, slightly flattened, 2.5–4 × 2–3 mm, dark grey-brown. Seed wings obliquely ovate, 5–8 × 3–5 mm, translucent, yellowish with a dark tinge.

Distribution

Mexico: along the Sierra Madre Occidental and more abundantly along the Sierra Madre del Sur; in SW Chihuahua, Sinaloa, Durango, W and S Jalisco, Michoacán and Guerrero.

TDWG codes: 79 MXE-CU MXE-DU MXN-SI MXS-GR MXS-JA MXS-MI

Ecology

The altitudinal range of *P. herrerae* is (1100–)1500–2600 m a.s.l.; its lowest altitude apparently is reached in the Sierra de Cuale in W Jalisco. It occurs in the mesic forest belt, with annual precipitation of ca. 900–1600 mm, but with a dry season lasting from November to May. From N to S annual precipitation increases. Mixed pine and pine-oak forest is its usual habitat, in which it is associated with many other pines according to their ranges, further with *Pseudotsuga* locally. Other broad-leaved trees, e.g. *Arbutus, Alnus, Clethra, Juglans, Persea, Clusia*, and *Tilia*, are sometimes common. In many areas the forests are greatly influenced by man-made changes in their composition, e.g. by selective felling of larger trees of *Pinus*, or by recurrent fires and grazing.

Conservation

IUCN: LC

Uses

Along with other tall growing pines, this species is (heavily) exploited for timber throughout almost all of its range. It is considered to be of good wood quality. Provenance sampling has been started and is recommended by foresters (Dvorak & Donahue, 1992) to be conducted on a larger scale. This pine is unknown in horticulture.

Pinus hwangshanensis W. Y. Hsia, Contr. Inst. Bot. Natl. Acad. Peiping 4: 155. 1936. *Pinus luchuensis* Mayr var. *hwangshanensis* (W. Y. Hsia) C. L. Wu, Acta Phytotax. Sin. 5 (3): 158. 1956; *Pinus luchuensis* Mayr subsp. *hwangshanensis* (W. Y. Hsia) D. Z. Li, Edinburgh J. Bot. 54 (3): 341. 1997. Type: China: Anhui, Huang Shan, Si Hai Men, *P. C. Tsoong 3111* (holotype PE).

Pinus taiwanensis Hayata var. *damingshanensis* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 85. 1975.

Etymology

The species epithet *hwangshanensis* refers to the Huang Shan mountain range in S Anhui, China.

Vernacular names

Huang Shan pine; huang shan song (Chinese)

Description

Trees to 45 m tall; trunk to 1 m d.b.h, bole straight or more or less tortuous. Bark on trunk rough and scaly, breaking into large plates and deep fissures, grey-brown to dark grey. First order branches long and spreading, slowly and sometimes only partly self-pruning, leaving stumps on the trunk; higher order branches assurgent and densely crowded, forming flat-topped or domed crowns in natural habitat. Foliage branches glabrous, more or less smooth, light yellowish brown. Buds ovoid-conical to cylindrical, 10–15 mm long, 5–7 mm wide, resinous; cataphylls appressed, reddish or chestnut brown. Leaves in fascicles of 2, held by a persistent, slender basal sheath 5–10 mm long, straight or slightly curved, (5–)10–17 cm long, slender, pliant, slightly twisted, 0.6–1 mm wide; margins minutely serrulate; apex acute; stomata in fine lines on all surfaces. Pollen cones clustered, spirally arranged, short cylindrical, 1.5–2 cm long, yellow tinged with red, becoming reddish brown. Seed cones solitary or sometimes in pairs, persistent on short peduncles, spreading, 3–6 cm long, narrowly ovoid when closed, widening to 2.5–5 cm when open. Seed scales thin woody, rigid, oblong, ca, 2.5 × 1.3 cm at mid cone (in larger cones), straight when spreading, chocolate brown.

Apophysis rhombic in outline or with rounded upper margin, nearly flat, transversely keeled, slightly rugose, lustrous light brown; umbo broadly ellipsoid, depressed, armed with a small, persistent prickle. Seeds ellipsoid-ovoid, 5–6 mm long, slightly flattened; wing 15–20 mm long, persistent.

Taxonomic notes

The variety *Pinus taiwanensis* var. *damingshanensis* W. C. Cheng & L. K. Fu was described from mainland China (Guangxi, Daming Shan), with both marginal and medial resin ducts. Needles of the same species in Taiwan are reported to have medial, but rarely also marginal resin ducts. Probably this population, growing on a single mountain, belongs to *P. hwanshanensis* W. Y. Hsia. This species is very similar to both P. *luchuensis* and *P. taiwanensis*, but differs from them in having a persistent, mucronate prickle on a depressed seed scale umbo. The position of resin ducts is a variable character in this group of species and less reliable. The buds of *P. hwangshanensis* are darker brown than those of *P. taiwanensis*. Other characters, e.g. colour of pollen cones, need further verification based on multiple observations to see whether they hold true. I concur with Mill's observation in Flora of China 4: 17 (1999) and here restrict *P. taiwanensis* to the island of Taiwan.

Distribution

China: Anhui, Fujian, Guangxi, Guizhou, S Henan, Hubei, Hunan, Jiangsu, Jiangxi, SE Yunnan, Zhejiang.
TDWG codes: 36 CHC-GZ CHC-HU CHC-YN CHS-AH CHS-FJ CHS-GX CHS-HE CHS-HN CHS-JS CHS-JX CHS-ZJ

Ecology

Pinus hwangshanensis occurs in mixed montane deciduous forests, in open areas on slopes and ridges. This forest type is known in China as Mixed Mesophytic Forest (Wang, 1961) and occurs generally to the north of evergreen broad-leaved forests, with a wide transitional zone. It is also prevalent at higher altitudes further south, where the evergreen forest in the valleys and plains has all but disappeared due to agriculture. Its altitudinal range is approximately between 500 m and 2500 m a.s.l. and the most common angiosperm (broad-leaved) trees belong to the *Fagaceae*. In undisturbed forest the pines would occupy areas with shallow, sandy acidic soils and rocky outcrops, but in many areas forest disturbance has probably favoured the light demanding pines over broad-leaved trees.

Conservation

IUCN: LC

Uses

This pine has good quality timber with suitable strength for construction, e.g. in buildings and wooden bridges, use as railway sleepers and mine props. Its wood is also used for building fences and gates, crates and boxes, panelling, flooring, furniture making, industrial and domestic woodware, tools, plywood, fibreboard, and wood pulp. Forestry plantation of this species (and its varieties) is restricted to SE China as far as is known. In horticulture it is rare, except for the use for bonsai growing popular in E Asia. It may occur in arboreta under the name *P. taiwanensis*, but if these trees originated from mainland China they are more likely *P. hwangshanensis*.

Pinus jaliscana Pérez de la Rosa, Phytologia 54: 290. 1983. *Pinus patula* Schiede *ex* Schltdl. & Cham. var. *jaliscana* (Pérez de la Rosa) Silba, Phytologia 58: 368. 1985. Type: Mexico: Jalisco, Sierra del Cuale, near road ca. 4 km N of El Tuito to Zimapan mine, 7 km from Hwy. 200, *J. A. Pérez de la Rosa 370* (holotype IBUG).

Pinus macvaughii Carvajal, Phytologia 59: 139. 1986; *Pinus oocarpa* Schiede *ex* Schltdl. var. *macvaughii* (Carvajal) Silba, Phytologia 68: 57. 1990.

Etymology

The species epithet refers to the Mexican State of Jalisco, where it was found.

Vernacular names

Jalisco pine

Description

Trees to 25–30(–35) m tall, d.b.h. to 60–80(–100) cm; trunk monopodial, straight. Bark moderately thick, rough, scaly with irregular, longitudinal plates and shallow fissures, reddish to greyish brown. Branches spreading or ascending; branches of higher orders slender, flexible, slightly pendulous, forming a rounded, rather open crown. Shoots smooth, orange-brown, later grey-brown. Cataphylls small, subulate, recurving at apex. Vegetative buds ovoid-oblong to conical; terminal bud 10–15 mm long; lateral buds ovoid-acute, smaller, not resinous. Fascicle sheaths up to 15 mm long, light brown, persistent but reduced to 8–10 mm on mature fascicles, weathering light grey. Leaves in fascicles of (4–)5, rarely 3, persisting 2–3 years, slender, lax, erect or slightly drooping, 12–18(–22) cm long, (0.5–)0.6–0.8 mm wide, with serrulate margins, acute, light green to yellowish green. Stomata on all faces of leaves, sometimes inconspicuous. Pollen cones ovoid-oblong to cylindrical, 1.2–1.8 cm × 5–6 mm, purplish yellow, turning light brown. Seed cones subterminal, solitary or in whorls of 2–3 on stout, curved, 7–15 mm long peduncles remaining attached to fallen cones. Mature cones ovoid-oblong to ovoid-attenuate when closed, often oblique at base, (4.5–)6–8.5(–9.8) cm long, (3–)4–5(–6) cm wide when open. Seed scales oblong, straight or slightly reflexed, thick woody. Apophyses slightly raised to gibbous, more pronounced on one side of cone towards base, transversely keeled, rhombic to pentagonal in outline, with sometimes crenate upper margins, radially striate, lustrous ochraceous or light brown. Umbo dorsal, flat to slightly raised, with a minute, deciduous prickle. Seeds obovoid, slightly flattened, 3.5–6 × 2–3.5 mm, dark grey-brown. Seed wings obliquely ovate-oblong, 13–17 × 6–8 mm, yellowish, translucent, with a grey or black tinge.

Distribution

Mexico: Jalisco, in the NW part of the Sierra Madre del Sur, on the Pacific slope, mainly in the Sierra de Cuale (Sierra el Tuito) and S of Villa Purificación.
TDWG codes: 79 MXS-JA

Ecology

This species occurs at altitudes between 800–1200(–1650) m a.s.l. in mountainous terrain on deep, acidic soils derived from granitic rocks. The climate is subtropical, with a 5–6 month dry season from December to May and annual precipitation from 1000–1500 mm depending on altitude and exposition. *Pinus jaliscana* is a local constituent of pine or pine-oak forests with a limited extent in most localities known so far. More common and widespread species that grow with it are *P. maximinoi* and *P. oocarpa*, and at slightly higher altitudes also *P. douglasiana*. Several species of *Quercus* are often codominant, *Clusia salvinii* is also common.

Conservation

IUCN: NT

Uses

No particular preference to single this species out as a source of timber is known to occur; it is locally exploited with other pines that grow with it and are more abundant. This species is not known to be in cultivation.

Pinus jeffreyi Balf., in Murray, Bot. Exped. Oregon 8: 2. 1853. Type: USA: California, Shasta Co., Shasta Valley, ("Chastey Valley, Lat. 41° 30' N"), *J. Jeffrey 731* (holotype E) & USA: California, Trinity Co., west side of Scott Mountain, on Trinity – Siskiyou County line, *R. O. Alava & A. Alava 2439A* (epitype E).

Pinus jeffreyi Balf. var. *baja-californica* Silba, Phytologia 68: 52. 1990.

Etymology

This species was named after John Jeffrey, a plant collector who discovered it in 1852 in the Shasta Valley of California.

Vernacular names

Jeffrey pine, Jeffrey's pine

Description

Trees to 50 m tall, d.b.h. to 1.5 m; trunk monopodial, straight. Bark thick, rough and scaly, divided by deep fissures into thick, elongated plates, light buff to light brown or red-brown, the fissures dark grey-brown. Branches spreading horizontally or assurgent at ends, persistent, forming an open pyramidal or flat-topped crown. Shoots stout, very rough and scaly, light orange-brown, often glaucous. Cataphylls ca. 20 mm long, triangular-subulate, reflexed, scarious, with erose-ciliate margins, light brown. Vegetative buds ovoid-acute or subglobose; terminal bud 15–20 mm long; lateral buds smaller, not resinous. Fascicle sheaths to 20–25 mm long, persistent but reduced to 10–15 mm in older fascicles. Leaves in fascicles of 3, sometimes a few fascicles of 2, persisting (3–)4–5(–6) years, thick, rigid, straight or slightly curved, sometimes twisted, (12–)15–22(–25) cm long, 1.5–1.9(–2) mm wide, with serrulate margins, acute-pungent to acuminate, light yellowish green to greyish green. Stomata on all faces of leaves, in conspicuous lines. Pollen cones ovoid-oblong to cylindrical, 2–3.5 cm × 6–7 mm, yellow or purplish yellow. Seed cones subterminal, solitary or in pairs on short, stout, persistent peduncles, spreading and seemingly sessile at maturity, leaving a few basal scales on the branch when falling. Mature cones broadly ovoid to subglobose, with a slightly oblique, flattened base, (10–)12–25(–30) × 9–14(–16) cm when open. Seed scales parting soon and wide, thin woody, straight or slightly curved, up to 20 mm wide. Apophysis slightly raised, transversely keeled, broadly rhombic in outline, on the proximal scales more gibbous, often resinous, ochraceous to light brown. Umbo dorsal, moderately raised, transversely keeled, terminating in a distinct, curved, 3–5 mm long spine. Seeds obliquely ovoid, slightly flattened, 9–12 mm long, light yellowish brown with faintly darker spots. Seed wings oblique, with a straight and a curved side, 20–25 × 10 mm, light yellowish brown to light brown.

Taxonomic notes

Pinus jeffreyi is closely related to *P. ponderosa* and *P. coulteri* and introgression via pollen may occasionally occur where these species occur together.

Distribution

USA: California, W Nevada, S Oregon; Mexico: Baja California Norte.
TDWG codes: 73 ORE 76 CAL NEV 79 MXN-BC

Ecology

Pinus jeffreyi is a montane to subalpine species largely confined to the mountains of California, with an altitudinal range of (50–)300 m to 3050 m a.s.l. It is tolerant of low temperatures in winter and can grow on thin soil or even in crevices of bare granite rock. In the Sierra Nevada of California the species, with its close relative *P. ponderosa*, is characteristic of open, dry and summer-warm mixed forests of the 'Yellow pine belt' where it tends to occupy the upper zone towards the tree line. In the southern part of this mountain range it occurs in diverse mixed coniferous forest with e.g. *Pinus ponderosa, P. lambertiana, P. monticola, P. contorta, Abies concolor, A. magnifica, Calocedrus decurrens, Juniperus occidentalis*, and *Sequoiadendron giganteum*. In southern California and Baja California only *Abies concolor, Calocedrus decurrens, Pinus contorta*, and *P. lambertiana* accompany *P. jeffreyi*. In the Klamath Mountains of Oregon *P. jeffreyi* occurs on thin ultramafic soils of volcanic origin (peridotites and serpentine) which are poor in nutrients; on these soils its most common associate is *Calocedrus decurrens*. Here it descends to low elevations (around 100 m), while in the Sierra Nevada it ascends to 2900 m and in the Sierra San Pedro Martír of Baja California to 3050 m.

Conservation

IUCN: LC

Uses

Jeffrey pine is very similar to Ponderosa pine in its wood properties and is consequently an important timber tree. It has a 'preference' for poorer sites and higher altitudes, and consequently grows slower than Ponderosa pine in its natural habitat, but it grows as fast or faster in plantations. The timber industry does not differentiate the wood from the two species; details are therefore given under *P. ponderosa*.

The resin of *P. jeffreyi* contains much heptane and lower levels of terpenes than found in other pines; in the past this biochemical product was distilled and used as an additive to raise the octane levels of petrol (gasoline), as well as for medicinal applications. Jeffrey pine is not uncommon in cultivation, but it is mostly restricted to large parks and gardens with tree collections (arboreta). In forestry, crosses and back-crosses have been experimented with a number of related pines, in particular *P. coulteri* and *P. ponderosa* and its varieties.

Pinus kesiya Royle *ex* Gordon, Gard. Mag. & Reg. Rural Domest. Improv. 16: 8. 1840.

Etymology

The species epithet refers to the Khasi Hills in NE India, from where it was first reported by J. F. Royle; its spelling has long been a matter of unnecessesary controversy. Royle's (European) spelling of the toponym at the time was as good as any other and must be followed for the name of this pine in botanical nomenclature.

Vernacular names

Khasia pine, Khasi pine, Luzon pine, Benguet pine; dingsa, far, saral (India); tinyu (Myanmar).

Description

Trees to 30–35(–45) m tall; trunk to 1 m d.b.h., often straight and columnar. Bark on trunk thick, deeply fissured forming irregular plates, rough and flaking, brown weathering grey-brown. Branches spreading, usually crooked, slowly self-pruning, forming a broadly domed crown. Foliage branches slender, rough with pulvini from fallen leaf fascicles, later more or less smooth as these disappear, lustrous yellowish brown, darkening to orange-brown, shoots multi-nodal within one year. Buds small, conical, without resin or slightly resinous; cataphylls red-brown. Leaves in fascicles of 3, held together in a 15–20 mm long, persistent basal sheath, (10–)12–22(–25) cm long, slender, very lax or flexible, 0.5–0.7(–1) mm wide; margins minutely serrulate; apex long acuminate; stomata in fine lines on all surfaces. Pollen cones clustered and spirally arranged at base of new shoots, short cylindrical, yellow. Seed cones solitary or in pairs or threes, short pedunculate, spreading or reflexed, persistent, 4.5–7(–8) cm long, narrowly ovoid-conical when closed, symmetrical or slightly non-symmetrical, ovoid to subglobose when opened, then 3–4(–5.5) cm wide. Seed scales woody, rigid, more or less recurved when spreading, narrowly oblong, 2.5–3 × 1–1.5 cm, dark brown. Apophysis prominently raised, more or less pyramidal, irregularly rhombic in outline, transversely keeled, light brown. Umbo small, ellipsoid or at least protruding, armed with a very small, persistent prickle. Seeds ellipsoid, 5–7(–8) mm long, slightly appressed, dark brown to nearly black; wing 15–20 mm long, 6–8 mm wide, persistent.

Distribution

China: Yunnan; NE India: Assam; Indochina; Malesia: Philippines (Luzon).

TDWG codes: 36 CHC-YN 40 ASS-AS ASS-MA ASS-ME ASS-MI ASS-NA 41 CBD LAO MYA THA VIE 42 PHI

Ecology

Pinus kesiya occurs in pine savannas, pure stands with nearly closed canopy, and mixed pine-broadleaved forests in valleys with e.g. *Quercus serrata* and *Alnus nepalensis* along streams. It occupies drier sites in NE India, Myanmar and Thailand, at altitudes generally between 800 and 1500 m a.s.l., occasionally to 2000 m. Further east, in Lao PDR, Viet Nam and on the island of Luzon in the Philippines, its altitudinal range is greater and it is found up to 2700–3000 m a.s.l. in a much wetter climate. Despite this, fires are frequent, creating an open, grass-dominated woodland or savanna with scattered stands of pines or solitary trees. The soils are usually sandy or loamy and derived from sandstone or quarzite. *Pinus kesiya* is a pioneer in deforested secondary vegetation, especially if fire has been a factor in the disturbance.

Uses

Khasia pine is an important timber tree in much of SE Asia and has been planted as a forestry tree in many countries in Africa, South America and Oceania (including Australia). It is a quickly establishing and fast growing species and as a result its most common use is for pulpwood in the paper industry (class A Kraft paper). In India charcoal burning has been important but has much declined. Other wood uses are roundwood (poles), construction timber, floorboards, plywood, and furniture. It is a tropical pine, but it does not grow well in the hot and humid lowland tropics; it clearly needs seasonality of precipitation. In the Philippines coffee plantations are often established under natural stands of Khasia pine. The resin is of high quality, but the trees of this species do not yield it freely and therefore they are not tapped on a large economic scale. In horticulture its use is limited to a few arboreta and botanic gardens, but in the Philippines it is cultivated as a Christmas tree.

2 varieties are recognized:

Pinus kesiya Royle *ex* Gordon var. ***kesiya***. *Pinus insularis* Endl. var. *khasyana* (Griff.) Silba, Phytologia 68: 51. 1990. Type: India: Meghalaya, Khasi Hills, ["regio temp. alt. 2–6000 ft."], *J. D. Hooker & T. Thomson s.n.* (lectotype K).

Description

Trees to 35 m tall; trunk to 1 m d.b.h. Leaves long and lax, 12–25 cm long, 0.5–0.7 mm wide. Seed cones 4.5–7 cm long and 3–4.5 cm wide when opened.

Distribution

NE India: Assam; China: Yunnan; Indochina: Kampuchea [Cambodia], Lao PDR, Myanmar [Burma], Thailand.
TDWG codes: 36 CHC-YN 40 ASS-AS ASS-MA ASS-ME ASS-MI ASS-NA 41 CBD LAO MYA THA

Conservation

IUCN: LC

Pinus kesiya Royle *ex* Gordon var. ***langbianensis*** (A. Chev.) Gaussen *ex* N.-S. Bui, Adansonia, sér. 2, 2: 338. 1962. *Pinus langbianensis* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 24: 25. 1944; *Pinus insularis* Endl. var. *langbianensis* (A. Chev.) Silba, Phytologia 68: 51. 1990. Type not designated.

Pinus insularis Endl., Syn. Conif.: 157. 1847; *Pinus kesiya* Royle *ex* Gordon subsp. *insularis* (Endl.) D. Z. Li, Edinburgh J. Bot. 54 (3): 346. 1997.

Description

Trees to 45 m tall. Leaves (10–)12–18 cm long, flexible but not lax, 0.7–1 mm wide. Seed cones 5–8 cm long and 4–5.5 cm wide when opened.

Taxonomic notes

This taxon was apparently first described by Endlicher (1947) as *Pinus insularis* from the Philippines. Later comparisons have found it not to be distinct enough to warrant species status and it becomes either a synonym of *P. kesiya* (as spelled by Royle and Gordon, not by subsequent authors) or of its variety, first described from Viet Nam, but apparently present in much of the range of the species. The latter taxonomy has here been adopted (Farjon, 1998, [2001], 2005b), but this remains somewhat tentative and other workers on conifers (e.g. Nguyen Tien Hiep *et al.*, 2004) have considered it as a synonym of *P. kesiya* if circumscribed slightly wider.

Distribution

China: S Yunnan; Viet Nam; Lao PDR; Philippines.
TDWG codes: 36 CHC-YN 41 LAO VIE 42 PHI

Conservation

IUCN: LC

Pinus koraiensis Siebold & Zucc., Fl. Japon. 2 (3): 28, t. 116. 1842. Type: Illustration in Siebold & Zuccarini, Fl. Japon. 2: t. 116, f. 5–6. 1842. (lectotype).

Pinus prokoraiensis Y. T. Zhao, Bull. Bot. Res. North-East. Forest. Inst. 10 (4): 69. 1990.

Etymology

The species epithet refers to Korea.

Vernacular names

Korean pine; chas namu (Korea, DPR); hong song (Chinese)

Description

Trees to 25–30 m tall (in China reported to attain 50 m); trunk to 1 m d.b.h., growing to a straight, columnar bole. Bark smooth in young trees, in larger trees becoming rough and scaly, with shallow grooves and longitudinal fissures, forming oblong, reddish grey or grey-brown plates; inner bark red-brown. Branches spreading or ascending, forming a broad crown; top of trees often forked. Foliage branchlets slender, new shoots occasionally pubescent with yellowish hairs, red-brown becoming grey-brown. Buds oblong or ovoid, the central bud to 10 mm long, slightly resinous; cataphylls reddish brown. Leaves in fascicles of 5, persisting 2–3 years, held in a deciduous basal sheath of orange-brown flimsy scales, slender, straight or abruptly bent, 6–13 cm long, pliant or lax, ca. 1 mm wide, green on abaxial surface; margins minutely serrulate; stomata in bluish white lines on the two adaxial faces. Pollen cones in small clusters at base of new shoots, short ellipsoid-cylindrical, ca. 15 mm long, yellow. Seed cones solitary or in whorls of 2–4 on stout, 1–1.5 cm long peduncles, semi-persistent, initially erect, becoming spreading to pendulous as they grow, blue-green and resinous, when mature 9–14 cm long and 6–8 cm wide, ovoid-oblong, light brown or grey-brown. Seed scales at base of cones reflexed or recurved, more or less indehiscent to slightly spreading but not releasing the seeds, more or less rhombic in outline, the middle scales ca. 3 cm long, 2.5 cm wide at transition to apophysis, with two deep seed cavities adaxially; apophyses broadly triangular, slightly thickened, oblong at cone apex, longitudinally striated or grooved, nearly straight but recurved or reflexed at the margin towards apex; umbo terminal, obtuse or acute. Seeds triangular-obovoid, 12–16 mm long, light brown or grey-brown, without a wing when removed from the scale.

Distribution

China: Heilongjiang, Jilin, Liaoning; Japan: Hokkaido, Honshu; North & South Korea; Russian Far East: Amur, Khabarovsk, Primorye.
TDWG codes: 31 AMU KHA PRM 36 CHM-HJ CHM-JL CHM-LN 38 JAP-HK JAP-HN KOR-NK KOR-SK

Ecology

In the Russian Far East this pine grows from 200 m to 600 m a.s.l., 500 m to 1300 m a.s.l. in China, and in Japan it occurs to an altitude of 2500 m. The climate has a summer monsoon character within proximity of the coast, but with a strong continental influence further inland. Temperature extremes range from +37° C to –45° C within its natural range. *Pinus koraiensis* grows in dry places on podzols among deciduous broad-leaved trees like oaks, poplars and birches, but on the Russian coast of the Sea of Japan it is codominant with *Abies holophylla*, forming groves of conifers in a more varied deciduous broad-leaved forest. In Japan it also occurs together with other pines. In Korea and NE China ('Manchuria') this pine has been heavily exploited, resulting in the disappearance of many magnificent pine forests.

Conservation

Despite over-exploitation resulting in removal of many indigenous forests with this species, its wide distribution and partial regeneration (outside afforestation) appears to guarantee the survival of this species, which is therefore not considered threatened under IUCN criteria.
IUCN: LC

Uses

Korean pine is a highly important timber tree; in large parts of its range it has been over-exploited, but it is now used widely in afforestation schemes especially in NE China. Its timber is of good quality, light and soft, straight grained and easy to work with in milling and carpentry. It is fairly decay resistant and therefore finds uses like telephone poles, railway sleepers, wooden bridges, and boat building. In construction it provides building timbers as well as flooring, plywood and veneers. It can be chipped for

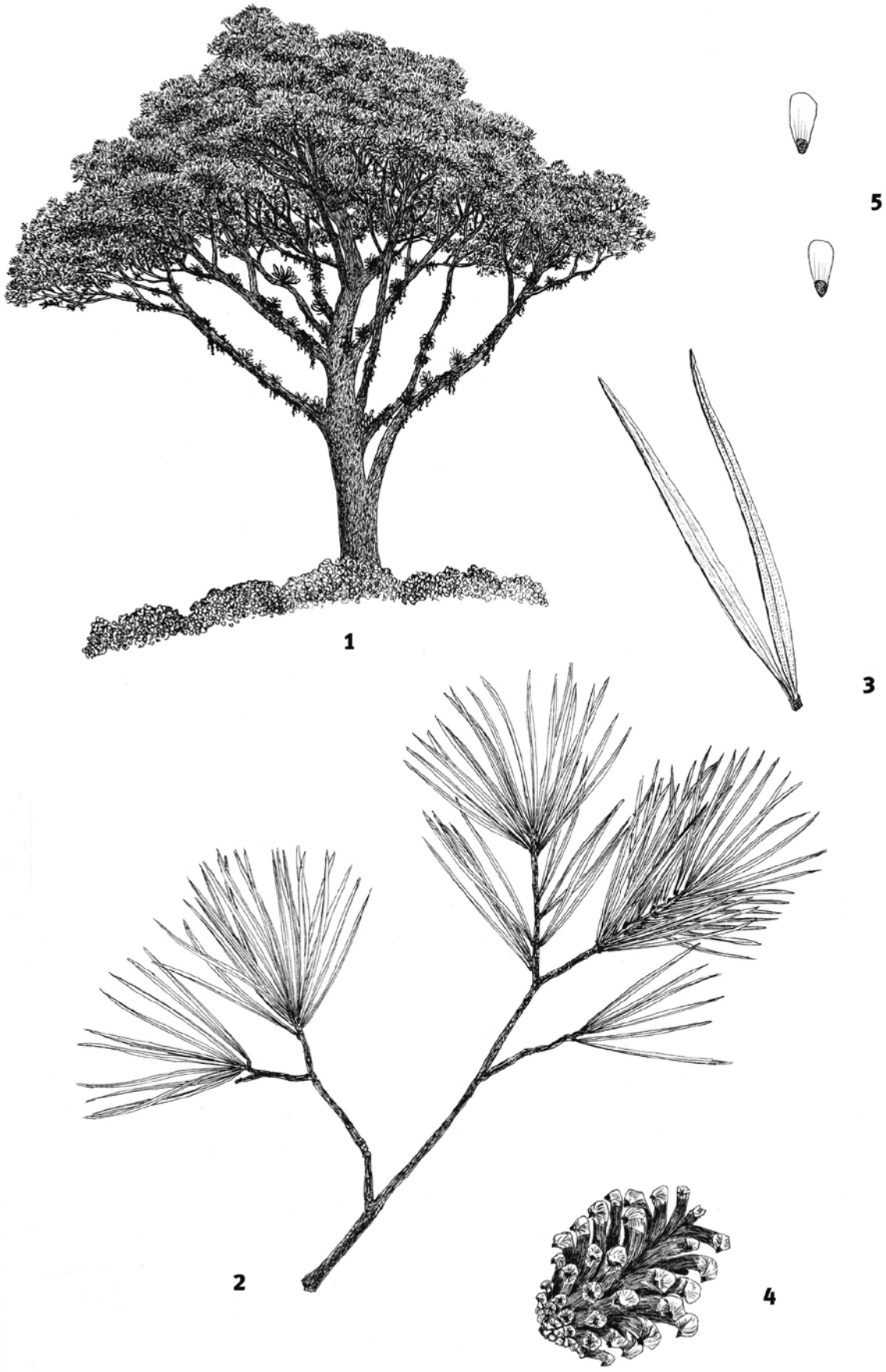

PLATE 30. *Pinus krempfii*. **1.** Habit of tree. **2.** Branch with foliage. **3.** Leaves. **4.** Seed cone. **5.** Seeds.

particleboard or flakeboard manufacture, or pulped for the paper industry. More specialized uses are furniture, sports equipment and musical instruments. Resin is extracted from wood pulp and used to produce turpentine and other products. The seeds are rich in vegetative oil with a high nutritive value, and this is used in the food processing industry; seeds can also be consumed whole and most of the imported pine kernels in Europe and the USA are now sourced from this species. It is widely cultivated as an ornamental tree in China, Korea and Japan, but less common in Europe and the US, where until recently only a limited number of cultivars was known, but now on the increase.

Pinus krempfii Lecomte, Bull. Mus. Hist. Nat. (Paris) 27: 191. 1921. *Ducampopinus krempfii* (Lecomte) A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 24: 30. 1944. Type: Viet Nam: South Viet Nam, Tinh Khanh Hoa, near Nha Trang, *M. Krempf 1537* (holotype P). Pl. 30

Pinus krempfii Lecomte var. *poilanei* Lecomte, Bull. Mus. Hist. Nat. (Paris) 30: 325. 1924.

Etymology

This species was named after the collector of the type specimen, M. Krempf.

Vernacular names

Krempf's pine; Thông lá dẹt (Vietnamese)

Description

Trees to 40(–50) m tall; trunk to 3(–4) m d.b.h., erect, straight, massive, often butressed. Bark smooth on young trees, becoming rough and scaly on large trunks, with irregular plates divided by shallow fissures, grey-brown to grey. Branches long, spreading wide and near the top ascending, forming a broadly domed or flat-topped, dense or more open crown. Foliage branches slender, multinodal, smooth after leaves have fallen, light brown turning grey with age. Buds small, almost continuously producing new shoots and leaves, not resinous. Leaves in fascicles of 2, with early deciduous basal sheaths consisting of a few thin, acute scales which fall separately, spreading, straight or slightly curved, 4–5(–7) cm long, extremely flat, 1.5–5 mm wide, often twisted in the lower, narrower fourth to third of their length, with a narrow median rib on each side, gradually tapering to an acute apex, green on adaxial side, glaucous green on abaxial side; stomata in fine lines on abaxial face. Pollen cones small, in groups at base of new shoots, 7 mm long when full-grown. Seed cones solitary or more commonly in pairs on short peduncles, maturing within 2 years, spreading and opening, falling after seed dispersal, 5–7 cm long, narrowly ovoid when closed, light green, opening to 3–5 cm wide, becoming brown. Seed scales relatively few, soft woody, oblong-concave, dark brown when mature; apophyses hard woody, thickened, raised and often curved, prominently transversely keeled, more or less rhombic in outline or with rounded upper margins, light brown or light reddish brown; umbo dorsal, raised, acute or more or less flat with a minute prickle. Seeds very small, 2.5–3 mm long, more or less ovoid, nearly black; wing long and narrow, 17–20 mm long, 4–5 mm wide, detachable from the seed.

Taxonomic notes

This remarkable pine has long been considered distinct from all other species, even to the extent that it should be classified in its own genus (or subgenus) *Ducampopinus* A. Chev. This opinion was mostly based on the peculiar, flat needles; virtually all other organs, including the dwarf shoots that produce the needles, are matched by other pines and are mostly unique to the genus. More recent phylogenetic analyses based on DNA data have given results that do not support this major distinction and have placed the species firmly within the genus *Pinus* and as almost certainly belonging to subgenus *Strobus* (Liston *et al.* in Mill, 2003). It is definitely an ancient relict species, as are several other species in this subgenus.

Distribution

S Viet Nam (southern Truong Son Range, between Dalat and Nhatrang and N of Nhatrang).
TDWG codes: 41 VIE

Ecology

Pinus krempfii is rare and grows in primary closed evergreen tropical montane rainforest, where it is an emergent above the general canopy dominated by angiosperm trees. Its altitudinal range is between 1200 m and 2000 m a.s.l. (most common between 1500 m and 1800 m) and it is often found on steep slopes and on mountain ridges. The mean annual temperature is 14–20° C and mean annual rainfall is in excess of 1500 mm, with a dry season from December to July. It grows predominantly in well-drained, low-pH lateritic clay soils indicating low nutrient availability. Other conifers with which this species is associated are *Fokienia hodginsii, Pinus dalatensis* and *Dacrydium elatum*. It is probably a long-lived emergent tree dependent on episodal disturbance regimes for successful regeneration, but no detailed observations have been made to verify this and its ecology remains poorly known.

Conservation

The recent decline of this species has been attributed to the effects of the American War (also known as Viet Nam War) in the 1960s and the clearance of forested land for agriculture in the following decades under pressure of rapid population increase. Its limited distribution and the inaccessibility of much of its habitat mean that there has been little direct exploitation. Most populations are now within recently established nature reserves around the Bi Doup massif. This species is listed in Group IIA of the List of Rare and Precious Flora and Fauna [Viet Nam] for limited use.
IUCN: VU [A2c; B1ab (iii)]

Uses

This species could be a valuable timber tree because of its size and good quality of wood, but it is not commercially exploited. Attempts at cultivation in Viet Nam have remained unsuccessful, due to its apparently very specific conditions for growing. It is not known to be in cultivation. More serious attempts should be made to grow this pine in areas with a warm, moist climate, which requires study of its development from seed to young tree in its natural habitat.

Pinus lambertiana Douglas, Trans. Linn. Soc. London 16: 500. 1827. Type: USA: Oregon, [locality unknown], *D. Douglas s.n.* (lectotype K). Pl. 31

Pinus lambertiana Douglas var. *martirensis* Silba, Phytologia 68: 52. 1990.

Etymology

This great pine was named by David Douglas, who introduced it to England, after Aylmer Bourke Lambert (1761–1842), a gentleman botanist.

Vernacular names

Sugar pine

Description

Trees to 70–75 m tall, d.b.h. to 3–3.8 m; trunk straight; bole often free of branches half or more of its length. Bark thick, rough, scaly, on lower part of trunk breaking into increasingly large, irregular to longitudinal plates separated by deep fissures, cinnamon to grey-brown or purplish brown. Branches up to 12 m long, spreading horizontally, curved downwards towards ends; crown broadly conical, in old trees often flat-topped from windbreak. Shoots slender, flexible, puberulent at first but soon glabrous, orange-brown turning light grey. Cataphylls small, triangular, scarious. Vegetative buds ovoid-oblong; terminal bud 5–10 × 4–6 mm; lateral buds smaller, not resinous. Fascicle sheaths 10–15 mm long on young fascicles, soon deciduous and absent when the leaves are full-grown. Leaves in fascicles of 5, persisting 2–4 years, straight, slightly twisted, lax, (3.5–)4–8(–10) cm long, 0.8–1.5 mm wide, with remotely and sometimes scarcely serrulate margins; apex acute-acuminate; leaf colour green to glaucous green. Stomata on all faces of leaves. Pollen cones forming more or less elongated 'spikes', ellipsoid-cylindric, 10–15 mm long, yellowish. Seed cones at ends of main branches, subterminal, solitary or in whorls of 2–4, erect on 5–12 cm long peduncles, becoming pendulous. Mature cones narrowly cylindrical when closed, straight or slightly curved, broadly cylindrical when opened, then (30–)40–45(–56) × 8–15 cm. Seed scales readily opening, patent or slightly reflexed, with basal sterile scales

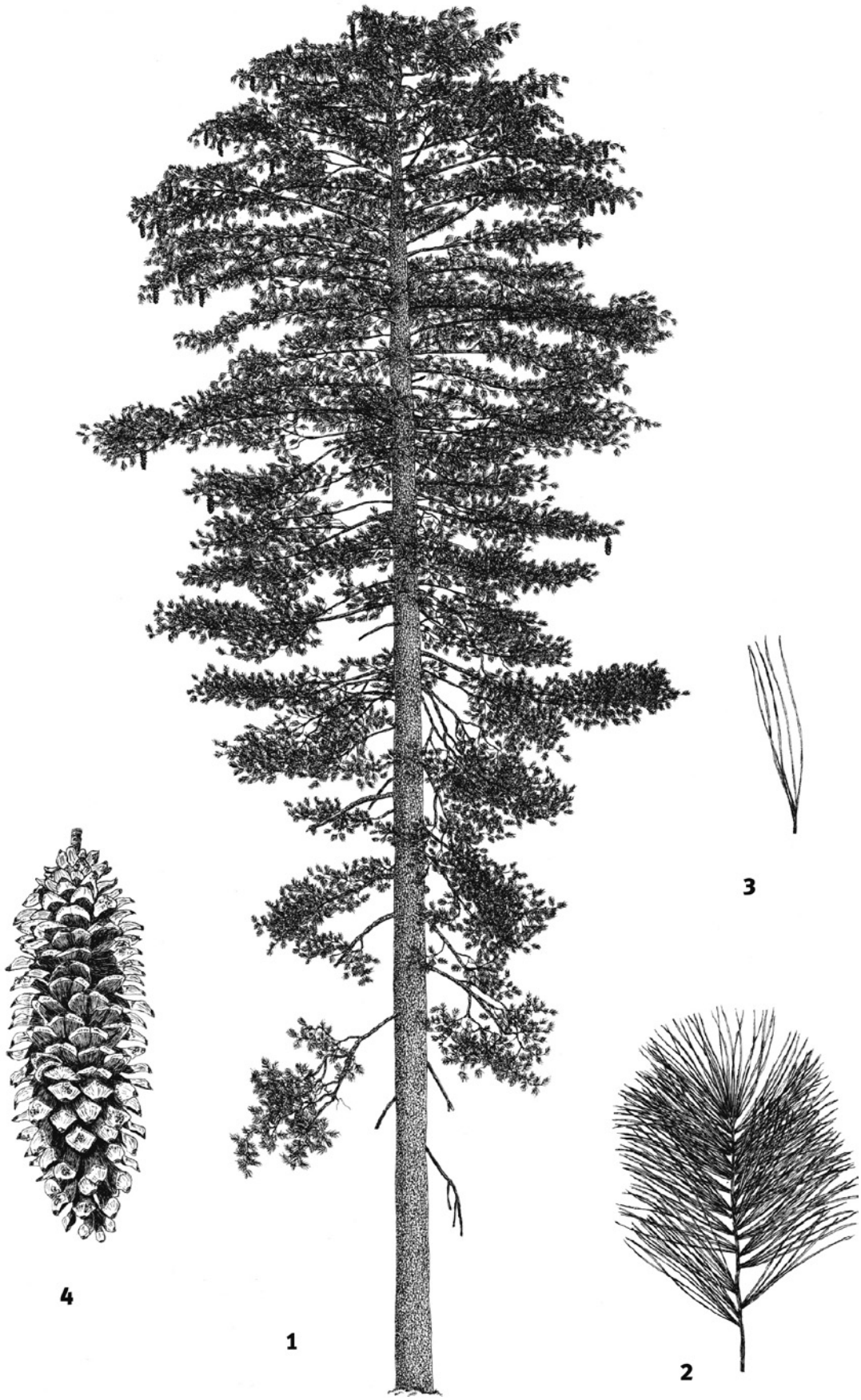

PLATE 31. *Pinus lambertiana*. 1. Habit of tree. 2. Branchlet with leaves. 3. Leaves. 4. Seed cone.

often more reflexed, angular-obovate to obtrullate, up to 40 mm wide and 4–5 mm thick. Apophysis triangular to obtusely rhombic, 5–8 mm thick at base, straight, smooth or radially striated, yellowish brown, often with yellow resin blobs. Umbo terminal, obtuse-triangular. Seeds obovoid or obliquely obovoid, (10–)12–15(–18) mm long, 6–10 mm wide, dark brown. Seed wings broadly obovoid to dolabriform or truncate, 20–30 mm long, 12–15 mm wide, light brown.

Distribution

USA: California, Oregon, Nevada (extreme western part); NW Mexico: Baja California Norte (Sierra San Pedro Martír).
TDWG codes: 73 ORE 76 CAL NEV 79 MXN-BC

Ecology

This majestic pine is common in the mixed and varied conifer forests of the Transition Zone in the high mountains of Oregon and California commonly between 600 m and 2400 m a.s.l., but reaching 2800–3200 m in the south of its range. In the Sierra Nevada of California it is restricted to the western slopes at middle elevation, between the warmer Upper Sonoran Zone and the colder Canadian Zone. Here one of the most impressive conifer forests in the world occurs, dominated by gigantic trees; indeed the largest tree species in the world, *Sequoiadendron giganteum*, is restricted to this zone and this mountain range. Other species are *Pinus monticola, P. ponderosa, P. jeffreyi, P. contorta* var. *murrayana, Abies magnifica, A. procera, Calocedrus decurrens*, and in the north of the range *Pseudotsuga menziesii*. A hospitable climate with warm, sunny summers moistened by rain showers and snowy but not extremely cold winters marks this zone. In Oregon *Pseudotsuga menziesii, Abies grandis, Tsuga heterophylla, Thuja plicata*, and *Calocedrus decurrens* are its most common associate conifers. Broad-leaved trees are rare and much smaller, *Arbutus menziesii* and *Quercus kelloggii* are perhaps the most common. The ground is open, littered with conifer needles, interspersed with small, flowery meadows and lush streamsides full of flowering shrubs. The bright yellow lichen *Letharia vulpina* festoons trunks and branches everywhere. This type of forest becomes resticted to the highest mountain summits further south and the diversity of conifers dimishes as does their size.

Conservation

IUCN: LC

Uses

Sugar pine is the most valuable of the pines due to its enormous size and its light, soft, even-grained, knot-free wood of which very large, straight pieces can be sawn. Consequently, old growth stands of this species command very high prizes; fortunately many are now protected in National Parks and other reserves. This species is used for high quality construction timber and the finished milled wood of this 'king of pines' as John Muir called it, makes it ideal for high standard windows and doors as well as foundry casting and even musical instruments such as organ pipes and piano keys. Plantation forestry has not been very successful and in Europe few trees have survived for long in arboreta and parks due to white pine blister rust (*Cronartium ribicola, Basidiomycota*) to which it is exceptionally sensistive. The vernacular name refers to the sugar content of the resin; in the past native tribes used it as a chewing gum. This use was first noted by David Douglas, who thought the native people were eating it.

Pinus latteri Mason, J. Asiat. Soc. Bengal. Sci. 18: 74. 1849. *Pinus merkusii* Jungh. & de Vriese var. *latteri* (Mason) Silba, Phytologia 68: 53. 1990; *Pinus merkusii* Jungh. & de Vriese subsp. *latteri* (Mason) D. Z. Li, Edinburgh J. Bot. 54 (3): 346. 1997. Type not designated. Fig. 227

Etymology

This species was named by the Rev. F. Mason after "Capt. Latter, the discoverer".

Vernacular names

Tenasserim pine; shaja, tinshu (Burmese); son-song-bai (Thai); nan ya song (Chinese)

Description

Trees to 30 m tall; trunk to 2 m d.b.h. Bark thick and scaly, rough, breaking into numerous small, dark grey plates. Branches spreading and assurgent, forming a broadly domed or umbrella-shaped crown in older trees. Foliage branches stout, glabrous, brown or dark brown. Buds cylindrical; terminal bud 1.5–2 cm long, without resin; cataphylls brown. Leaves in fascicles of 2, held by a persistent, 15–20 mm long basal sheath, long and slender but rigid, 15–25(–27) cm long, straight, semi-circular in transverse section, ca. 1.5 mm wide, dull green; margins minutely serrulate; apex long acute; stomata in numerous lines on all surfaces. Pollen cones clustered, spirally arranged, erect, cylindrical, 2–3 cm long. Seed cones sub-lateral on new shoots, usually solitary, sometimes in pairs, on ca. 1 cm long, stout peduncles, spreading at nearly right angles from branch, ovoid-conical or oblong-conical when closed, (5–)6–10(–13) cm long, widening to 4–9 cm and becoming broadly ovoid with a flat base and spreading scales. Seed scales woody, rigid, oblong, twice as long as wide, ca. 3 × 1.2–1.5 cm at mid cone in the larger cones, light reddish brown; apophyses rhombic or unequally pentagonal in outline, raised and strongly transversely keeled, radially striated or ridged, lustrous red-brown to dark brown; umbo dorsal, more or less central, slightly sunken or flat to obtuse, unarmed. Seeds ellipsoid to obovoid, 5–8 mm long, 4 mm wide, slightly appressed, grey-brown, with a 15–20 mm long persistent wing.

Taxonomic notes

The occurrence of a so-called grass stage in the seedlings of *Pinus latteri* and its close relative *P. merkusii* has been variously reported. Cooling & Gaussen (1970) first described a grass stage in *P. merkusii* (Sumatera, Philippines), which was said to be absent in "*Pinus merkusiana*" (an invalidly published name = *P. latteri*) from mainland Asia. This observation was reiterated in the second edition of my book Pines (Farjon, 2005b), but Vidaković (1991) stated that the grass stage is absent in trees from Sumatera (*P. merkusii*), but present in trees from the mainland (*P. latteri*). Information in PROSEA, a database on plant resources of SE Asia (PROSEA, 1993) likewise mentions the grass stage for "mainland *P. merkusii*" = *P. latteri*. If this information is authentic, and I see no reason to doubt it, then perhaps this distinction between the two species does not hold true. In that case, it could be argued that the other morphological differences between *P. latteri* and *P. merkusii* are minor and mostly of a quantitative nature, character states that may only justify distinction as a variety or subspecies for *P. latteri* under *P. merkusii*, the earlier name at species rank.

Distribution

China: Hainan (introduced?), Guangxi; Indochina: SE Myanmar [Burma], Kampuchea [Cambodia], Lao PDR, Thailand, Viet Nam.
TDWG codes: 36 CHH CHS-GX 41 CBD LAO MYA THA VIE

Ecology

Pinus latteri is a widespread species occurring from near sea level to ca. 1200 m a.s.l., forming more or less open stands on old river terraces with sandy or gravelly soil or in seasonally dry hills. It is a fire-adapted species capable of surviving grass fires through a 'grass stage' as a seedling (see also under Taxonomic Notes) and can quickly invade open terrain especially in nutrient-poor soils. Its range is within the influence of SE monsoons, with mean annual precipitation around 1500 mm in Myanmar and Thailand. It is also a constuent tree in dipterocarp forests (e.g. *Dipterocarpus tuberculatus*), especially in more open situations on drier sites of ridges and spurs in the hill country of Myanmar [Burma] and other countries in mainland SE Asia.

Conservation

IUCN: NT

Uses

Tenasserim pine is a timber tree used in SE Asia for light construction purposes. The wood is moderately hard and very resinous and only suitable for indoor applications when processed as sawn timber. Doors, window frames and flooring are common uses; some provenances can be put to veneers. Large quantities are nowadays used in the wood pulp industry, while

charcoal burning is a more traditional use still current. It is also an important tree for resin tapping in some countries. In China, the resin of this species has some medicinal applications, e.g. in making ointments. This tropical pine has been introduced for afforestation in several countries in Africa, but the results have on the whole been unsatisfactory because of difficulties with raising it beyond the seedling stage in all situations where competition from other plants ('weeds') is a factor.

Pinus lawsonii Roezl *ex* Gordon, Pinetum Suppl.: 64. 1862 ["*lawsoni*"]. Type: Mexico: Michoacan, Uruapán, Cerro de la Cruz, *C. G. Pringle 10141* (neotype NY).

Pinus lawsonii Roezl *ex* Gordon var. *gracilis* Debreczy & Rácz, Phytologia 78 (3): 19. 1995.

Etymology

Roezl named this species after the English gardener and plantsman Charles Lawson (1794–1873), who validated David Douglas' name *Pinus ponderosa* in the same way as did George Gordon with this name from him.

Vernacular names

Lawson's pine; pino ortiguillo (Spanish)

Description

Trees to 25–30 m, d.b.h. to 75 cm; trunk monopodial, straight, sometimes tortuous. Bark thick, rough and scaly, with broad and deep longitudinal fissures; outer bark dark blackish brown. Branches spreading horizontally, assurgent in the higher part of the crown; forming a broadly domed but open and irregular crown. Shoots smooth, orange-brown, often glaucous. Cataphylls subulate-lanceolate, ca. 10 mm long, scarious, erose-ciliate at margins, dull brown. Vegetative buds ovoid-oblong to cylindrical; terminal bud 10–15 mm long; lateral buds shorter, acute, not resinous. Fascicle sheaths of young leaves up to 25 mm long, persistent but reduced to 10–15 mm in older fascicles. Leaves in fascicles of 3–4(–5), very seldom 2, persisting 2–3 years, straight or nearly straight, rigid, 12–20(–25) cm long, 1.0–1.2(–1.5) mm wide, serrulate at margins, acute-pungent, glaucous green. Stomata on all faces of the leaves. Pollen cones ovoid-oblong to cylindrical, 1–2 cm × 5–6 mm, yellowish green, turning light brown. Seed cones subterminal, sometimes solitary, commonly opposite on short, stout, curved peduncles which usually fall with cone. Mature cones narrowly ovoid to ovoid-attenuate when closed, more or less asymmetrical, ovoid when open, with a more or less flattened base, then 5–8(–9) × 4–6(–7) cm. Seed scales thick woody, oblong, recurved when fully spread. Apophysis slightly raised, transversely keeled, rhombic in outline, with undulate-crenate upper margin, radially striate, light brown to grey-brown. Umbo dorsal, pyramidal, curved, lacking a distinct prickle. Seeds obovoid, slightly flattened, 4–5 mm long, dark brown. Seed wings 12–16 × 5–6 mm, translucent, light brown with a dark tinge.

Distribution

Mexico: Michoacán, México, Morelos, Distrito Federal, Guanajuato, (one locality in) Veracruz, Guerrero and Oaxaca.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXE-GU MXG-VC MXS-GR MXS-MI MXS-OA

Ecology

Pinus lawsonii has an altitudinal range of 1300–2600 m a.s.l. It is a constituent of warm-temperate to temperate montane forest or woodland, with annual precipitation ranging from 600–1500 mm and a dry season from November to May. It is most commonly found in pine-oak forest, also in pine forest with e.g. *Pinus pringlei, P. patula, P. montezumae, P. oocarpa, P. leiophylla, P. herrerae, P. teocote*, and *P. pseudostrobus*. On sites with sandy, shallow soil *Juniperus* can be codominant.

Conservation

IUCN: LC

Uses

Along with other pines, which are often more abundant in the mixed pine or pine-oak forests, this spe-

cies is cut commercially for lumber, although most trees are of medium size and the boles sometimes tortuous. In several places with abundant trees of this species, resin may be tapped as well. As an ornamental tree this species will only grow successfully in countries with very mild climate; it is not known to be in cultivation for this purpose.

Pinus leiophylla Schiede *ex* Schltdl. & Cham., Linnaea 6: 354. 1831.

Etymology

The species epithet is derived from Latin: *lenis* = soft and Greek: *phyllos* = leaf.

Vernacular names

Smooth-leaved pine; Chihuahua pine; pino chino, palo otomite (Mexico)

Description

Trees to 15–30(–35) m tall, d.b.h. to 20–85 cm; trunk monopodial, erect. Bark very thick, rough, scaly, divided into elongated, irregular, scaly plates and deep, mainly longitudinal fissures, dark grey-brown. Branches long, slender, spreading or ascending, but lower ones curved down, forming an open, rounded crown. Shoots more or less scaly, initially reddish brown or glaucous, soon grey-brown. Cataphylls ca. 6 mm long, lanceolate-subulate, soon recurved, light orange-brown. Vegetative buds ovoid-conical, obtuse; terminal bud 10–15 × 5–7 mm; lateral buds smaller, not or slightly resinous. Fascicle sheaths 12–20 mm long, early deciduous leaving the full-grown fascicles devoid of a sheath. Leaves in fascicles of (2–)3–5(–6), spreading in lax or rigid tufts near ends of branches, persisting 2–3 years, sometimes subpendulous, straight, variable in length on the same branch, (4–)6–15(–17) cm long, 0.5–1.3(–1.5) mm wide; margins (minutely) serrulate; apex acute or acute-pungent; leaf colour light green or glaucous green. Stomata on all faces of leaves. Pollen cones cylindrical, 1–1.5(–2) cm × 4–6 mm, yellowish pink. Seed cones subterminal, solitary or in whorls of 2–5 on stout, 10–20 mm long, spreading or recurved peduncles, persisting a few years after seed dispersal. Mature cones (narrowly) ovoid when closed, nearly symmetrical, (broadly) ovoid when opened, (4–)5–7(–8) × (3–)4–5.5 cm when open. Seed scales straight or recurved near base of cone, oblong, with nearly straight margins. Apophysis raised, transversely keeled, with the central section of the second season's growth distinctly marked as a narrow band around the umbo, rhombic in outline, dull brown to grey-brown. Umbo dorsal, pyramidal, with a blunt prickle, darker than the apophysis. Seeds obliquely ovoid, slightly flattened, 3–4(–5) mm long, dark grey-brown with black spots. Seed wings obliquely oval, 10–18 × 4–8 mm, yellowish brown, translucent, with a dark tinge.

Distribution

SW USA: SE Arizona, SW New Mexico; in Mexico along the Sierra Madre Occidental, the "Eje Volcánico Transversal" and in the Sierra Madre del Sur as far SE as the highlands of central Oaxaca.
TDWG codes: 76 ARI 77 NWM 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-AG MXE-CU MXE-DU MXE-GU MXE-HI MXE-QU MXE-SL MXE-ZA MXG-VC MXN-SI MXN-SO MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA

Ecology

Pinus leiophylla var. *leiophylla* is a widespread constituent of montane to high montane pine and pine-oak forests on deep, well drained soils derived from various, but usually volcanic or metamorphic rock. Its altitudinal range is (1500–)1900–2900(–3300) m a.s.l., gradually increasing from north to south. It occurs most frequently with *Quercus* spp. and/or with *Pinus patula, P. pringlei, P. teocote, P. lawsonii, P. pseudostrobus, P. montezumae, P. douglasiana, P. durangensis*, and at lower altitudes *P. oocarpa*. In the NW of its range *P. arizonica, P. engelmannii* and *P. leiophylla* var. *chihuahuana* grow commonly with it. Locally, *Juniperus* spp. or *Cupressus lusitanica* are found with it. Annual precipitation varies greatly with locality and altitude, from a low of ca. 700 mm to 1950 mm. In the north and at high altitudes, frost and snow are common in winter. It is one of the few pines with a capacity to coppice. The seed cones take three seasons to mature, which is exceptional in pines. Although largely sympatric with var. *leio-*

phylla, the altitudinal range of var. *chihuahuana* is narrower: 1500–2700(–2950) m, but this is in part due to the fact that it does not occur on some of the high volcanos of central Mexico. In the Sierra Madre Occidental its lower limit usually is below the level of var. *leiophylla*. Here it may be found in semi-arid habitat with *P. cembroides, Juniperus* spp. and xerophytes like *Opuntia* and *Arctostaphylos*. Higher up, its habitat is similar to that described above. Its poor growth in some areas is related to lower precipitation and rocky, poor, shallow soils especially at lower and middle altitudes.

Uses

Along with many other species of pine in the Sierra Madre Occidental, *Pinus leiophylla* has been heavily exploited for timber in the latter half of the 20th century. Due to its high resin content it does not provide high quality wood but at the same time is a producer of good resin, for which it is tapped. The wood is used in heavy construction and for crates and boxes. The variety *chihuahuana* is less exploited for timber, but an equally prolific producer of resin. Smooth-leaved pine has been planted in various parts of the world, especially in Africa, as a plantation forestry tree.

2 varieties are recognized:

Pinus leiophylla Schiede *ex* Schltdl. & Cham. var. ***leiophylla***. Type: Mexico: Veracruz, Cruz Blanca, ["inter Cruz Blanca et Jalacingo"], *C. J. W. Schiede 1109* (holotype HAL).

Pinus lumholtzii B. L. Rob & Fernald var. *microphylla* Carvajal, Phytologia 59: 135. 1986.

Description

Trees to 20–30(–35) m tall, d.b.h. to 50–85 cm. Shoots reddish brown, sometimes glaucous. Leaves in fascicles of (4–)5(–6), 4 more often than 6, (6–)8–15(–17) cm long, 0.5–0.9 mm wide. Stomata in (3–)4–6(–7) lines on the convex abaxial face, in (2–)3–4 lines on each adaxial face. Resin ducts in the leaves (1–)2–3(–4), medial, occasionally 1 internal.

Distribution

Mexico: in NE Sonora, W Chihuahua, Durango, Nayarit, Zacatecas, Jalisco, Michoacán, México, D. F., Hidalgo, Morelos, Tlaxcala, Puebla, Veracruz, Guerrero and Oaxaca.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-CU MXE-DU MXE-HI MXG-VC MXN-SO MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA

Conservation

IUCN: LC

Pinus leiophylla Schiede *ex* Schltdl. & Cham. var. ***chihuahuana*** (Engelm.) Shaw, [Pines Mexico] Publ. Arnold Arbor. 1: 14. 1909. *Pinus chihuahuana* Engelm., in Wislizenus, Mem. Tour N. Mexico: 103. 1848; *Pinus leiophylla* Schiede *ex* Schltdl. & Cham. subsp. *chihuahuana* (Engelm.) E. Murray, Kalmia 12: 23. 1982. Type: Mexico: Chihuahua, Cosiquiriachi, *F. A. Wislizenus 232* (holotype MO).

Description

Trees to 15–25 m tall, often not more than 10 m, d.b.h. to 20–60 cm. Shoots reddish brown, often glaucous. Leaves in fascicles of (2–)3(–4, rarely 5), (4–)6–12 (–14) cm long, 0.9–1.3(–1.5) mm wide. Stomata in (4–)5–8(–9) lines on the convex abaxial face, in 3–4 lines on each adaxial face. Resin ducts in the leaves (3–)4–6(–7), medial, occasionally 1–2 internal.

Distribution

USA: SE Arizona, SW New Mexico; Mexico: along the Sierra Madre Occidental in NE Sonora, W Chihuahua, Durango, Nayarit, N Jalisco and Zacatecas.

TDWG codes: 76 ARI 77 NWM 79 MXE-CU MXE-DU MXE-ZA MXN-SO MXS-JA MXS-NA

Conservation

IUCN: LC

Pinus longaeva D. K. Bailey, Ann. Missouri Bot. Gard. 57: 243. 1971. *Pinus aristata* Engelm. var. *longaeva* (D. K. Bailey) Little, Phytologia 42: 221. 1979; *Pinus balfouriana* Balf. subsp. *longaeva* (D. K. Bailey) E. Murray, Kalmia 12: 23. 1982; *Pinus aristata* Engelm. subsp. *longaeva* (D. K. Bailey) E. Murray, Kalmia 13: 21. 1983. Type: USA: Nevada, Wheeler Peak Scenic Area, Wheeler Peak, *D. K. Bailey & J. E. Whitson 7001* (holotype COLO). Fig. 228

Etymology

The species epithet *longaeva* refers to the longivity of this pine.

Vernacular names

Great Basin Bristlecone pine, Intermountain Bristlecone pine

Description

Trees, small to medium, height to 16 m; trunk d.b.h. to 3 m. Trunk monopodial, straight or contorted, often strongly tapering in old trees or sometimes multi-stemmed, branching very low and much reduced in size at tree line. Bark thin, shallowly to deeply fissured, breaking into irregular, scaly ridges, reddish brown, weathering grey. Branches of first order contorted, ascending or spreading, persistent, of higher orders flexible and often pendent. Shoots puberulent, with short, non-decurrent pulvini, pale red-brown, ageing to yellowish grey or grey. Cataphylls 5–7 mm long, subulate, scarious, brown, with entire margins, soon deciduous. Vegetative buds ovoid and acute, resinous; terminal bud 8–10 mm long; lateral buds smaller, all with imbricate, appressed, subulate, red-brown scales. Fascicle sheaths deciduous and absent in second year's fascicles. Leaves in fascicles of 5, in dense tufts persisting up to 30 years, mostly connivent, curved forward against shoot, (1.5–)2–3.5(–4) cm long, 0.8–1.2 mm wide, lacking resin droplets or only a few present; margins entire or distally serrulate; apex acute or short acuminate; leaf colour deep green on the smooth abaxial face, white stomatal lines on both adaxial faces. Pollen cones crowded at the proximal end of a new shoot, spreading, subtended by light brown bracts, ellipsoid or ovoid, ca. 10 mm long, red or purple (sometimes yellow), maturing to brown. Microsporophylls peltate, the distal part cordate to rounded, smooth, ca. 1 mm wide. Seed cones subterminal, solitary or in pairs, nearly sessile, falling after seed dispersal. Immature cones erect, ovoid, dark purple (sometimes green), maturing in two seasons. Mature cones ovoid-cylindric becoming more ovoid when open, 6–10 × 4–6 cm. Apophyses on seed scales thick, triangular to rhombic, transversely keeled, recurved, red-brown. Umbo dorsal, transverse-triangular at base, terminating in a slender but rigid, variable prickle 1–6 mm long. Seeds ellipsoid or obovoid, 5–8 × 3–5 mm, light brown with darker red-brown specks. Seed wings 10–13 mm long.

Distribution

USA: E California, Nevada, Utah.
TDWG codes: 76 CAL NEV UTA

Ecology

Like its relatives *Pinus aristata* and *P. balfouriana, P. longaeva* is a subalpine to alpine species and like the others a xerophyte, adapted to extreme conditions and fluctuations of temperature and moisture. Its altitudinal range is between 2130 and 3700 m above sea level and it often grows with *P. flexilis*, but with few other trees or shrubs, and often in bare, rocky ground. Weather conditions are often extreme in all seasons, ranging from heat, extreme radiation and desiccating winds to snow and ice storms that blast the bark off the trunks. Growth is therefore exceedingly slow, producing very dense and hard wood with annual increments of minimal width, often restricted to only parts of the trunk and some of the branches, the remainder being already dead wood. Yet these trees even when 4000 years old still produce cones with viable seeds, and seedlings and saplings can be found growing around them.

Conservation

Pinus longaeva was considered vulnerable to extinction because of its fragmented occurrence in a limited number of populations, often with only a few hundred or at most 500–1000 mature individual trees. Recruitment is very slow and it seemed uncertain, given the great age of these trees, whether this constitutes sufficient replacement of (eventually) dying old trees. Recently, a re-assessment by USDA forest

ecologists concluded: "Per our analysis there are no known subpopulations where *Pinus longaeva* numbers are decreasing. Throughout its range we observe populations as either increasing or remaining stable. Projection of population trends due to climate change are unknown and would be speculative at best. At most occurrences there is additional elevation to allow for subpopulations of *Pinus longaeva* to move up slope. To date white pine blister rust is not adversely affecting Great Basin Bristlecone Pine populations." (Reviewed by Larry Stritch & associates, 2012)
IUCN: LC

Uses

Great Basin bristlecone pine is now a protected tree in its native habitat. It was never a timber tree due to extremely slow growth and trunks of any usable size being contorted or otherwise 'mis-shaped' from a lumberman's viewpoint. Dead wood lends itself beautifully for wood turning and may have been used before the gathering of this commodity was outlawed. This tree has become famous in the science of dendrochronology, which was pioneered by E. Schulman in the 1960s. Ages of individual living trees exceeding 4000 years were found, with some between 4500 and 5000 years. Analyzing tree ring patterns of these trees and adding those of dead trees (which in the dry climate at high altitude do not rot) a tree ring calendar of 8200 years has been constructed, enabling archaeologists to date their finds precisely if good pieces of wood are preserved. It even led to the 'calibration' of dates based on C14 (^{14}C) isotope decay and the realization that the rate of this decay has not been entirely constant. This species is not common in cultivation; it is a relatively recent taxonomic split from *P. aristata*, which can be found more often in collections or in large rock gardens. Its very slow growth under conditions of stress should make it an ideal plant for bonsai culture.

Pinus luchuensis Mayr, Bot. Centralbl. 58 (5): 149. 1894. Type: Japan: Ryukyu Islands, *H. Mayr s.n.*, March 1891 (type not located, A?, PC?).

Etymology

This species is named after the Luchu Islands [Ryukyu Islands] in the East China Sea.

Vernacular names

Luchu pine, Okinawa pine; Ryûkyû-matsu, Okinawa-matsu (Japanese); maachi, machi (Okinawan)

Description

Trees to 15(–20) m tall; trunk to 60 cm d.b.h. Bark on trunk rough and scaly, breaking into large plates on lower part of trunk, but thinner, smooth and greyish on young trees and on branches in crown. First order branches few, long and spreading (trees in natural habitat are mostly wind-deformed), higher order branches assurgent and densely crowded, forming flat-topped or domed crowns in natural habitat. Foliage branches glabrous, more or less smooth, grey. Buds ovoid-conical, 10–15 mm long, 5–7 mm wide, resinous; cataphylls appressed, orange or rusty brown. Leaves in fascicles of 2, held by a persistent, slender basal sheath ca. 10 mm long, straight or slightly curved, 10–15 cm long, slender, pliant, slightly twisted, 0.7–1 mm wide; margins minutely serrulate; apex acute; stomata in fine lines on all surfaces. Pollen cones clustered, spirally arranged, short cylindrical, 1.5–2 cm long, yellow tinged with red, becoming reddish brown. Seed cones solitary or sometimes in pairs, persistent on short peduncles, spreading, 4–5.5 cm long, narrowly ovoid when closed, widening to 2.5–3 cm when open. Seed scales thin woody, rigid, oblong, ca, 2 × 1 cm at mid cone, straight or slightly recurved when spreading, dull brown; apophyses rhombic in outline or with rounded upper margin, slightly raised, transversely keeled, lustrous brown; umbo small, pyramidal, armed with a sharp, mucronate prickle. Seeds ellipsoid-ovoid, 4–5 mm long, slightly flattened; wing 10–15 mm long, persistent.

Distribution

Japan: Ryukyu Islands (Sakishima-shoto, Okinawa-shoto, Amami-shoto, Tokara-shoto).
TDWG codes: 38 NNS

Ecology

Pinus luchuensis is a maritime pine, occurring in coastal areas of Okinawa and on smaller islands from near sea level to 700 m a.s.l. It grows on sand dunes as well as on rocky outcrops and hillsides, often on

very wind-exposed slopes or close to the sea, where it becomes wind distorted. This species is very tolerant of saline air and ocean spray, but grows well in planted situations away from strong winds and airborne salt. In its natural habitat it mostly forms pure, open stands with a low vegetation of grasses and shrubs stabilizing drifting sand, virtually free from competition by other trees.

Conservation

IUCN: LC

Uses

This pine is not important as a timber resource and as such only of local use. It is well adapted to salt-laden sea winds and has been planted to stablize sand dunes in coastal areas in other parts of Japan as well as in Taiwan. It is not known to be used as an ornamental tree and no cultivars are known of this species.

Pinus lumholtzii B. L. Rob & Fernald, Proc. Amer. Acad. Arts 30: 122. 1894. Type: Mexico: Chihuahua, Coloradas, *C. V. Hartman 541* (holotype GH).

Etymology

This species was named after the plant collector Carl Lumholtz (fl. 1900).

Vernacular names

Lumholtz's pine; pino triste (Spanish)

Description

Trees to 20 m tall, d.b.h. to 50–70 cm; trunk monopodial, straight. Bark thick, scaly, very rough, divided into elongated, irregular plates and deep, wide, longitudinal fissures, greyish brown to dark grey. Branches spreading or ascending, branches of higher orders slender, flexible, drooping. Crown broad, rounded and usually open. Shoots initially glaucous, turning reddish brown, then grey. Cataphylls subulate, up to 10 mm long, scarious, red-brown. Vegetative buds ovoid-conical, acute; terminal bud ca. 15 × 8 mm; lateral buds smaller, resinous. Fascicle sheaths (20–)25–35 mm long on juvenile fascicles, consisting of ca. 10 reddish brown scales, soon coming apart, forming a tuft of curling scales at the base of fascicles before they fall at maturity, leaving fascicles bare. Leaves in fascicles of 3 (exceptionally 2 or 4), usually extremely pendulous, persisting two years, lax but not thin, (15–)20–30(–40+) cm long, (1–)1.2–1.5 mm wide, with serrulate margins, acute, light green. Stomata on all faces of leaves, in conspicuous lines. Pollen cones sparsely clustered, cylindrical, 2–3 cm × 5 mm when mature, at first pinkish, turning yellow. Seed cones subterminal or lateral, solitary (sometimes in whorls of 2, rarely 3) on 10–15 mm long, curved peduncles, breaking off easily and remaining with the soon deciduous cones. Mature cones ovoid to ovoid-attenuate when closed, ovoid to ovoid-acute when opened, then (3–)3.5–5.5(–7) × (2.5–)3–4.5 cm. Seed scales thick woody, oblong, spreading wide or lower scales remaining closed, with smaller basal scales remaining connate. Apophyses slightly raised, thickened along the distal margin, obscurely transversely keeled, those on basal scales gibbous, rhombic to pentagonal in outline, ochraceous to reddish brown. Umbo dorsal, often tilted towards distal margin of apophysis, flat or slightly raised, with a minute, soon deciduous prickle. Seeds obliquely obovoid, slightly flattened, 3–5 mm long, dark brown, often with black dots. Seed wings oblique, widest below apex, (8–)10–14 × 4–6 mm, light yellowish or greyish brown.

Distribution

Mexico: Sierra Madre Occidental, in Chihuahua, Sinaloa, Durango, Nayarit, Jalisco, Zacatecas, Aguascalientes and Guanajuato.

TDWG codes: 79 MXE-AG MXE-CU MXE-DU MXE-GU MXE-ZA MXN-SI MXS-JA MXS-NA

Ecology

The altitudinal range of this species is (1500–)1700–2600(–2900) m a.s.l., which corresponds to the lower and middle slopes of the Sierra Madre. It grows usually mixed with several species of *Quercus* and other pines in pine-oak forest, or on the wetter western slopes of the Sierra Madre, in mixed pine forest. Associated pines are e.g. *P. leiophylla,*

P. arizonica, P. douglasiana, P. teocote, and *P. oocarpa*; on more mesic sites one can expect *P. ayacahuite* and *Pseudotsuga menziesii*, while in dry habitats *Pinus cembroides* can occur with it. The annual precipitation, mostly as summer rains, is a moderate 500–600 mm (except on the driest and wettest sites).

Conservation

IUCN: NT

Uses

Pinus lumholtzii is generally known as 'pino triste' for its striking pendulous foliage. It has been overexploited with other pines in some areas for timber, but due to its scattered occurrence, especially in pine-oak forest and in drier sites, it is not a commercially important tree. This species, despite its striking foliage, is not known in cultivation.

Pinus luzmariae Pérez de la Rosa, Bol. Inst. Bot. (Guadalajara) 5 (1–3): 127. 1998. *Pinus oocarpa* Schiede *ex* Schltdl. f. *trifoliata* Martínez, Anales Inst. Biol. Univ. Nac. México 16: 297. 1945; *Pinus oocarpa* Schiede *ex* Schltdl. var. *trifoliata* Martínez, Pinos Mexic., ed. 2: 308, f. 252–253. 1948. Type: Mexico: Durango, Sierra de Chavarria, *M. Martínez 3458* (holotype MEXU).

Etymology

This species was named after it's author's village school mistress Luz Maria Villareal de Puga, who first taught him about plants.

Vernacular names

No common names have been recorded for this little known species.

Description

Trees to 10–15 m tall, d.b.h. to 40–60 cm. Leaves in fascicles of 3, rarely of 4, straight, rigid, (11–)14–17 (–20) cm long, 1.2–1.6 mm wide. Seed cones 3–5.5 × 3–5(–6) cm when open.

Taxonomic notes

This taxon was until recently known as *Pinus oocarpa* var. *trifoliata* (Farjon & Styles, 1997), but Pérez de la Rosa (*op. cit.*) has made a case for its recognition as a species, finding additional characters besides the numbers of needles in a fascicle to distinguish it. The scattered distribution across a large part of Mexico and beyond, always within the very wide range of *P. oocarpa*, and the rarity of the trees with these characters in any location, seem to go against this, but it can be given the benefit of the doubt in the absence of evidence, e.g. based on DNA data, to the contrary.

Distribution

Mexico; Honduras (distribution imperfectly known).
TDWG codes: 79 MXE-DU MXS-JA MXS-MI MXS-OA 80 HON

Ecology

Similar to that of *Pinus oocarpa*.

Conservation

IUCN: LC

Uses

No uses have been recorded, but it will be used in the same way as *Pinus oocarpa*.

Pinus massoniana Lamb., Descr. Pinus 1: 17, t. 12. 1803.

Etymology

This species commemorates the botanist Francis Masson (1741–1805) who never visited China and is best known for his plant collecting at the Cape of Good Hope in South Africa in the 1770s.

Vernacular names

Masson's pine, Chinese red pine; ma wei song (Chinese)

Description

Trees to 45 m tall; trunk to 1.5 m d.b.h., usually a straight bole. Bark in the upper part of stem and crown thin, flaking, reddish brown; lower down trunk becoming thick, with long vertical fissures, rough and scaly, grey-brown or red-brown. Branches spreading and ascending, self-pruning, higher order branches more or less pendulous, forming a rounded or domed crown. Foliage branches slender, rough with decurrent pulvini after leaf fascicles have fallen; shoots elongating twice per year, glabrous, yellowish brown, sometimes glaucous, turning light brown in the second or third year. Vegetative buds small, ovoid-cylindric; apical bud ca. 10 mm long, non-resinous; cataphylls brown. Leaves in fascicles of 2, sometimes of 3, held in persitent fascicle sheaths 15–20 mm long, spreading wide, 12–20 cm long, straight or slightly contorted, slender, pliant, ca. 1 mm wide, slightly twisted; margins minutely serrulate; leaf colour bright green; stomata in fine lines on all surfaces. Pollen cones in clusters near base of new shoots, spirally arranged, short cylindrical, yellow to orange-brown. Seed cones mostly solitary on short peduncles, spreading or down-curved, falling soon after seed dispersal, variable in size, 3–9 cm long, narrowly ovoid when closed, ovoid when opened and then 2.5–5 cm wide, symmetrical or nearly so. Seed scales thin woody, not spreading widely, oblong to obovoid-oblong; apophyses nearly flat or slightly raised, sub-rhombic in outline, with rounded upper margin and cuneate lower margin, transversely keeled in a down-curved line, becoming chestnut-brown; umbo dorsal, more or less central, obtuse or shortly mucronate. Seeds more or less obovoid, 4–8 mm long, dark brown; wing 12–21 mm long, 5–7 mm wide, persistent.

Distribution

Central and SE China (accross 15 provinces); Taiwan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-GZ CHC-HU CHC-SC CHC-YN CHH CHN-SA CHN-SX CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HN CHS-JS CHS-JX CHS-ZJ 38 TAI

Ecology

Pinus massoniana is a pine which grows as well in the lowlands as in the highlands, and occurs from a few meters to an altitude of about 2000 m a.s.l. Because of this, it occurs in greatly varying climatological conditions, from the moist lowland river valleys to the dry mountain plateaus of the interior parts of China. In general, it is a conifer inhabiting a region with a warm temperate climate. Extensive stands of this pine occur in several areas where cultivation of the land has been marginal, i.e. in hilly or rocky terrains and on the poorer acidic soils of mountain slopes and ridges. This species is not found in limestone formations. It occurs often in mixed light forest or woodland with angiosperms such as *Lithocarpus* and *Quercus* (*Fagaceae*) and some other conifers, e.g. *Keteleeria davidiana* and *Cunninghamia lanceolata*. It is often a pioneer species invading abandoned agricultural fields or secondary vegetation in forest clearings.

Uses

Masson's pine is one of the most important conifer trees in China. It is fast growing and widely used in plantations grown for wood, pulp, resin and other products. The wood is of good quality and used for construction as well as the pulp and wood fibre industries. Natural stands, especially old growth, provide most of the sawn timber, while fast growing plantations are mostly converted into pulpwood. Many uses are given to the sawn timber, ranging from poles, railway sleepers and heavy or light construction and plywood to boxes, furniture, veneers, cooperage, tool handles, wood carving, and musical instruments. Pine resin of this species forms the basis for a variety of chemical products, the so-called naval stores industry. China is now the world's leading producer of gum rosin, both for domestic consumption and export, and Masson's pine is the major provider of this, supplying 95% of China's oleoresin and employing 200,000 workers (Langenheim, 2003). Oil is extracted from the needles, and this and other parts of the tree are extensively used in traditional Chinese medicine. Edible mushrooms are cultivated on bedlogs of this pine laid out in limestone caves. Masson's pine is not widely planted outside China, and is rather uncommon as an amenity tree in regions with a mild climate.

2 varieties are recognized:

Pinus massoniana Lamb. var. ***massoniana***. Type: Illustration in Lambert, Descr. *Pinus* 1: t. 12. 1803 (lectotype).

Pinus crassicorticea Y. C. Zhong & K. X. Huang, Guihaia 10 (4): 287. 1990.
Pinus massoniana Lamb. var. *shaxianensis* D. X. Zhou, Bull. Bot. Res. North-East. Forest. Inst. 11 (3): 41. 1991.

Description

Bark grey-brown towards base of trunk. Seed cones ovoid or conical-ovoid when opened, 3–9 × 2.5–4 cm.

Distribution

South Central and SE China; Taiwan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-SA CHN-SX CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JS CHS-JX CHS-ZJ 38 TAI

Conservation

IUCN: LC

Pinus massoniana Lamb. var. ***hainanensis*** W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 85. 1975. Type: China: Hainan, *Wang Chin 3117* (holotype PE).

Description

Bark red-brown towards base of trunk. Seed cones ovoid when opened, 4–7 × 2.5–5 cm.

Taxonomic notes

In Flora of China 4 (1999) two varieties are recognized besides var. *massoniana*; one of these, var. *shaxianensis* D. X. Zhou is in Farjon (2005b) considered to be synonymous with var. *massoniana*. The other variety, var. *hainanensis* W. C. Cheng *et* L. K. Fu, was described from Hainan Island in southern China and has red-brown bark not only in the upper parts of the tree, but also on the lower trunk. The cones seem to be less variable in size and more consistently ovoid and perhaps smaller, but there may be much overlap of these continuous measurements with cones of var. *massoniana* on the mainland. This variety is here only tentatively accepted.

Distribution

China: Hainan Island (Yajiadaling).
TDWG codes: 36 CHH

Ecology

Said to be growing on hills, without further details.

Conservation

This variety is poorly known but appears to occur in a limited area in the western part of Hainan Island, where it is declining due to deforestation.
IUCN: CR [B1ac (ii), B2ac (ii)]

Pinus maximartinezii Rzed., Ciencia (Mexico) 23: 17, t. 2. 1964. Type: Mexico: Zacatecas, Juchipila, Pueblo Viejo, ["Cerro de Pinones"], *J. Rzedowski 18258* (holotype MEXU). Fig. 229, 230

Etymology

The species epithet commemorates the Mexican botanist Maximino Martínez (1888–1964), who studied the conifers of Mexico, but did not know this pine; a concomitant meaning refers to the size (Latin: *maxime*) of the cones and seeds.

Vernacular names

Martinez pinyon; piñon real (Spanish, Mexico)

Description

Trees to 5–10(–15) m tall, d.b.h. to 40–50 cm; trunk monopodial, short, branching low, often contorted or curved. Bark relatively thick on lower trunk, thin elsewhere, smooth but eventually rough, tessellated into square, ca. 10 cm wide plates; outer bark grey. Branches long, ascending to erect in the top, but lower branches spreading, those bearing cones becoming pendulous. Shoots glabrous or with puberulent bases of fascicles, initially glaucous or greyish

green, turning orange-brown to grey. Cataphylls ca. 5 mm long, narrowly triangular-caudate, recurved. Vegetative buds small, ovoid-conical; terminal buds 5–8 mm long, resinous. Fascicle sheaths 7–8 mm long, light brown; the outer scales deciduous, the inner scales recoiling, semi-persistent, forming a small rosette at base of fascicle. Leaves in fascicles of 5, very rarely 3 or 4, persisting two years, straight, lax, 7–11(–13) cm long, 0.5–0.7 mm wide, with entire margins, acute, glaucous green, in some trees green, the two adaxial faces often whitish. Stomata only on adaxial faces. Pollen forming an elongated 'spike', ovoid-oblong, 8–10 mm long, yellowish. Seed cones lateral, solitary on ultimate branches, on a very short peduncle or almost sessile. Mature cones broadly ovoid-truncate, (15–)17–25(–27) × 10–15 cm when the scales have parted. Seed scales parting slowly, usually insufficiently wide to release the seeds, very thick woody, rigid, obtrullate, up to 50 mm wide below the apophysis, of similar shape around the cone but differentiating from base to apex, with deep seed cavities on adaxial side. Apophyses very prominent, 35–50 × 20–35 mm, rhombic-pyramidal at mid-cone, usually straight, transversely keeled, with angular upper margin, those on the proximal and distal scales narrowly conical, often curved, dull light brown or reddish brown, often resinous. Umbo dorsal, obtuse-triangular or rhombic-pyramidal, sometimes with a minute prickle, concolorous or grey-brown. Seeds oblong or ovoid-oblong, slightly flattened, 20–28 × (8–)10–12 × 7–10 mm, wingless when the seed is free; integument ca. 2 mm thick, very hard. Seedlings large, with 18–24 cotyledons; juvenile leaves curved, flattened, ca. 8 cm long, silvery-blue, persisting well beyond the development of adult leaves, sometimes up to 20 years.

Distribution

Mexico: Durango (La Muralla), S Zacatecas (Sierra de Morones).
TDWG codes: 79 MXE-DU MXE-ZA

Ecology

The rock of the mountain in Zacatecas where *P. maximartinezii* occurs is in part sandstone or limestone and also metamorphic, the soils are very rocky and shallow. In Durango it grows on rocky soils of igneous origin. Precipitation is probably ca. 700–800 mm annually, virtually restricted to four months in the summer. *Pinus maximartinezii* is virtually the only pine here, but a few scattered individuals of *P. leiophylla* var. *chihuahuana* have been seen. Its altitudinal range is 1750–2400 m a.s.l. Abundant are various large leaved species of deciduous *Quercus*, e.g. *Q. macrophylla*, which are bare during the long dry season from September to May. Fires occur regularly in the region in all vegetation types; it is not known whether this species is adapted well to reseed itself after fire. Pollen dispersal is usually in May-June; the ovuliferous cones take 18–24 months to reach maturity, and perhaps longer for the seeds to ripen fully, which mostly remain in the cones. Squirrels are capable of biting off the apohyses to reach the seeds and probably store them. They, and probably also birds, may play a crucial role in effective seed dispersal, but this has not been investigated to date.

Conservation

The species is considered Endangered due to fire and grazing hazards resulting in few seedlings that succeed in establishing themselves. Intensive harvesting of cones and seeds may also diminish its chances of reproduction. Although there is an awareness amongst botanists and foresters in Mexico of its importance, current *in situ* protection (fire prevention and fighting) seems inadequate to ensure long term preservation of this interesting narrow endemic. Seed collections have been made in recent years to ensure *ex situ* conservation programmes. The land on which most of these pines grow is privately owned by villagers, who have an interest in the seed harvests as well as cattle grazing.
IUCN: EN [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Uses

Like other 'piñon' (pinyon pines) in Mexico, this species is of local importance for its edible seeds, which are harvested by local people and marketed in the region. Due to its low stature and branching of the trunk, its timber is not used. In Mexico, it is sometimes planted as an ornamental tree; elsewhere it is only grown in a few botanic gardens (e.g. at the University of California in Berkeley) and research

nurseries; its horticultural merits could be greater than that since it is not too difficult to grow from seed in the nursery. Young trees retain an attractive blue juvenile foliage for several years.

Pinus maximinoi H. E. Moore, Baileya 14: 8. 1966. *Pinus tenuifolia* Benth., Pl. Hartweg.: 92. 1842, non Salisb. (1796); *Pinus douglasiana* Martínez var. *maximinoi* (H. E. Moore) Silba, Phytologia 68: 50. 1990. Type: Guatemala: ["In montibus para ruptis que Canales dictis, nec non ad pagum Chinanta prope Guatemala, et in summo jugo Choacas prope Salama."], *C. T. Hartweg 620* (holotype K).

Etymology

This species was named after the Mexican botanist Maximino Martínez (1888–1964), who studied the pines of Mexico.

Vernacular names

Thin-leaf pine; ocote, pino canís (Mexico, Honduras)

Description

Trees to 20–40(–50) m tall, d.b.h. to 70–90 (–100+) cm; trunk monopodial, straight. Bark thick on lower part of trunk, with relatively smooth, longitudinal plates and deep longitudinal fissures, grey-brown. Branches spreading or ascending, forming a pyramidal crown in young trees and an open or dense, rounded crown in mature trees. Shoots uni-nodal, green or light brown, rarely glaucous. Cataphylls subulate-caudate, soon reflexed, 10–15 mm long. Vegetative buds ovoid-conical; terminal bud 15–20 mm long; lateral buds smaller, not resinous. Fascicle sheaths 15–25(–30) mm long, persistent, (lustrous) grey-brown to grey. Leaves in fascicles of 5, rarely 4 or 6, persisting 2–2.5 years, slender, lax, drooping, sometimes pendulous, 20–35 cm long, 0.6–1.0(–1.1) mm wide, with serrulate margins, acute, (yellowish) light green to glaucous green. Stomata on all faces of leaves. Pollen cones densely clustered, cylindrical, 3–4 cm × 5–8 mm when full grown, light pinkish brown, turning darker. Seed cones subterminal, solitary or in pairs on distinct, stout, curved peduncles which fall with cones. Mature cones narrowly ovoid to ovoid-attenuate when closed, more or less ovoid, slightly curved, with an obliquely flattened base when opened, (4–)5–10(–12) × (3–)4–8 cm when open. Seed scales thin woody, flexible, oblong, straight, spreading wide or often reflexed. Apophysis flattened or slightly raised and then transversely keeled, 8–15 mm wide, irregularly rhombic to pentagonal in outline, variably light brown. Umbo dorsal, raised, curved, transverse-rhombic in outline. Seeds obliquely ovoid, slightly flattened, 4–6 × 3–4 mm, ochraceous or dark brown, with or without dark spots. Seed wings oblong, with a straight side, widest near the middle, 13–22 × 4–8 mm, yellowish brown, translucent.

Distribution

Mexico: Sinaloa, Jalisco, Michoacán, México, Hidalgo, Tlaxcala, Puebla, Veracruz, Guerrero, Oaxaca and Chiapas; Guatemala; Honduras; El Salvador and NW Nicaragua.

TDWG codes: 79 MXC-ME MXC-PU MXC-TL MXE-HI MXG-VC MXN-SI MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 ELS GUA HON NIC

Ecology

Pinus maximinoi is a species with a wide ecological amplitude, occurring from wet subtropical forest, where it is a gap pioneer, well up into the cooler cloud forests on high mountains in Mesoamerica. In Mexico it also occupies drier sites as a constituent of pine or oak-pine forest or woodland. Its altitudinal range is great: (450–)600–2800 m, with an optimum at 900–1800 m a.s.l. In the NW of its range the species occurs between 1500–2800 m. It occurs on a variety of soils under various climatic conditions; in Mesoamerica annual precipitation ranges from ca. 900–2500 mm, with the wettest conditions on the Atlantic and Pacific slopes of the mountains. Under these conditions it occurs frequently with *Pinus tecunumanii* and *Liquidambar styraciflua*, at lower altitudes with *P. oocarpa*. In secondary broad-leaved forest other pines may join: *P. devoniana, P. pseudostrobus*, and pine woodland may prevail under a regime of grazing or burning, with the undergrowth dominated by grasses or the fern *Pteridium aquilinum*. In Central Mexico, it grows at the higher sites with *Abies religiosa, P. ayacahuite, P. patula,*

P. pseudostrobus, P. douglasiana, and often *Quercus* in mixed pine or oak-pine forest, where precipitation is more moderate but the seasonal temperature range greater, with some frosts occurring in winter.

Conservation

IUCN: LC

Uses

Thin-leaf pine is an important timber tree in most of its range, where it is exploited with other tall growing pines. It has also been the subject of experimental forestry in various subtropical and tropical countries under programmes such as those initiated by the Central America & Mexico Coniferous Resources Cooperative (CAMCORE). The wood is relatively soft and light and easily worked and is used for construction (beams and planks), carpentry and joinery, crates, containers and boxes, woodware, tool handles, and matches, as well as various types of board, plywood and pulp. Thin-leaf pine is scarcely known in cultivation as an ornamental tree, but it has been imported as a forestry tree in Nepal as well as in southern Africa and in Colombia, mostly in the context of experimental tree breeding programmes with the objective of producing fast growing plantation trees for industry. These trials have as yet not led to large scale economic use.

Pinus merkusii Jungh. & de Vriese, in De Vriese, Pl. Nov. Ind. Bat.: 5, t. 2. 1845. Type: Indonesia: Sumatera, Aceh, ["hab. in provincia Battarum in montibus et rupibus Tanna Hurung et Tobak"], *F. W. Junghuhn & W. H. de Vriese 1* (holotype L).

Pinus merkusii Jungh. & de Vriese subsp. *ustulata* Businský, Acta Pruhon. 88: 7. 2008.

Etymology

This species was named after the Lieutenant Governor-General of the Dutch East Indies Hendrik Merkus de Kock, who held this post in 1826–1830.

Vernacular names

Merkus's pine, Mindoro pine; Tapulaw (Philippines)

Description

Trees to 45(–70?) m tall; trunk to 2 m d.b.h., erect, straight. Bark thin and almost smooth, reddish brown or dark brown, or thick and scaly, rough, breaking into numerous small, dark grey plates. Branches spreading and ascending, forming an open, broadly conical or irregular crown. Foliage branches stout, glabrous, brown or dark brown. Buds cylindrical; terminal bud 1.5–2 cm long, all without resin; cataphylls brown. Leaves in fascicles of 2, held by a persistent, 12–18 mm long, reddish brown basal sheath, falling in their second year, long and very slender, pliant, 15–20 cm long, straight or slightly contorted, 1 mm wide, dull green; margins minutely serrulate; apex short acute; stomata in numerous lines on all surfaces. Pollen cones clustered, spirally arranged, erect, cylindrical, 1.5–2.5 cm long, 5 mm wide. Seed cones sub-lateral on new shoots, usually solitary, sometimes in pairs, on ca. 1 cm long, stout peduncles, spreading at nearly right angles from branch, oblong-conical when closed, (5–)6–10(–11) cm long, widening to 4–8 cm and becoming broadly ovoid with spreading scales. Seed scales woody, rigid, oblong, twice as long as wide, ca. 3 × 1.2–1.5 cm at mid cone in the larger cones, light reddish brown; apophyses rhombic or unequally pentagonal in outline, raised and strongly transversely keeled, radially striated or ridged, lustrous red-brown to dark brown; umbo dorsal, more or less central, slightly sunken or flat to obtuse, unarmed. Seeds obovoid, 5–7 mm long, 4.5 mm wide, slightly appressed, grey-brown, with a 20–25 mm long persistent wing.

Taxonomic notes

In most of the previous handbooks or manuals on conifers, *Pinus merkusii* has been treated in the broad sense to include populations occurring in mainland SE Asia, here considered to belong to *P. latteri* Mason. See for a discussion on this issue and the (purported) differences between the two taxa under *P. latteri*.

Distribution

Malesia: N Sumatera, from around Lake Toba NE along mountains; Philippines, in Luzon and Mindoro.
TDWG codes: 42 PHI SUM

Ecology

Pinus merkusii occurs in mountainous regions and forms more or less open pine woods or pine savannas influenced by periodic grass fires. This ecosystem is much influenced by man and may even have been created by people over thousands of years of occupation. Like its vicariant species on the SE Asian mainland, *P. latteri*, a 'grass stage' is reported to occur as an adaptation to these grass fires in the seedling to sapling stages of its development. In Sumatera, this is the only pine that crosses the equator into the southern hemisphere.

Conservation

Pinus merkusii is threatened by over-exploitation, habitat degradation and overgrazing. Around Lake Toba in northern Sumatera historical decline has fragmented the population and exploitation has progressed to the NE from there. In the Philippines the much smaller populations are now also fragmented.
IUCN: VU [B2ab (ii, iii, v)]

Uses

Merkus's pine has been extensively planted throughout Indonesia (where it is only indigenous in northern Sumatera) by the Dutch in colonial times. Indonesian foresters have continued this practice as it is the country's most important producer of pine resin. Young planted trees are better for tapping than 'old growth' trees in natural stands. Indonesia is a major producer of turpentines distilled from this resin. In the Philippines, this species is tapped together with *P. kesiya*, which is indigenous on these islands, but not in Indonesia. When trees have grown beyond good yield of resin, their wood is harvested for the pulp industry to manufacture paper, a process which allows final extraction of the resin in the wood. If well managed, these plantations are a renewable resource and can assist in the preservation of the natural stands of *P. merkusii*. The wood of higher grade is also used in house construction, panelling and furniture making. This species seems not to have been planted as an ornamental, but it is present in a few botanic gardens in Indonesia and the Philippines.

Pinus monophylla Torr. & Frém., in Frémont, Rep. Exped. Rocky Mts.: 319, t. 4. 1845, ["*monophyllus*"]. *Pinus cembroides* Zucc. subsp. *monophylla* (Torr. & Frém.) E. Murray, Kalmia 12: 22. 1982. Type: USA: California, ["collected in northern California"], *J. C. Frémont 367* (holotype NY). Fig. 231, 232

Pinus edulis Engelm. var. *fallax* Little, Phytologia 17: 331. 1968; *Pinus californiarum* D. K. Bailey subsp. *fallax* (Little) D. K. Bailey, Notes Roy. Bot. Gard. Edinburgh 44: 279. 1987; *Pinus monophylla* Torr. & Frém. var. *fallax* (Little) Silba, Phytologia 68: 54. 1990; *Pinus* ×*fallax* (Little) Businský, Acta Pruhon. 88: 11. 2008.
Pinus californiarum D. K. Bailey, Notes Roy. Bot. Gard. Edinburgh 44: 278. 1987; *Pinus monophylla* Torr. & Frém. var. *californiarum* (D. K. Bailey) Silba, Phytologia 68: 54. 1990.

Etymology

The species epithet *monophylla* refers to the single leaf (needle) in a fascicle.

Vernacular names

Singleleaf Pinyon pine

Description

Trees or a large shrubs to 15–20 m tall, d.b.h. to 40–50 cm. Trunk monopodial, usually short, low branched, straight or contorted. Bark thick, rough and scaly, with shallow, fissures, exfoliating in small plates; outer bark reddish brown to grey. Branches spreading or ascending, forming a wide spreading, rounded but irregular, open crown often extending low above the ground. Shoots short, stout, orange-yellow, turning grey after 1–2 years. Cataphylls short, triangular, rigid and spreading. Vegetative buds ovoid-conical, acute; terminal bud 10–15 × 5–7 mm; lateral buds smaller, (slightly) resinous. Fascicle

sheaths of young fascicles to 11 mm long, soon disintegrating in recoiling but almost simultaneously deciduous scales of which only the basal parts persist (not forming rosettes). Leaves in fascicles of 1, rarely 2, persisting 4–8 years, rigid, curved at least near base, (2–)2.5–6 cm long, 1.2–2.2(–2.5) mm wide, in rare fascicles of 2 with entire margins, acuminate-pungent, usually lustrous, green, grey-green or glaucous green. Stomata around the leaves, with 12–25 lines in grooves. Pollen cones ovoid-globose to short cylindrical, up to 10 mm long when shedding pollen, initially purplish red, then yellowish. Seed cones sub-terminal, solitary or in whorls of 2–4 on slender, 5–10 mm long peduncles which are deciduous with cones. Mature cones ovoid-globose to globose when closed, irregular when opened, often somewhat wider than long, 4–6 × 4.5–7 cm when open. Seed scales parting widely, spreading but not reflexed, moveable, irregular, concavo-convex, with 1–2 deep seed. Apophysis thick woody, raised, pyramidal or obtuse conical, transversely keeled, recurved or straight, lustrous, ochraceous to yellowish brown, often resinous. Umbo dorsal, flat or obtuse-pyramidal, rhombic in outline, centrally indented. Seeds obliquely obovoid, 13–18 × 8–12 mm, integument thin (0.3–0.5 mm), greyish brown to grey. Megagametophyte ('endosperm') white. Seed wings absent from the free seed.

Distribution

USA: Arizona, SW New Mexico, California, S Idaho, Nevada, W Colorado, Utah; NW Mexico: Baja California Norte.

TDWG codes: 73 COL IDA 76 ARI CAL NEV UTA 77 NWM 79 MXN-BC

Ecology

This species of pinyon pine is common on the dry mountain slopes of the Great Basin. It is the major component of the extensive Pinyon-Juniper woodland in this area; the most common juniper is *Juniperus osteosperma*, in the NW replaced by *J. occidentalis*. At higher altitudes *P. ponderosa* can be mixed in as an indicator of the transition to tall pine forests; in the White Mountains of California *P. monophylla* has been found with *P. longaeva* at 3000 m. Its altitudinal range is from 950 m to 3000 m a.s.l. The undergrowth is dominated by sagebrush (*Seriphidium* spp. [*Artemisia*]) and numerous other xerophytic shrubs are common. In southern California and Baja California, *P. monophylla* is locally common in, or just above, a high chaparral zone but does not form extensive Pinyon-Juniper woodland. Other common pines here are *P. quadrifolia* and *P. jeffreyi*, the latter species extending to higher altitude. *Juniperus californica* and *Quercus turbinella* commonly occur with *P. monophylla* in areas with granite rock outcrops and on steep slopes. Annual precipitation is low to moderate from 200–600 mm, highly variable, in California concentrated in the winter and part of it as snow at higher altitudes. Severe frost can occur in the Great Basin, which has a continental climate.

Conservation

IUCN: LC

Uses

Due to its irregular shape and slow growth, this tree is not used for lumber; locally it is used as firewood. The edible seeds are locally harvested and sold on village markets or alongside the highways. In countries with hot summers this would be an excellent small pine for amenity planting, but it is little used and only present in a few collections. In the USA, where pines are grown for Christmas trees, it can be put to this use, but it is slow growing and needs much clipping to attain the desirable shape.

Pinus montezumae Lamb., Descr. Pinus, ed. 8°, 1: 39, t. 22. 1832.

Etymology

Montezuma II was the Aztec emperor killed in a riot in Tenochtitlán (Mexico City) in 1520 shortly before the Spanish conquest.

Vernacular names

Montezuma pine, Rough-branched Mexican pine; ocote blanco, pino de Montezuma, pino real (Mexico).

Description

Trees to 20–30 m tall, d.b.h. to 1 m; trunk monopodial, erect. Bark thick, scaly, breaking into numerous, relatively small, irregular, slightly elongated plates divided by shallow fissures, dark brown, weathering grey-black. Branches spreading wide, assurgent towards ends, forming a dense, usually broad, rounded crown. Shoots very rough and scaly, brown, sometimes glaucous. Cataphylls ca. 15 mm long, subulate, recurved or reflexed, scarious, dark brown, weathering grey. Vegetative buds ovoid; terminal bud 15–30 mm long; lateral buds smaller, not resinous. Fascicle sheaths (20–)25–35 mm long, 1.5–2.5 mm wide, remaining tight, weathering grey to black, sometimes resinous. Leaves in fascicles of (4–)5 (rarely 3 or 6), persisting 2–3 years, slender, flexible and drooping, or lax to rigid and spreading, straight, (15–)20–35(–40) cm long, 0.8–1.3 mm wide, with serrulate margins, acute or pungent, (light) green to glaucous green. Stomata on all faces of leaves. Pollen cones cylindrical, 20–40 × 6–8 mm, initially pink or purplish, turning reddish brown. Seed cones subterminal, solitary or in whorls of 3–6, spreading or recurved on short, stout peduncles. Mature cones variable, from ovoid or symmetrical ovoid-oblong to ovoid-attenuate, often curved, with a more or less flattened base when opened, 8–20 × 5–10 cm when open. Seed scales parting to release the seeds, the proximal, infertile scales remaining on branch when cone falls, thin or thick woody, oblong, straight or curved. Apophysis flat or raised especially on proximal scales, if raised with a transverse keel, (transverse-)rhombic in outline, sometimes irregular, often rugose or radially striate, in various shades of ochraceous to brown. Umbo dorsal, depressed, flat or raised, obtuse or terminating in a small prickle. Seeds obliquely ovoid, 5–7 × 4–5 mm, light brown, often with dark spots. Seed wings oblong, 18–28 × 7–12 mm, light brown with dark stripes.

Distribution

Mexico: Nuevo León, SW Tamaulipas, Nayarit, S Zacatecas, Jalisco, Michoacán, México, Distrito Federal, Querétaro, Hidalgo, Morelos, Tlaxcala, Puebla, Central Veracruz, Guerrero, Oaxaca and Chiapas; in Guatemala in the highland departments.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-NL MXE-QU MXE-HI MXE-TA MXE-ZA MXG-VC MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 GUA

Ecology

Pinus montezumae occurs in a wide range of edaphic and climatic conditions throughout the mountainous regions of Central and S Mexico and the Guatemalan highlands. In Nuevo León it reaches from semi-arid Pinyon-Juniper woodland up to cold temperate mixed conifer forest. Its altitudinal range is also great, from (1200–)2000–3200(–3500) m overall, with occurrences below 2000 m mainly in Nayarit, Nuevo León and Tamaulipas. It is most abundant and best developed in the temperate zone at ca. 2400–2800 m a.s.l., with annual precipitation exceeding 800 mm, most of it falling from June through September. Throughout its wide geographical range, it occurs together with many other tree species, mainly in pine-oak and mixed pine forests, but also with *Abies religiosa, A. guatemalensis* and *Cupressus lusitanica*. Many of these forests have been depleted or even turned into small scale farms with groups of scattered trees, among which *P. montezumae* is often present.

Uses

Pinus montezumae is exploited as a timber tree throughout its range. The timber is heavy and strong and in demand for constructional purposes, plywood, parquet flooring, and furniture. Together with the wood of other pines it is pulped for the paper industry. Locally, especially in the southern part of its range, this (and other) species, growing often near habitations among fields as remnants of more contiguous forests, has its branches cut off due to the incessant demand of firewood of the rural population. Since pines rarely regenerate (only one Mexican species is known to do so) and none can be coppiced or pollarded indefinitely, this use will be detrimental and lead to the demise of the trees. *Pinus montezumae* is a very handsome pine grown in horticulture for large gardens and parks; it is moderately hardy depending on provenance.

2 varieties are recognized:

Pinus montezumae Lamb. var. ***montezumae***. Type: Mexico: Veracruz, ["inter Cruz Blanca et Jalacingo, reg. frig. Nov. 28"], *C. J. W. Schiede & F. Deppe s.n.* (lectotype BM).

Pinus montezumae Lamb. var. *mezambrana* Carvajal, Phytologia 59: 138. 1986 ["*mezambranus*"].

Description

Leaves in fascicles of (4–)5(rarely 3 or 6), variable, slender and drooping or more rigid, 1.0–1.3 mm wide. Seed cones variable in shape and size, broadly ovoid, ovoid-oblong or ovoid-attenuate, 8–20 × 5–10 cm when open. Apophysis raised, especially towards base of cone, transversely keeled, often rugose; umbo raised, sometimes with a small prickle.

Distribution

Central Mexico south to Chiapas; Guatemala (highlands).
TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-HI MXE-NL MXE-QU MXE-TA MXE-ZA MXG-VC MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 GUA

Conservation

IUCN: LC

Pinus montezumae Lamb. var. ***gordoniana*** (Hartw. *ex* Gordon) Silba, Phytologia 68: 55. 1990. *Pinus gordoniana* Hartw. *ex* Gordon, J. Hort. Soc. London 2: 79. 1847. Type: Illustration in J. Hort. Soc. 2: fig. on p. 80. 1847 (lectotype).

Description

Leaves in fascicles of (4–)5, slender and drooping, 0.8–1.0 mm wide. Seed cones ovoid-oblong or ovoid-attenuate, 10–15 × 5–7 cm when open. Apophysis flat, especially towards base of cone, with a weak transverse line, often smooth; umbo flat or obtuse.

Distribution

Central and S Mexico to Oaxaca.

TDWG codes: 79 MXC-PU MXE-QU MXG-VC MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA

Conservation

IUCN: LC

Pinus monticola Douglas *ex* D. Don, in Lambert, Descr. *Pinus*, ed. 8°, 2: p. s.n. inter 144 et 145. 1832. *Pinus strobus* L. var. *monticola* (Douglas *ex* D. Don) Nuttall, N. Amer. Sylva 2: 118. 1849; *Pinus strobus* L. subsp. *monticola* (Douglas *ex* D. Don) E. Murray, Kalmia 12: 23. 1982. Type: USA: Washington, ["high mountains at the Grand Rapids"], *D. Douglas s.n.* (holotype not located, isotype K).

Etymology

The species epithet *monticola* means 'inhabitant of mountains'.

Vernacular names

Western white pine

Description

Trees to 60–70 m tall; trunk to 2.5–3.3 m d.b.h., growing to a straight and columnar bole, scarcely tapering in lower half of its length. Bark smooth in young trees, on large trunks becoming scaly, exfoliating in small or large, rectangular plates, cinnamon to grey-brown. Branches numerous, relatively short, spreading or down-curved, forming a conical but in old trees rounded crown. Foliage branches slender, smooth, young shoots puberulent with brown, downy hairs, later glabrous, grey-green or reddish tan, becoming grey. Buds small, with the terminal bud to 6 mm long, ovoid-ellipsoid, orange-brown or red-brown, slightly resinous. Leaves in fascicles of 5, persisting 3–4 years, held in a soon deciduous sheath of light orange-brown flimsy scales, spreading, (4–)5–10 cm long, straight, slender, flexible, 0.7–1 mm wide, slightly twisted, glaucous green with lines of stomata on the two adaxial faces only; margins minutely serrulate; apex acute. Pollen cones ellipsoid to short cylindrical, 10–15 mm long, yellow. Seed cones clustered, erect at first, becoming

pendulous as they grow on 20 mm long peduncles, soon falling after seed dispersal, 10–25(–30) cm long, variable in length on the same tree, oblong cylindrical becoming ellipsoid cylindrical when open, symmetrical or nearly so. Seed scales thin woody, more or less flexible, small scales near the cone base reflexed, larger scales more or less straight or with an upturned apophysis, extremely resinous. Apohysis more or less rhombic in outline on central scales, tan coloured (lower part of scales purplish brown), narrowing to an obtuse terminal umbo. Seeds broadly obovoid to deltoid, flattened, 5–8 mm long, red-brown; wing 20–25 mm long.

Taxonomic notes

The morphological differences between *Pinus monticola* and *P. strobus* are small, but a few are discontinuous. The bark of large boles in *P. monticola* breaks into plates, but does not become longitudinally furrowed as in *P. strobus*. The basal scales of the seed cones of *P. monticola* are recurved, in *P. strobus* they are incurved or straight. There are some minor differences in leaf apices and in the colour of the ripe and dry scales of the seed cones, but they seem less consistent. It could well be argued (see also the case of *P. strobus* var. *chiapensis*), that here we have an eastern (*P. strobus*) and a western (*P. monticola*) vicariant population of a single species, which has evolved a few minor distinctions recognizable at the rank of subspecies. However, some phylogenetic analyses based on DNA sequence data indicated a closer relationship between *P. monticola* and *P. lambertiana* than between *P. monticola* and *P. strobus*. These results support the separation of *P. monticola* and *P. strobus* as distinct species.

Distribution

W North America, from British Columbia to California, most widespread in the north of its range. **TDWG codes:** 71 ABT BRC 73 IDA MNT ORE WAS 76 CAL NEV

Ecology

Pinus monticola has its greatest extent in the cool maritime Pacific Northwest of the USA and Canada, its southward spread is limited to the western slopes of the high mountain ranges. In interior British Columbia it is restricted to the valleys and basins and does not ascend beyond 450 m a.s.l. while in the Sierra Nevada of California it climbs to beyond 3000 m. In the interior and in the south, this species occurs on a diversity of soil types. *Pinus monticola* can form extensive pure stands, but old growth forests are usally mixed conifer forests with several other species. Depending on region and site conditions, the most common are *Pseudotsuga menziesii, Pinus contorta, P. ponderosa, P. lambertiana, P. jeffreyi, Tsuga heterophylla, Larix occidentalis, Abies grandis, A. lasiocarpa, A. magnifica, A. concolor, A. procera, Thuja plicata, Calocedrus decurrens, Picea sitchensis, P. engelmannii, and Tsuga mertensiana*. More local are *Chamaecyparis lawsoniana, Pinus balfouriana, P. flexilis*, and *P. albicaulis. Taxus brevifolia* is an understorey conifer. Broad-leaved trees are less common and usually restricted to sites with better moisture and nutrient availability. These are some of the most diverse conifer forests in the world. *Pinus monticola* is an early seral species in this assembly and requires disturbance of the forest (by fire, storm or felling) to regenerate.

Conservation

IUCN: NT

Uses

Western white pine is an important timber tree which yields high quality, straight-grained wood of good dimensions and strength. It is used for interior construction and panelling, doors and windows of houses and plywood; other applications of the wood are furniture, matches and tooth picks. Matches have become a major application of the wood of smaller trees of this species produced in secondary growth forests. Its wood does not produce sugary exudates (resin containing a high content of saccharine) as in *P. lambertiana*, a closely related species of the American West. Western white pine grows rapidly and can be easily regenerated after felling and grows straight up forming tall stems. As with *P. lambertiana*, its susceptibility to Western white pine blister rust (*Cronartium ribicola, Basidiomycota*) makes it unsuitable as an exotic timber tree in Europe and other parts of the temperate climate zones where

this pathogen occurs. It is present in a few arboreta and landscape parks, but uncommonly used in horticulture and only a few cultivars are known from this species.

Pinus morrisonicola Hayata, Gard. Chron., ser. 3, 43: 194. 1908. *Pinus parviflora* Siebold & Zucc. var. *morrisonicola* (Hayata) C. L. Wu, Acta Phytotax. Sin. 5 (3): 141. 1956. Type: Taiwan: ["Shokakulin"], *C. Owatari s.n.*, 21 Jan 1898 (holotype TI).

Pinus formosana Hayata, J. Linn. Soc., Bot. 38: 297. 1908.
Pinus uyematsui Hayata, Icon. Pl. Formos. 3: 192, t. 35. 1913.
Pinus ×*hayatana* Businský, Willdenowia 34 (1): 245. 2004. [putative hybrid between *P. uyematsui* and *P. morrisonicola*]

Etymology

The species epithet means 'growing on Mt. Morrison', the highest mountain in Taiwan, now known as Yu-Shan.

Vernacular names

Taiwan white pine; tai wan wu zhen song (Chinese)

Description

Trees to 30–35 m tall; trunk to 1.5 m d.b.h., usually a straight, columnar bole. Bark smooth in young trees and in upper part of crown, becoming rough and scaly on trunk, flaking in thin plates, grey to dark grey. Branches whorled in young trees, later spreading and ascending, stem sometimes forked near the top, forming a conical to rounded crown, on exposed sites often flattened and open. Foliage branches slender, new shoots initially yellowish pubescent, soon glabrous or with remnant hairs in grooves, reddish brown. Buds small, ovoid, not resinous, pale brown. Leaves in fascicles of 5, held by deciduous sheaths with soon falling thin scales, persisting 3–4 years, sometimes longer, curved and slightly twisted, 4–9 cm long, slender and flexible, 0.6–1 mm wide, triangular in cross-section, green; stomata in prominent white lines on the two adaxial surfaces; margins minutely serrulate; apex acute. Pollen cones in small clusters near base of new shoots, spirally arranged, ovoid-oblong to cylindrical, 1.5–2.5 cm long, yellow turning light brown. Seed cones in whorls of 3–4 on short, stout, curved peduncles, erect at first, becoming pendulous when growing, (narrowly) ovoid-ellipsoid, 6–11 cm long, green or glaucous, very resinous, with opened scales to 5–6 cm wide, becoming more ovoid. Seed scales thin woody, somewhat flexible, with basal smaller scales mostly recurved and larger scales nearly straight, 3–3.5 cm long, 1.5–2 cm wide, cuneate from their base; apophyses rhombic, middle portion thickened, longitudinally grooved, becoming lustrous brown; umbo terminal, obtuse, slightly upturned. Seeds ellipsoid-ovoid or narrowly ovoid, 7–10 mm long, 5–6 mm wide; wing 15–20 mm long, 5–8 mm wide, light brown.

Distribution

Taiwan.
TDWG codes: 38 TAI

Ecology

Pinus morrisonicola occurs in the mountains of Taiwan on rocky ridges and spurs at various altitudes between ca. 300 m and 2300 m a.s.l. Occasionally it occupies slopes where the forest canopy has been opened, e.g. due to rock slides, so it can compete for a time with broad-leaved trees until the forest succeeds to a closed canopy again.

Conservation

IUCN: NT

Uses

Taiwan white pine is a minor timber tree for local use, with wood properties similar to those of *P. parviflora* and other E Asian white pines. It is better known in Asian horticulture, especially in the art of bonsai culture, and particularly in China. In Western horticulture it is uncommon and probably often confused with the much more commonly used Japanese white pine (*P. parviflora*), to which it is closely related, but differs in the longer leaves and larger seed cones. As an endemic species of Taiwan, it should not be difficult to establish its identity in cultivation, provided that proper records

of provenance were kept with the plants in tree nurseries.

Pinus mugo Turra, Giorn. Italia Sci. Nat. 1: 152. 1764.

Etymology

The species epithet uses the Italian vernacular name for this pine.

Vernacular names

Dwarf mountain pine, Mountain pine, Mugo pine; Bergkiefer (German); pin de montagne (French); mugo (Italian); kosodrzewina (Polish).

Description

Shrubs to 5 m tall, main branches ascending to erect, sometimes a small erect tree. Bark breaking into small, rectangular plates and sometimes curling scales on larger stems, grey. Foliage branches slender, smooth with prominent ribs, glabrous, at first light greenish brown, later reddish brown to greyish black. Buds cylindrical, acute, strongly resinous, 10–15 mm long. Leaves in fascicles of 2, rarely 3, held in 10–18 mm long, later much shorter, basal fascicle sheaths, densely set on branches, directed forward, persisting (2–)4–9(–10) years, (2.3–)3–7(–8) cm long, slightly curved and rigid, often twisted, 1.5–2.2 mm wide, dark or light green; margins minutely serrulate; apex more or less pungent; stomata in fine lines on all sides. Pollen cones clusterd at base of new shoots, spirally arranged, short cylindrical, 10–12 mm long, 5 mm wide, yellow or red. Seed cones solitary or in whorls of 2–3 on short peduncles below shoot apex, or sometimes more in a cluster near its base and subsessile, patent or more or less reflexed, falling at maturity or persisting up to 4 years, (obliquely) ovoid, 2–6 cm long, 2–4.5 cm wide when opened, with an asymmetrical or symmetrical, flattened base. Seed scales thin woody, rigid, oblong, spreading wide, reddish or blackish brown; apophyses nearly flat to prominently raised, gibbous or transversely keeled, on the outer, sun-exposed side of cone sometimes larger and recurved or longitudinally ridged, lustrous yellowish or reddish brown; umbo dorsal, small, depressed, flat or conical, central or excentric, armed with a minute, often breaking prickle. Seeds small, 3–4 mm long; wing articulate, 10–13 mm long.

Taxonomic notes

Pinus mugo is probably the species of pine with the longest list of synonyms. Central and East European botanists in particular have described the observed variation in this pine as distinct species, subspecies, or varieties in almost every conceivable nomenclatural combination. Despite several efforts at distentangling the taxonomy and nomenclature, a consensus may still elude us as some recent papers seem to attest. A full synonymy following what was then in my view the most reasonable taxonomy by 2000 has been given in my World Checklist & Bibliography of Conifers (Farjon, 1998, [2001]), several new names had to be added since and it does not look as if it will end there yet. The only subspecies recognized here is subsp. *rotundata*, which is usually a small erect tree. The distinct asymmetric cones with prominent apophyses on the exposed side have been found in some populations of shrubby forms and are not restricted to the tree forms of the western Alps and Pyrenees. The seed cones of *P. mugo* appear to be highly variable and too much taxonomic significance has been given to these variations.

Distribution

Europe, in mountains from S France to Bulgaria and Romania.

TDWG codes: 11 AUT-AU CZE-CZ CZE-SL GER HUN POL SWI 12 FRA-FR 13 ALB BUL ITA-IT ROM YUG-BH YUG-CR YUG-KO YUG-MN YUG-SE YUG-SL 14 UKR-UK

Ecology

There are two principal growth forms of *Pinus mugo*, commonly recognised as distinct taxa: a shrub-like, sometimes nearly decumbent form (subsp. *mugo*) and an erect tree (subsp. *rotundata*), which occupy different habitats. The shrubby form grows on mountain slopes and ridges from about 600 m to 2700 m a.s.l. in the mountain ranges of Europe most exposed to storms associated with depression systems in the North Atlantic. Especially in the Carpathians, it forms dense mat-like thickets

above montane forests dominated by *Fagus* or *Picea*; in the western Alps the upright form (subspecies) dominates on nutrient poor slopes. *Pinus mugo* in the eastern Alps may have replaced original Larch-Arolla pine woods which were disturbed by human activities and grazing of their animals. The species often occurs on dolomite limestone, but is in fact indifferent to soil type; this prevalence probably has historical reasons (Ellenberg, 1988). While upright stands of *P. mugo* subsp. *rotundata* can be fairly rich plant communities, the associated species with the decumbent subsp. *mugo* are much fewer due to harsh environmental conditions, such as exposure and long-lasting snow cover.

Uses

The shrubby subspecies of Dwarf mountain pine has been used in some parts of northern Europe to stabilize drifting sand dunes and as initial shelter belts for plantations with Scotch pine in similar sandy areas. In horticulture it is mainly planted in spaces created by roundabouts and other types of road intersection, both in Europe and in the USA. For gardens many cultivars that remain more dwarfish than the subspecies *mugo* have been and are being selected, and some of these are suitable in larger rock gardens as they grow very slowly. For this reason this species has also been used in bonsai culture. The tree form (subsp. *rotundata*) is too uncommon and also grows too slowly to be of importance as a timber tree. Its horticultural interest is limited to arboreta, where it is often labeled as a distinct species (*P. uncinata*) and can grow into an erect small tree. Hybrids have been described between subsp. *mugo* and subsp. *rotundata*, and such plants may also occasionally be in cultivation.

2 subspecies are recognized:

Pinus mugo Turra subsp. ***mugo***. Types: Italy: Alto Adige, Vicenza, Monte Baldo, *J. F. Séguier s.n.* (lectotype [NIMES]) & *J. B. Saint-Lager s.n.* (epitype G).

Description

Shrubs to 5 m tall, sometimes decumbent. Seed cones more or less symmetrical; apophyses of seed scales usually more or less equally developed around cone, but variable.

Distribution

Europe: Alps (rare in W Alps), Jura, Vosges, Erzgebirge, Böhmerwald, Sudeten, Carpathians, Rhodope Mts., Dinaric Alps, central Apennines.
TDWG codes: 11 AUT-AU CZE-CZ CZE-SL GER POL SWI 12 FRA-FR 13 ALB BUL ITA-IT ROM YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 UKR-UK

Conservation

IUCN: LC

Pinus mugo Turra subsp. ***rotundata*** (Link) Janch. & H. Neumayer, Oesterr. Bot. Z. 91: 214. 1942. *Pinus rotundata* Link, Abh. Akad. Wiss. Berlin 1827: 168. 1830. Type: [locality not mentioned], 2/6 July 1981, *K. I. Christensen A4* (neotype B).

Pinus uliginosa Neuman *ex* Wimm., Uebers. Arbeiten Veränd. Schles. Ges. Vaterl. Cult. 1837: 96. 1838; *Pinus uncinata* Ramond *ex* DC. subsp. *uliginosa* (Neumann *ex* Wimm.) Businský, Phyton (Horn, Austria) 46 (1): 132. 2006.
Pinus uncinata Ramond *ex* DC. var. *pseudopumilio* Willk., Jahrb. Königl. Sächs. Akad. Forst- Landwirte Tharandt 40: 218. 1861; *Pinus mugo* Turra subsp. *rotundata* (Link) Janch. & H. Neumayer var. *pseudopumilio* (Willk.) P. Schmidt, Sammelbl. Gebirgspfl. (Karl-Marx-Stadt) 1982: 3. 1982.

Description

Small, erect trees, rarely erect shrubs. Seed cones asymmetrical; apophyses of outer (sun-exposed) seed scales enlarged, curved, longitudinally ridged or keeled.

Distribution

Europe, Alps, Erzgebirge, Böhmerwald, Sudeten, NW Carpathians.
TDWG codes: 11 AUT-AU CZE-CZ CZE-SL GER HUN POL SWI 12 FRA-FR 13 ITA-IT

Conservation

Although widespread in Central Europe the AOO is less than 100 km². There is continuous decline as many of the bogs in which this subspecies occurs are not or inadequately protected against draining and afforestation. It is assessed as Endangered under the B2 criterion.
IUCN: EN [B2ab (ii–v)]

Pinus muricata D. Don, Trans. Linn. Soc. London 17: 441. 1836. Type: USA: California, San Luis Obispo Co., Coon Creek, *T. Coulter 712* (holotype not located, isotype TCD). Fig. 233, 234

Pinus muricata D. Don var. *borealis* Axelrod *ex* Farjon, in Greuter (ed.), Names in Current Use 2, Pinaceae: 136. 1993.
Pinus muricata D. Don var. *stantonii* Axelrod *ex* Farjon, in Greuter (ed.), Names in Current Use 2, Pinaceae: 136. 1993.

Etymology

The species epithet (Latin adj. *muricatim* = 'shaped like a purple snail') is emigmatic.

Vernacular names

Bishop pine, Swamp pine

Description

Shrubs or small trees to 15(–25) m tall, d.b.h. to 20–50(–100) cm. Trunk monopodial, often branching near the ground, erect or curved and crooked. Bark rough and scaly, exfoliating, on larger trunks with deep longitudinal fissures, dark brown to grey. Branches spreading or ascending, in shrubs often assurging, forming an open, broad, irregular crown. Shoots multi-nodal, rough with large, short decurrent, persistent pulvini. Cataphylls ca. 10 mm long, subulate, curved or reflexed, scarious, brown. Vegetative buds ovoid-acute; terminal bud 10–15 mm long; lateral buds smaller, not or slightly resinous. Fascicle sheaths 10–14 mm long initially, reduced to less than 10 mm on mature fascicles. Leaves in fascicles of 2, persisting 2–3 years, straight or slightly curved, rigid, (7–)10–14(–16) cm long, 1.3–2.0 mm wide, with serrulate margins, acute, light green or dark green. Stomata on both faces of leaves. Pollen cones oblong-cylindrical, 1.5–2 cm long, pink to reddish. Seed cones sub-terminal, solitary or in whorls of 2–5 on stout, 5–10 mm long peduncles, reflexed, tenacious; mature cones seemingly sessile, opening only partly, serotinous, narrowly ovoid to ovoid-attenuate when closed, or strongly asymmetrical, broadly ovoid, 5–7(–8) × 4–5(–6) cm when (half) open. Seed scales parting very slowly except those at base or lower half of cone, oblong, straight or slightly curved, thick woody. Apophyses very variable, from slightly raised to extremely elongated, especially on upperside of cone, sometimes curved, up to 15 mm wide and 20 mm long, from dull, dark brown to lustrous light brown. Umbo dorsal, if enlarged forming a flattened, curved spine, armed with a sharp prickle in obtuse forms, 2–10 mm long. Seeds obliquely ovoid, 5–6 × 3–4.5 mm, grey to black. Seed wings 14–18 × 5–8 mm, yellowish brown to grey-brown.

Distribution

USA: Coastal California (incl. Santa Cruz Island and Santa Rosa Island); Mexico: Baja California Norte.
TDWG codes: 76 CAL 79 MXN-BC

Ecology

Pinus muricata occurs from near sea-level to ca. 300 m a.s.l. in coastal areas. It grows within the chaparral zone influenced by (summer and autumn) fog and winter rain, probably amounting to ca, 500 mm annually. Often brush fires sweep the area during the long, hot summers, killing stands of pines, but the serotinous cones are adapted to open quickly after fire to release the seeds when the undergrowth has been cleared away. Massive regeneration then quickly reoccupies these sites. This species grows in dry sandy soils, on clay barrens and on swampy ground or in peat bogs. The associated vegetation often consists of *Adenostoma, Arctostaphylos, Seriphidium* (*Artemisia*), *Ceanothus, Heteromeles, Salvia*, and other shrubs.

Conservation

The population is declining due to habitat changes mainly related to suppression of natural fires.
IUCN: VU [B2ab (iii)]

Uses

Due to a limited range and small populations Bishop pine is not a commercially valuable timber tree. Its wood properties are of medium quality, with a coarse grain and much resin; its uses are therefore mainly heavy construction, beams, crates and some light construction, and carpentry or joinery, with the higher grades obtained from larger trees. This species is well known in horticulture and amenity planting, it is often planted in parks and large gardens, though not nearly as common as *Pinus radiata*, which is also a 'closed-cone' pine from coastal and insular California. Bishop pine grows poorly on calacareous soils. Its botanical characters are quite variable, yet no cultivars are known under this species.

Pinus* ×*neilreichiana Reichardt, Verh. Zool. Bot. Ges. Wien 26: 461. 1876. Type: Austria: Niederösterreich, Baden, Grossau, along footpath to Pottenstein, *[?] Reichardt s.n.* (lectotype C).

Etymology

The epithet commemorates the German botanist August Neilreich (1803–1871).

Vernacular names

none are recorded.

Description

This natural hybrid is morphologically closest to *P. nigra* subsp. *nigra*, from which it differs in having reddish bark on the branches and nearly flat apophyses on the seed cone scales. From *P. sylvestris* it differs in having longer, thicker, dark green leaves with medial resin ducts and nearly sessile cones.

Taxonomic notes

This is perhaps the better known hybrid taxon involving Scots pine and Black pine *Pinus sylvestris* L. × *P. nigra* J. F. Arnold; other hybrids between the two have been described and named. Controlled hybridization between these species has also been attempted and reported to be successful (Vidaković, 1991), so it is probable that hybrids occur occasionally in nature where the two species meet, as in Austria.

Distribution

Austria (limited to the more restricted distribution of *P. nigra* subsp. *nigra* and vicinity).
TDWG codes: 11 AUT-AU

Conservation

IUCN: NE

Pinus nelsonii Shaw, Gard. Chron., ser. 3, 36: 122. 1904 ["*nelsoni*"]. Type: Mexico: Tamaulipas, Miquihuana, *E. W. Nelson 4501* (holotype US).
Fig. 235

Etymology

This species was named after E. W. Nelson, who collected the type specimen in June 1898.

Vernacular names

Nelson Pinyon pine, Nelson's pine; piñon prieto (Mexico)

Description

Trees to 5–10 m tall, sometimes bushy, d.b.h. to 15–30 cm. Trunk monopodial, usually straight, erect, some trees branching low near the ground. Bark thin, smooth, only on lower part of larger trees becoming scaly, ash-grey, with darker, brownish banded areas. Branches assurgent to irregularly disposed, forming a conical crown with assurgent branches in young trees and a broad, irregular, very open crown in mature trees. Shoots elongating before leaves start to grow, becoming stiff, assurgent, greyish white, sometimes glaucous. Cataphylls 5–8 mm long, subulate, brittle, with erose margins, dark brown. Vegetative buds ovoid-acute to oval; terminal bud ca. 10 mm long; lateral buds smaller, resinous. Fascicle sheaths initially 7–9 mm long, persistent, dark brown, weathering grey. Leaves in fascicles of 3, rarely 4, connate, appearing as a single

leaf, not parting until the final year, persisting 2–3 years, stiff, straight or slightly curved, often twisted, 4–8(–10) cm long, 0.7–0.8 mm wide, with serrulate margins and acuminate apex, dark green. Stomata on all faces of leaves. Pollen cones forming an elongated 'spike', ovoid-oblong to cylindrical, 7–9 × 3–3.5 mm, pinkish, turning brown. Seed cones solitary or in pairs on 2.5–6.5 cm long, recurved peduncles. Mature cones irregularly cylindrical, usually falling from the persistent peduncle, (5–)7–12 × 4–5.5 cm when open. Seed scales parting slightly or more widely but usually not enough to allow the seeds to fall, rather weakly attached to a thick rachis with a cuneate base (thereby moveable), thick, irregular, with 1–2 deep, cup-like depressions holding the seeds. Apophysis irregular, prominently raised and transversely keeled, often rugose, red-brown to dark brown. Umbo dorsal, transversely keeled, obtuse, up to 3–4 mm high, with a small, triangular spine. Seeds obliquely obovoid, 12–15 × 8–10 mm, the integument hard, 1 mm thick, pale to dark brown; wing absent.

Taxonomic notes

Pinus nelsonii is a fairly unique species in subgenus *Strobus*, section *Parrya*. Its position varies somewhat with the data and other taxa used in cladistic analyses (molecular as well as morphological data), but is probably basal in the section, or perhaps sister to an expanded group of 'pinyon pines' (see Phylogeny and classification of the genus *Pinus* in Farjon, 2005b: 218–224). This species shares various morphological characters with Asian 'lace-bark' pines and with the Mexican species *P. pinceana*. However, based on a wider sampling of data and species as in the above mentioned analyses, these taxa do not appear to be more closely related to *P. nelsonii* than to other species in the section or even in the entire subgenus *Strobus*. The nearest relatives to *P. nelsonii* from recent molecular analyses appear to be the 'foxtail pines' (*P. aristata, P. balfouriana* and *P. longaeva*).

Distribution

Mexico: Coahuila (Mont. del Carmen), Nuevo León, San Luis Potosí, Tamaulipas.
TDWG codes: 79 MXE-CO MXE-NL MXE-SL MXE-TA

Ecology

Pinus nelsonii is a rare pine occurring in the semi-arid foothills and on mesas of the Sierra Madre Oriental; the most extensive populations are found around the Sierra Peña Nevada in Nuevo León-Tamaulipas. It is restricted to sites on rocky limestone with shallow soils. Its altitudinal range is 1600–2300(–2450) m a.s.l. Annual precipitation ranges from 300–600 mm, falling mostly in the summer during brief thunderstorms. Associated conifers are *P. cembroides, P. remota and Juniperus* spp. It occurs in a scrubland zone with deciduous woody taxa, e.g. *Quercus, Mahonia, Comarostaphylis, Brahea*, and *Sophora*, and arborescent monocots, such as *Yucca* and *Dasilyrion*. At higher altitudes it may grade into Pinyon-Juniper woodland, while lower down it is bounded by a hotter and drier semi-desert scrubland often dominated by *Cactaceae* and *Yucca* spp. Like several other narrow endemic conifers, *P. nelsonii* is probably an edaphic relict on limestone.

Conservation

Pinus nelsonii is by all accounts a rare pine with a scattered occurrence largely limited to limestone outcrops. Its total 'population' almost certainly numbers fewer than 10,000 mature trees, mostly in (sub)populations of a few hundred individuals. It is thought to decline due to habitat disturbance and loss associated with increased cattle ranging and incidence of destructive fires associated with this type of land use. Several localities with this little tree reported in the literature or with older herbarium collections have not been retraced in recent years and the populations may have disappeared.
IUCN: EN [B2ab (ii–v)]

Uses

There is no commercial exploitation of this species due to its low stature and its rarity in remote and inaccessible locations. Its seeds resemble those of the true pinyon pines (*Pinus* subsect. *Cembroides*) and are edible like these, but the seed crop is usually low compared with these species. Apart from a few specimens in botanic gardens and other dendrological collections, this interesting pine is

not known in horticulture. It should be suitable to Mediterranean-type climate regions and other dry, warm temperate areas in Europe, the USA, Australia, and South Africa.

Pinus nigra J. F. Arnold, Reise Mariazell: 8, t. s.n. 1785.

Etymology

The species epithet means black, this probably refers to the bark which is much darker than that of *P. sylvestris*, with which it is often found together.

Vernacular names

Austrian pine, Black pine; pino nigro (Spanish); pin noir (French); Schwarzföhre (German); Karaçam (Turkish)

Description

Trees to 40 m tall (–50 m in Corsica), max. d.b.h. 1.89 m (a tree in Corsica), monopodial but sometimes with multiple stems from a low basal trunk. Bark becoming thick and breaking into scaly ridges or large plates, separated by irregular, dark fissures, grey with pinkish or purplish hue, dark grey-brown or nearly black. Branches spreading and ascending, sometimes heavy, forming broadly conical to domed crowns. Foliage branches stout, rough with pulvini from fallen leaf fascicles, glabrous, new shoots yellowish green, becoming light orange-brown to red-brown. Buds ovoid to oblong-conical, sharply acute, non-resinous or resinous; cataphylls brown, thin, with papery, grey fringes. Leaves in fascicles of 2, held by a persistent, 10–12 mm long basal sheath, remaining 2–3 years on branchlets, straight or more often curved, rigid or flexible, (4–)8–16(–18) cm long, sometimes twisted, 1–2 mm wide, light green or dark green; margins minutely serrate; apex acute; stomata in fine lines on all faces. Pollen cones clustered near base of new shoots, spirally arranged, ovoid-conical to short cylindrical, 1.5–2.5 cm long, 0.5–0.7 mm wide, yellow. Seed cones solitary or in whorls of 2–5 on short peduncles, falling shortly after seed dispersal, ovoid-conical when closed, (3.5–)5–10(–12) cm long, 2–4 cm wide, opening to ovoid or slightly curved ovoid, usually light brown or pale grey-brown, rarely darker. Seed scales thin woody, rigid, narrowly oblong; apophyses slightly raised, transversely keeled, light yellowish brown, more or less lustrous; umbo dorsal, small, usually unarmed or with a minute, deciduous prickle. Seeds obovoid, slightly flattened, (4–)6–8 mm long, grey or mottled darker; wing obliquely oblong, 15–25 mm long, pale light brown.

Taxonomic notes

Few other species have a taxonomic history as convoluted as *Pinus nigra*, with numerous taxa at all ranks from species down to forma decribed and named, often in a three tiered system with varieties within subspecies within species (for a fairly comprehensive list of names and their synonyms with references see Farjon, 1998, [2001]). It is almost impossible to list all the synonyms as many were published in regional Floras or periodicals that have not even reached the major botanical libraries. Especially in southern and southeastern Europe a tendency to split this species on perceived differences of all kinds, including numbers of resin ducts in needles, is still prevalent (see e.g. Vidacović, 1991). While it is appropriate to recognize a few infraspecific taxa in a species with a variable morphology and a wide but disjunct distribution, extreme splitting would amount to a refutation that a species after all is made up of variable individuals and ditto populations. A conservative treatment is favoured here, largely based on the treatment in Flora Europaea 1 (1993). Even among the five subspecies recognized here, the distinctions are often not as clear-cut as is claimed by those who are thoroughly convinced of them.

Distribution

SW, S and SE Europe; N Algeria; N Morocco; Cyprus; Turkey; from the Krym [Crimea] in Ukraine along the Black Sea coast eastwards to Krasnodar in the Caucasus.

TDWG codes: 11 AUT-AU 12 COR FRA-FR SPA-AN SPA-SP 13 ALB BUL GRC ITA-IT KRI ROM SIC-SI TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 KRY 20 ALG MOR-MO 33 NCS-KR 34 CYP EAI TUR

Ecology

The wide but fragmented (disjunct) range of *P. nigra* throughout S Europe and Turkey guarantees a diverse ecology. It is generally a lower montane species, but around the Black Sea it is found in hills. It grows on a variety of soils, from podzolic sands to limestone, often dependent on region and climate. It can form pure stands (which may have been helped by foresters), but is more commonly associated with *Pinus sylvestris* throughout its range, while regionally *P. halepensis, P. brutia, P. mugo, P. pinea, P. peuce*, or *P. heldreichii* can be found with it. It is more tolerant to maritime influences like salt-laden winds than *P. sylvestris*, so it often occurs closer to the sea. The geographic variation is partly ecologically determined, with subsp. *laricio* more salt tolerant than subsp. *nigra*, which occurs further inland. Undergrowth in dense pine forests dominated by this species is usually sparse; more often it forms a mozaic with heathland (*Erica, Calluna, Vaccinium*), which can also be present under more open canopies after selective felling or natural disturbance. The extensive plantations and forest management of this species in Europe over several centuries have made the distinctions with natural forests less clear.

Uses

Austrian or Black pine is an important timber tree as well as amenity tree and has been extensively planted in Europe and to a lesser extent in the USA. In Austria and the Balkans, its wood is traditionally used to build houses; modern uses include interior flooring (the stage of the Viennese State Opera House is made of this wood!) and panelling, doors, staircases, furniture, etc. In the past there was a substantial industry based on resin tapping, but this has almost disappeared. In the Mediterranean, it is the major pine for general construction, fuelwood, pulp for paper and to make crates and pallets. Along the North Sea coast it has been used to stabilize coastal dunes, especially subsp. *laricio* (Corsican pine) which is the most salt wind tolerant form of the species. The subspecies *pallasiana* (Crimean pine), native in Turkey and around the Black Sea, often grows with multiple stems above a basal trunk when in cultivation in NW Europe and has attractive bark with large, light grey plates, so it was extensively planted as specimen trees in Victorian period gardens and parks in Britain. The species is also tolerant to various forms of industrial pollution (especially subsp. *nigra*, Austrian pine), and in the USA in particular it is therefore popular for plantings in urban and industrial settings. There are a number of cultivars named and in the horticultural trade.

5 subspecies and 1 variety are recognized:

Pinus nigra J. F. Arnold subsp. ***nigra***. Type: Illustration in J. F. Arnold, Reise Mariazell: 8, t. *s.n.* 1785.

Pinus nigra J. F. Arnold subsp. *croatica* Lovric, Oesterr. Bot. Z. 119: 569. 1972.

Description

Trees to 40 m tall; bark breaking into longitudinal ridges and fissures and small, scaly plates, dark grey. Leaves rigid, curved, 8–13 cm long, dark green, with 2–3 hypodermal cell layers.

Distribution

E Austria; N Italy; Balkan Peninsula; Bulgaria; Romania; Turkey-in-Europe.
TDWG codes: 11 AUT-AU 13 ALB BUL GRC ITA-IT ROM TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL

Conservation

IUCN: LC

Pinus nigra J. F. Arnold subsp. ***dalmatica*** (Vis.) Franco, Dendrol. Florest.: 55. 1943. *Pinus dalmatica* Vis., Fl. dalm. 1: 199. 1842. [in obs.]; Fl. dalm. suppl.: 43. 1872; *Pinus nigra* J. F. Arnold var. *dalmatica* (Vis.) Businský, Acta Pruhon. 88: 11. 2008. Type not designated.

Description

Small trees to 15 m tall, often with flat-topped crowns; leaves short, 4–7 cm long, with 2–5 hypodermal

layers and 10–11 resin ducts; seed cones small, (3–)4–6(–7) cm long.

Distribution

SE Europe: Croatia.
TDWG codes: 13 YUG-CR

Conservation

This subspecies of *Pinus nigra* has a limited distribution along the coast and on some islands in the Adriatic Sea and is mainly threatened by habitat degradation. Many areas are seriously overgrazed especially by goats, preventing regeneration.
IUCN: EN [B1ab (iii, v), B2ab (ii, v)]

Pinus nigra J. F. Arnold subsp. ***laricio*** (Poir.) Maire, Bull. Soc. Hist. Nat. Afrique N. 19: 66. 1928. *Pinus laricio* Poir., in Lamarck, Encycl. 5: 839. 1804, *non* Savi (1798. Type not designated. Fig. 236

Pinus laricio Poir. var. *calabrica* Loudon, Arbor. Frut. Brit. 4: 2201. 1838; *Pinus nigra* J. F. Arnold var. *calabrica* (Loudon) C. K. Schneid., in Silva-Tarouca, Uns. Freil.-Nadelhölzer: 261. 1913; *Pinus nigra* J. F. Arnold subsp. *calabrica* (Loudon) E. Murray, Kalmia 13: 23. 1983; *Pinus laricio* Poir. subsp. *calabrica* (Loudon) Cesca & Peruzzi, Caryologia 55 (1): 24. 2002.

Description

Trees to 50 m tall; bark grey, with deep, longitudinal fissures and irregular, scaly plates. Foliage branches orange-brown, becoming light grey-brown; leaves 8–15 cm long, slender, flexible, 1.2–1.5 mm wide, light green, with 1–2 hypodermal cell layers.

Distribution

Mediterranean: France (Corsica); Italy (S Apennines, Sicily).
TDWG codes: 12 COR 13 ITA-IT

Conservation

IUCN: LC

Pinus nigra J. F. Arnold subsp. ***pallasiana*** (Lamb.) Holmboe var. ***pallasiana***, [Stud. Veg. Cyprus] Bergens Mus. Skr., ser. 2, 1 (2): 29. 1914. *Pinus pallasiana* Lamb., Descr. *Pinus* 2: 1, t. 1. 1824. Type: Illustration in Lambert, Descr. *Pinus* 2: t. 1. 1824 (lectotype, designated here).

Pinus laricio Poir. var. *caramanica* Loudon, Arbor. Frut. Brit. 4: 2201. 1838; *Pinus nigra* J. F. Arnold var. *caramanica* (Loudon) Rehd., Man. Cult. Trees: 61. 1927; *Pinus nigra* J. F. Arnold subsp. *caramanica* (Loudon) Businský, Acta Pruhoniciana 68: 22. 1999; *Pinus pallasiana* Lamb. subsp. *caramanica* (Loudon) Chrtek & B. Slavik, Flora Mediterranea 10: 236. 2000. *Pinus nigra* J. F. Arnold var. *yaltirikiana* C. U. Alptekin, Istanbul Univ. Orman Fak. Dergisi, ser. A, 36 (2): 147. 1987.
Pinus nigra J. F. Arnold var. *columnaris-pendula* Boydak, Karaca Arbor. Mag. 6 (1): 17. 2001.

Description

Trees to 40 m tall, commonly (in cultivation?) forked into 2 or more ascending trunks; bark light grey, with deep, longitudinal, dark fissures and often very large, irregular, scaly plates. Foliage branches orange-brown; leaves rigid, straight or curved, (8–)12–17 cm long, light green, with 2–5 hypodermal cell layers and 6–9 resin ducts.

Distribution

Cyprus; from the Krym [Crimea] along the Black Sea coast to Krasnodar; Turkey (W Anatolia).
TDWG codes: 14 KRY 33 NCS-KR 34 CYP TUR

Conservation

IUCN: LC

Pinus nigra J. F. Arnold subsp. ***pallasiana*** (Lamb.) Holmboe var. ***fastigiata*** Businský, Acta Pruhon. 88: 8. 2008.

Description

A fastigiate branching growth form of *Pinus nigra* subsp. *pallasiana*.

Taxonomic notes

This apparent mutational form would have been more appropriately treated as a forma, not a variety. It was earlier named as *Pinus nigra* var. *pyramidata*, a later homonym, hence the new name published by Businský (*op. cit.*).

Distribution

Turkey: Kütahya, near Dulkadir village.

Pinus nigra J. F. Arnold subsp. ***salzmannii*** (Dunal) Franco, \Dendrol. Florest.: 56. 1943. *Pinus salzmannii* Dunal, Mém. Sect. Sci. Acad. Sci. Montpellier 2: 82. 1851; *Pinus nigra* J. F. Arnold var. *salzmannii* (Dunal) Laguna Lumbreras, Flora Montiberica 15: 28. 2000. Type: France: Languedoc, Hérault, St. Guillaume-le-désert, *P. Salzmann s.n.* (holotype MPU). Fig. 237

Pinus clusiana Clemente, in Arias, Adic. Agric. Gen. Herrera 2: 404. 1818; *Pinus nigra* J. F. Arnold subsp. *clusiana* (Clemente) Rivas-Martínez, Mem. Mapa Ser. Veget. Potencial España: 146. 1988.
Pinus laricio Poir. var. *angustisquama* Willk., in Willkomm & Lange, Prodr. Fl. Hispan. 1: 18, 73. 1870; *Pinus nigra* J. F. Arnold var. *angustisquama* (Willk.) Laguna Lumbreras, Flora Montiberica 15: 28. 2000.
Pinus laricio Poir. var. *latisquama* Willk., in Willkomm & Lange, Prodr. Fl. Hispan. 1: 18, 73. 1870; *Pinus nigra* J. F. Arnold var. *latisquama* (Willk.) Laguna Lumbreras, Flora Montiberica 15: 28. 2000.

Description

Trees to 30 m tall; bark with irregular, scaly plates, variously fissured, light brown to grey-brown. Buds resinous; leaves slender, 8–16 cm long, 1–1.3 mm wide, flexible, with (1–)2 hypodermal cell layers.

Distribution

SW Europe, France (Hérault, Pyrenees), Spain; Algeria (Djebel Djurdura); Morocco (Rif Mountains).
TDWG codes: 12 FRA-FR SPA-AN SPA-SP 20 ALG MOR-MO

Conservation

IUCN: LC

Pinus occidentalis Sw., Prodr.: 103. 1788. Type: Haiti: Nippes, ["Hispaniola: aux Pins, quartier des Nippes, du côté septentrional"], *O. P. Swartz s.n.* (lectotype BM).

Pinus occidentalis Sw. var. *baorucoensis* Silba, Phytologia 58: 368.

Etymology

The species epithet means 'from the west' (where it occurs from a European perspective).

Vernacular names

Cuban pine is a misnomer, it should be more appropriately named Hispaniolan pine.

Description

Trees to 30–40 m tall, d.b.h. to 1–1.2 m; trunk monopodial, erect. Bark thick, rough, scaly, breaking into irregularly square plates divided by deep fissures, turning grey-brown to grey. Branches spreading or ascending, in lower crown curved and drooping, forming an irregular, open crown. Shoots uni-nodal, glaucous to pruinose in the first year, later brown. Cataphylls slender, subulate to caudate, straight or recurved, scarious, brown. Vegetative buds ovoid to ovoid-oblong, acute; terminal bud 10–15 mm long; lateral buds shorter, usually slightly resinous. Fascicle sheaths persistent, (8–)10–15 mm long, lustrous silvery brown, weathering grey-brown. Leaves in fascicles of 3–5, persisting to third year, straight or slightly curved, more or less rigid, (11–)14–18 (–20) cm long, 1.2–1.4 mm wide, with serrulate margins, acute, pungent, light green. Stomata on all faces of leaves. Pollen cones cylindrical, 1.5–2.5 cm × 5 mm, pinkish yellow, turning yellowish brown. Seed cones sub-terminal, solitary or in pairs on 1–2 cm long, straight or recurved peduncles, persisting several years after seed dispersal, falling with peduncle attached. Mature cones ovoid to ovoid-conical, straight or curved, nearly symmetrical, (4–)5–9(–11)

× 3.5–6.5 cm when open. Seed scales oblong, straight or recurved, thin woody. Apophysis slightly raised, transversely keeled, rhombic to pentagonal in outline, on the proximal scales more or less gibbous, (lustrous) dark brown, radially striate, weathering dull grey. Umbo dorsal, raised and often curved, usually armed with an inflexed, 2–3 mm long spine. Seeds obliquely obovoid, flattened, 5–6 × 3–4 mm, light, mottled grey-brown. Seed wings obliquely ovate or oblong, 12–18 × 4–6 mm, ochraceous with black or grey tinge or stripes.

Distribution

Hispaniola: Dominican Republic; Haiti.
TDWG codes: 81 DOM HAI-HA

Ecology

This species occurs in diverse habitats from the lowlands at about 200 m a.s.l. to the highest mountain ridges (Pico Duarte and Pico La Pelona) on the island at almost 3200 m. The more extensive and pure stands occur from 900–2700 m, but in more accessible areas these are much depleted. Soils are either derived from limestone at lower altitudes, or more acid, clay-like and shallow in the Cordillera Central. *Pinus occidentalis* consequently is found in a variety of vegetation types, mostly occupying the shallow, nutrient-poor soils and rock outcrops, where it may occur in open or dense, pure stands or mixed with various broad-leaved trees and shrubs. In disturbed (grazed) areas *Pteridium aquilinum* can dominate the ground cover; in frequently burnt areas grasses (e.g. *Danthonia domingensis, Andropogon* spp.) and again *Pteridium* replace shrubs and small trees. Annual precipitation varies greatly with exposition, but ranges between 1200–1600 mm where most pine forests occur, it exceeds 2300 mm in the N and E of the Cordillera Central. There is a 3–5 month dry season during winter, which may bring frost, but rarely snow, at the higher altitudes above 1600–1800 m.

Conservation

Being the only species of *Pinus* on Hispaniola and formerly abundant over much of the island, it has been heavily exploited for timber. According to Darrow & Zanoni (1991) it has been depleted from an estimated 3 million ha of primeval more or less pure pine forests to perhaps less than 5% of that area, but accurate estimates of even the present forest extent are lacking. Protection in the Dominican Republic is inadequate, but existent, contrary to the virtually uncontrolled situation in Haiti.
IUCN: EN [A2a, c, d; B2ab (ii, iii, v)]

Uses

Cuban pine (Hispaniolan pine) is an important timber tree on its native island Hispaniola, where despite intensive exploitation it is still common. Its wood has good qualities comparable to those found in the more widespread species *P. caribaea* and is used as round wood for transmission poles, fence posts, construction timber, crates, boxes, and made into wood pulp for particleboard as well as paper. There is limited resin tapping for local use only. It is a tropical pine and even those trees at the highest altitudes in the Dominican Republic are not likely to yield progeny that can be grown successfully in cool temperate climates. Growing pines in greenhouses is problematic: unlike many other subtropical or tropical conifers they do not produce strong wood to hold the tree upright without the influence of wind that moves the stems during secondary growth.

Pinus oocarpa Schiede *ex* Schltdl., Linnaea 12: 491. 1838. Type: Mexico: Michoacan, Aguililla, Las Playitas Forest Station, along the track to Cañas, *B. T. Styles 36* (neotype FHO).

Pinus oocarpa Schiede *ex* Schltdl. var. *manzanoi* Martínez, Anales Inst. Biol. Univ. Nac. México 11: 70. 1940.

Etymology

The species epithet (Greek: *oos* = egg, *carpos* = fruit) refers to the shape of closed seed cones.

Vernacular names

Egg-cone pine; ocote chino, pino chino, pino colorado (Spanish)

Description

Trees to 30–35 m tall, d.b.h. to 1–1.3 m; trunk monopodial, erect. Bark thick, rough, scaly, breaking into small or large, longitudinal plates and shallow fissures, dark brown to grey-brown. Branches long, often tortuous, spreading, forming a rounded or irregular, open crown. Shoots rough and scaly, reddish brown. Cataphylls 10–15 mm long, subulate, recurved, scarious, brown, weathering blackish grey. Vegetative buds ovoid-oblong to fusiform; terminal bud 15–25 mm long; lateral buds ovoid-acute, smaller, none resinous. Fascicle sheaths up to 25 mm long, persistent, not reduced in length, red-brown weathering to nearly black. Leaves in fascicles of 4–5, persisting 2–3 years, straight, rigid or less commonly pliant, (11–)14–25(–30) cm long, 0.8–1.6 mm wide, with serrulate margins, acute-pungent, lustrous (yellowish) green. Stomata on all faces of leaves. Pollen cones oblong-cylindrical, 1.5–2 cm × 5–6 mm, pink or reddish, turning yellowish brown. Seed cones subterminal, solitary or in whorls of 2–4 on stout, up to 35 mm long, recurved peduncles which eventually fall with cones, persisting for several years after seed dispersal. Mature cones broadly ovoid to subglobose, semi-serotinous, when opened often wider than long, with a flattened base, 3–8(–10) × 3–9(–12) cm when open. Seed scales thick woody, symmetrical, oblong, straight or slightly recurved. Apophysis nearly flat or slightly raised, in some cones pyramidal, (weakly) transversely keeled, rhombic to pentagonal in outline, lustrous, ochraceous to light brown, weathering grey. Umbo dorsal, flat or raised, sometimes curved, obtuse or rarely with a minute prickle. Seeds obliquely ovoid, slightly flattened, 4–8 × 3–4.5 mm, blackish grey, often with black spots. Seed wings 8–18 × 4–8 mm, greyish brown.

Distribution

Mexico: from the Sierra Madre Occidental SE to Mesoamerica, in S Sonora, Sinaloa, SW Durango, Nayarit, S Zacatecas, Jalisco, Michoacán, México, Distrito Federal, Hidalgo, N Puebla, Morelos, Tlaxcala, Guerrero, Oaxaca, S Veracruz and Chiapas; widespread in the highlands of Guatemala; Honduras; El Salvador and NW Nicaragua.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-AG MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-SI MXN-SO MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 ELS GUA HON NIC

Ecology

This species extends over a NW-SE distance of ca. 3000 km and consequently is found under very different ecological conditions. This is expressed in its altitudinal range, from (200–)500–2300(–2700) m a.s.l., and in the variation of annual precipitation, from 700–3000 mm. Seasonality is mainly expressed in a (long) dry season from October to June in much of its range. Nearly everywhere, fire is an integral part of the ecosystem, but man-made fires, often deliberate, add substantially to the frequency with which they occur. *Pinus oocarpa* has semi-serotinous cones and is adapted to fire, at least at natural frequencies. It occurs in usually open woodland or forest, often in pure stands or as a constituent of pine-oak woodland. Other pines commonly associated with it are *P. engelmannii, P. leiophylla* and *P. douglasiana* in the NW and *P. maximinoi, P. devoniana* and *P. tecunumanii* to the SE. If fires are less frequent, there can be an understorey of shrubs with, e.g. *Calliandra, Acacia, Leucaena, Hybosema, Byrsonima*, and *Leucothoe*, but often the burning favours *Pteridium aquilinum* or grasses.

Conservation

The greatly increased frequency of fires, often deliberately ignited, poses a serious threat to the development of mature stands of this pine. The problem is especially poignant in Mesoamerica, where both fires and infestations by the pine bark beetle (*Dendroctonus mexicanus*) are frequently followed by 'lumber salvation operations' and subsequent conversion into pasture (Perry, 1991). Despite this, the species is very widespread and numerous in many areas, so it does not meet any of IUCN's criteria of a threatened species.

IUCN: LC

Uses

Throughout its range, *Pinus oocarpa* is an important timber tree, especially for local and regional

markets. The wood is of better quality than that of *P. caribaea*, it is stronger and less resinous. It is much used for sawn timber, especially applied to light construction like carpentry and joinery and floors in houses. Courser uses are railway sleepers and beams or transmission poles. The species is also widely tapped for resin, but only for a few years before felling. This species has been introduced to many subtropical and tropical countries as a plantation forestry tree, it is perhaps most successful in W Africa, South Africa, and in Brazil, Colombia and Argentina. In horticulture it is very rare and limited to a few botanic gardens and other tree collections in countries with warm climates.

Pinus palustris Mill., Gard. Dict., ed. 8: Pinus No. 14. 1768. Type not designated.

Etymology

The species epithet means 'of the marsh', referring to the habitat of the species.

Vernacular names

Longleaf pine, Florida pine, Georgia pine

Description

Trees to 45(–47) m tall; trunk to 1.2 m d.b.h., bole straight and columnar. Bark breaking into large, irregularly rectangular, scaly plates separated by deep fissures, orange-brown or reddish brown. Branches relatively sparse, spreading and descending, forming an open, rounded crown. Foliage branches stout, up to 2 cm thick in leading shoots, upturned at apex, prominently ridged and grooved between decurrent pulvini, glabrous, orange-brown turning darker reddish brown. Buds large; terminal bud 3–4.5 cm long, narrowly ovoid, not resinous; cataphylls narrowly oblong, with fringed margins and recurved at apex, silvery white. Leaves in fascicles of 3, rarely 2 or 5, held together in 20–25(–30) mm long sheaths, persisting 2 years, 20–45 cm long (longest in young, vigorous trees), spreading and drooping, slender and flexible, slightly twisted, ca. 1.5 mm wide; margins minutely serrulate; apex shortly acute to acuminate; leaf colour bright lustrous green; stomata in fine lines on all surfaces. Pollen cones clustered at base of new shoots, spirally arranged, spreading out radially, cylindrical, 4–7(–8) cm long, 0.8–1.5 cm wide, purplish red, turning red-brown. Seed cones solitary or in pairs near ends of foliage branches, sessile or very short pedunculate, soon falling after seed dispersal, often leaving a rosette of basal scales on branch, (15–)20–25 cm long, symmetric, narrowly ovoid when closed, broadly ovoid-cylindric when open, with a flat base. Seed scales oblong, thin woody, rigid, recurved near base of cone, elsewhere spreading wide, dull brown; apophyses slightly raised, transversely keeled, rhombic in outline, dull tan or brown in colour; umbo dorsal and central, broadly triangular, obtuse, armed with a small, persistent, recurved prickle. Seeds obovoid, slightly flattened, 9–12 mm long, pale brown mottled with darker specks; wing 30–40 mm long, 10–12 mm wide. Seedlings with a definite and prolonged 'grass stage'.

Distribution

SE USA, from Virginia to E Texas in the Atlantic and Gulf Coastal Plains.

TDWG codes: 77 TEX 78 ALA FLA GEO LOU MSI NCA SCA VRG

Ecology

Pinus palustris grows mostly in the warm temperate to subtropical coastal plain of the SE United States, but it extends into the uplands and foothills of the southern Appalachian Mountains to about 700 m a.s.l. It requires a warm, humid climate and a moist soil, although the latter can vary from wet, poorly drained clay in swampland to thin stony soils on rocky mountain slopes and ridges. For the most part soils are sandy, acidic and poor in nutrients. This species can grow in pure stands but is often found together with other pines, like *P. elliottii, P. echinata* and *P. taeda*. Many broad-leaved trees (angiosperms) grow with it, too, forming mixed forests on mesic sites with e.g. *Quercus* spp., *Nyssa sylvatica, Liquidambar styraciflua, Cornus florida, Sassafras albidum*, and *Diospyros virginiana* and many shrubs. In the foothills in Alabama many oaks (*Quercus* spp.) accompany *Pinus palustris*, forming mixed pine-oak woods. This species of pine is well adapted to fires through its grass stage and succeeds quickly

from seed to take advantage of freed space and nutrients, while it can survive the next ground fire by resprouting from the very short stem until it has built enough of a root system to accelerate its stem growth dramatically and rise above the damaging flames.

Conservation

Pinus palustris was once the most common pine in the Coastal Plains, perhaps covering 25 million ha. Exploitation for timber and naval stores and conversion to farmland and pasture reduced this by 1985 to less than 1.6 million ha. This decline, although its rate has slowed, is ongoing. Foresters and landowners prefer other species that do not delay initial growth with a grass stage and many sites originally occupied by *P. palustris* are now dominated by other species. Prevention of fires increases competition from herbs and shrubs as well as other pines, as the seedlings of *P. palustris* do not initially grow in height, unlike other pines common on the Coastal Plains. Controlled burning is therefore necessary for its successful establishment, but only *P. palustris* will survive this at a juvenile stage and in managed pine forest this practice would exclude other pine species.
IUCN: EN (A2c, d, e)

Uses

Longleaf pine is an important species providing good quality timber as well as naval stores derived from its resin. It was heavily exploited since Europeans settled in the Coastal Plains and served a major forest industry in the region. Its wood is used for sawlogs, stage flooring, plywood, pulpwood and produces poles, fence posts, and piling as it makes straight stems largely free of branches when grown in closed stands. Turpentine and other chemicals can be distilled from the chipped wood and even stumps of trees are pulled from the soil for this purpose. Longleaf pine is not planted for forestry outside its natural range and it is relatively rare as an amenity tree, mainly confined to coastal areas in the SE of the USA. The species is somewhat difficult to grow through its 'grass stage' to the sapling stage and beyond and needs a protected location in a mild climate.

Pinus parviflora Siebold & Zucc., Fl. Japon. 2 (3): 27, t. 115. 1842.

Etymology

The species epithet means 'with little flowers' which perhaps refers to an early stage of the seed cones.

Vernacular names

Japanese white pine; goyō-matsu, himeko-matsu (Japanese)

Description

Trees to 15–20 m tall; trunk to 1 m d.b.h., usually a straight, columnar bole. Bark smooth in young trees and in upper part of the crown, becoming rough and scaly on trunk, shallowly grooved, grey to dark grey. Branches whorled in young trees, later spreading and ascending; stem sometimes forked near the top, forming a conical to rounded crown, on exposed sites often flattened and open. Foliage branches slender, new shoots initially pubescent, soon glabrous or with remnant hairs in grooves, grey-green turning light brown. Buds small, ovoid, non-resinous or slightly resinous; cataphylls free at apex, light orange-brown. Leaves crowded in dense tufts towards end of shoots, persisting 3–5 years, in fascicles of 5, held by deciduous sheaths with thin scales falling in the second year, curved and slightly twisted, (3–)4–7(–8) cm long, slender and flexible, 0.7–1 mm wide, triangular in cross-section, often twisted, green to glaucous green; stomata in 3–4 prominent white lines on the two adaxial surfaces; margins minutely serrulate; apex acute. Pollen cones in small clusters near base of new shoots, spirally arranged, ovoid-oblong to cylindrical, 1.5–2.5 cm long, yellow turning light brown. Seed cones in whorls of 4–8(–10) on branches, persistent, sessile or very short peduncculate, spreading, when still growing ovoid or subglobose, green or glaucous, very resinous, with opened scales 4–7 cm long and to 4 cm wide, becoming more ovoid or irregular. Seed scales few, thin woody, flexible, with larger scales straight or curved, but basal smaller scales not recurved; apophyses variously shaped, strongly concavo-convex ('cupped') or more or less flat, incurved, becoming dull brown; umbo terminal, obtuse. Seeds ellipsoid-ovoid or obovoid,

7–10 mm long, 5–6 mm wide; wing to 12 mm long, or rudimentary.

Taxonomic notes

Pinus parviflora is closely related to a group of pines that includes *P. fenzeliana* (syn. *P. kwangtungensis*), *P. dalatensis, P. wangii*, and *P. morrisonicola*, but occurs at a considerable distance from these in Japan. One variety is commonly recognized: *P. parviflora* var. *pentaphylla* (Mayr) A. Henry (syn. *P. pentaphylla* Mayr), with a more or less well developed seed wing and flatter, less cup-like seed cone scales. Wingless seeds and hollowed, cup-like scales that accommodate them are not independent characters but form an 'adaptive complex' to prevent the seeds from falling where the seedlings have little chance of growing up under the parent trees. Persistence of cones may also be part of this syndrome, depending on the feeding habits of the bird species that feed on them and (presumably) play a role in their dispersal.

Distribution

Japan: Hokkaido, Honshu, Kyushu, Shikoku; South Korea, Ullung-do (island).
TDWG codes: 38 JAP-HK JAP-HN JAP-KY JAP-SH KOR-SK

Ecology

Pinus parviflora occurs at altitudes from just above sea level to about 2500 m, with an optimum between 1000 and 1500 m a.s.l. in montane forests. It is found in both pure and mixed stands with other conifers and also with angiosperms, usually on steep slopes, dry sites or rocky ridges. At high, subalpine habitats this species becomes dwarfed and some of the cultivated forms may have been derived from such provenances.

Uses

Japanese white pine has little value as a timber tree, but great value as an ornamental. In Japan, this species has been in cultivation in gardens and parks and in temple grounds for many centuries. Growth forms that stay low and form picturesque shapes are highly sought after and these preferences culminate in the art of bonsai, for which this is the most commonly used species of pine. In bonsai culture growth is inhibited and plants are slowly forced by various techniques into shapes that appear to imitate ancient trees growing on exposed mountains in a miniature fashion. In Western horticulture, the species is also popular and a substantial number of cultivars has been produced, predominantly dwarf forms with strongly glaucous foliage and some with variegated needles. Naturally growing trees of the species are relatively rare and mostly confined to collections in arboreta. Most plants in the trade under the species name are derived from Japanese garden selections (cultivars without a name).

2 varieties are recognized:

Pinus parviflora Siebold & Zucc. var. ***parviflora***. Type: Japan: [locality unknown], "*Pinus cembra*", *P. F. von Siebold s.n.* (lectotype L, acc. no. 901.138–394).

Description

Seed scales cup-like in shape, with deep seed cavities. Wings of seeds 3–7 mm long, 6–8 mm wide, rudimentary (shorter than the seed body).

Distribution

Japan: Honshu, Kyushu, Shikoku.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Conservation

IUCN: LC

Pinus parviflora Siebold & Zucc. var. ***pentaphylla*** (Mayr) A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 5: 1033. 1910. *Pinus pentaphylla* Mayr, Monogr. Abiet. Japan. Reich.: 78. 1890; *Pinus parviflora* Siebold & Zucc. subsp. *pentaphylla* (Mayr) Businský, Acta Pruhoniciana 68: 12. 1999. Type not designated.

Description

Seed scales more or less flat, not cup-like in shape. Wings of seeds 10–12 mm long, 6–8 mm wide (approx. as long as the seed body).

Distribution

Japan: Hokkaido, Honshu; South Korea: Utsurio-To.
TDWG codes: 38 JAP-HK JAP-HN KOR-SK

Conservation

IUCN: LC

Pinus patula Schiede *ex* Schltdl. & Cham., Linnaea 6: 354. 1831.

Etymology

The species epithet means 'spreading wide' and refers to the leaves, which are in fact drooping or pendulous.

Vernacular names

Jelecote pine, Spreading-leaved pine, Mexican weeping pine; ocote, pino triste (Mexico)

Description

Trees to 35–40 m tall, d.b.h. to 1 m; trunk monopodial, erect, straight. Bark thick, rough and scaly, with large elongated plates and deep, longitudinal fissures, dark grey-brown below, lighter above. Branches spreading or slightly ascending; branches of higher orders slender, drooping or sub-pendulous, with ultimate branches pendant, forming a conical to domed, open crown. Shoots often multinodal, rough and scaly, yellowish to reddish brown. Cataphylls subulate, recurved at apex, scarious, brown. Vegetative buds oval-oblong to cylindrical; terminal bud 15–20 mm long; lateral buds shorter, all brown, not resinous. Fascicle sheaths initially long, 20–30 mm, persistent but reduced to 12–15 mm in mature fascicles. Leaves in fascicles of 3–4(–5), persisting 2–3 years, thin, lax, drooping to pendant, (11–)15–25(–30) cm long, 0.7–0.9(–1) mm wide, serrulate at margins, acute, pale green to dark green. Stomata on all faces of the leaves. Pollen cones ovoid-oblong to cylindrical, 1.5–2 cm × 5–6 mm, pinkish yellow. Seed cones subterminal or lateral, in whorls of 2–many, rarely solitary, persistent or deciduous, pedunculate. Mature cones ovoid or ovoid-attenuate when closed, usually slightly curved, 5–10(–12) × (3–)4–6.5 cm when open. Seed scales oblong, usually curved when spreading, the proximal scales connate. Apophysis nearly flat to slightly raised, transversely keeled, more or less gibbous on the proximal scales, more so on one side of the cone; upper margin acute or obtuse-rounded; colour yellowish brown. Umbo dorsal, flat or raised, often sunken into the apophysis, with a minute, deciduous prickle. Seeds 4–6 × 2–4 mm, blackish grey. Seed wings 12–18 × 5–8 mm, light brown with dark stripes.

Distribution

Mexico: Tamaulipas, Querétaro, Hidalgo, México, Distrito Federal, Morelos, Tlaxcala, Puebla, Veracruz, Oaxaca and Chiapas.
TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-HI MXE-QU MXE-TA MXG-VC MXS-OA MXT-CI

Ecology

Pinus patula occurs in the warm to temperate highlands of central and southern Mexico, at altitudes between 1500 and 3000 m a.s.l. and in areas with abundant precipitation ranging from 1000–2200 mm. According to altitude, the climate ranges from subtropical to temperate. Fog plays a significant part in the availability of moisture through much of the dry season. It occurs in a variety of forest types, with conifers or with angiosperms, especially in the *Liquidambar* forests on the eastern slopes facing the Caribbean Sea which receive most of the rain and fog. These forests are famous for their abundance of epiphytes, among which are ferns, bromeliads and orchids. *Pinus patula* is also associated with other pines, e.g. *Pinus pseudostrobus, P. maximinoi, P. ayacahuite*, and locally, *P. greggii*, in mixed pine or pine-oak forest; in a few places it is found associated with *Abies religiosa*.

Uses

This species is one of the most important pines for timber in Mexico, as it grows fast and produces a long, straight bole, for the most part free of branches. It is also widely introduced in other tropical countries in plantation forestry, where in some cases it has become problematic as an invasive species. In southern and eastern Africa it is planted commercially;

other countries where it has been introduced for plantation forestry on a large scale are Colombia, Brazil and Argentina and to a more limited extent India, Nepal and New Zealand. Much work has been done by forest geneticists and tree growers in breeding programmes to improve seed provenances for timber growing in tropical countries. The wood is soft and light coloured and easily worked, but can be susceptible to blue stain without treatment. It finds applications in flooring and panelling, plywood and particleboard manufacture, veneers, crates and boxes, and of course for its softness, pulp for paper; it is therefore less suitable for high quality furniture and tools. In horticulture it has made some progress in recent years as it forms an attractive tree with its fine foliage and several provenances have proved to be quite hardy.

2 varieties are recognized:

Pinus patula Schiede *ex* Schltdl. & Cham. var. ***patula***. Type: Mexico: Veracruz, Cruz Blanca, ["Inter Cruz blanca & Jalacingo"], *C. J. W. Schiede & F. Deppe 1108* (lectotype HAL, sheet 1/4). Fig. 238, 239

Description

Seed cones (very) short pedunculate, seemingly sessile at maturity, in whorls of 2–many, tenacious, persisting many years, serotinous, ovoid when closed, broadly ovoid and (5–)7–10(–12) × (3–)4–6.5 cm when open. Seed scales ca. 120–150, (thick) woody, rigid, many of the proximal scales remaining connate.

Distribution

Mexico: in a few localities in Tamaulipas, in Querétaro, Hidalgo, México, Distrito Federal, Morelos, Tlaxcala, Puebla, Veracruz, Oaxaca and Chiapas.
TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-HI MXE-QU MXE-TA MXG-VC MXS-OA MXT-CI

Conservation

IUCN: LC

Pinus patula Schiede *ex* Schltdl. & Cham. var. ***longipedunculata*** Loock *ex* Martínez, Pinos Mexic., ed. 2: 333, f. 276–280. 1948 ["*longepedunculata*"]. *Pinus* ×*longipedunculata* (Loock *ex* Martínez) Businský, Acta Pruhon. 88: 11. 2008. Type: Mexico: Oaxaca, Sierra Benito Juarez, Rancho Benito Juarez, (Rancho Tablas), *E. E. M. Loock 113a* (holotype PRF).

Description

Seed cones distinctly pedunculate, peduncles up to 20 mm long, curved, falling with cones after a few years. Cones opening readily, narrowly ovoid to ovoid-attenuate when closed, (narrowly) ovoid when open, then 5–8 × 3.5–4.5(–5) cm. Seed scales ca. 100–120, (thin) woody, somewhat flexible, parting readily to release the seeds.

Distribution

Mexico: known from only two localities in Hidalgo and Veracruz, but more widespread in Oaxaca, also in Guerrero and in central Chiapas.
TDWG codes: 79 MXE-HI MXG-VC MXS-GR MXS-OA MXT-CI

Conservation

IUCN: LC

Pinus peuce Griseb., Spicil. Fl. Rumel. 2: 349. 1846. Type: Macedonia: NW Macedonia, Sar Planina, ["in m. Peristeri supra Bitoliam"], *A. H. R. Grisebach s.n.* (holotype not located, isotype K).

Etymology

The species epithet derives from the Greek *peuke* = pine tree.

Vernacular names

Balkan pine, Macedonian pine

Description

Trees to 25(–30) m tall; trunk to 1 m d.b.h., bole usually straight. Bark thin and smooth on young trees

and branches, becoming thicker and breaking into small plates, at lower trunk longitudinally fissured, grey-brown; inner bark purplish brown. Branches spreading more or less horizontally, relatively short or longer and assurgent in solitary trees, poorly self-pruning, forming a dense, conical or narrowly conical, sometimes broadly conical crown. Foliage branches stout; new shoots glabrous, smooth, often glaucous, turning grey-green and finally grey-brown. Buds ovoid-conical, ca. 10 mm long, acute, resinous or without resin; cataphylls brown with a narrow, whitish margin. Leaves in fascicles of 5, initially held in a deciduous, 15–18 mm long basal sheath, persisting 3–4 years in tufts on branchlets, straight, more or less rigid, 7–10(–12) cm long, slender, 0.5–0.7 mm wide; margins minutely serrulate; leaf colour grey-green or slightly glaucous; apex acute; stomata in fine whitish lines on all surfaces, but only a few on the abaxial side. Pollen cones few and small, 10–15 mm long, clustered in spiral arrangement at base of new shoots, yellow with a purple hue. Seed cones solitary or in whorls of 2–4 on short, curved peduncles, initially erect, green becoming red or purple, when fully grown becoming pendulous, cylindrical, (7–)8–15(–20) cm long, obliquely curved at base, 2–3(–4) cm wide when closed, opening to 4–5(–6) cm wide, resinous. Seed scales thin woody, flexible, cuneate to obovate, more or less flat; basal scales not recurved but imbricate; apophyses broadly rhombic to rounded distally, slightly thickened, mostly incurved at apex, longitudinally striate or grooved, light brown when dried; umbo terminal, obtuse, dark grey-brown. Seeds obovoid, slightly flattened, (5–)6–8 mm long, grey; wing adnate, 15–20 mm long.

Taxonomic notes

The relationships of this species, the only European member of Subsection *Strobi* in Europe according to the classification adopted in the first edition of the book Pines (Farjon, 1984: 194), have recently been revised on the basis of molecular evidence (Liston *et al.* in Mill, 2003). The division into subsections *Cembrae* and *Strobi* based on cone and seed morphology appear to break down, with similar results from both chloroplast and nuclear DNA. The wingless seeds, dispersed by birds, have resulted in a specific type of cone (see e.g. *P. albicaulis* and *P. cembra*) amounting to convergent evolution. These pines are not necessarily closely related because of these similarities. Instead, *P. cembra* is probably more closely related to *P. peuce* than to *P. albicaulis*. A more careful second look at anatomy and morphology, avoiding strongly adaptive traits that have led to convergence, may yet detect characters that support the results from DNA studies, or refute them, as the case may be. It is important to include all species of section *Quinquefolius* and appropriate outgroup taxa in such studies.

Distribution

SE Europe: Albania; W Bulgaria; Kosovo; Macedonia; Montenegro; N Greece; Serbia.
TDWG codes: 13 ALB BUL GRC YUG-KO YUG-MA YUG-MN YUG-SE

Ecology

Pinus peuce is a montane pine, growing between 600 m and 2200 m above sea level and usually on silicate rock types. In Albania and Serbia it is also found on serpentine. It can grow on a variety of soil types, usually poor in nutrients and acidic to basic. In Grecian Macedonia it forms pure stands on gentle mountain slopes, interspersed with grassy glades and meadows. In most areas where it occurs, it is mixed with *Picea abies* and/or *Abies alba* / *A. borisii-regis*, with which it can compete due to relatively high shade tolerance.

Conservation

This species is probably a Tertiary relict that has survived severe contractions of its range due to Alpine glaciations during the Pleistocene. Its current range consists of two disjunct populations, one in the west centered in Albania and one in the east in W Bulgaria. The two populations have sometimes been viewed as two distinct varieties, with "*Pinus peuce* var. *vermiculata* Christ" (cited in Vidaković, 1991: 532 but orig. publ. not traced) in Bulgaria, but this is not generally accepted as the stated differences: length of leaves and cones, are continuous and partly overlapping. Extensive exploitation in the past has undoubtedly had an impact on its abundance but no details of a possible reduction are known. At present, this species occurs in several protected areas in the Balkan mountains.
IUCN: NT

Uses

Balkan pine is a minor timber tree in the Balkans; it is now commonly planted for forestry in the region and natural stands are less intensively exploited than in the past. The wood is used only locally for carpentry and furniture and can be rather knotty, but when plantation-grown trees come of age to be harvested, this tendency will be reduced. Inter-specific hybrids with other species in subsection *Strobus* have been tested in forestry nurseries for growth performance. Balkan pine, in contrast with several other species, is resistant to the pathogenic fungus *Cronartium ribicola* (*Basidiomycota*) and hybrids may also become resistant to the disease. In horticulture it has long been used, being first introduced north of the Alps in Germany in 1863. It is mostly grown as a 'species tree' for large gardens and parks; only a limited number of cultivars, mostly producing dwarfed forms, is known.

Pinus pinaster Aiton, Hort. Kew. 3: 367. 1789.

Etymology

Pinastre (also pinastro) is one of the vernacular names for this pine, which was adopted for the species epithet by William Aiton.

Vernacular names

Maritime pine; pino gallego, pino resinero (Spanish); pin maritime, pin des landes, pinastre (French); pinastro, pino marittimo (Italian); pinheiro-bravo (Portuguese)

Description

Trees to (25–)30(–40) m tall; trunk to 1.5 m d.b.h., straight or curved. Bark on trunks of larger trees breaking into large, irregular, more or less smooth plates separated by broad and deep, blackish fissures. Branches long, spreading and ascending; higher order branches in lower crown drooping, forming a dense, rounded crown. Foliage branches stout; new shoots green with brown-red spots, turning to pinkish brown on the upperside and fading to grey-brown. Buds large; terminal bud 20–35 mm long, 8–12 mm wide, oblong-conical, not resinous; cataphylls red-brown, reflexed. Leaves in fascicles of 2, held by a persistent, 20–30 mm long, dark grey basal sheath, remaining on branchlets 2–3 years, straight or sometimes slightly curved, rigid, 10–20(–25) cm long, not or slightly twisted, 1.5–2 mm wide, lustrous grey-green or dark green; margins denticulate; apex acute or pungent; stomata in conspicuous lines on all faces. Pollen cones cylindrical, 2–4 cm long, yellow. Seed cones solitary or more often in whorls of 2–4, short pedunculate, persistent several years, spreading or reflexed, narrowly ovoid-conical when closed, 10–20(–22) cm long and 5–8 cm wide when closed, not opening soon but usually open before falling. Seed scales thick woody, rigid, small and imbricate near the slightly oblique cone base, much larger and longer beyond, spreading wide, oblong, more or less flat. Apophyses broadly rhombic in outline, raised and thickened to pyramidal, prominently transversely keeled and mostly also with 2–3 raised longitudinal ridges, lustrous orange-brown or red-brown; umbo dorsal, central, forming a straight or forward curved, short spine. Seeds obovoid-oblong, (7–)8–10(–12) mm long, grey or blackish grey (sometimes different on two sides); wing 22–30 mm long, 7–10 mm wide, oblique.

Taxonomic notes

This species is divided into three subspecies in several recent European standard Floras. Their morphological differences are small and are probably to some extent due to differences in climate and/or habitat. These subspecies are listed below. There has long been a keen interest in forestry to discover differences in growth, habit, and frost resistance between the two provenances represented by *P. pinaster* subsp. *pinaster* ("var./subsp. *atlantica*", an illegitimate name) and subsp. *escarena* (*P. mesogeensis* of several authors) from the Atlantic and Mediterranean coasts respectively. This excludes the upland North African taxon, *P. pinaster* subsp. *renoui*; these rare trees were never in the focus of foresters. It may be, on closer scrutiny, the only subspecies (or variety) worthy of taxonomic recognition, as it has more slender leaves with only 2 resin ducts and smaller seed cones. The distinguishing morphological character states cited for the other two are, to the contrary, not discontinuous and even largely overlapping; the taxonomic case for their separation is therefore less convincing.

Distribution

SW and S Europe; N Africa, Morocco, border between Algeria and Tunisia.
TDWG codes: 12 BAL COR FRA-FR POR SAR SPA-SP 13 ITA-IT SAR SIC-SI 20 ALG MOR-MO TUN

Ecology

Pinus pinaster is mainly a pine of low-lying, coastal plains, usually on sandy soils of sea shore dunes and flats; however, in Morocco this species extends into the mountains to an elevation of ca. 2000 m. Extensive planting, e.g. in sand dunes, for centuries has established this species in areas where it may not have occurred naturally but where it has subsequently often been naturalized. It forms tall pine forests and if with a more or less open canopy the understorey is of evergreen maquis shrubs. This species is frost sensitive, which is probably a reason why only in the far south of its range it ascends into the mountains. In Morocco it is a constituent of mixed coniferous forest with *Pinus nigra* subsp. *salzmannii, Abies pinsapo* var. *marocana, Cedrus atlantica*, and *Taxus baccata*. Common angiosperm trees in this forest type are *Quercus ilex* and at the higher altitudes *Populus tremula*.

Uses

Maritime pine is an important timber tree as well as Europe's major source of turpentine since the 16th century. It has been planted to stabilize dunes in coastal areas within as well as far outside its natural range where frost is a minimal risk due to the maritime influence on the microclimate. The region Les Landes in SW France is one of the principal areas where this pine has been planted for forestry purposes, including resin tapping. Another centre for resin production is Corsica. It has also been planted on a forestry scale in many parts of the Mediterranean region and in South Africa, where it has become one of the invasive species of pine as a result. The wood is of coarse grain and very resinous. It is (or was) used for mining pit props, construction, telephone poles and posts for fencing, boat-building, and furniture. Smaller sized logs with many knots or blemishes are usually chipped or pulped for particleboard and paper. The large volume of bark per unit of wood makes this a pine suitable for production of mulch. Resin is extracted by tapping as well as distillation of bark and wood pulp, and used to produce turpentine, pitch, oils, varnishes, waxes and soap. The large, decorative cones are sold as ornamental pieces in flower displays and for Christmas decorations. In horticulture it is less common and most suitable for dry, sandy soils; only a few cultivars are known.

3 subspecies are recognized:

Pinus pinaster Aiton subsp. ***pinaster***. *Pinus pinaster* Aiton subsp. *atlantica* Villar, Bol. Soc. Esp. Hist. Nat. 33: 427. 1934. Type not designated. Fig. 240, 241

Pinus pinaster Aiton var. *acutisquama* Boiss., Voy. Bot. Espagne 2: 583. 1841; *Pinus pinaster* Aiton subsp. *acutisquama* (Boiss.) Rivas-Martínez, Rivasgodaya 6: 52. 1991.

Description

Trees to 30 m tall. Leaves 10–20 cm long; resin ducts at base of leaves (within sheath) limited to the two lateral, larger ducts, at mid-leaf several additional small ducts; seed cones 10–18 cm long.

Distribution

France (Atlantic coast), Portugal, Spain; natural distribution uncertain due to long-time extensive planting.
TDWG codes: 12 FRA-FR POR SPA-SP

Conservation

IUCN: LC

Pinus pinaster Aiton subsp. ***escarena*** (Risso) K. Richt., Pl. Europ. 1: 1. 1890. *Pinus escarena* Risso, Hist. Nat. Europ. Mérid. 2: 340, 459. 1826. Type not designated.

Pinus mesogeensis Fieschi & Gaussen, Bull. Soc. Hist. Nat. Toulouse 64: 440. 1932; *Pinus pinaster* Aiton var. *mesogeensis* (Fieschi & Gaussen) Silba, Phytologia 68: 59. 1990.

Description

Trees to 40 m tall. Leaves up to 25 cm long, 2 mm wide; resin ducts at base of leaves (within sheath) usually more than the two larger lateral ducts, at mid-leaf numerous; seed cones up to 22 cm long.

Distribution

W Mediterranean: France, Spain, Baleares, Corsica, Sardinia, Italy, Sicily, Malta.

TDWG codes: 12 BAL COR FRA-FR SPA-SP 13 ITA-IT SAR SIC-MA SIC-SI

Conservation

IUCN: LC

Pinus pinaster Aiton subsp. ***renoui*** (Villar) Maire, [Fl. Afrique N.] Encycl. Biol. 33: 145. 1952. *Pinus pinaster* Aiton var. *renoui* Villar, Vol. Jubil. Soc. Sci. Nat. Maroc: 241. 1948; *Pinus renoui* (Villar) Gaussen, Rev. Int. Bot. Appl. Agric. Trop. 32: 515. 1952. Type not designated.

Description

Trees to 25 m tall, crown umbrella-shaped or domed, dense. Leaves 12–20 cm long, slender, 1.5–2 mm wide, with only 2 lateral, large resin ducts at mid-leaf. Seed cones 10–15 cm long.

Distribution

N Africa: Morocco, and on Algerian-Tunisian border near the coast.

TDWG codes: 20 ALG MOR-MO TUN

Ecology

In Morocco this subspecies is reported to occur at elevations up to 2000 m in the mountains, which is unusual for the species.

Conservation

This subspecies of *Pinus pinaster* is very rare and known from only two widely separated populations on the African Mediterranean coast, the largest being in Morocco. These are relict occurrences and may indeed be genetically distinct. Logging and habitat degradation are known to occur, but to what extent is presently unknown. Afforestation with other pines, especially with *P. pinaster* from European provenance, threatens the genetic integrity of these relict populations.

IUCN: EN [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Pinus pinceana Gordon, Pinetum: 204. 1858. Type: Mexico: Morelos, Cuernavaca, *C. A. Ehrenberg s.n.* (holotype not located, isotype W). Pl. 32

Etymology

This species was named after "Mr Pince of Exeter", presumably a nurseryman.

Vernacular names

Weeping pinyon pine, Pince's pinyon pine; piñon (Spanish)

Description

Trees or large shrubs to 6–10(–12) m tall, d.b.h. to 20–30 cm. Trunk short, often branching from near the ground, erect, monopodial, contorted or forked. Bark on lower part of trunk and lowest branches exfoliating into irregular plates, brownish grey. Branches ascending or spreading, of higher orders long, slender, flexible, the ultimate branches drooping to pendulous, forming a broad, irregular, open crown. Shoots slender, flexible, glabrous and smooth, brownish grey to grey. Cataphylls 3–4 mm long, light brown. Vegetative buds ovoid-globose to ovoid-conical, to 4 mm long, not resinous. Fascicle sheaths ca. 10 mm long, soon spreading or curling and deciduous. Leaves in fascicles of 3, rarely 4, remote, persisting 2–3 years, straight, rigid, 5–12(–14) cm long, 0.8–1.2 mm wide, with entire margins, acute, greyish green. Stomata mostly in 2–4(–5) lines on each adaxial face. Pollen cones ovoid-oblong, 8–10 × 4–5 mm, purplish or yellowish. Seed cones lateral, not on ultimate branches, solitary or rarely in pairs on slender, curved and easily breaking peduncles, ovoid-oblong to short

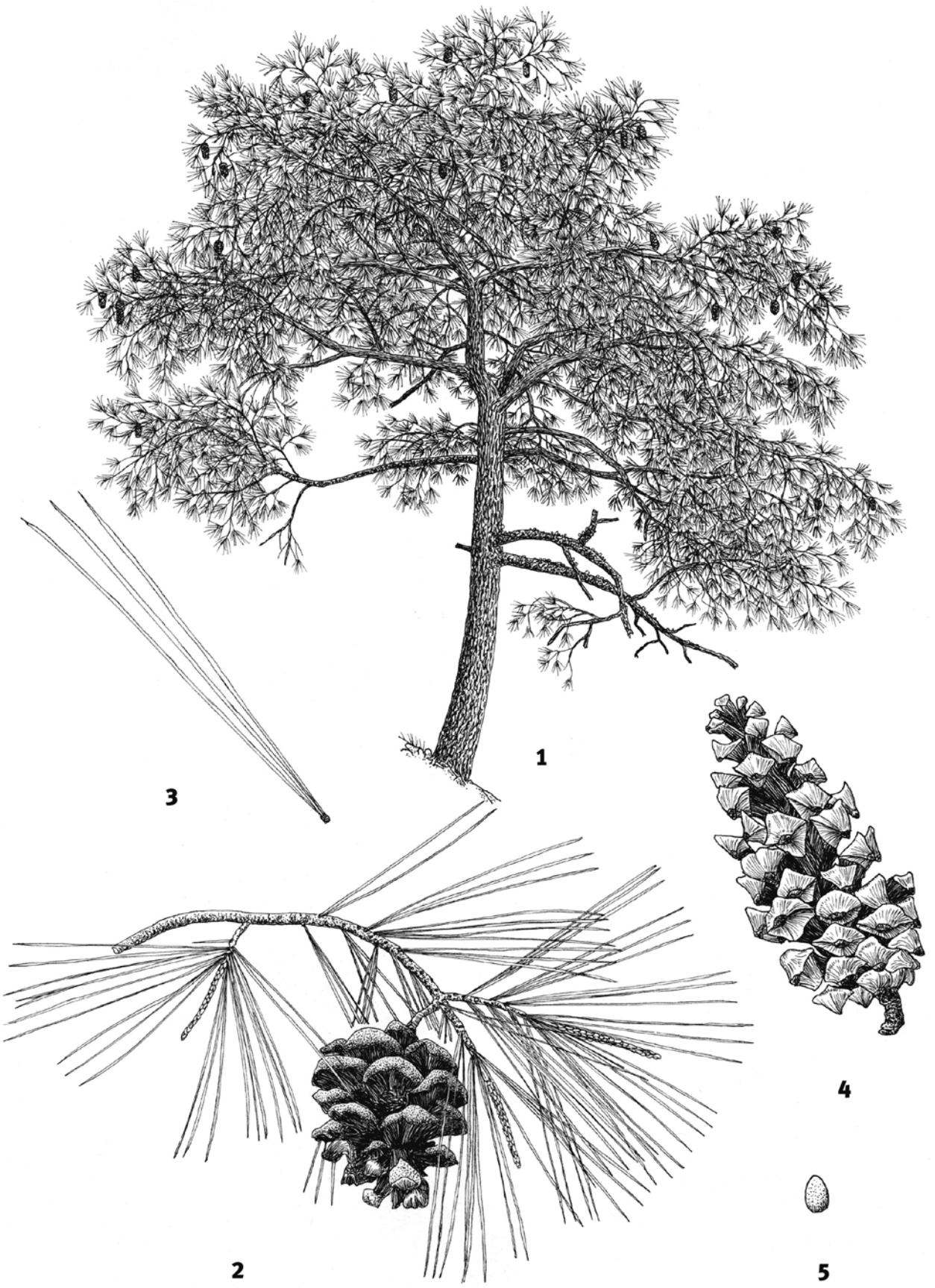

PLATE 32. *Pinus pinceana*. **1.** Habit of tree. **2.** Branch with foliage and seed cone. **3.** Leaves. **4.** Seed cone. **5.** Seed.

cylindrical, often irregular, 5–10 × 3.5–6(–7) cm when open. Seed scales parting only slightly or sometimes more widely, easily moveable, thick woody, concavo-convex, with (1–)2 deep, cup-like depressions holding the seeds. Apophysis irregular, prominently raised, transversely keeled, rhombic to pentagonal in outline, with angular or undulating upper margin, lustrous red-brown, sometimes with concentric colour rings or radially striated. Umbo dorsal, flattened at apex, up to 5 mm high, with a minute prickle. Seeds obovoid, 11–14 × 7–8 mm, wingless when detached from the scale, brown.

Distribution

Mexico: Coahuila, Hidalgo, Querétaro, San Luis Potosí, Zacatecas.
TDWG codes: 79 MXE-CO MXE-HI MXE-QU MXE-SL MXE-ZA

Ecology

This species occurs often on calcareous slopes and in ravines (barrancas) at altitudes between 1400–2300 m a.s.l. in arid and semi-arid mountains of NE Mexico. Annual precipitation is lower than in the Pinyon-Juniper belt (ca. 300–400 mm according to Perry, 1991) and is concentrated in the summer. This species sometimes occurs with *Pinus cembroides*, more often with *Juniperus flaccida*, and usually with numerous sclerophyllous or deciduous shrubs, e.g. *Prosopis* (in arroyos), *Mimosa, Karwinskia, Leucaena, Sophora, Quercus, Cercocarpus, Gochnatia*, and *Fouquieria*, as well as the succulent genera *Yucca, Agave* and *Opuntia*. The trees are often widely scattered in this vegetation.

Conservation

IUCN: LC

Uses

This species is not commercially used; the seeds are edible ('piñones'), but trees are scarce, inaccessible and far apart and usually with a low crop of cones compared to *P. cembroides* and its close relatives. It is not known in cultivation outside a few botanic gardens and arboreta; it will be suitable in gardens with a Mediterranean climate or nearly equivalent.

Pinus pinea L., Sp. Pl. 2: 1000. 1753. Type: Illustration: "*Pinus ossiculis duris, foliis longis*" in Bauhin & Cherler, Hist. Pl. Univ. 1 (2): 248. 1650 (lectotype). Fig. 242, 243

Etymology

The species epithet is a Latin adjective (with feminine gender) meaning 'of pines' (masc. = *pineus*).

Vernacular names

Stone pine, Umbrella pine; pino domestico, pino da pinoli (Italian); pino piñonero, pino manso (Spanish); pinheiro manso (Portuguese); pin pignon, pin parasol (French)

Description

Trees to 20–25 m tall; trunk to 1 m d.b.h., monopodial or soon forked into more stems. Bark scaly, becoming thick on trunk, breaking into large, hard plates divided by deep, irregular, dark brown to black fissures, orange-brown to reddish brown with grey patches of flakes that remained longer. Branches numerous, spreading and ascending, the higher order branches assurgent to erect, forming an umbrella-shaped, dense crown; young trees are more or less conical with an erect stem. Foliage branches slender or stout, new shoots glabrous, rough with pulvini of fallen leaf fascicles, pale green to yellowish brown, turning orange-brown. Buds ovoid-conical, 6–12 mm long, acute, not resinous; cataphylls light brown or red-brown, with fringed margins and reflexed apex. Leaves in fascicles of 2 held by a short, persistent basal sheath, remaining 3–4 years, rigid and spreading, 8–12(–15) cm long, usually twisted, 1.2–1.8 mm wide; margins minutely serrate; leaf colour on young plants glaucous, becoming lustrous dark green; stomata in fine lines on all surfaces. Pollen cones short cylindrical, yellow. Seed cones solitary or sometimes in whorls of 2–3 on short peduncles, persisting several years, serotinous or semi-serotinous, ripening in the third year, symmetrical, broadly ovoid to subglobose, (8–)9–13(–15) cm

long, 8–10 cm wide when closed, when finally opening up to 13 cm wide near the depressed base, leaving some basal scales on branch when falling. Seed scales thick woody, rigid, with 2 deep depressions on adaxial side holding the seeds. Apophysis (slightly) raised, angular in outline, convex with 4–6 ridges converging on the dorsal, central, obtuse umbo, maturing from olive green to lustrous orange-brown or red-brown, weathering grey. Seeds obovoid, 15–20(–22) mm long, 8–10 mm wide, brown; wing mostly rudimentary, oblique, 3–10(–15) mm long.

Distribution

Mediterranean Europe and Near East (doubtfully native in many areas of E Mediterranean).
TDWG codes: 12 BAL COR FRA-FR FRA-MO POR SAR SPA-SP 13 ALB GRC ITA-IT KRI SIC-SI YUG-CR 34 CYP EAI LBS-LB TUR

Ecology

This is primarily a pine of coastal areas in the Mediterranean, at elevations from sea level to 600 m, on coastal dunes and flats as well as on lower slopes of mountains and in the hills. Many present-day stands are the result of historic plantings, some going back to Roman times, and if managed well, these can have a natural understorey of maquis scrub or mixture with smaller broad-leaved trees. Mature trees have a thick, fire resistant bark and the massive cones take three years to mature and are serotinous or semi-serotinous. Seeds are nearly wingless and dispersed by birds (also eaten by rodents) or may scatter after fire burned off the undergrowth and its heat assisted in opening the cones. *Pinus pinea* is usually an emergent tree above shrubs (maquis) or in low, open forests; it can also occur with *Pinus halepensis* and in *Quercus ilex* maquis-woodland.

Conservation

IUCN: LC

Uses

Although depending on stand density the Stone pine may develop a tall, straight bole, most commonly its branches spread out and the trunk remains short. The quality of the wood for sawn timber is poor, being coarse and resinous and seldom straight for any substantial length. It is locally used to make furniture. The true economic value of this pine has since ancient times mostly resided in the edible seeds. These are harvested while still inside the closed cones, which are pulled down with hooked poles; the cones open when heated. For this purpose lower tree crowns are favoured, which is accomplished by keeping the canopy open. Seeds are a delicacy in themselves, but are also used in recipies ranging from pasta dishes to pastries. Millions of kilogrammes of seeds or 'pine kernels' are harvested in the Mediterranean countries each year. Empty pine cones are good, hot burning fuel (bakeries), but can also be sold as ornamental objects to florists. The resin is tapped and used for medicinal treatments, wax for violin bows, varnishes, and waterproofing. A green dye is made from the needles. The species is also much valued as an ornamental tree in gardens and parks around the Mediterranean and in other parts of Europe with mild winters. In South Africa it has become naturalized and is an invasive and noxious species in the fynbos biome of the Cape.

Pinus ponderosa Douglas *ex* C. Lawson, Agric. Man.: 354. 1836.

Etymology

The species epithet (Latin, fem. of *ponderosus*) means ponderous or massive.

Vernacular names

Ponderosa pine, Western Yellow pine

Description

Trees to 65(–72) m tall, but in substantial parts of its range 20–30 m is more commonly the maximum height; trunk to 2.5 m d.b.h., usually forming a straight, columnar bole. Bark on trunk breaking up into large to very large (30–40 cm diam.) irregular or oblong plates divided by broad fissures, exfoliating in small chips, bright orange-yellow or reddish brown with darker brown or blackish fissures. Branches persisting or self-pruning, spreading and assurgent,

often long, with lower branches down-curved, contorted or more or less pendulous, forming broad, columnar or domed, open crowns. Foliage branches stout; new shoots 0.7–2 cm thick, rough with pulvini from fallen leaf fascicles, orange-brown, becoming brown. Buds ovoid, to 2 cm long; terminal bud to 1 cm wide, all resinous; cataphylls red-brown with white fringes. Leaves in fascicles of 2–3, persisting 2–3 years, held by a ca. 15–20(–25) mm long, persistent basal sheath, spreading, straight or curved, 15–25 cm long, rigid or pliant, slightly twisted, (1–)1.2–1.8 mm wide; margins minutely serrulate; apex acute or acuminate; leaf colour green; fine lines of stomata on all surfaces. Pollen cones spirally arranged, erect and standing out radially, 3–4.5 cm long when full-grown, ellipsoid-cylindric, initially bright red or magenta, turning yellow at anthesis from yellow pollen sacs. Seed cones solitary or rarely in pairs on short peduncles to nearly sessile, leaving some scales on branch when falling, nearly symmetrical, ovoid-conical when closed, ovoid to subglobose when opened and 5–12 cm long. Seed scales oblong, spreading wide or reflexed, thin woody, rigid. Apophyses slightly to prominently raised, transversely keeled, more or less rhombic in outline, dull tan or lustrous reddish brown; umbo raised (rarely flat), pyramidal, keeled, recurved and usually armed with a hooked prickle. Seeds ellipsoid or obovoid, (4–)5–7(–8) mm long, brown or light brown, often mottled darker; wing 15–25 mm long.

Taxonomic notes

Pinus ponderosa is morphologically variable mainly in a north-south gradient from Canada to Mexico, but also from the Pacific coast to the Rocky Mountains. Its economic importance has stimulated numerous studies into this variation, but much of it has not been built on a sound taxonomic basis. It has appeared from taxonomic studies, that what David Douglas collected as *P. ponderosa* is called by foresters the 'North Plateau Race' of that species and is conspecific with *P. washoensis*, described from Lake Tahoe in Nevada. The Ponderosa pine of the Cascade Range in Oregon and the western slopes of the Sierra Nevada in California, while here included in *P. ponderosa* ('Pacific Race' of foresters), would, if sufficiently different and distinct as a species from *P. washoensis*, have to be called *P. benthamiana*. American foresters treated this pine as if it included the type of *P. ponderosa*. Nobody seems to have bothered to ask what the type specimen of *P. ponderosa* might be and where it had been collected; these questions have now been resolved (Lauria, 1996). Only *P. ponderosa* var. *scopulorum* is here recognized as a botanical variety within the species; *P. arizonica* is treated as a distinct species largely, but not exclusively, occuring in Mexico. If we include the smaller trees of the 'North Plateau Race' in *P. ponderosa* var. *ponderosa* (as we must), as well as the spurious taxon *P. washoensis* and the tall trees of the Cascades – Sierra Nevada, then the only morphological difference that appears to hold up more or less consistently is the number of leaves per fascicle: predominantly 2, rarely 3 in var. *ponderosa*, 2–3 (with a N-S cline towards increasing frequency of 3) in var. *scopulorum*. This is a difference that barely merits taxonomic recognition in conifers.

Distribution

W North America, from S British Columbia to just south of the Mexico-USA border.

TDWG codes: 71 BRC 73 COL IDA MNT ORE WAS WYO 74 NDA NEB OKL SDA 76 ARI CAL NEV UTA 77 NWM TEX 79 MXE-CO MXN-SO

Ecology

Pinus ponderosa is one of the most widely distributed pines, with a range spanning 20 degrees of latitude and from the lowlands to 3300 m a.s.l. While in the north and east its limits are defined by temperature and rainfall respectively, in the south it is replaced by related species. The lower limit of average annual precipitation is around 300 mm, the upper limit 1750 mm. It grows on soils derived from many rock types, both acidic and basic varying from around pH 5 to pH 9, and usually with a capacity to retain moisture but well drained. Its great altitudinal range as well as geographic spread causes huge variations in temperature, both summer and winter, but to thrive and compete well it requires ample sunshine in the growing season. *Pinus ponderosa* is the first tall pine to appear above Pinyon-Juniper woodland in the interior of the western USA, but it is a seral species in the mesic mixed conifer forests of the Cascades and Sierra Nevada, where other conifers will eventually

dominate. It grows with numerous other conifers (for listings see under *P. monticola* and *P. jeffreyi*) in these mountain ranges. Its relatively high tolerance of fire assures it a place in the succession in natural forests, but selective logging as well as fire prevention have altered the forest composition to the disadvantage of *P. ponderosa* in many managed forests.

Uses

Ponderosa pine is one of the most important timber trees in the USA. Its wood properties and potential size make it ideally suitable for sawn timber used in construction. It is used as roundwood for posts and sawn for crates as well as made into particle board and pulp. Timber of large sizes and high grade is sawn for light construction like window frames, doors, stairs, flooring, sidings, panelling, veneers and for furniture, cabinetwork, boxes, and woodware. In the National Forests of the USA the recreational and ecological functions of the open, sunny forests of Ponderosa pine at relatively low altitudes are increasingly recognized and on public lands these trees are no longer exclusively regarded as a source of timber. The species and its variety *scopulorum* are common in horticulture in parts of Europe, but usually limited to large parks and arboreta. A few cultivars have been named, but they are uncommon. Introductions for forestry plantations have been less successful due to fungal diseases, e.g. in New Zealand.

2 varieties are recognized:

Pinus ponderosa Douglas *ex* C. Lawson var. ***ponderosa***. Type: ovuliferous cone with appended label stating: "Bayford – Bury January 2° – 1849" (neotype W). Fig. 244

Pinus washoensis Mason & Stockw., Madroño 8: 62. 1945; *Pinus ponderosa* Douglas *ex* C. Lawson subsp. *washoensis* (Mason & Stockw.) E. Murray, Kalmia 12: 23. 1982.

Description

Leaves mostly in fascicles of 2, rarely of 3. Seed cones 8–12 cm long; seeds 6–8 mm long; seed wings 15–25 mm long (seed character states are correlated with cone size, not independent character states, and larger in this variety because the cones are larger).

Distribution

Pacific W North America, from S British Columbia to S California.

TDWG codes: 71 BRC 73 IDA MNT ORE WAS 76 CAL NEV

Conservation

IUCN: LC

Pinus ponderosa Douglas *ex* C. Lawson var. ***scopulorum*** Engelm., in Watson, Bot. California 2: 126. 1880. *Pinus scopulorum* (Engelm.) Lemmon, Gard. & Forest 10: 183. 1897; *Pinus ponderosa* Douglas *ex* C. Lawson subsp. *scopulorum* (Engelm.) E. Murray, Kalmia 12: 23. 1982. Type: USA: Colorado ["Colorado Territory, lat. 39°–41°, Alpine and Subalpine"], *C. C. Parry s.n.* (lectotype MO).

Description

Leaves in fascicles of 2–3. Seed cones 5–10 cm long; seeds 3–5 mm long; seed wings 12–15 mm long (seed character states are correlated with cone size and smaller in this variety because the cones are smaller).

Distribution

USA: Rocky Mts., Black Hills; Mexico: near the border in Coahuila and Sonora.

TDWG codes: 73 COL MNT WYO 74 NDA NEB OKL SDA 76 ARI NEV UTA 77 NWM TEX 79 MXE-CO MXN-SO

Conservation

IUCN: LC

Pinus praetermissa Styles & McVaugh, Contr. Univ. Michigan Herb. 17: 310, f. 2. 1990. Type: Mexico: Nayarit, Jalá, Cerro Juanacata, *J. W. Stead & B. T. Styles 475* (holotype FHO).

Etymology

The species epithet means 'overlooked' or 'neglected' and refers to the fact that this species was previously not recognized as distinct.

Vernacular names

No vernacular names have been recorded for this species.

Description

Trees to 10–15(–20) m tall, d.b.h. to 30 cm; trunk monopodial, tortuous or curved, sometimes branching low. Bark irregularly fissured longitudinally, reddish brown. Branches long, spreading, tortuous, not pendulous, forming a broad, irregular, open crown. Shoots slender, reddish brown, turning greyish. Cataphylls 7–10 mm long, subulate, not recurved, scarious, light brown. Vegetative buds oval-oblong to cylindrical; terminal bud 10–15 mm long; lateral buds ovoid-acute, smaller, not resinous. Fascicle sheaths 10–14 mm long, persistent, weathering dark brown to grey. Leaves in fascicles of (4–)5, persisting up to 3 years, straight, delicate and lax but not pendulous, (8–)10–16 cm long, 0.5–0.8 mm wide, serrulate at margins, acute, bright green. Stomata on all faces of the leaves. Pollen cones ovoid-oblong to cylindrical, 1–1.5 cm × 5 mm, pink to reddish. Seed cones subterminal, commonly solitary, occasionally opposite, on up to 35 mm long, recurved, slender peduncles, deciduous, non-serotinous, falling without basal scales and peduncle in most cases. Mature cones broadly ovoid to subglobose (wider than long), often with a flattened base when opened and missing the proximal scales, (4–)5–6.5(–7) × (5–)6–8 cm when open. Seed scales thin woody but rigid, oblong, straight or recurved, more or less symmetrical. Apophysis flat to slightly raised, radially striate or ridged to transversely keeled, rhombic to pentagonal in outline, lustrous light brown or yellowish brown. Umbo dorsal, flat or slightly raised, obtuse. Seeds obliquely ovoid, 5–8 × 3–4 mm, blackish grey or with black dots; wings 12–18 × 5–8 mm, greyish brown.

Distribution

Mexico: Durango, Jalisco, Nayarit, Sinaloa.
TDWG codes: 79 MXE-DU MXN-SI MXS-JA MXS-NA

Ecology

Pinus praetermissa occurs in open, dry pine-oak woodlands or tropical broad-leaved forests, often on rocky slopes. Its altitudinal range is 900–1900 m a.s.l. The dry season is from November to May, annual precipitation varies between 1000–1500 mm. Associated pines are *P. devoniana, P. lumholtzii, P. pseudostrobus*, and possibly *P. oocarpa*, but further investigation is necessary to evaluate its sympatry with these and other pines.

Conservation

IUCN: NT

Uses

This scattered species is rarely recognized as distinct from *P. oocarpa* by loggers and consequently no specific uses are known. It is likely to be exploited for timber together with other species. It is a subtropical species not known in horticulture.

Pinus pringlei Shaw, in Sargent, Trees & Shrubs 1: 211, t. 100. 1905. Type: Mexico: Michoacan, Uruapán, Cerro de la Cruz, ["hilltops near Uruapán"], *C. G. Pringle 10019* (lectotype GH).

Etymology

This species was named after Cyrus G. Pringle (1838–1911), who made many collections of plant specimens in Mexico.

Vernacular names

Pringle's pine; pino rojo (Spanish)

Description

Trees to 20–25 m tall, d.b.h. to 1 m; trunk monopodial, straight. Bark thick, rough, with small, scaly plates, fissured; inner bark orange-red; outer bark greyish brown. Branches spreading or arching, assurgent near the top, forming an open, broadly domed or irregular crown. Shoots thick, smooth, reddish brown, glaucous. Cataphylls lanceolate to subulate, 10–12 mm long, scarious, becoming reflexed at apex, reddish brown. Vegetative buds ovoid-oblong to cylindrical; terminal bud 10–15 mm long; lateral buds ovoid-acute, smaller, not resinous. Fascicle sheaths up to 20 mm long, persistent but reduced to 10–15 mm length, dark red-brown to blackish. Leaves in fascicles of 3(–4), persisting 2–3 years, rigid, straight, (15–)18–25(–30) cm long, 1–1.5(–1.7) mm wide, with serrulate margins, acute-pungent, lustrous (yellowish) green or glaucous green. Stomata on all faces of the leaves. Pollen cones ovoid-oblong to cylindrical, 1.5–2.5 cm × 8 mm when shedding pollen, yellowish. Seed cones subterminal, solitary or more commonly in whorls of 2–4 on short, stout, curved and tenacious peduncles. Mature cones ovoid, slightly curved or asymmetrical, 5–8(–10) × 3.5–6(–7) cm when open, but semi-serotinous (only partially opening), leaving some basal scales on branch when falling. Seed scales thick woody, oblong, almost straight, symmetrical. Apophyses on one side of cone nearly flat to slightly raised, on other (outer) side slightly more pronounced, these transversely keeled, rhombic to pentagonal in outline, lustrous ochraceous or light brown. Umbo dorsal, flat or depressed, with a minute, deciduous prickle. Seeds obovoid, 4–6 mm long, dark brown to grey-black; wings 14–18 × 6–8 mm, translucent, light brown.

Distribution

Mexico: Michoacán, México, Morelos, Guerrero and Oaxaca, perhaps in W Puebla.
TDWG codes: 79 MXC-ME MXC-MO MXS-GR MXS-MI MXS-OA

Ecology

This is a pine of the montane, mesic forests of the Sierra Madre del Sur and parts of the 'Eje Volcánico Transversal', where it is growing between 1500–2600(–2800) m a.s.l. This region has a subtropical to warm temperate climate; annual precipitation varies between 1000–2000 mm, mainly occurring in summer storms from June through September. It is a constituent of pine and pine-oak forests; associated pines include *Pinus douglasiana, P. maximinoi, P. pseudostrobus, P. oocarpa*, and *P. patula*. On drier sites, often in degraded or secondary forest, *P. lawsonii* and *P. devoniana* are more commonly growing with *P. pringlei*; in both forest types *Quercus* spp. are often (co-)dominant. Dvorak & Donahue (1992) report a grass stage of the seedlings of *P. pringlei*.

Conservation

IUCN: LC

Uses

This species is reported to have dense wood and is used for lumber; the resin is also tapped commercially. It is not known to be in horticultural use.

Pinus pseudostrobus Lindl., Edwards's Bot. Reg. 25: 63. Aug 1839. [Allg. Gartenzeitung 7: 325. 1839].
Pl. 33

Etymology

The species epithet refers to its (superficial) similarity with *P. strobus*.

Vernacular names

Smooth-bark Mexican pine, False Weymouth pine; pino blanco, pino chalmaite, pino lacio, pino liso (Spanish)

Description

Trees to 40(–45) m tall, d.b.h. to 1 m; trunk monopodial, erect. Bark thick, scaly, with elongated plates and deep, longitudinal fissures, dark brown to grey-brown. Branches spreading or ascending; lower branches curved down; upper branches ascending. Shoots slender, smooth, glaucous or pruinose. Cataphylls 10–15 mm long, subulate-caudate, soon

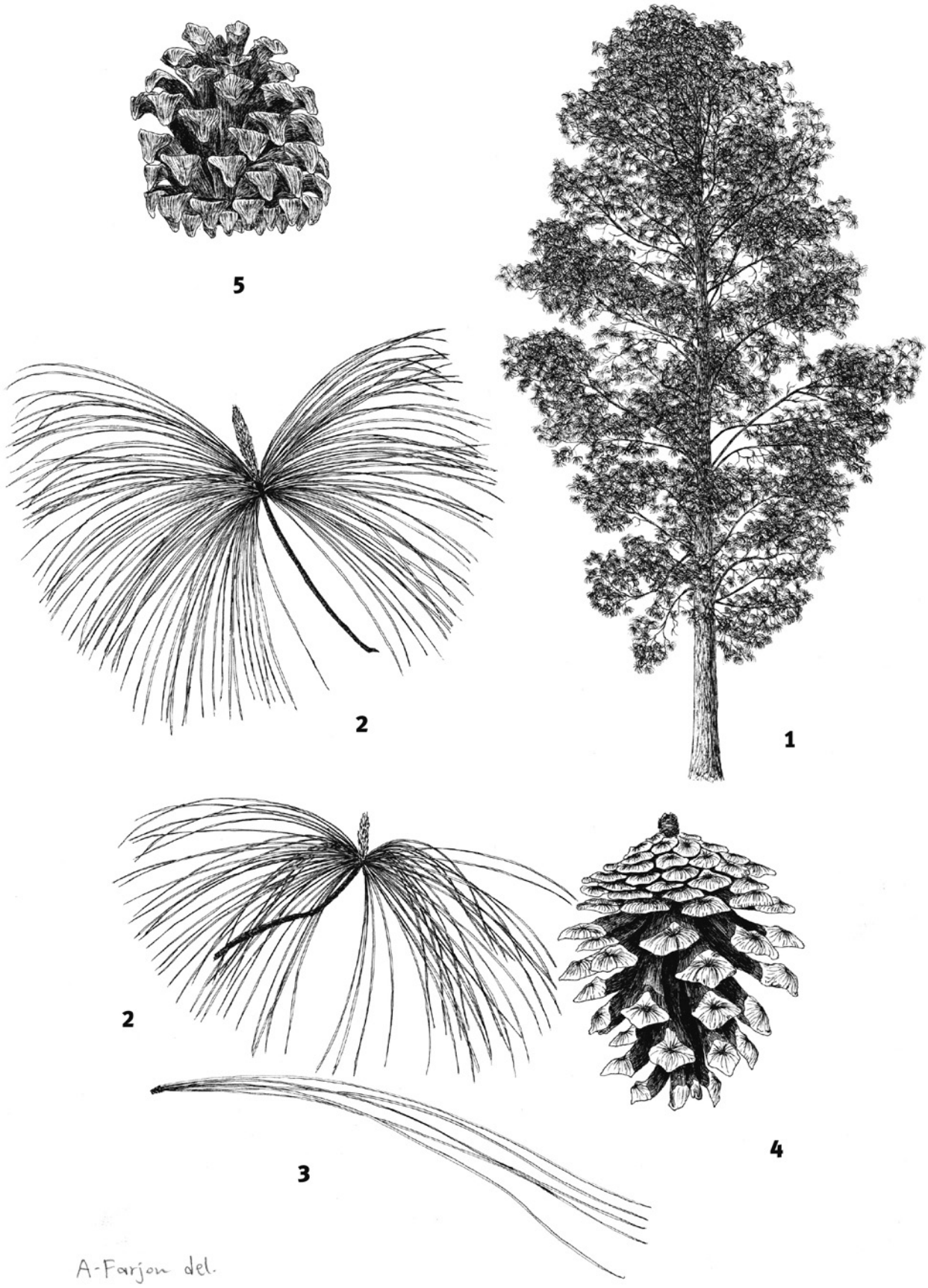

PLATE 33. *Pinus pseudostrobus.* **1.** Habit of tree. **2.** Branchlets with foliage. **3.** Leaves. **4.** Seed cone (var. *pseudostrobus*). **5.** Seed cone (var. *apulcensis*).

recurved, reddish brown to dark brown. Vegetative buds ovoid-conical, acute; terminal bud 15–20 × 10–15 mm; lateral buds smaller, not resinous. Fascicle sheaths (15–)20–30(–35) mm long, persistent, lustrous red-brown, weathering grey-brown. Leaves in fascicles of 5, rarely 4 or 6, persisting 2–3 years, slender, straight, spreading or drooping, usually lax, (18–)20–30(–35) cm long, 0.8–1.3 mm wide, with serrulate margins, acute, (light) green or glaucous green. Stomata on all faces of leaves. Pollen cones ovoid-oblong to cylindrical, 20–35 × 5–7 mm, purplish- or pinkish yellow. Seed cones subterminal, solitary or in pairs, more rarely in whorls of 3–4 on very short, stout peduncles remaining with a few cone scales on branch when cone has fallen. Mature cones more or less asymmetrical, often curved at base, ovoid-oblong to broadly ovoid when opened, then 7–16 × 6–13 cm. Seed scales usually thick woody, oblong, straight or slightly curved. Apophyses extremely variable, from nearly flat to elongated, more so on one side of cone and towards base, transversely keeled, tapering to an obtuse umbo (or umbo mucronate), rhombic or pentagonal in outline, upper margin angular, irregularly undulate, or rounded; colour in various hues of brown. Umbo dorsal, variable, from obtuse to prominent, 3–15 mm long, without a prickle or prickle deciduous. Seeds 5–7 × 3–4.5 mm, ochraceous to grey-brown, with or without dark spots; wings obliquely-ovate, with a straight side, 20–25 × 7–10 mm, yellowish brown.

Distribution

Mexico: Sinaloa-Durango border, Nuevo León, SE Coahuila, E Guanajuato(?), Jalisco, Michoacán, México, Distrito Federal, Morelos, Hidalgo, Puebla, Tlaxcala, W Central Veracruz, Guerrero, Oaxaca, Chiapas; Guatemala (highlands); W Honduras; N El Salvador.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-AG MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-SI MXN-SO MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 ELS GUA HON

Ecology

This is a widely distributed and in many places common or abundant pine of montane to high montane habitat in cold-temperate to warm-temperate zones. Its altitudinal range is considerable, but differs little along the entire 2500 km of its range: (850–)1900–3000(–3250) m a.s.l. Annual precipitation is also variable, but with a minimum of ca. 800 mm, in Guatemala and Honduras it can be over 2000 mm. Throughout its range it is an important constituent of mixed conifer pine and pine-oak forests, occasionally associated with *Liquidambar*, as on wet E slopes on the Gulf coast side of the mountains of Central and S Mexico. In the many disturbed forests it may survive as scattered groves or as individual trees, often with an understorey of e.g. *Gaultheria, Cassia* or, when associated with fire, grasses and/or *Pteridium aquilinum*. In its driest habitat in Central and NE Mexico it occurs with *P. cembroides, Juniperus flaccida*, and *Quercus* and an understorey with e.g. *Agave, Buddleja, Opuntia*, and *Salvia*, probably mostly in secondary forest.

Uses

Pinus pseudostrobus is one of the most common and important 'hard pines' in the southern half of Mexico and the highlands of Guatemala and parts of Honduras. Its wood is light yellowish in colour, light weight (specific gravity 0.45), strong, with long intervals of knot-free wood which is only slightly resinous. Exploitation for timber is widespread and has led to regional depletion of the best stands. The wood is used for light construction, carpentry and joinery, wall panelling, veneers, boxes and containers, matches, and wood pulp. In Mexico, this species is also used as a source of resin. This tree has been widely planted for forestry in Africa and to a lesser extent in India; in horticulture its is rare and generally only suitable in regions with a mild climate.

2 varieties are recognized:

Pinus pseudostrobus Lindl. var. ***pseudostrobus***.
Type: Mexico: Michoacan, Angangueo,
C. T. Hartweg s.n. (lectotype P).

Pinus pseudostrobus Lindl. var. *estevezii* Martínez, Anales Inst. Biol. Univ. Nac. México 16: 188. 1945; *Pinus estevezii* (Martínez) J. P. Perry, J. Arnold Arbor. 63: 187. 1982.

Pinus pseudostrobus Lindl. var. *apulcensis* (Lindl.) Martínez, Anales Inst. Biol. Univ. Nac. México 16: 192. 1945, *non* Shaw (1909); *Pinus pseudostrobus* Lindl. subsp. *apulcensis* (Lindl.) Stead, J. Linn. Soc., Bot. 89: 269. 1984, *excl. typus*.
Pinus nubicola J. P. Perry, J. Arnold Arbor. 68: 447. 1987.
Pinus pseudostrobus Lindl. var. *laubenfelsii* Silba, Phytologia 68: 60. 1990.
Pinus yecorensis Debreczy & Rácz, Phytologia 78 (3): 15. 1995.
Pinus yecorensis Debreczy & Rácz var. *sinaloensis* Debreczy & Rácz, Phytologia 78 (3): 18. 1995.

Description

Apophysis variable, from nearly flat to prominently raised, more so on one side of cone and towards base, transversely keeled, tapering to an obtuse umbo, rhombic or pentagonal in outline; upper margin angular, irregularly undulate, or rounded; colour in various hues of brown. Umbo dorsal, obtuse, 3–6 mm long, 4–6 mm wide at base, without a prickle or prickle deciduous, usually darker than the apophysis.

Distribution

Mexico; Guatemala; Honduras; N El Salvador.
TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-CO MXE-DU MXE-HI MXE-NL MXG-VC MXN-SI MXS-GR MXS-JA MXS-MI MXS-OA MXT-CI 80 ELS GUA HON

Conservation

IUCN: LC

Pinus pseudostrobus Lindl. var. ***apulcensis*** (Lindl.) Shaw, [Pines Mexico] Publ. Arnold Arbor. 1: 19, t. 12, f. 6–8. 1909. *Pinus apulcensis* Lindl., Edwards's Bot. Reg. 25: 63. Aug 1839. [Allg. Gartenzeitung 7: 325. 1839]. Type: Mexico: Hidalgo, Apulco, *C. T. Hartweg s.n.* (lectotype W (cone), isolectotype GH).

Pinus oaxacana Mirov, Madroño 14: 145. 1958; *Pinus pseudostrobus* Lindl. var. *oaxacana* (Mirov) S. G. Harrison, Taxon 14 (7): 247. 1965.
Pinus oaxacana Mirov var. *diversiformis* Debreczy & Rácz, Phytologia 78 (3): 19. 1995.

Description

Apophysis variable, prominently raised and partly elongated, especially on one side of cone and towards base, transversely keeled, rhombic or pentagonal in outline; upper margin angular, irregularly undulate, or rounded; colour in various hues of brown. Umbo dorsal, prominent and/or elongated, 5–15 mm long, 5–10 mm wide at base, without a prickle, usually darker than the apophysis.

Taxonomic notes

For a taxonomic assessment and the correct application of this infraspecific name and its synonyms, see Farjon (1995) and Farjon & Styles (1997).

Distribution

Mexico: México, Hidalgo, Puebla, Tlaxcala, W Central Veracruz, Guerrero, Oaxaca and Chiapas; also in the Guatemala highlands and in N El Salvador.
TDWG codes: 79 MXC-ME MXC-PU MXC-TL MXE-HI MXG-VC MXS-GR MXS-OA MXT-CI 80 ELS GUA

Conservation

IUCN: LC

Pinus pumila (Pall.) Regel, in Kuester & al., Index Sem. Hort. Bot. Imp. Petrop. 1858: 23. 1859. *Pinus cembra* L. var. *pumila* Pall., Fl. Ross. 1 (1): 5, t. 2, f. F-I. 1784. Type: Illustration in Pallas, Fl. Ross. 1 (1): t. 2, f. F-I. 1784 (lectotype, designated here).

Etymology

The species epithet means 'dwarfish' or 'low' growing and refers to its habit.

Vernacular names

Dwarf Siberian pine; Kiedrovnik (Russian)

Description

Prostrate or spreading, sometimes erect shrubs 1–4(–6) m tall, with layering branches and often forming extensive thickets; rooted new stems ascending or assurgent. Bark thin, smooth, flaking on larger stems, grey-brown. Foliage branches slender, flexible, not breaking easily, new shoots at first densely pubescent, later glabrous, initially grey-green or brown, turning darker red-brown in the second or third year, weathering grey-brown. Buds ovoid-conical, to 10 mm long, acute, resinous; cataphylls reddish brown. Leaves crowded in dense tufts at end of shoots, persisting 3–4 years, in fascicles of 5 with a deciduous basal sheath, 4–7(–8) cm long, more or less rigid, spreading but curved forward, ca. 1 mm wide, trapezoid in cross-section; margins minutely serrulate; leaf colour green abaxially, glaucous green adaxially; stomata on the two adaxial faces in white lines. Pollen cones crowded, spirally arranged, ovoid-ellipsoid, conspicuously red-purple before anthesis. Seed cones solitary or in whorls of 2–4, short pedunculate or sessile, semi-persistent, remaining closed or the scales parting only slightly, 3–5 cm long, ovoid to barrel-shaped, 2.5–3 cm wide, green turning brown, resinous. Seed scales imbricate, rhombic to obovate, with 2 deep seed cavities adaxially; apophyses broadly triangular, thickened, longitudinally striated or grooved, distal margins slightly upturned; umbo (sub)terminal, distinct, dark purple turning black. Seeds relatively large, 7–10 mm long, obovoid, 5–7 mm wide, somewhat angular or with a ridged abaxial margin, dark brown and wingless, remaining inside cone.

Distribution

N Mongolia; Russian Federation: E Siberia, Russian Far East (including islands); China: Inner Mongolia, Manchuria (scattered); North & South Korea; Japan: Hokkaido, N Honshu.

TDWG codes: 30 BRY CTA IRK YAK 31 36 CHI-NM CHM 37 MON 38 JAP-HK JAP-HN KOR-NK KOR-SK

Ecology

This is a pine well adapted to the extreme climate which prevails above the line of forests of *Pinus sylveslris* in the southern part of its range, while it replaces *Larix gmelinii* or birch forests at high altitude in the northern regions. It can be found scattered in the understorey of these forests, too. Especially on exposed mountain slopes close to the summer snow-line it forms extensive, dense thickets. In Japan the Dwarf Siberian pine occurs from 1400 m to 3200 m a.s.l., but on the Kamchatka Peninsula it is found from sea level up to 1200 m in favorable localities. Its seeds are distributed by birds in the family *Corvidae*.

Conservation

IUCN: LC

Uses

Dwarf Siberian pine is of little economic value. Its wood is of small, contorted size and shape and only good for firewood in a region where there is plenty of this commodity of better quality. The seeds are edible, but difficult to harvest and mostly left to birds, rodents and bears. In horticulture it is rarely met with and mostly confined to botanic gardens and arboreta, although in Russia and northern Japan it is also planted in some parks, road reservations and other amenity spaces. It should be a good species for rock gardens in countries with cold winters.

Pinus pungens Lamb., Ann. Bot. (König & Sims) 2: 198. 1805. Type not designated. Fig. 245

Etymology

The species epithet means 'prickly' and refers to the sharp spines on the umbos of the cone scales.

Vernacular names

Table Mountain pine, Prickly pine, Hickory pine

Description

Small trees to 12–15 m tall; trunk to 60 cm d.b.h., straight or crooked. Bark rough and scaly, breaking into irregular plates, reddish brown or grey-brown. Branches sparse, spreading widely, persistent, usually forming a wide, flat-topped crown. Foliage branches spreading and assurging, slender, rough with pulvini

from fallen leaf fascicles, glabrous, yellowish green turning yellowish brown to darker reddish brown. Buds ovoid to short cylindric, up to 10 mm long, resinous, red-brown. Leaves in fascicles of 2, occasionally 3, held by a short, persistant basal sheath, spreading, persisting 3 years, (3–)5–7(–8) cm long, straight or more or less contorted, rigid, 1–1.5 mm wide, often twisted, green; margins serrulate; apex acute to short acuminate; stomata in fine lines on all surfaces. Pollen cones in dense clusters, spirally arranged, ca, 1.5 cm long, conspicuously red when growing, turning yellow with the swelling of pollen sacs and ripening of pollen. Seed cones lateral on branches, rarely solitary, usually in whorls of 3–6, sometimes more, nearly sessile or on short peduncles, long persistent, variously serotinous but eventually opening, asymmetrically ovoid-conical, 5–10 cm long, 4–6 cm wide, opening widest near base to 8 cm. Seed scales thick woody, cuneate from base; apophyses prominently raised, diamond-shaped at mid-cone, conical and recurved near base, transversely keeled, largest on sun-exposed side of cone, orange-brown or yellowish brown; umbo dorsal and nearly central, stout and armed with a dark, sharp spine. Seeds obovoid, somewhat angular and flattened, 5–6 mm long, blackish brown; wing 15–25(–30) mm long, brown.

Distribution

E USA: Appalachian Mts. and some outliers, mainly in the Piedmont.

TDWG codes: 75 PEN WVA 78 GEO MRY NCA SCA TEN VRG

Ecology

Pinus pungens is found in the Appalachian Mountains from the foothills to the crests, it becomes the dominant or single species of pine above 1300 m a.s.l. in the southern part of its range. It grows on a variety of soils, but is absent from limestone derived substrates. In the surrounding broad-leaved forests it is restricted to outcrops or ridges of exposed rock. Precipitation levels vary from north to south and with altitude between 760 mm and 2100 mm annually; summers are cool to warm while winters are moderately cold and wet. This pine is a pioneer species, able to take advantage of sudden environmental changes, e.g. disturbance by forest fire; it invades abandoned agricultural fields in many areas. In well established stands in the mountains it is often mixed with *Pinus rigida* or *P. virginiana* (at lower altitudes) and the angiosperms *Acer rubrum, Nyssa sylvatica, Quercus prinus, Q. coccinea, Q. velutina, Castanea dentata*, and *Oxydendrum arboreum*. Several species of *Rhododendron, Vaccinium, Gaylussacia*, and *Kalmia latifolia, Ilex montana* and *Smilax glauca* often form a dense understorey in stands of *Pinus pungens* on steep mountain slopes.

Conservation

IUCN: LC

Uses

Table mountain pine is of low value as a timber tree due to small size and 'poor' form, with crooked stems and long branches. Pulpwood and firewood are the only uses commonly cited to have any commercial value. Its worth to society is more of an ecological kind, as protective forest cover on unstable, shallow rocky soils on mountain slopes and as habitat for wildlife. This species is not often seen in cultivation as it does not make a shapely tree; its gnarled form on rocky outcrops in nature can be very picturesque and reminiscent of Chinese or Japanese landscape paintings. It is restricted to botanic gardens and arboreta in Europe and North America.

Pinus quadrifolia Parl. *ex* Sudw., U.S.D.A. Div. Forest. Bull. 14: 17. 1897. *Pinus cembroides* Zucc. var. *quadrifolia* (Parl. *ex* Sudw.) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 29. 2000. Type: USA: California, San Diego Co., "mountains E of San Diego"(Boundary Survey under direction of major W. H. Emory), *C. C. Parry 1390* (holotype US).
Fig. 246

Pinus juarezensis Lanner, Southw. Naturalist 19 (1): 77. 1974; *Pinus cembroides* Zucc. var. *juarezensis* (Lanner) Silba, Phytologia 68: 48. 1990.

Etymology

The species epithet refers to the common number of four leaves in a fascicle.

Vernacular names

Parry pinyon, Nut pine; piñon (Spanish)

Description

Trees or large shrubs to 10–15 m tall, d.b.h. to 30–50 cm; trunk short, erect, low branched or with a short, clear bole. Bark thick, rough and scaly, with deep lateral and longitudinal fissures, reddish brown; outer bark weathering grey. Branches spreading or ascending, the higher order branches slender, spreading or assurgent; crown rounded, becoming wide and open in old trees. Shoots stout, rough with short decurrent pulvini and small cataphylls. Vegetative buds ovoid-conical; terminal bud 6–10 × 4–5 mm; lateral buds acute, orange-brown, slightly resinous. Fascicle sheaths initially 5–8 mm long, soon breaking up in recurving but early falling scales (not or rarely forming rosettes). Leaves in fascicles of (3–)4(–5), rarely a few fascicles 2 or 6; fascicles persisting (3–)4–7 years; leaves curved or sometimes straight, rigid, often connivent for some time, (1.5–)2–4(–5) cm long, (0.8–)1–1.5(–1.7) mm wide, entire, acute-pungent, dull or lustrous grey-green to glaucous green, with whitish stomatal bands. Stomata in two bands on adaxial faces. Pollen cones ovoid-globose to short cylindrical, ca. 10 mm long, purplish red, turning yellowish. Seed cones solitary or in whorls of 2–4 on short, slender peduncles falling with cones. Mature cones ovoid-globose to globose when closed, irregular when opened, 4–6 × 4.5–7 cm when open. Seed scales parting widely, moveable, irregular, concavo-convex, with 1–2 deep seed. Apophysis thick woody, raised, pyramidal or obtuse conical, transversely keeled, recurved or straight, ochraceous to yellowish brown or reddish brown, often resinous. Umbo dorsal, flat or obtuse-pyramidal, centrally indented. Seeds obliquely obovoid or elliptic, 12–18 × 8–12 mm; integument thin (0.3–0.5 mm); megagametophyte ('endosperm') white. Seed wings rudimentary on the scale, absent from the developed, free seed.

Distribution

USA: California (Riverside and San Diego Co.); Mexico: Baja California Norte.
TDWG codes: 76 CAL 79 MXN-BC

Ecology

The altitudinal range of *Pinus quadrifolia* is 900–2400(–2700) m a.s.l. It grows between the semi-desert and the chaparral scrub zones (and partly within the latter) and the mixed coniferous forest on the highest parts of the mountains. It is more widely distributed and often more common than *P. monophylla* in the Pinyon-Juniper woodland, but occurs often with it. *Pinus jeffreyi* is the only other pine with which it occurs in Mexico. *Juniperus californica* and *Quercus turbinella* are common; in the chaparral zone many shrubs, e.g. *Adenostoma, Ceanothus, Artemisia, Cercocarpus, Rhus, Eriodictyon, Arctostaphylos*, and *Yucca*, dominate. Most of these mountains are granitic, but in the south of the ranges more volcanic rock is found. *Pinus quadrifolia* often grows in cracks among boulders. Annual precipitation is a moderate 300–500 mm, but it is very variable; most of it comes during winter cyclonic storms and there is a long dry season from spring through summer.

Conservation

IUCN: LC

Uses

There is no use of this species for timber. It is locally used for firewood. The seeds are edible and are harvested to be sold in local markets. Resin may be tapped on a small scale as well. It is not in cultivation outside a few botanic gardens and other collections; it should be suitable in regions with hot, dry summers and can endure frost and snow if not for prolonged time and of high altitude provenance.

Pinus radiata D. Don, Trans. Linn. Soc. London 17: 442. 1836.

Etymology

The species epithet is said to refer to the radial markings on the apophyses of some cones.

Vernacular names

Monterey pine, Radiata pine; pino insigne (Spanish)

Description

Trees to 20–25(–33) m tall, d.b.h. to 2–2.2 m; trunk monopodial, often branched or forked near the ground. Bark thick, rough and scaly, deeply fissured vertically and horizontally, dark brown, weathering blackish grey. Branches spreading or ascending, forming a dense, flat-topped or bushy crown. Shoots multi-nodal, rough with prominent, decurrent pulvini and 5–10 mm long cataphylls. Vegetative buds ovoid-acute; terminal bud 10–15 mm long; lateral budss smaller, all not resinous, orange-brown. Fascicle sheaths initially to 15 mm long, orange-brown, later 5–8 mm long, dark brown, persistent. Leaves in fascicles of 2–3 (rarely 4 or 5), persisting ca. 3 years, straight or curved to twisted, rigid, 8–15 cm long, 1.1–1.6 mm wide, with serrulate margins, acute-pungent, bright green or dark green. Stomata on all faces of leaves. Pollen cones oblong to cylindrical, 1.5–2 cm long, pink to reddish, turning yellowish brown. Seed cones usually in whorls of 2–5, sometimes solitary, on short, stout peduncles, very tenacious, serotinous. Mature cones ovoid, nearly symmetrical or asymmetrical with an oblique base, (5–)7–12(–15) × (4–)6–10(–12) cm when open. Seed scales parting after a considerable time or only after extreme heating, oblong, straight, thick woody. Apophysis slightly raised, transversely keeled, or gibbous especially towards base on one side of asymmetrical cones, rhombic to weakly pentagonal in outline, with radial lines or markings, lustrous light brown. Umbo dorsal, flat or depressed, without a prickle. Seeds obliquely ovoid, (5–)7–10 × 4–6 mm, grey-brown with dark spots. Seed wings 14–20 × 7–10 mm, yellowish brown, with grey-brown stripes.

Distribution

USA: California, Pacific coast in three localities from Monterey southward; Mexico: Baja California Norte (Cedros Island, Guadalupe Island).
TDWG codes: 76 CAL 79 MXI-GU MXN-BC

Ecology

Pinus radiata is in its natural habitat confined to promontories and strips of rocky coast as well as two offshore islands; it is rarely found more than 11 km from the sea. The cold ocean water moving down the Californian coast substantially influences the local climate, raising humidity, tempering heat from the sun and causing almost daily summer fogs. On a rare clear day in summer temperatures can quickly rise to 40° C, coming down to only 15° C on the next foggy day. On Guadalupe Island, which lies ca. 250 km offshore surrounded by deep, cold water, fog is nearly perpetual during the growing season. Rain fall is erratic, fog drip provides most of the moisture to the soil and the trees. On the islands the species does not grow below 300 m and ascends to the summit ridges at 1100 m a.s.l. on Guadalupe Island, but on the mainland it grows from sea level to the base of inland hills and does not exceed 400 m a.s.l. The island populations form pure stands with some undergrowth of *Quercus tomentella* (Guadalupe Island) or *Juniperus californica* (Cedros Island). On the mainland it forms pure stands or mixed stands with *Cupressus macrocarpa, Pinus attenuata* (both like *P. radiata* with serotinous cones adapted to fire), *Arbutus menziesii*, and *Quercus agrifolia*. In the absence of fire, *Pseudotsuga menziesii* establishes itself, especially in the southernmost population at Año Nuevo, and would become dominant to the exclusion of *P. radiata*. In stands with *Cupressus macrocarpa* there is very little or no undergrowth.

Uses

Radiata pine, as it is now commonly called among foresters internationally, is the most widely planted tree species in the world. Its tiny natural relict stands fall into insignificance to the millions of hectares planted in Australia, New Zealand, Chile, Argentina, Uruguay, South Africa, Kenya, and Spain. Provenance is almost exclusively from mainland California. Its spectacularly rapid growth under plantation conditions is the main reason for its success in commercial forestry and for many of the above mentioned countries it is the most important timber tree. The wood is rather brittle and coarse grained and most suitable for pulp wood, but in many countries where it has been introduced it is also put to other uses. These are e.g. construction, carpentry and joinery, veneers, furniture, laminated wood, and crates and boxes. This species has been widely planted as a landscape tree in urban areas, parks and large gardens, where it can grow to huge size in relatively short time. It is a very suitable tree to form a living screen against wind and traffic noise and tolerates relatively high levels of air pollution.

2 varieties are recognized:

Pinus radiata D. Don var. ***radiata***. Type: USA: California, Monterey, near the coast, *J. Coulter* (type specimen not located, a seed cone).

Description

Leaves in fascicles of 3, rarely 2. Seed cones (7–)9–15 cm long, usually strongly asymmetrical.

Distribution

USA: California (Monterey, San Luis Obispo, San Mateo & Santa Cruz Counties).
TDWG codes: 76 CAL

Conservation

The total area of occupancy (AOO) of *Pinus radiata* var. *radiata* has been reduced to about 50% of the ca. 10,000 ha estimated to have been covered by it on the arrival of Europeans in California. The current main, but still minor threat to this variety is forest succession, particularly in the southernmost population. *Pinus radiata* var. *radiata* has extended it range there in recent decades, but succession to a forest type that eventually excludes this pine is also taking place in the absence of fire. Urbanisation interferes with the natural fire cycles which favour regeneration of *P. radiata* var. *radiata*. The (genetic) distinction between natural and semi-natural occurrence is also blurred by plantings in this and other areas. The accidental introduction of pitch canker in 1986 (*Fusarium circinatum* [anamorph] *Ascomycetes*) poses another recent threat; in some stands 80–90% of trees are infected.
IUCN: CR [B2ab (ii, iii)]

Pinus radiata D. Don var. ***binata*** (Engelm.) Lemmon, Handb. W. Amer. Cone-bearers, ed. 3: 42. 1895. *Pinus insignis* Douglas *ex* Loudon var. *binata* Engelm., in Watson, Bot. California 2: 127–128. 1880; *Pinus radiata* D. Don subsp. *binata* (Engelm.) E. Murray, Kalmia 13: 24. 1983. Type: Mexico: Baja California Norte, Guadalupe Island, *E. J. Palmer s.n.* (holotype MO).

Pinus muricata D. Don var. *cedrosensis* J. T. Howell, Leafl. W. Bot. 3: 7. 1941; *Pinus radiata* D. Don var. *cedrosensis* (J. T. Howell) Silba, Phytologia 68: 60. 1990.

Description

Leaves in fascicles of 2(–3 on leading shoots). Seed cones (5–)6.5–9(–13) cm long, moderately asymmetrical.

Distribution

Mexico: Baja California Norte (Cedros Island, Guadalupe Island).
TDWG codes: 79 MXI-GU MXN-BC

Conservation

This variety, confined to two islands, was until very recently under serious threat from feral goats on Guadalupe Island, which is almost uninhabited. It is estimated that only 250 (over-)mature trees remain there and reproduction is scarce. Total eradication of goats appears to be difficult, but apparently has been achieved recently. Exclosures to keep goats out of some of the most sensitive areas have been realized with help from outside and this has helped establishment of several hundred pine seedlings. *Pinus radiata* var. *binata* does better on Cedros Island which has (had) no feral goats. It is hoped that with the removal of goats on Guadalupe Island the population will increase in future.
IUCN: VU (D2)

Pinus remota (Little) D. K. Bailey & Hawksw., Phytologia 44: 129. 1979. *Pinus cembroides* Zucc. var. *remota* Little, Wrightia 3: 183. 1966. Type: USA: Texas, Val Verde Co., 48 km N of Del Rio, 21 km S of Loma Alta, on "cedar brake", *E. L. Little & D. S. Correll 18991* (holotype US).

Pinus catarinae Rob.-Pass., Bull. Mus. Hist. Nat. (Paris), ser. B, Adansonia 1: 70. 1981.

Etymology

The species epithet refers to the relatively large distance between leaf fascicles.

Vernacular names

Texas pinyon pine, Nut pine; piñon (Spanish)

Description

Small trees or shrubs to 3–9 m tall, d.b.h. to 15–40 cm; trunk short, contorted, soon branching. Bark thick, rough and scaly, exfoliating with thin, scaly plates, in old trees on lower part of trunk longitudinally furrowed, grey to blackish grey. Branches spreading or ascending, the ultimate branches stout, assurgent. Shoots rough with prominent, non-decurrent pulvini, which leave circular scars after fascicles have fallen. Cataphylls ca. 5 mm long, subulate, reflexed, grey. Vegetative buds ovoid to ovoid-cylindric; terminal bud 5–7 mm long; lateral buds shorter, acute, not resinous or sometimes slightly resinous. Fascicle sheaths initially ca. 5 mm long, soon caducous, not recoiling to form a rosette. Leaves in fascicles of 2(–3), persisting 4–5 years, slightly curved to falcate, rigid, (2–)3–4.5(–5.5) cm long, 0.8–1.1 mm wide; margins entire; apex acute-acuminate; abaxial face dull light green or yellowish green; adaxial face(s) slightly glaucous, with inconspicuous whitish stomatal lines. Stomata on all faces of the leaves. Pollen cones subglobose to ovoid, 4–5 mm long, pink or purplish, turning light yellow. Seed cones solitary or sometimes in pairs on 5–8 mm long, slender, curved peduncles, maturing in two years. Mature cones subglobose or globose when closed, (2–)2.5–4 × 3–6 cm when open. Seed scales parting widely; basal scales remaining connate; all scales loosely attached to the rachis, irregularly shaped, concavo-convex, with incurved margins and 1–2 deep seed cavities. Apophysis prominently raised, transversely or radially keeled, irregularly rhombic to pentagonal in outline; upper margin angular and irregular; colour (lustrous) light brown to reddish brown. Umbo dorsal, flat or indented, with a minute, deciduous prickle. Seeds obovoid-angular or ellipsoidal, 12–16 × 8–10 mm, light ochraceous with a grey tinge; integument very thin, 0.1–0.4 mm; megagametophyte ('endosperm') white. Seed wings vestigial, remnants remain on the scale when the seeds are dispersed.

Distribution

Mexico: NE and SE Chihuahua, Coahuila, and extreme W Nuevo León; USA: Texas (Edwards Plateau, W Texas along the Rio Grande).
TDWG codes: 77 TEX 79 MXE-CO MXE-CU MXE-NL

Ecology

The populations of *Pinus remota* are almost all highly disjunct; the species has obviously retreated to isolated mountains. Its altitudinal range is 1200–1600(–1850) m a.s.l. (on the Edwards Plateau in Texas it occurs considerably lower, the type collection is from 450 m). It is restricted to canyons or rocky mountain slopes, often on calcareous soil or limestone rock, on dry sites where Pinyon-Juniper woodland is not well developed and the pines often remain shrubby. Annual precipitation ranges from 300–500 mm, but is extremely variable from year to year. Frost is common in December and January. This species occasionally occurs with *P. cembroides* and more rarely with *P. arizonica* var. *stormiae*, common are *Juniperus monosperma* and *J. ashei* (in the northern part of the range), *Quercus, Cercocarpus* and semi-desert plants e.g. *Agave lecheguilla, Opuntia* and *Fouquieria splendens*.

Conservation

IUCN: LC

Uses

Any use of this species (firewood, edible seeds) is probably incidental or at most on a very small scale due to its scattered occurrence in often remote places. The edible seeds are harvested and sold with those of other pinyons. It is not known to be in cultivation outside a few botanic gardens, but should be well adapted to gardens with a dry, hot summer.

Pinus resinosa Aiton, Hort. Kew. 3: 367. 1789. Type not designated.

Etymology

The species epithet means 'resinous'.

Vernacular names

Red pine, Norway pine; pin rouge (French)

Description

Trees to 37 m tall; trunk to 1.5 m d.b.h., straight, shorter and with heavy branches in solitary trees. Bark on young trees and in crown of older trees thin, orange-brown, on trunk becoming thick and breaking into irregularly shaped but wide, elongated, scaly, reddish brown plates divided by grey-brown fissures. Branches spreading wide, forming a rounded crown. Foliage branches moderately slender, new shoots to 1 cm thick, light orange-brown or red-brown, turning darker brown, rough with pulvini from fallen leaf fascicles. Buds ovoid to cylindrical; terminal bud to 20 mm long, resinous; cataphylls red-brown, fringed, some free at the apex. Leaves in fascicles of 2, held in a basal sheath initially 15–20 mm long, but eroding to basal part of only 5–6 mm length, persisting 3–4 years, straight or curved, 12–18 cm long, slightly twisted, brittle, breaking easily, ca. 1.2 mm wide, dark green; margins minutely serrulate; apex abruptly acute; stomata in fine lines on all surfaces. Pollen cones clustered at base of new shoots, spirally arranged, ovoid-oblong, 1.5 cm long, conspicuously red or purple to dark purple, turning dark brown shortly before they fall. Seed cones solitary or in pairs, nearly sessile, falling without the short peduncle and often leaving a few basal scales behind, 4–6 cm long, narrowly ovoid-conical when closed, symmetric or slightly asymmetric at base, opening soon after maturation to a broadly ovoid or sub-globose shape with a more or less level base. Seed scales thin woody, rigid, oblong, dark brown; apophyses slightly raised, transversely keeled, sometimes more pronounced on exposed side of cone near base; umbo central, flat or depressed, unarmed or with a minute, deciduous prickle. Seeds ovoid, 4–5 mm long, slightly flattened, rugose, brown; wing 15–20 mm long, narrow, pale brown.

Distribution

E North America, from Newfoundland and West Virginia westward to Manitoba and Minnesota.

TDWG codes: 71 MAN 72 NBR NFL-NE NSC ONT QUE 74 ILL MIN WIS 75 CNT MAI MAS MIC NWH NWJ NWY PEN VER WVA

Ecology

Pinus resinosa is a species of pine occupying the northeastern mixed conifer-deciduous broad-leaved forest bordering on the boreal conifer forest at its northern limit. This area was heavily glaciated during the last Ice Age and the glaciers left huge deposits of sand, some of which in post glacial time was blown into sand dunes. It is to these sands that this pine is largely confined, as here it can successfully compete with other trees. Another type of habitat for *P. resinosa* is swamp margins. The species avoids non-acidic soils and only grows over limestone when there is a leached, acid top layer. It is largely a lowland pine growing at altitudes between 200 m and 450 m, but ascends to 1300 m a.s.l. in the Appalachian Mountains. In the northern parts of its range it can form extensive pure stands, but more often it is growing together with *Pinus banksiana, P. strobus*, or both. *Populus* spp. are common in the sub-boreal zone, further to the south *Abies balsamifera, Acer rubrum, A. saccharum, Quercus alba, Q. rubra, Fagus grandifolia*, and *Betula papyrifera* can come into the forest, especially on more fertile soils. In mountainous areas, *Pinus rigida, P. pungens, P. virginiana*, and *Tsuga canadensis* are other conifers growing with *P. resinosa*. Where this pine is attaining good size most of the associated tree species remain lower, but in some of the broad-leaved forest types *P. resinosa* is only a minor component restricted to the poorest sites. This pine is dependent on fire for its natural reproduction and is therefore a seral species on most sites.

Conservation

IUCN: LC

Uses

Red pine is an important timber tree and is widely planted for this purpose in the NE USA and E Canada. Its other English name, Norway pine, refers to the homeland of the men who logged this pine in Minnesota, where it is the state tree. The pale reddish wood is close-grained and used mostly for pulpwood and rough construction timbers used in piling, cabin logs, posts, railway sleepers, paving

blocks, crates, and nowadays less frequently mine timbers. It is also planted for Christmas trees, which use requires pruning the branches to obtain a desired shape and density of foliage. Large tracts of dunes have been planted with this pine to stabilize blown sand and the species has been used to form shelter belts to prevent wind erosion on farmland. Red pine was introduced to Britain as early as 1756, but is there little used in amenity planting and horticulture. In the NE USA and E Canada the situation is the reverse and several cultivars, mainly dwarfed and shrub forms, have been produced for garden use.

Pinus* ×*rhaetica Brügger, Flora 47: 150. 1864. Type: Switzerland: Ober-Engadin, *K. I. Christensen CH 2–5a* (neotype C).

Etymology

The epithet refers to the Rhaetica Alps, located in E Switzerland and W Austria.

Vernacular names

none are recorded.

Description

This natural hybrid between *Pinus mugo* Turra and *Pinus sylvestris* L. differs from *P. mugo* in its habit: it is a tree, rarely a shrub. Its bark on major branches resembles that of *P. sylvestris* in being reddish brown with papery flakes, but it can also be more like *P. mugo* and greyish and persistent. Its seed cones resemble those of *P. mugo*, with strongly developed apophyses on one side, and are often more robust than those of *P. sylvestris*.

Taxonomic notes

Hybridization between *Pinus mugo* and/or its various forms and *P. sylvestris* has been described by several authors from several localities within the range of *P. mugo s. l.* and several of these hybrids have been named (Christensen, 1987; Vidaković, 1991). Probably the most common form of this is the hybrid species listed here and described in detail in Christensen (1987) and Christensen & Dar (1997).

Distribution

Europe: from Alps to western Carpathians.
TDWG codes: 11 AUT-AU CZE-CZ GER POL SWI 12 FRA-FR 13 ITA-IT

Conservation

IUCN: NE

Pinus rigida Mill., Gard. Dict., ed. 8: Pinus No. 10. 1768. Type not designated.

Etymology

The species epithet means 'rigid' or 'stiff' and refers to the stiff needles.

Vernacular names

Pitch pine, Hard pine; pin rigide (French)

Description

Trees to 30 m tall; trunk to 1 m d.b.h., straight or curved near base, shorter to 20 m in the northern part of its range. Bark thick and breaking into irregularly shaped but elongated, scaly, reddish brown plates divided by deep and long, dark fissures. Adventitious foliage shoots common on trunk; primary branches spreading and ascending, often bent to one side, poorly self pruning, forming an irregular crown. Foliage branches sparse, assurging, moderately slender, new shoots 0.5–1 cm thick, yellowish green soon turning orange-brown or red-brown, rough with pulvini from fallen leaf fascicles. Buds ovoid to cylindrical; terminal bud 15–20 mm long, resinous; cataphylls appressed, red-brown, fringed; apex cuspidate. Leaves in fascicles of 3, occasionally 2 (adventitious shoots can have dwarf shoots with 3–5 leaves), held in a basal sheath 10–15 mm long, persisting 2–3 years, straight or curved, 6–12(–15) cm long, rigid, twisted, 1.2–1.5(–2) mm wide, green; margins minutely serrulate; apex abruptly acuminate; stomata in fine lines on all surfaces. Pollen cones clustered at base of new shoots, spirally arranged, cylindric, 1.5–2 cm long, yellow. Seed cones solitary or in whorls of 2–5, nearly sessile, persistent,

variously serotinous or opening in the second year, 3–8 cm long, ovoid-conical when closed, symmetric, opening to a broadly ovoid or subglobose shape to 7 cm wide with a level or slightly convex base. Seed scales thin woody, rigid, oblong, dull brown with a red-brown sealing band; apophyses slightly raised, more or less rhombic, markedly transversely keeled, light brown or light red-brown; umbo dorsal and central, low triangular, armed with a slender, curved prickle. Seeds obliquely obovoid, 4–5(–6) mm long, slightly flattened, dark brown, mottled black or near black; wing 15–20 mm long, blackish brown. Perhaps the only pine with a (moderate) coppicing capacity.

Distribution

Extreme SE Canada (Ontario, Quebec); NE and E USA westwards to Kentucky and Ohio, southwards to South Carolina and N Georgia.
TDWG codes: 72 ONT QUE 75 CNT DEL MAI MAS NWH NWJ NWY OHI PEN RHO VER WVA 78 GEO KTY MRY NCA SCA VRG TEN

Ecology

This species occupies the cool maritime and partly mountainous NE of the USA, where it occurs from sea level in the north to nearly 1400 m in the southern Appalachians. It grows on shallow sandy or gravelly soils poor in nutrients, usually well drained, but sometimes water-logged, as in the swamps of New Jersey. It is a seral species, most commonly associated with oaks (*Quercus* spp.) or with other pines e.g. *P. virginiana, P. echinata*, or *P. pungens*. In swamp areas it grows with *Chamaecyparis thyoides*. On some sandy sea shores (e.g. at Cape Cod, Massachusetts) a decumbent, wind-swept form 1–5 m tall occurs. It is exceptional in its capacity to resprout from stumps; small tufts of adventitious foliage appear on the trunks even of healthy trees. Its ability to regrow foliage after severe damage at any stage in its development enables this species to survive fires as well as browsing of seedlings and saplings. In areas with regular occurrence of fire many trees are multi-stemmed from a basal stool.

Conservation

IUCN: LC

Uses

The wood of Pitch pine is coarse and resinous, of small or moderate size and often not straight for any considerable length except in planted and well maintained stands. It is therefore of limited commercial value, used mainly for rough construction. ['Pitch pine' in the timber trade may refer to *P. palustris* instead of this species.] The high resin content makes it decay resistant, a property which was made use of in past ship building and more recently railway sleepers. If 'destructively' distilled it yielded naval stores i.e. turpentine and related chemicals, also important in times of wooden ships. It now finds more use in charcoal burning. The adaptability of this pine to poor soil conditions makes it suitable for replanting of wasteland. It is of some interest in horticulture because of its tufts of foliage on the stem and its persistent cones, but usually confined to the arboreta and pineta of botanic gardens and private collectors, and only a few cultivars are known. Its resprouting from epicormic buds make it ideal for bonsai culture.

Pinus roxburghii Sarg., Silva N. Amer. 11: 9. 1897. Type: India: Himalaya, [locality not given], *W. Roxburgh B-W 17762* (holotype not located, isotype B-W).

Etymology

The species name commemorates William Roxburgh (1751–1815), a Scottish botanist working for the East India Company and Superindentent of the Calcutta Botanic Garden.

Vernacular names

Chir pine, Long-leaved Indian pine; Chil (Hindi); Dhup (Nepalese); Chir, Sula (Pakistan)

Description

Trees to 50–55 m tall, usually not taller than 30 m; trunk to 3 m d.b.h., usually to 1 m d.b.h., bole straight and columnar. Bark becoming thick and divided by long, deep fissures, breaking into large, elongated, scaly plates, weathering grey-brown, with

dark brown and purplish hues. Branches self-pruning, long and spreading to ascending, forming an open, domed crown in mature to old trees. Foliage branches slender or stout, pale grey or light brown, covered with leaf-like brown cataphylls remaining several years and becoming recurved at their apices. Buds small, ovoid, without resin. Leaves near ends of branchlets, persisting 1–2 years, in fascicles of 3, held together by persistent, 25–30 mm long basal sheaths, spreading and slightly drooping, 25–30(–35) cm long, pliant, slender, broadly triangular in cross-section, 1.2–1.7 mm wide; margins minutely serrulate; leaf colour bright green; apex thinly acute-acuminate; stomata in fine lines on all surfaces. Pollen cones clustered near base of new shoots, spirally arranged, ovoid-oblong, 13–15 mm long. Seed cones solitary or in whorls of 2–5 on stout branches, short peduncculate, persistent, heavy, broadly ovoid or ovoid-conical when olive green, growing to 10–15(–20) cm long, 7–12 cm wide when closed, opening only slightly after several years to 13 cm max. width. Seed scales oblong, woody and rigid; apopyses strongly developed, thick, conical, with rhombic to irregularly pentagonal bases, sharply transversely keeled, (strongly) recurved, smooth, lustrous yellowish brown or grey-brown; umbo triangular, obtuse and unarmed. Seeds obovoid, 8–12(–15) mm long, slightly flattened; wing adnate, oblique, 20–25 mm long, 8–10 mm wide, lighter brown than the seed.

Distribution

Himalaya, from Pakistan to NE India, Arunachal Pradesh (Assam, Kameng District).

TDWG codes: 36 CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

Pinus roxburghii is widespread and common in the north-south oriented outer valleys of the Himalaya and its foothills and often forms pure stands especially on dry, fire-prone slopes. Mature trees are relatively fire resistant; regeneration after destructive fires can be massive and rapid when it acts as a pioneer species. In prolonged dry seasons it may drop most of its leaves. It occurs on a variety of substrates, from deep soil to bare rocks. Its altitudinal range is from 400 m to 2300 m a.s.l., with the highest growing, scattered individuals at 2500 m. *Pinus roxburghii* is restricted to the monsoon belt with summer rains. In its higher altitudinal range this pine species is commonly mixed with *Cedrus deodara* and *Pinus wallichiana*, but occurs below the forest zone characterized by species of *Abies*. Broad-leaved trees (angiosperms) are commonly *Quercus incana, Schima wallichii* and *Rhododendron arboreum*. Towards its lower limit angiosperms become more dominant and the pines occur on rocky slopes with a northern or eastern aspect.

Conservation

While forest destruction and logging have reduced the area of occupancy (AOO) of *P. roxburghii*, it is still covering extensive areas (an estimated 0.87 million ha in India alone) and is therefore not considered to be threatened with extinction.

IUCN: LC

Uses

Chir pine is an important pine for resin production in the Himalayan region, especially in NW India. It has been the basis of the Indian naval stores industry, initiated by the Indian Forest Department under British rule in 1888 (Langenheim, 2003) to supply the British Empire with turpentine and related products. Later, it became the main source of these substances for India, but production was falling dramatically due to poor management of the forests and destructive tapping methods. In recent years these have improved under more rigorous management. Artificial camphor is the main end product derived from resin of *P. roxburgii* in the region; it is also used for medicinal treatments. The wood is of importance for railway sleepers after treatment for preservation, and for construction, carpentry and joinery; it is also pulped for the paper industry. The bark has a high tannin content (11–14%) and is used for tanning leather and for staining wood to give it an orange colour. The seeds are edible but not very good. The needles are used for animal bedding and mixed with manure serve as a traditional fertilizer for agriculture. This species is uncommon in cultivation outside India and Pakistan, but has been introduced to South Africa as a forestry plantation tree. It is sometimes seen as an ornamental tree in countries

around the Mediterranean Sea. Despite the fact that in its natural habitat *P. roxburghii* does not occur in the Himalayan frost zone, some provenances could prove to be hardy.

Pinus rzedowskii Madrigal & M. Caball., Bol. Técn. Secr. Agric. Ganad. Subsecr. Forest. Fauna 26: 1. 1969. Type: Mexico: Michoacan, Coalcomán de Matamoros, Dos Aguas Forest Station, Pinabete, *X. Madrigal 2202* (holotype INIF). Fig. 247, 248

Etymology

This species was named after the botanist Jerzy Rzedowski, a student of the Mexican flora.

Vernacular names

Rzedowski's pine

Description

Trees to 15–30 m, d.b.h. to 30–60 cm; trunk monopodial, erect, often curved or contorted. Bark up to 5–6 cm thick on lower part of larger trunks, rough and scaly, breaking into large, exfoliating plates divided by deep, longitudinal fissures, dark brown, weathering grey. Branches spreading and ascending, often contorted; crown pyramidal in young trees, open and irregular in old trees. Shoots slender, glabrous and smooth, greyish. Cataphylls ca. 5 mm long, fragile, soon deciduous. Vegetative buds ovoid-oblong; terminal bud 8–10 × 4–5 mm; lateral buds of nearly equal size, not resinous. Fascicle sheaths of young leaves 7–9 mm long, soon recoiling, forming a rosette at base of fascicle, finally deciduous before fascicles. Leaves in fascicles of (3–)4–5, persisting 2–3 years on branchlets, straight or slightly reflexed, lax but not drooping, 6–10 cm long, 0.6–0.8 mm wide, with irregularly serrulate margins, acute-acuminate, yellowish green or greyish green, weakly glaucous on adaxial faces. Stomata on the two adaxial faces only. Pollen cones after shoot elongation forming a 5–7 cm long "spike" leaving shoot base and apex free; cones small, 5 × 3 mm, purplish, turning brown. Seed cones solitary or in whorls of 2–4 on 15–30 mm long peduncles which fall with cones. Mature cones ovoid to ovoid-conical when closed, ovoid when opened, usually symmetrical, slightly flattened at base, 10–15 × 6–8.5 cm when open, very resinous. Seed scales thin woody, rigid, oblong, concavo-convex, often wider than apophysis. Apophysis prominent, similarly shaped around cone, transversely keeled, rhombic or pentagonal in outline, turning ochraceous or light brown. Umbo dorsal, rhombic-pyramidal, transversely keeled, obtuse or with a minute prickle. Seeds (6–)8(–10) × (4–)5–6 mm, brown; wings 20–30(–35) × 8–13 mm, brown, with darker stripes.

Distribution

Mexico, W Michoacan (municipality Coacomán, W and SW of Dos Aguas in 10–12 localities).
TDWG codes: 79 MXS-MI

Ecology

The two smaller 'classical' subpopulations, Cerro de Chiqueritas and Cerro Ocotoso, are on steep talus of large, eroded limestone blocks, near the summits of small mountains in the mainly volcanic Sierra Madre del Sur. Each have only from 10 to a few score trees, from old to saplings. Some subpopulations are on more level ground, also with limestone boulders, but interspaced with other rocky substrates. In the two former areas, the trees remain small, less than 15 m tall; in some of the larger subpopulations trees to 30 m have been found. The altitudinal range is 1714–2480 m a.s.l. Annual precipitation is ca. 1500 mm, most of it occurs from June to October. The climate is warm-temperate, with a minimum of –5° C (December) and a maximum of 30° C (April). Although surrounded by extensive mixed pine forest with species like *P. pseudostrobus, P. herrerae* and *P. oocarpa*, these species do not grow on the limestone talus. There, *Quercus* and shrubs, e.g. *Clusia salvinii*, form an understorey with *Agave* and tall herbs. Fires occur frequently, but rejuvenation seemed good at least at Cerro Chiquerita visited by me in 1994.

Conservation

The population is small and consists of 12 subpopulations, ranging from 1 to 3500 individuals, totaling 6000–6500 individuals (Delgado *et al.*, 1999).

Regeneration is quite abundant at some of the sites. From this it is here inferred that the total of mature trees is probably around 1000. There is considerable genetic diversity, indicating a larger population in the (geological?) past (Delgado *et al.*, 1999). The greatest threat to this species would appear to be a forest fire, as it is not a fire-adapted pine. Its occurrence amidst extensive pine forests make it vulnerable to this hazard. There is evidence in several of the scattered stands of ground fires having occurred (Perry, 1991).

IUCN: VU (D1, 2)

Uses

No uses are recorded of this species. It is a botanical rarity only present in a few botanic gardens and private collections. Its altitudinal range implies occasional light frosts, so it might prove hardy in mild regions and as an attractive tree should be worthy of cultivation, which would also help its conservation as a species.

Pinus sabiniana Douglas *ex* D. Don, in Lambert, Descr. Pinus, ed. 8°, 2: p. s.n. inter 144 et 145, t. 80. 1832. Type: USA: California, *D. Douglas s.n.* 1826 (holotype not located, isotypes GH, K [ex Herb. Hort. Soc. London]).

Etymology

This species was named after Sir Edward Sabine, former President of the Royal Society.

Vernacular names

Gray pine, Bull pine, Digger pine (deprecated)

Description

Trees to 25 m tall, usually remaining smaller; trunk to 1 m d.b.h., monopodial or forked, straight or curved. Bark on trunk thick, rough, scaly, divided into irregular plates and deep, longitudinal fissures, brown-grey or blackish grey with reddish brown fissures. Branches of first order long, spreading horizontally or ascending, usually persistent along much of trunk; branches of higher orders sparse, forming a broad, irregular and open crown. Shoots slender or stout, rough with prominent, decurrent pulvini from fallen leaf fascicles, pale grey-brown becoming darker brown. Buds ovoid-conical; terminal bud 15–25 mm long; lateral buds smaller, all resinous, acute; cataphylls appressed, reddish brown, with paler fringed margins. Leaves in fascicles of 3, held by persistent, initially 20 mm long but later much reduced (5–7 mm) sheaths, spreading or drooping, persisting 3–4 years, (15–)20–28(–32) cm long, pliant, slightly twisted, 1.5 mm wide; margins serrulate; apex acute-pungent to subulate; leaf colour grey-green; stomata in conspicuous lines on all faces of leaves. Pollen cones ovoid to ellipsoid, 10–15 mm long, yellow becoming orange-brown. Seed cones at base of a subsequent leading shoot, solitary or occasionally in pairs, on short, persistent peduncles, holding the cone to the branch for up to 7 years and retaining a few basal scales when falling; mature cones broadly ovoid, massive, nearly symmetrical, opening slowly, 17–25 × 15–20 cm when open, more or less flat or convex at base, extremely resinous. Seed scales thick woody and rigid, widest towards the apophysis, with two seed cavities on adaxial side, dull brown; apophyses very strongly developed, thick woody, sharply transversely keeled, more or less abruptly (or gradually) merging into a long, curved umbo, up to 20 mm wide, chocolate-brown. Umbos dorsal, elongate, curved, with keeled sides, 10–20 mm long, to 12 mm wide at base, ending in a sharp uncinate claw. Seeds narrowly obovoid, slightly flattened, 15–20 × 7–10 mm, smooth, dark brown; wings short and wide, ca. 10 mm long, largely ineffective.

Distribution

USA: California (lower slopes and mountains around Central Valley), Oregon (Jackson Co.).
TDWG codes: 73 ORE 76 CAL

Ecology

Pinus sabiniana grows in the summer-dry mountains and foothills that encircle the Central Valley of California, from the edge of the Mojave Desert to the slopes above the Pacific Ocean. Its altitudinal range is from 50 m to 1800 m a.s.l. Annual precipitation varies much within its range, from 250 mm per annum near the desert to 1780 mm at its upper limits in the

Sierra Nevada. It grows inland from the coastal fog belt and does not tolerate hard frosts. Near the coast, it grows in the chaparral zone with ericaceous shrubs which is subject to frequent fires. On the lower slopes of the Sierra Nevada it grows in the Upper Sonoran Life Zone, mainly accompanied by various species of *Quercus*, as it does at higher elevations in the Coast Ranges. Here *Pinus coulteri* can be an associate, in the north of its range it grows with *Juniperus occidentalis*. The woodlands with *P. sabiniana* are usually very open, with trees emering from shrubs or standing in areas covered with sparse grasses and herbs. The heavy cones are predated by squirrels and jays, the former can detach cones from the trees and gnaw through the thick scales to obtain the seeds, the latter play a role in seed dispersal and germination.

Conservation

IUCN: LC

Uses

Gray pine nowadays has little value as a timber tree; it only played a major part during the California Gold Rush period due to its proximity to the gold fields. Native American tribes used the seeds for food and the copious resin to seal drums and baskets. The nutritional value of the seeds can well compete with most other edible pine seeds, yet there is little or no commercial use at present. The wood, because of its irregular size and shape and high resin content, is only used for railroad sleepers, pallets and wood chips. The needles and twigs yield oils and turpentine. Its irregular, open crown and twisted growth, usually making several stems, discourages use as an amenity plantation tree; its only interest is in arboreta and pineta where the climate is suitable, e.g. in the south of England, western France, around the Mediterranean, or in Australia.

Pinus serotina Michx., Fl. Bor. Amer. 2: 205. 1803. Type not designated.

Etymology

The species epithet (Latin: *serotinus* = late flowering) refers to the delayed opening of the cones.

Vernacular names

Pond pine, Marsh pine, Pocosin pine

Description

Trees to 20 m tall; trunk to 60 cm d.b.h., straight or often crooked. Bark thick and breaking into irregularly shaped, flat but scaly, dark reddish brown plates divided by deep fissures. Adventitious foliage shoots common in crown on largest branches, few on trunk; primary branches spreading and ascending, tortuous, poorly self pruning, forming an irregular and thin crown. Foliage branches sparse, stout, new shoots 1 cm thick, yellowish orange, frequently glaucous, turning brown, forming numerous buds. Buds narrowly ovoid to cylindrical; terminal bud 15–20 mm long, extremely resinous; cataphylls appressed, red-brown, fringed; apex cuspidate. Leaves in fascicles of 3, occasionally 4 (adventitious shoots can have dwarf shoots with 3–5 leaves), held in a basal sheath initially 20–25 mm long, reducing to ca. 10 mm, persisting 2–3 years in tufts at the ends of branchlets, straight, (13–)15–20(–21) cm long, flexible, slightly twisted, 1.3–1.5(–2) mm wide, green; margins minutely serrulate; apex acuminate; stomata in fine lines on all surfaces. Pollen cones clustered at base of new shoots, spirally arranged, cylindric, 2–3 cm long, yellowish brown. Seed cones solitary or in whorls of 2–5, sessile or on a 1 cm long peduncle, long persistent, variously serotinous or opening in the second year, (5–)6–10 cm long, ovoid-conical when closed, symmetric, opening to a broadly ovoid or subglobose shape to 8 cm wide with a flattened base. Seed scales thin woody, rigid, oblong, dull brown with a dark red-brown sealing band; apophyses slightly raised, more or less rhombic, transversely keeled, light brown or pale red-brown; umbo dorsal and central, small, armed with a short, weak prickle, sometimes unarmed. Seeds obliquely ellipsoid, 5–6 mm long, slightly flattened, pale brown, or mottled dark brown; wing 15–20 mm long.

Taxonomic notes

Although this pine forms hybrids with *Pinus rigida*, as well as with *P. taeda*, it is generally considered to be a distinct species. It is undoubtedly closely related to *P. rigida*, with which it shares the uncommon

character of adventitious shoots. There are sufficient independent character differences to separate the two species, although several of these are quantitative (to do with measurements) rather than qualitative (absent or present). Distribution and ecology of the two species only overlap marginally.

Distribution

SE USA: from New Jersey to Alabama and Florida (coastal plain).

TDWG codes: 75 DEL MRY NWJ 78 ALA FLA GEO NCA SCA VRG

Ecology

Pinus serotina is a lowland pine of wet, swampy areas on the coastal plains of the Atlantic Ocean and the Gulf of Mexico. It occurs on sandy flats with a high water table and in swamps. The climate on these plains is mild and humid with annual precipitation ranging from 1120 mm to 1420 mm, with the driest months in winter. In so-called pocosins, peat swamps that have risen above the water table and drain outwards, *P. serotina* is common (a local vernacular name is Pocosin pine). Ponds are swamps in depressions with very poor drainage. In both types of swamp the pines form a tall, open canopy, under which is a dense and varied shrub layer characterized by *Smilax laurifolia. Pinus serotina* is often associated with *Taxodium distichum* or with other pines, e.g. *P. taeda* and *P. elliottii*. Common broad-leaved trees (angiosperms) belong to the genera *Nyssa, Magnolia, Liriodendron, Persea*, and *Ilex*. Its capability to resprout differs from that of *P. rigida* in that adventitious shoots appear more in the crown than on the trunk, probably because fires tend to be crown fires in the wetter forests with water-logged forest floors where this species occurs.

Conservation

IUCN: LC

Uses

The wood of Pond pine is coarse grained and resinous, while the tree only attains modest size and is often crooked or divided into long branches at two thirds of its height. Its wood is therefore mainly used as pulp wood. Slow growth in the nutrient poor acidic swamps makes commercial use unlikely; however, its growth is considerably better in plantations on well drained sandy soils. It is of limited value in amenity planting and horticulture and attempts at forestry plantations in China, South Africa and Zimbabwe have generally had poor results compared to other pine species.

Pinus sibirica Du Tour, in Déterville, Nouv. Dict. Hist. Nat. 18: 18. 1803. *Pinus cembra* L. var. *sibirica* (Du Tour) G. Don, in Loudon, Hort. Brit. 1: 387. 1830. *Pinus cembra* L. subsp. *sibirica* (Du Tour) Krylov, Fl. Altai. Tomsk. 7: 1724. 1914 [& in Fl. Zap. Sibir. 1: 77. 1927]. Type not designated.

Pinus hingganensis H. J. Zhang, Bull. Bot. Res. North-East. Forest. Inst. 5 (1): 151. 1985; *Pinus sibirica* Du Tour var. *hingganensis* (H. J. Zhang) Silba, Phytologia 68: 61. 1990.

Etymology

The species epithet refers to its natural occurrence in Siberia.

Vernacular names

Siberian pine, Siberian stone pine; Sibirskii kedr, Kedr (Russian)

Description

Trees to 35–40 m tall; trunk to 1.8 m d.b.h. Bark smooth and pale brown on young trees and on branches, becoming scaly and deeply fissured on trunks of large trees, turning grey. Branches numerous, spreading and assurging, forming a dense, broadly conical crown. Foliage branches slender to stout, initially with a dense, pale yellow pubescence, then glabrous, smooth, yellowish brown or light brown. Buds ovoid-conical, without resin; cataphylls reddish brown. Leaves in dense tufts towards end of shoots, persiting 2–4 years, in fascicles of 5 held by deciduous basal sheaths of thin, orange-brown scales that fall away in the second year, spreading wide or forward, straight or slightly curved, more or less rigid

to flexible but not lax, 6–11(–13) cm long, triangular in cross-section, not twisted, 1.2–1.7 mm wide; margins minutely serrulate; leaf colour green; stomata in white lines on the two adaxial faces. Pollen cones clustered, spirally arranged, short cylindrical, initially reddish turning red-brown. Seed cones intitially erect, becoming patent, single or in 2–3 in whorls on very short peduncles, remaining closed or opening only slightly at maturity, from glaucous green to purplish when growing, resinous, ovoid-conical, usually longer than wide but variable, (5–)7–10(–12) cm long, 4–6(–8) cm wide, dark brown when ripe. Seed scales imbricate, widely cuneate proximally, with 2 deep seed cavities adaxially, soft woody; apophyses broadly rhombic or widely triangular to semi-orbicular, thickened, pilose when growing, longitudinally striated when full grown and drying to dark brown; umbo terminal, obtuse, slightly upturned, lighter coloured than the rest of the scale. Seeds oblong-obovoid, 10–14 × 5–7 mm, slightly ridged across one end but without a true wing.

Distribution

China: Heilongjiang (Tuqiang), Nei Mongol, Xinjiang; Kazakhstan; Mongolia; Siberia; an isolated population is reported from the Kola Peninsula in NW Russia.

TDWG codes: 14 RUE RUN 30 ALT BRY CTA IRK KRA TVA WSB YAK 32 KAZ 36 CHI-NM CHM-HJ CHX 37 MON

Ecology

This is a species growing both in lowland areas along the great Siberian rivers like the Ob and the Yenisei Rivers between 100 m and 200 m a.s.l., and in the mountains to an altitude of around 2400 m, where it forms dense, pure forests. In the lowlands, it occurs with *Pinus sylvestris, Larix gmelinii* or *L. sibirica* and *Betula pendula* on drier sites that regularly burn and with *Abies sibirica* and *Picea obovata* ('dark coniferous forests') and *Betula* sp. on more mesic sites in the river basins, in bog margins, and uplands. *Pinus sibirica* is one of the major forest-forming conifers in the Siberian taiga and is estimated to cover ca. 45 million hectares. It is the slowest growing species in these extensive forests and may live up to 850 years. Its edible seeds are harvested by local people as well as birds and other animals; the Eurasian Nutcracker (*Nucifraga cariocatactes*, fam. *Corvidae*) is almost entirely responsible for the effective dispersal of the seeds by making food caches.

Conservation

IUCN: LC

Uses

The wood of Siberian pine is considered inferior in quality to that of Scots pine and Siberian spruce, two of the (co)dominant conifers in Russia/Siberia. However, it still serves numerous uses, such as roundwood for poles, sawn timber for light construction, carpentry, furniture, veneers, utensils, boxes, wood carving, and musical instruments. The wood is soft, lightweight and rose-coloured with a good texture for finer applications. Trees are also tapped for resin, mainly to produce turpentine. The edible seeds have a very high fat content (ca. 65%) and contain many vitamins. In the Altai Mountains harvests may yield 200–300 kg of 'nuts' or 'kernels' (= seeds) per ha. The seeds have to be separated from the cones with a mechanical cone-thresher as the cone scales do not open to release the seeds (which in nature is done by the Eurasian Nutcracker's strong bill). In Russia this species is commonly planted as an amenity tree in large gardens and parks. Few cultivars are known, but in Russia several dwarfed growth forms found at high altitude or in peat bogs have been described as botanical forms and may also be in cultivation. In Europe, the closely related Arolla pine (*P. cembra*) is more commonly planted.

Pinus squamata X. W. Li, Acta Bot. Yunnanica 14 (3): 259. 1992. Type: China: Yunnan, Qiaojia Xian, *X. W. Li 91250* (holotype SWFC).

Etymology

The species epithet (Latin *squamata* = 'furnished with scales') refers to the scaly bark of larger trees.

Vernacular names

qiao jia wu zhen song (Chinese)

Description

Trees to 20 m tall; trunk monopodial, erect, to 60 cm d.b.h. (no old trees are known). Bark smooth, hard, irregularly exfoliating with thin flakes, exposing light yellowish patches, which later turn from grey-green to variable brown, creating a multi-coloured pattern on trunk. First order and highest order branches in pseudo-whorls, spreading and assurgent, forming a conical to rounded, open crown. Foliage branches slender, smooth, densely yellow- or grey-brown pubescent, or glabrous, pale reddish brown, becoming grey-brown. Buds ovoid, to 10 mm long, resinous; cataphylls imbricate, triangular-lanceolate, red-brown. Leaves in remote fascicles of 4–5, held by a deciduous basal sheath, spreading, rigid or pliant, 9–17 cm long, 0.8–1 mm wide, broadly triangular in cross-section; margins serrulate; apex acute; leaf colour light green with whitish lines; stomata on all surfaces. Leaf anatomy with a uniform epidermis, 3–5 external (marginal) resin ducts and a single vascular bundle. Pollen cones in elongated clusters on new shoots, spirally arranged, axillary to broad cataphylls, ovoid-cylindrical, 10–15 mm long. Seed cones solitary on 1.5–2 cm long peduncles, erect or spreading, falling at maturity, ovoid-conical when closed, broadly ovoid when open, (7–)8–10 cm long, 5–6 cm wide, turning from green to variable brown. Seed scales oblong-elliptical, woody and rigid, ca. 2.7 × 1.8 cm; apophyses thickened, broadly rhombic in outline, transversely keeled; umbo dorsal, flat or more or less depressed, unarmed. Seeds oblong or obovoid, slightly flattened, 8–10 × 5 mm, striated black; wing ca. 15 mm long, articulate, with blackish stripes.

Taxonomic notes

This species was discovered in 1991 and briefly described in Latin and Chinese, with an illustration, in 1992. Its affinity is clearly with *Pinus bungeana* and *P. gerardiana* and together these three pines make up the subsection *Gerardianae* (Section *Quinquefolius*) in subgenus *Strobus* of the pines (Farjon, 2005b: 223). It is distinct from both in several characters, e.g. the smooth grey-green bark turning brown on older trees, the greater number of needles per fascicle and the cones, which are larger than those of *P. bungeana* but smaller than those of *P. gerardiana*. In the protologue an error occurs regarding the type citation: *J. Q. Pang* "*zhao–44*" (KUN) is called an isotype and *X. W. Li 91250* (SWFC) is called the holotype. Holotype and isotype have to be duplicates of the same collection.

Distribution

China: Yunnan (Qiaojia Xian); known from a single locality only.
TDWG codes: 36 CHC-YN

Ecology

This extremely rare pine grows at approximately 2200 m altitude on a mountain slope with open (disturbed) woodland and grassland with shrubs. It is associated with *Pinus yunnanensis* and various broad-leaved shrubs and trees.

Conservation

This is one of the rarest conifers known, its population is restricted to a single locality and consists of around 30 (20 mature) trees. They occur on a partly deforested mountain on a NW-facing slope, surrounded by fire-prone grass and scrubland. The area is now a nature reserve (Qiaojia Xian), and the trees are now strictly protected. With help from the local foresters, a farmer in the vicinity has successfully propagated young trees to be eventually planted in habitat.
IUCN: CR (D1)

Uses

No uses have been recorded; the species is locally propagated for conservation purposes. It may eventually appear in the horticultural domain, first in China and perhaps later abroad. There is substantial interest as this is most probably the rarest species of pine in the world.

Pinus strobiformis Engelm., in Wislizenus, Mem. Tour N. Mexico: 102. 1848. *Pinus ayacahuite* Ehrenb. *ex* Schltdl. subsp. *strobiformis* (Engelm.) E. Murray, Kalmia 13: 21. 1983. Type: Mexico: Chihuahua, Cosiquiriachi, *F. A. Wislizenus 231* (holotype MO).

Pinus strobiformis Engelm. var. *carvajalii* Silba, Phytologia 68: 61. 1990.
Pinus ayacahuite Ehrenb. *ex* Schltdl. var. *novogaliciana* Carvajal, in McVaugh, Fl. Novo-Galiciana 17: 48. 1992.

Etymology

The species epithet means 'shaped like strobus', i.e. it is compared with *Pinus strobus*.

Vernacular names

Southwestern white pine; pino blanco, pinabete, pino nayar (Spanish)

Description

Trees to 25–30 m tall, d.b.h. to 1 m; trunk monopodial, straight, erect. Bark on trunk thick, rough and scaly, fissured, breaking into small, irregular plates, dark brown, weathering grey. Branches spreading horizontally, curved down or assurgent; crown conical or pyramidal in young trees, becoming more rounded or irregular in older trees. Shoots smooth, puberulent or glabrous, pale reddish brown, with 5–10 mm long, early deciduous cataphylls. Vegetative buds ovoid to ovoid-oblong; terminal bud 8–15 × 5–8 mm; lateral buds smaller, not or only slightly resinous. Fascicle sheaths 20–25 mm long, soon disintegrating and deciduous at end of the growing season. Leaves in fascicles of 5, very rarely 6, persisting 3–5 years, lax, straight or slightly curved proximally or slightly twisted, (5–)7–11(–12) cm long, (0.6–)0.8–1.1(–1.2) mm wide, with serrulate or nearly entire margins, acute, dark green to glaucous green. Stomata either on all faces or, more commonly, only on adaxial face. Pollen cones ovoid-oblong to short cylindrical, 6–10 mm long, yellow. Seed cones solitary or in pairs or sometimes whorls of 3–4 on stout, 15–25 mm long peduncles, maturing in two seasons. Mature cones variable, mostly cylindrical or broad cylindrical to ovoid-oblong when opened, 12–30(–60) × 7–11 cm when open. Seed scales spreading obliquely to patent; basal scales recurved or reflexed; most scales with curved margins, thick woody, of similar shape around the cone but differentiating from base to apex, with one or two deep seed cavities adaxially. Apophysis more or less cuneate or elongated, thick at the proximal end, thinning out and straight, recurved or reflexed distally, smooth or longitudinally furrowed, often very resinous, light yellowish brown or dark ochraceous. Umbo terminal, broadly triangular, obtuse. Seeds obovoid, 12–18 × 8–11 mm, reddish brown or brown. Seed wings vestigial to very small, up to half the length of the seed in some cones.

Distribution

USA: Arizona, New Mexico, rare in Trans-Pecos Texas; Mexico: in Sonora, Chihuahua, Coahuila, Nuevo León, Sinaloa, Durango, Jalisco, very local in Zacatecas and San Luís Potosí.
TDWG codes: 76 ARI 77 NWM TEX 79 MXE-CO MXE-CU MXE-DU MXE-NL MXE-SL MXE-ZA MXN-SI MXN-SO MXS-JA

Ecology

Pinus strobiformis is a montane pine of mesic sites, its altitudinal range is 1900–3500 m a.s.l. It occurs on sites with relatively deep, humus-rich though often rocky soils, especially on N-facing slopes or along mountain streams. It grows in small, pure stands within pine or pine-oak forest, but more commonly it is mixed with *P. arizonica, P. engelmannii, P. leiophylla* var. *chihuahuana, P. durangensis, P. lumholtzii*, and/or various species of *Quercus* and *Arbutus*. In a more mesic forest type, it is associated with *Abies* and *Pseudotsuga*, and at the highest altitudes with *P. hartwegii*. The climate in the Sierra Madre Occidental is characterized by summer rains (thunderstorms) as well as winter precipitation; winter snows are common at the higher altitudes.

Conservation

IUCN: LC

Uses

As one of the 'soft pines', *P. strobiformis*, in the vernacular of N Mexico often equated with *P. ayacahuite*, is sought after by lumbermen as it is considered to supply wood of good quality for construction and carpentry work. The wood is also considered good for making violins. The resin is used medicinally. It is rare in horticulture and mostly confined to arboreta. Difficulties with the correct identification of the 'grade' or 'complex' of species, from *P. flexilis* to *P. ayacahuite*, to which this taxon belongs, means that trees that belong here may be grown under another name.

Pinus strobus L., Sp. Pl. 2: 1001. 1753.

Etymology

The species epithet is probably derived from the Greek *strobilos* = pine cone.

Vernacular names

Eastern white pine, Weymouth pine; pin blanc (French)

Description

Trees to 67 m tall (most large trees now only to 50 m); trunk to 1.5–2 m d.b.h., growing to a straight and columnar bole, scarcely tapering in lower half of its length. Bark smooth in young trees, becoming scaly and eventually deeply furrowed, exfoliating in small or large, rectangular plates, dark grey-brown. Branches whorled, spreading to assurgent, forming a conical but in old trees rounded crown. Foliage branches slender, smooth, young shoots glabrous or puberulent with pale brown, downy hairs near base of pulvini, grey-green or pale reddish brown, becoming grey. Buds small; terminal bud to 10 mm long, ovoid-cylindrical, acute, light red-brown, slightly resinous. Leaves in fascicles of 5, persisting 2–3 years, held in a soon deciduous sheath of light orange-brown flimsy scales, spreading, 6–10(–12) cm long, straight, slender, flexible, 0.7–1 mm wide, slightly twisted, deep green or glaucous green, with lines of stomata on the two adaxial faces only; margins minutely serrulate; apex acute to acuminate. Pollen cones ellipsoid to short cylindrical, 10–15 mm long, yellow. Seed cones clustered, usually 2–4 together, erect at first, becoming pendulous as they grow on 20 mm long peduncles, soon falling after seed dispersal, (5–)8–20(–25) cm long, sometimes highly variable in length on the same tree, oblong cylindrical becoming ellipsoid cylindrical when open, then 4–8 cm wide, usually curved but often straight and symmetrical. Seed scales thin woody, more or less flexible; small scales near cone base imbricate and straight or incurved; larger scales more or less straight or with an incurved apohysis, extremely resinous. Apohysis more or less rhombic in outline on central scales, dull pale brown to grey-brown (lower part of scales purplish brown), narrowing to an obtuse terminal umbo. Seeds broadly obovoid to deltoid, flattened, (5–)7–8(–9) mm long, red-brown mottled black; wing 20–28 mm long, pale brown.

Distribution

E North America: from Newfoundland to N Georgia, westward to Manitoba and Minnesota; S Mexico; Guatemala (highlands).

TDWG codes: 71 MAN 72 NBR NFL-NE NSC ONT PEI QUE 74 ILL IOW MIN WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 78 DEL GEO KTY MRY NCA SCA TEN VRG 79 MXC-PU MXG-VC MXS-GR MXS-OA MXT-CI 80 GUA

Ecology

Pinus strobus is widely (and disjunctly) distributed in regions as widely different in climate and topography as Newfoundland and Chiapas, Mexico. The variety *strobus* is confined to the NE part of the species range, where winters are cold and snowy; var. *chiapensis* occurs in the wet mountains with frequent fog in the S part. These populations were once connected, presumably as late as the last Ice Age, when *P. strobus* and other trees were all pushed southward before the advance of the Laurentide Ice Sheet. In the northern part, *P. strobus* mainly grows in the lowland hills around the St. Lawrence River and the Great Lakes, in the Appalachian Mountains to 1200 m a.s.l. In its southern extension it is confined to much higher altitudes between 800 m and

2000 m a.s.l. Annual precipitation varies greatly from area to area, with lows at around 500 mm and highs in Mexico to 3000 mm. The southern var. *chiapensis* experiences no frost, while long and cold winters are the norm in most of the range of var. *strobus*. Both varieties are major or minor components of mixed forests, with other conifers and/or with broad-leaved trees. There is a similarity of several broad-leaved (angiosperm) tree species in the forests of the southern Appalachians and the mountains of Veracruz and Chiapas, Mexico, but in the colder north *P. strobus* grows with species not common to both the northern and southern ranges.

Conservation

See under varieties

Uses

Eastern white pine was once the most important timber tree in eastern North America and in colonial times the British government forbade European colonists to cut the larger trees (marked with the 'broad arrow') as it wished to reserve these for the British Navy as ship masts. Its fine grained, smooth textured wood low in resin makes excellent construction timbers, while doors and windows, furniture, and matches are other uses. In the USA and Canada it is widely planted both for timber and for urban planting as shelter belts, as well as restoration of areas disturbed by strip mining of coal. Americans and Canadians use this pine for Christmas trees as its foliage can be clipped into shape. As an ornamental tree it is not very common in Europe, probably due to susceptability to White pine blister rust (*Cronartium ribicola, Basidiomycota*) and poor shape in cultivation. Attempts at forestry plantation in Britain also failed due to this disease, as well as to aphid insect predation (*Pineus strobus*). In the colder, drier winters of North America it thrives better; several cultivars are well known and used in gardens, especially some of the dwarfed forms.

2 varieties are recognized:

Pinus strobus L. var. ***strobus***. Type: North America: [locality not stated] "5 K Strobus", *P. Kalm LINN 1135.10* (lectotype LINN).

Description

Seed cones (8–)10–18(–20) cm long.

Distribution

E North America: from Newfoundland to N Georgia, westward to Minnesota.
TDWG codes: 72 74 75 78

Conservation

The vast resources of timber available to European colonists from this large pine had been depleted towards the end of the 19th century. However, as regrowth occurred, this has not threatened the continued existence and occurrence of the species significantly. Hence, while old growth Eastern white pine is now very rare, under IUCN criteria this variety of *P. strobus* is not under threat.
IUCN: LC

Pinus strobus L. var. ***chiapensis*** Martínez, Anales Inst. Biol. Univ. Nac. México 11: 81. 1940. *Pinus chiapensis* (Martínez) Andresen, Phytologia 10: 417. 1964; *Pinus strobus* L. subsp. *chiapensis* (Martínez) E. Murray, Kalmia 12: 23. 1982. Type: Mexico: Chiapas, Ocotepec, *M. Martínez s.n.* (lectotype MEXU).

Description

Seed cones highly variable in length, 6–25 cm.

Taxonomic notes

While Mártinez (*op. cit.*) described and named this taxon as a variety of *P. strobus* as it has only insignificant morphological character differences with that species, some others have treated it as a species. It does not have smaller cones as these are very variable in size and no discontinuous character states have been found between this variety and var. *strobus*. Statistical analysis applied to continuous

character states to demonstrate "significant" differences between the two taxa (Andresen, 1966) is in my view an unconvincing approach to the species problem. Its considerable distance (2400 km) from var. *strobus*, which can be explained by late Pleistocene climatic events, is not a sufficient reason to assign it the rank of species. If the disjunction persists, it may evolve truly distinct characters and become a full species eventually.

Distribution

Mexico: in Guerrero, E Puebla, Veracruz, Oaxaca and Chiapas; Guatemala: in the departments of El Quiche and Huehuetenango.
TDWG codes: 79 MXC-PU MXG-VC MXS-GR MXS-OA MXT-CI 80 GUA

Conservation

Although a valuable timber tree logged locally, the main reason for its decline is deforestation and/or forest degradation.
IUCN: EN [B2a (ii, iii, v)]

Pinus sylvestris L., Sp. Pl. 2: 1001. 1753.

Etymology

The Latin species epithet *sylvestris* means 'growing in the forest'.

Vernacular names

Scots pine; pin sylvestre (French); Gemeine Kiefer (German); furu (Norwegian); tall (Swedish); sosna zwyczajna (Polish); sosna lesnaya, sosna obiknovennaya (Russian)

Description

Trees to 35(–40) m tall (most trees in natural habitats not taller than 25 m); trunk to 1.5 m d.b.h., straight or slightly crooked, sometimes forked in crown. Bark thin and papery, flaking, orange-brown on young trees and in the crown of older trees, becoming thick and scaly on lower trunk, breaking into irregular plates, purplish brown weathering grey, flaking in small or large chips. Branches spreading or curving down to pendulous, contorted, forming domed or irregular, open crowns in most cases. Foliage branches slender, spreading or pendulous in lower crown, becoming rough with pulvini after shedding leaves, sometimes remaining smooth, glabrous, new shoots yellowish green, grey-green or pale yellow, turning light brown to grey-brown or grey. Buds ovoid or ellipsoid, acute; terminal bud to 15 mm long; lateral buds smaller, all without resin or slightly resinous; cataphylls red-brown or pale brown. Leaves in fascicles of 2, more or less remote, persisting 2–3 years, spreading, held in a short, persistent basal sheath, 4–7(–12) cm long, straight or slightly contorted, rigid, 1–2 mm wide, often slightly twisted, green or glaucous green; margins minutely serrulate; apex acute-acuminate or mucronate; stomata in fine grey-white lines on all surfaces. Pollen cones short cylindrical, elongating to 2–2.5 cm, yellow. Seed cones solitary or in whorls of 2–5, short pedunculate, usually falling soon after seed dispersal, ovoid-conical when closed, near-symmetrical, (2–)3–7 cm long and 2–3 cm wide, opening to 4–5 cm wide. Seed scales thin woody, rigid, oblong, spreading wide except basal scales, chestnut brown; apophyses nearly flat to slightly raised, transversely keeled, more or less rugose, ripening from green to pale grey-brown or reddish brown; umbo small, obtuse, unarmed or sometimes with a small, brittle prickle. Seeds ovoid-oblong, 3–5 mm long, grey-brown with dark specks, or dark brown entirely; wing 10–15 mm long, 5–6 mm wide, light brown or grey-brown.

Taxonomic notes

As can be expected, this is a variable species and more than 50 botanical varieties or subspecies have been named and described. Only three (including var. *sylvestris*) are recognized here.

Distribution

Eurasia: from N Spain and Scotland in the west to the Russian Far East, from Lapland in the north to Turkey in the south.
TDWG codes: 10 FIN GRB NOR SWE 11 AUT-AU AUT-LI BGM-BE BGM-LU CZE-CZ CZE-SL GER HUN POL SWI 12 FRA-FR POR SPA-AN SPA-SP 13 ALB BUL

GRC ITA-IT ITA-SM ROM TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 BLR BLT-ES BLT-KA BLT-LA BLT-LI KRY RUC RUE RUN RUS RUW UKR-MO UKR-UK 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KHA PRM 32 KAZ 33 TCS-AB TCS-GR 34 TUR 36 CHI-NM CHM-HJ CHM-JL 37 MON

Ecology

Across its enormous range *Pinus sylvestris* grows naturally in a variety of habitats, the common denominator of which is deficiency of nutrients in the soil. Thus on the Atlantic seaboard with high levels of precipitation it occupies ancient igneous or metamorphic rocks with little or no soil in Scotland and Norway up to 70° N, while south of the Baltic Sea it grows on podzolized glacial sands left after the Ice Age. In the central Alps it is restricted to the drier slopes and valleys below other conifers like *Larix* and *Picea*, while in the Caucasus it ascends to 2600 m on rocky outcrops and scree. In much of Siberia it occupies the drier sites, but in Scandinavia and NE Europe it often borders acidic peat bogs. In the steppes of Russia and Mongolia it occurs only along stream courses. *Pinus sylvestris* most commonly forms open pine forests and woodlands but in many areas it is associated with conifers like *Picea, Larix, Juniperus* and with broad-leaved trees, especially *Betula* spp. and *Populus tremula*. In old growth stands there is often a well developed ground cover of *Vaccinium* spp. or *Empetrum nigrum* in Atlantic regions, and such pine forests are rich in mycorrhizal fungi.

Uses

Scots pine is an important timber tree, but most of the production goes to the paper industry. In the past it was more often put to use as mining props and for interior construction; such uses are still common in E Europe. Most of the 'pine' used for furniture in W Europe is actually spruce (*Picea abies*), which has a smoother grain and is less resinous, but often has more and darker 'knots', which are the discarded lower branches on the trunks of densely planted trees. Other uses of Scots pine wood are (or were) street paving blocks, railway sleepers, fencing, crates, pallets, boxes, laminated wood, particleboard, fibreboard, and various wood-based materials. In Russia and Scandinavia resin is extracted by 'destructive distillation' from the stumps and roots of felled trees to produce 'Stockholm tar'. In much of western Europe it is a widely planted forestry tree for timber; it was introduced in the USA for similar purposes and for growing as Christmas trees. Scots pine is or was also used to stabilize dunes, but not those close to the sea as it is not very resistant to salt-laden winds. In Belgium, the Netherlands, Germany, and Denmark such plantations have led to massive spontaneous spread of pines onto heathland and the last remaining inland dune areas, and while the old plantations have in many places matured to mixed woodland now managed as 'multiple use' or even nature reserves, the invasivenes onto *Calluna* heathland is seen as a menace to biodiversity and an ancient semi-natural landscape. In horticulture a large number of cultivars is known, including dwarf forms from witches brooms; the species is being planted as an amenity tree in many countries.

3 varieties are recognized:

Pinus sylvestris L. var. ***sylvestris***. Type: ["Habitat in Europae borealis sylvis glareosis"], Illustration "*Pinus sylvestris*" in Daléchamps, Hist. General. Pl. 1: 45. 1587. Fig. 249

Pinus sylvestris L. var. *scotica* Beissn., in Jaeger & Beissner, Ziergehölze, ed. 2: 488. 1884.

Description

Young shoots usually rough with pulvini, light brown; bud scales (cataphylls) red-brown. Leaves 5–7(–8) cm long. Seed cones variable, but up to 7 cm long.

Taxonomic notes

There are no morphological or anatomical characters known to clearly distinguish the disjunct Scottish population from those of northern Europe, and consequently the 'Caledonian pine' is here treated as *Pinus sylvestris* var. *sylvestris*.

Distribution

Eurasia: from N Spain and Scotland in the west to the Russian Far East, from Lapland in the north to Turkey in the south.
TDWG codes: 10 FIN GRB NOR SWE 11 AUT-AU AUT-LI CZE-CZ CZE-SL GER HUN POL SWI 12 FRA-FR POR SPA-AN SPA-SP 13 ALB BUL GRC ITA-IT ITA-SM ROM TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 BLR BLT-ES BLT-KA BLT-LA BLT-LI RUC RUE RUN RUW UKR-MO UKR-UK 30 ALT BRY CTA IRK KRA TVA WSB YAK 31 AMU KHA PRM 32 KAZ 33 TCS-AB TCS-GR 34 TUR 36 CHM-HJ CHM-JL 37 MON

Conservation

IUCN: LC

Pinus sylvestris L. var. ***hamata*** Steven, Bull. Soc. Imp. Naturalistes Moscou 11: 52. 1838. *Pinus sylvestris* L. subsp. *hamata* (Steven) Fomin, Vestn. Tiflissk. Bot. Sada (Monit. Jard. Bot. Tiflis) 34: 20. 1914; *Pinus hamata* (Steven) Sosn., in Grossheim *et al.*, Fl. Tiflisa 1: 11. 1925, *non* Roezl. (1857); *Pinus sosnowskyi* Nakai, Chôsen Sanrin Kaihô 167: 32–33. 1939. Type: Caucasus Mts.: *H. Wittmann s.n.* (lectotype H No. 1002536, right hand specimen).

Pinus kochiana Klotzsch *ex* K. Koch, Linnaea 22: 296. 1849; *Pinus sylvestris* L. subsp. *kochiana* (Klotzsch *ex* K. Koch) Eliçin, Istanbul Univ. Orman Fak. Dergisi, ser. A, 20 (2): 289. 1971.

Description

Young shoots pale yellow, turning grey. Leaves 2–7 cm long, glaucescent; apex mucronate. Seed cones small, 2–5.5 cm long.

Distribution

Ukraine: Krym [Crimea]; Caucasus; Turkey.
TDWG codes: 14 KRY 33 NCS TCS 34 TUR

Conservation

IUCN: LC

Pinus sylvestris L. var. ***mongolica*** Litv., Sched. Herb. Fl. Ross. 5: 160. 1905 ["*mongholica*"]. Type: NE China: ["Mongholia, . . . in arenosis pr. stat. viae ferreae Charchonte"], *D. Litvinov 1599* (lectotype LE).

Pinus sylvestris L. var. *manguiensis* S. Y. Li & Adair, Sida 16 (1): 184. 1994.

Description

Young shoots smooth, grey-green; bud scales (cataphylls) pale brown or pale yellowish brown. Leaves 4–12 cm long.

Distribution

Russian Federation: E Siberia, around Lake Baikal (?); N Mongolia (very rare); China: Nei Monggol, Heilongjiang, Jilin, Liaoning.
TDWG codes: 30 BRY CTA IRK 36 CHI-NM CHM-HJ CHM-JL CHM-LN 37 MON

Conservation

IUCN: LC

Pinus tabuliformis Carrière, Traité Gén. Conif., ed. 2, 1: 510. 1867 ["*tabulaeformis*"].

Etymology

The species epithet may refer to a common use of the wood and is derived from the Latin *tabula* = plank, and *formare* = to form or make.

Vernacular names

Chinese red pine; you song (Chinese)

Description

Trees to 25(–30) m tall; trunk to 1.2 m d.b.h., monopodial, sometimes forked in or below crown. Bark scaly, fissured, breaking into large irregular plates, greyish brown weathering grey, flaking in small or large chips. Branches spreading or curving down, contorted, forming a domed or flat-topped crown. Foliage branches stout, becoming rough with pulvini

after shedding leaves, glabrous, new shoots yellowish brown, pale brown or slightly glaucous, turning light brown to grey-brown or grey. Buds oblong, acute; terminal bud to 20 mm long; lateral buds smaller, all slightly resinous; cataphylls appressed, pale brown. Leaves in fascicles of 2, sometimes 3, more or less remote, persisting 2–3 years, spreading, held in a 10–15 mm long, persistent basal sheath, 6–15 cm long, straight or curved, rigid, 1–1.5 mm wide, often slightly twisted, dark green; margins minutely serrulate; apex acute or acuminate; stomata in fine lines on all surfaces. Pollen cones short cylindrical, ca. 2 cm long, yellow. Seed cones solitary or in pairs, short pedunculate, usually persisting a few years but opening soon, ovoid when closed, near-symmetrical, 5–8.5 cm long and 3.5–5 cm wide, opening to 5–7.5 cm wide. Seed scales woody, rigid, oblong to obovate, spreading wide except basal scales, often recurving, brown; apophyses prominently raised, variously shaped, transversely keeled, ripening from green to yellowish brown or pale brown; umbo pyramidal, armed with a sharp, curved prickle. Seeds ovoid-oblong, 6–8 × 4–5 mm, pale brown, mottled; wing 12–18 mm long, 5–7 mm wide, light brown or grey-brown.

Distribution

China: from Jilin and Liaoning in the NE to Yunnan in the SW and from Shandong in the E to Qinghai and Sichuan in the W.

TDWG codes: 36 CHC-CQ CHC-SC CHC-YN CHI-NM CHI-NX CHM-LN CHN-BJ CHN-GS CHN-HB CHN-SA CHN-SD CHN-SX CHN-TJ CHQ CHS-HN

Ecology

Pinus tabuliformis is most common at middle elevations in the hills and mountains of NE and Central China, where it occurs from 100 m to 2600 m a.s.l.; in Sichuan it has been found to 3800 m. It prefers dry, sunny slopes and hills where competition from broad-leaved trees is less severe as the woods are more open and lower than in more mesic sites. It is also a pioneer in secondary vegetation and is there commonly mixed with deciduous shrubs and trees, in later stages of the succession often giving way to these angiosperms. Management of forests often has arrested this succession in favour of the pines, which are of economic importance as a forestry tree.

Uses

Chinese red pine is an important forestry tree yielding timber for construction; its wood is hard and strong with a straight grain. The wood is used for mining props, railway sleepers, to build wooden bridges and carts or wagons, to make tools, and for artificial fibres. The resin is extracted from the bark and leaves and produces turpentine; another product of these parts is tannin used to make leather from hides. Essential oils distilled from the leaves and the pollen are used in traditional Chinese medicine. In China, this species is commonly planted in plantations for forestry purposes and occasionally as an ornamental tree. Elsewhere it is uncommon, even in Japan, despite its suitability as an amenity or forestry tree. While the existence of a few botanical varieties, some or all of which may also be in cultivation, indicates its potential, no cultivars have been selected and named.

3 varieties are recognized:

Pinus tabuliformis Carrière var. ***tabuliformis***. Type not designated.

Pinus tabuliformis Carrière var. *brevifolia* S. Y. Wang & C. L. Chang, Fl. Henan: 1: 135. 1981.

Description

Bark grey or brown-grey, breaking into large plates. New shoots yellowish or pale brown, not glaucous. Leaves rigid, 1.2–1.5 mm wide.

Distribution

China: from Jilin and Liaoning in the NE to Yunnan in the SW and from Shandong in the E to Qinghai and Sichuan in the W.

TDWG codes: 36 CHC-SC CHI-NM CHI-NX CHN-BJ CHN-GS CHN-HB CHN-SA CHN-SD CHN-SX CHN-TJ CHS-HN

Conservation

IUCN: LC

Pinus tabuliformis Carrière var. ***mukdensis*** (Uyeki *ex* Nakai) Uyeki, J. Chôsen Nat. Hist. Soc. 3: 45. 1925. *Pinus mukdensis* Uyeki *ex* Nakai, Bot. Mag. (Tokyo) 33: 195. 1919; *Pinus tabuliformis* Carrière subsp. *mukdensis* (Uyeki *ex* Nakai) Businský, Acta Pruhoniciana 68: 26. 1999. Type: North Korea: [locality not stated], *H. Uyeki 2350* (holotype TI).

Description

Bark dark grey, longitudinally or irregularly fissured. Leaves 1–1.2 mm wide. Seed cones 4–8.5 cm long and to 7 cm wide when opened.

Distribution

NE China: Jilin (?), Liaoning; North Korea.
TDWG codes: 36 CHM-LN 38 KOR-NK

Conservation

IUCN: LC

Pinus tabuliformis Carrière var. ***umbraculifera*** T. N. Liou & Q. L. Wang, in Liou, Ill. Fl. Lign. Pl. N.E. China: 97, 548. 1958. Type: China: Hebei, Anshan Shi, *Chin. coll. n.v.* (holotype PE?).

Description

Trunk monopodial only towards base, usually forked from below the crown. New shoots yellowish or pale brown, not or only slightly glaucous. Leaves rigid, 1.2–1.5 mm wide.

Distribution

China: Hebei (Central Liaoning, Anshan Shi).
TDWG codes: 36 CHN-HB

Conservation

IUCN: LC

Pinus taeda L., Sp. Pl. 2: 1000. 1753. Type: USA: ["Habitat in Virginiae, Canadae paludosis"], *J. Clayton 496* (lectotype BM).

Etymology

The species epithet is a Latin word for 'pine tree' or its wood; its other meaning was a torch.

Vernacular names

Loblolly pine, Southern pine

Description

Trees to 45 m tall (usually to ca. 30 m); trunk to 1.6 m d.b.h., usually a straight bole. Bark thin, slightly scaly, orange-red in crown and upper bole, becoming thicker, breaking into more or less square, scaly plates on large trunks, darker red-brown. Branches spreading wide, self-pruning leaving a clear bole, forming a broadly conical or domed crown. Foliage branches moderately slender, 0.5–1 cm thick, rough with pulvini from fallen leaf fascicles, glabrous, prominently ridged, orange-brown to reddish brown, becoming darker with age. Buds cylindrical, acute, 10–15(–20) mm long, slightly resinous; cataphylls pale red-brown; margins fringed white; apex reflexed. Leaves in remote fascicles of (2–)3, held by persistent, 15–25 mm long basal sheaths, remaining 3 years on branchlet, spreading, straight, (10–)12–20(–23) cm long, rigid but more or less pliant, slightly twisted, 1.5–2 mm wide, lustrous light green; margins minutely serrulate; apex acute to abruptly subulate; stomata in lines on all surfaces. Pollen cones cylindrical, 2–4 cm long, 7–10 mm wide, radially spreading, yellow. Seed cones solitary or in pairs (sometimes more) on short peduncles, opening and falling soon, variable in size, (5–)6–12(–15) cm long, narrowly conical to oblong when closed, mostly symmetrical, opening to 6–9 cm wide, becoming more ovoid with a tapering, sometimes oblique base. Seed scales thin woody, oblong, nearly flat, dull brown; apophyses slightly raised, those on basal scales more gibbous, more or less rhombic or with a rounded upper margin, transversely keeled, often radially striated or wrinkled, dull pale brown; umbo dorsal and central, pyramidal or recurved, terminating in a strong, sharp prickle. Seeds obovoid, slightly

flattened, 5–6 mm long, red-brown, often with numerous black specks; wing 16–20 mm long.

Distribution

SE USA: from Delaware and New Jersey to central Florida and E Texas.
TDWG codes: 74 OKL 75 DEL MRY 77 TEX 78 ALA ARK DEL FLA GEO KTY LOU MRY MSI NCA SCA TEN VRG WDC

Ecology

Pinus taeda is widely distributed on the Atlantic Coastal Plain and extends into the plateaus and foothills around the southern Appalachians to ca. 700 m a.s.l. but avoids the Mississippi floodplain. The climate is warm-temperate and moist, with mild winters and long, hot summers; annual precipitation is between 1000 and 1500 mm. This pine forms extensive stands on low, sandy knolls in the 'prairie swamps' along the Gulf of Mexico; in the inland parts of the coastal plain it occurs on river floodplains and old river terraces with deep, relatively dry sandy or loamy soils. This species can form pure stands resulting from pioneer invasions after forest disturbance or onto abandoned fields, or in mixed pine-dominated forests with several other species of *Pinus*. It is also a component of forest types dominated by broad-leaved trees, especially species of oak (*Quercus* spp.) as well as *Acer rubrum, Liriodendron tulipifera, Fagus grandifolia, Fraxinus* spp., and *Diospyros virginiana* in upland sites. In the coastal swamplands *Magnolia grandiflora, Nyssa aquatica, Quercus michauxii, Carya aquatica*, and *Ulmus americana* are common associates of *P. taeda*, together with other pines and an undergrowth of shrubs and palmettos (dwarf palms).

Conservation

IUCN: LC

Uses

Loblolly pine is commercially the most important pine of the southern United States, where it makes up over half of the standing pine volume. It is much used in plantation forestry and is a fast grower. Its sawn wood properties are not of sufficient quality to be used in high grade construction and manufacture, and its fast growth and great volume is consequently put mainly to the wood pulp industry for paper and other long-fibre products. In urban settings the species finds a use as shelterbelt trees and for soil stabilization, again thanks to its rapid growth. This capacity for quick volume increase has also been reason to investigate its suitability as a biomass producer for the generation of energy. Plantations for this purpose are now being exploited and its use may well increase in future. Loblolly pine has also been introduced in many countries and is grown in forestry plantations on a large scale in South Africa, Brazil, China, Australia, and New Zealand. This species is little used in horticulture (except the use of leaf litter as a mulch); more northern provenances may well be hardy to light frosts. It has a preponderance to invasiveness.

Pinus taiwanensis Hayata, J. Coll. Sci. Imp. Univ. Tokyo 30 (1): 307. 1911.

Etymology

The species epithet denotes its origin, the island of Taiwan.

Vernacular names

Taiwan black pine, Formosa pine; huang shan song (Chinese)

Description

Trees to 45(–50) m tall; trunk to 1.2 m d.b.h, bole straight. Bark on trunk rough and scaly, breaking into large plates and deep fissures, grey-brown to dark grey. First order branches long and spreading, slowly and sometimes only partly self-pruning, leaving stumps on trunk; higher order branches assurgent and densely crowded, forming flat-topped or domed crowns in natural habitat. Foliage branches glabrous, more or less smooth, light brown. Buds ovoid-conical, 10–15 mm long, 5–7 mm wide, slightly resinous; cataphylls appressed, orange or rusty brown. Leaves in fascicles of 2, held by a persistent, slender basal sheath 10–15 mm long, straight or slightly curved,

(5–)10–20(–22) cm long, slender, pliant, slightly twisted, 0.7–1 mm wide; margins serrulate; apex acute; stomata in fine lines on all surfaces. Pollen cones clustered, spirally arranged, short cylindrical, 1.5–2 cm long, yellow, becoming yellowish brown. Seed cones solitary or sometimes in pairs, persistent on short peduncles, spreading or slightly reflexed, (3–)4–9(–10) cm long, more or less asymmetrical, narrowly ovoid when closed, widening to 2.5–5 cm when open. Seed scales thin woody, rigid, oblong, ca, 2.5 × 1.3 cm at mid cone (in larger cones), straight when spreading, dull brown; apophyses rhombic in outline or with rounded upper margin, nearly flat to slightly raised, transversely keeled, slightly rugose, lustrous brown; umbo broadly ellipsoid, flat, armed with a minute, often deciduous prickle or unarmed. Seeds ellipsoid-ovoid, 5–6 mm long, slightly flattened; wing 15–20 mm long, persistent.

Taxonomic notes

Pinus taiwanensis is similar to *P. hwangshanensis, P. luchuensis* and *P. densiflora* and these species are closely related according to phylogenetic analyses using DNA sequence data. Recently, Businský (2003) revisited the morphology of some of these pines and separated some trees in Taiwan as a new species, *Pinus fragilissima*. Most of the characters evaluated are either similar to those of *P. taiwanensis*, or they show overlapping states. The seed scales are described as "thin" in the formal description and elsewhere as "fragile" but these are difficult to quantify and may be attributes of the other taxa as well. What remains of this are somewhat longer leaves and only slightly longer seed cones. Species are expected to show distinct character state differences, without overlapping states. This taxon should be given the status of a variety only, as will be done below.

Distribution

Taiwan.
TDWG codes: 38 TAI

Ecology

Pinus taiwanensis grows in the mountains or along the mountainous coast; in the mountains of the interior of Taiwan it occurs from 800 m to 3000 m a.s.l., with exceptions to 3400 m where it is severely stunted. On the coastal slopes it comes down to 600 m a.s.l. Due to this altitudinal range, it occurs in different forest zones from warm temperate to subalpine, but at the lower and middle elevations it is mostly restricted to open spaces, exposed ridges and places with sandy, acidic and nutrient-poor soils. It is associated with various species of oak (*Castanopsis, Quercus*), forming pine-oak woodland in such places.

Uses

Taiwan black pine has good quality timber with suitable strength for construction, e.g. in buildings and wooden bridges, and use as railway sleepers and mine props. Its wood is also used for building fences and gates, crates and boxes, panelling, flooring, furniture making, industrial and domestic woodware, tools, plywood, fibreboard and wood pulp. In horticulture it is rare except for the use for bonsai growing, which is very popular in E Asia.

2 varieties are recognized:

Pinus taiwanensis Hayata var. ***taiwanensis***. Type: Taiwan: Central Mts., *T. Kawakami & U. Mori 2097* (lectotype TI). Fig. 250

Description

Leaves (5–)10–15(–17) cm long. Seed cones (3–)4–6(–8) cm long.

Distribution

Taiwan.
TDWG codes: 38 TAI

Conservation

IUCN: LC

Pinus taiwanensis Hayata var. ***fragilissima*** (Businský) Farjon, *comb. et stat. nov*. Basionym: *Pinus fragilissima* Businský, Novon 13 (3): 282. 2003. Type: Taiwan: Taitung Co., 1 km N of Wulu along Southern Cross-Island Hwy., *R. Businský 32172* (holotype PR).

Description

Leaves (12–)16–20(–22) cm long. Seed cones (5–)6–9(–10) cm long; seed scales often somewhat thinner than in var. *taiwanensis*.

Distribution

Taiwan (Taitung Co., Kuan Shan massif).
TDWG codes: 38 TAI

Conservation

IUCN: NT

Pinus tecunumanii Eguiluz & J. P. Perry, Revista Ci. Forest. 8: 4. 1983. *Pinus patula* Schiede *ex* Schltdl. & Cham. subsp. *tecunumanii* (Eguiluz & J. P. Perry) Styles, F.A.O. Forest Genet. Resources Inform. 13: 50. 1984. Type: Guatemala: Baja Verapaz, Sierra de Chuacus, San Jéronimo, *T. Eguiluz 2* (holotype GH).

Pinus oocarpa Schiede *ex* Schltdl. var. *ochoterenae* Martínez, Anales Inst. Biol. Univ. Nac. México 11: 65. 1940.

Etymology

This species was named after Tecun Uman, a leader of the Quiche Indians who was killed during the Spanish conquest of the Central American Isthmus.

Vernacular names

Schwerdtfeger's pine, Tecun Uman pine; pino tecun uman, ocote de caretilla (Spanish)

Description

Trees to 50–55 m tall, d.b.h. to 1.2–1.4 m; trunk monopodial, erect, straight. Bark on lower part of trunk ca. 5 cm thick, grey-brown, above 3–4 m thinning out, reddish brown. Branches spreading or slightly ascending, the higher order branches flexible but not pendulous. Shoots rough, reddish brown, often glaucous. Cataphylls subulate, erose-ciliate at margins, scarious, brown. Vegetative buds oval-oblong to cylindrical; terminal bud 15–20 mm long; lateral buds smaller, not resinous. Fascicle sheaths initially up to 25 mm long, orange-brown, in mature fascicles reduced to 12–18 mm, grey-brown. Leaves in fascicles of 4(3–5), persisting 2–3 years, lax and drooping but not pendant, (14–)16–18(–25) cm long, 0.7–1(–1.3) mm wide, serrulate at margins, acute, bright green. Stomata on all faces of the leaves. Pollen cones ovoid-oblong to cylindrical, 1.5–2 cm × 5–6 mm when shedding pollen, yellowish. Seed cones subterminal, in whorls of 2–4, rarely solitary, on (15–)20–25 mm long peduncles, semi-serotinous, persisting 1–3 years after shedding seeds, falling with peduncles. Mature cones ovoid to broadly ovoid, nearly symmetrical or asymmetrical, (3.5–)4–7(–7.5) × (3–)3.5–6 cm when open. Seed scales thin woody, parting usually within 1–2 years after maturity, oblong, straight or slightly curved. Apophysis raised, transversely keeled, on proximal scales more or less gibbous, striate, dull light brown or slightly lustrous. Umbo dorsal, flat or slightly raised, with a minute, deciduous prickle, grey. Seeds obliquely ovoid, 4–7 × 2–4 mm, dark grey-brown, with blackish dots, or blackish grey; wings articulate, 10–13 × 4–8 mm, grey-brown.

Distribution

S. Mexico: Oaxaca, Chiapas; Belize; Guatemala; Honduras; El Salvador; Nicaragua.
TDWG codes: 79 MXS-OA MXT-CI 80 BLZ ELS GUA HON NIC

Ecology

The altitudinal range of this species is considerable: (300–)550–2500(–2900) m a.s.l. In Belize it is found between 300–760 m a.s.l. It is a major constituent of more or less open to closed-canopy pine and pine-oak forests in climatic zones which receive at least 1000 mm of rainfall per annum, and up to 2500–3000 mm in some places. The dry season is usually long, lasting from November to May, so that at lower to middle altitudes fires are an integral phenomenon in the ecosystem, the frequency of which has

been however greatly accelerated by humans. Here, open pine stands with grasses, *Pteridium aquilinum, Rubus, Calliandra*, and *Leucaena* are predominant as long as the disturbances do not lead to further degradation. In less disturbed areas, mostly at higher altitudes, *P. tecunumanii* is often associated with other pines, such as *P. oocarpa, P. maximinoi*, and *P. pseudostrobus*, and at the more mesic sites *P. ayacahuite* and *P. strobus* var. *chiapensis. Abies guatemalensis* and *Cupressus lusitanica* are other conifers on these high mountain ridges. On the Atlantic slopes in Chiapas a mixed angiosperm forest with *Liquidambar, Magnolia, Clethra, Carpinus, Symplocos, Quercus* and many other species predominates, and *Pinus tecunumanii* and other pines occur either on poorer sites or at an earlier stage in a sere leading back to dominance of broad-leaved trees.

Conservation

While occasionally still abundant and of very tall stature, this pine is now usually scattered in small, disjunct populations and has been depleted by overexploitation and forest clearing, especially at lower elevations, to such an extend that many of these populations are now vulnerable to extinction (Dvorak & Donahue, 1992).
IUCN: VU [A2cd, A3cd; B2ab (ii, v)]

Uses

Pinus tecunumanii is an important timber tree in Central America, where it can grow a straight bole with large dimensions. It is largely exploited for sawn timber and other local wood products in its native range; potentials for wood pulp production are considered to be high if it was to be grown extensively in plantations. This taxon has received considerable interest from foresters as a species for potential plantation forestry to be introduced in tropical countries. A comprehensive collection of seed and specimens was carried out by the Oxford Forestry Institute (OFI), as well as by other organizations, throughout its entire range. A major limitation to introductions on a large scale is the limited availability of seeds, both from natural stands and from so-called seed orchards. It has been planted as a forestry tree in Africa, India, South America and Australia (Queensland). It is not known to be used as an amenity tree.

Pinus teocote Schiede *ex* Schltdl. & Cham., Linnaea 5: 76. 1830. Type: Mexico: Veracruz, Pico de Orizaba, (Volcan Citlaltepetl), *C. J. W. Schiede & F. Deppe s.n.* (holotype HAL).

Etymology

Teocote was apparently one of the Aztec names used for pines in Mexico.

Vernacular names

Aztec pine, Teocote pine; pino chino, pino colorado, pino real, pino rosillo (Spanish)

Description

Trees to 20–25 m tall, d.b.h. to 75 cm; trunk monopodial, sometimes forked, straight. Bark thick, rough and scaly, forming longitudinal plates divided by deep, wide fissures, dark greyish brown. Branches spreading horizontally or curved down; branches of higher orders slightly pendulous, forming a pyramidal to rounded crown. Shoots smooth, orange-brown. Cataphylls subulate, curved at apex, with ciliate margins, brown. Vegetative buds ovoid-oblong; terminal bud 10–15 mm long; lateral buds ovoid-acute, smaller, all not resinous. Fascicle sheaths initially up to 20 mm long, in mature fascicles reduced to ca. 10 mm. Leaves in fascicles of 3(2–5), persisting 2–3 years, straight or slightly curved, rigid, (7–)10–15(–18) cm long, 1–1.4 mm wide, with serrulate margins, acute-pungent, light green. Stomata on all faces of leaves. Pollen cones ovoid-oblong to cylindrical, 1–1.8 cm long, ca. 5 mm wide, yellowish green. Seed cones commonly opposite, sometimes 1–3, on short, stout, curved peduncles falling with cones. Mature cones ovoid to ovoid-oblong when closed, slightly asymmetrical, with a broad, flattened but oblique base when opened, (3–)4–6(–7) × 2.5–5 cm when open, often persistent. Seed scales thick woody, oblong, straight or recurved. Apophysis slightly raised, in some cones more or less flat, transversely keeled, apical margin angular or crenate, light brown, in some cones with radial marks. Umbo dorsal, flat to blunt-pyramidal, with a minute, deciduous prickle. Seeds 3–5 mm long, dark grey-brown; 12–18 × 6–8 mm, translucent, yellowish with a dark tinge.

Distribution

Mexico: Chihuahua, Coahuila, Nuevo León, Tamaulipas, Sinaloa, Durango, Zacatecas, San Luís Potosí, Nayarit, Aguascalientes, Jalisco, Guanajuato, Querétaro, Hidalgo, Michoacán, México, Distrito Federal, Tlaxcala, Puebla, Veracruz, Guerrero, Oaxaca and Chiapas.

TDWG codes: 79 MXC-DF MXC-ME MXC-PU MXC-TL MXE-AG MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-SI MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI

Ecology

Pinus teocote occurs in various habitats, most commonly in rather open forest or woodland associated with *Quercus* spp., on relatively dry sites with shallow soils. Its altitudinal range is (1000–)1500–3000(–3300) m a.s.l., a few collections are recorded from 700–800 m but these may be based on incorrect estimates. This species often occupies dry ridges, sometimes on calcareous outcrops. Annual precipitation is usually moderate, from 500–1000 mm, but much higher in parts of the central highlands of Chiapas, where it is growing in broad-leaved forest dominated by *Liquidambar* and *Styrax. Pinus teocote* occurs with a number of other pines in various parts of its range, the most common of which are from N to S: *P. arizonica, P. engelmannii, P. durangensis, P. leiophylla, P. montezumae, P. oocarpa*, and *P. patula*.

Conservation

IUCN: LC

Uses

Aztec pine is of importance as a timber tree. Apparently due to its moderate size especially in the southern part of its range, resin production may locally count as the more important mode of exploitation. The wood is used as sawn timber, mainly for railway sleepers, coarse construction work, containers and crates, particleboard, and also for pulp. Resin tapping is still an important industry, but it will fluctuate much with market prices for naval stores. In horticulture this species is hardly known, despite its wide range geographically and altitudinally, indicating hardiness of at least some provenances. Hardiness requirements, of course, make the implicit assumption that only people living in cool or cold winter climates want to (or should) grow trees. In addition, notions written in conifer handbooks like "least attractive of Mexican pines" first of all fail to acknowledge that taste is a personal thing and second do no good to promote its cultivation, which may well be of interest to dendrologists.

Pinus thunbergii Parl., in Candolle, Prodr. 16 (2): 388. 1868. *Pinus thunbergiana* Franco, Anais Inst. Super. Agron. (Lisboa) 16: 130. 1949. Type not designated.

Etymology

This species was named after Carl Peter Thunberg (1743–1828), who published an early Flora of Japan.

Vernacular names

Japanese black pine; kuro-matsu (Japanese); haesong (Korean)

Description

Trees to 40 m tall; trunk to 2 m d.b.h., often forked in crown. Bark on trunk thick and breaking into scaly ridges separated by longitudinal, deep fissures, grey with a purplish hue, nearly black in the fissures. Branches spreading and ascending, sometimes heavy, forming broadly conical to domed crowns. Foliage branches stout, rough with pulvini from fallen leaf fascicles, glabrous, new shoots yellowish green, becoming light brown or yellowish brown to grey. Buds ovoid-oblong to ellipsoid-cylindrical, acuminate, 12–20 mm long, non-resinous or resinous; cataphylls light brown, thin, with papery, grey-white to silver-white fringes. Leaves in fascicles of 2, held by a persistent, 10–12 mm long basal sheath, remaining 2–3 years on branchlets, straight, rigid, (6–)7–12 cm long, usually twisted, 1–2 mm wide, dark green; margins minutely serrate; apex acute or pungent; stomata in fine lines on all faces. Pollen ovoid-conical to short cylindrical, 1–1.5 cm long, 0.5 mm wide, yellow; Seed cones solitary or in whorls of 2–3 on short

peduncles, falling shortly after seed dispersal, ovoid-conical when closed, 4–6(–7) cm long, opening to (broadly) ovoid, 3–4.5 cm wide. Seed scales woody, rigid, oblong; apophyses nearly flat to slightly raised, transversely keeled, rhombic or with a rounded upper margin, light brown, more or less lustrous; umbo dorsal, small, unarmed. Seeds obovoid, slightly flattened, 5–7 mm long, grey-brown; wing oblong, 10–15 mm long, pale brown with dark stripes.

Distribution

Japan: S Hokkaido, Honshu, Kyushu, Shikoku; South Korea (near the coast).
TDWG codes: 38 JAP-HK JAP-HN JAP-KY JAP-SH KOR-SK

Ecology

This is a species of pine growing at low to middle elevations (up to ca. 1000 m above sea level) in the coastal hills and mountains of the islands of Japan and South Korea, where the climate is warm temperate (with little or no frost) and moist. These regions would have had a predominantly deciduous angiosperm forest cover, with conifers mixed in especially on poor, water-logged soils and on dry slopes and mountain ridges. *Pinus thunbergii* would have occupied these habitats as well as those in close proximity to the sea coast. Extensive cultivation has removed the natural vegetation in most areas, but as a pioneer species *P. thunbergii* has been able to hold its own; it has been much planted in afforestation schemes from where it could spread in adjacent uncultivated areas. Its tolerance of salty winds makes it a species that grows well on the sea coasts of Japan, both naturally and when planted; naturally its trunk becomes bent and the crown flattened under severe exposure.

Conservation

IUCN: LC

Uses

The wood of this pine is similar to that of the Black pine (*Pinus nigra*) and is used for general construction, poles, railway sleepers, fences, pallets and crates, flooring, fibreboard, and wood pulp. Japanese black pine is mostly used as a windbreak tree and to stabilize sand dunes in coastal areas near urbanization. It is also widely planted as an ornamental tree in Japan and Korea (somewhat less commonly in other countries) and some cultivars have been selected especially in Japan to suit traditional Japanese gardening. It is also being used in bonsai growing. In the USA this species was widely planted for afforestation in coastal areas of New England, until susceptibility to pests and diseases put an end to these schemes and forced the species back to arboreta and parks, where solitary trees are usually safe. Minor uses in Korea are of the needles in pastry and in (medicinal) soft drinks.

Pinus torreyana Parry *ex* Carrière, Traité Gén. Conif.: 326. 1855.

Etymology

This species was named by W. E. Parry, who failed to validly publish it, after the American botanist John Torrey (1796–1873).

Vernacular names

Torrey pine, Soledad pine, Del Mar pine

Description

Trees to 15(–23) m tall; trunk to 1 m d.b.h., mostly curved or crooked in habitat. Bark rough and scaly, deeply fissured on trunk, reddish brown turning to purplish grey. Branches spreading and assurgent or ascending, irregular, forming an open or flattened crown. Foliage branches stout, ca. 10 mm thick (20 mm thick on coning shoots), new shoots glabrous, greenish, becoming purplish brown to nearly black. Buds ovoid-conical, 20–30 mm long, without resin; cataphylls light brown with white fringed margins. Leaves in fascicles of 5, rarely 4 or 6, held in up to 20 mm long but later shortening, persistent basal sheaths, persisting 3–4 years, spreading, rigid, 15–25 cm long, straight or curved, slightly twisted, ca. 2 mm wide, greyish green; margins minutely serrulate; apex abruptly acute; stomata in lines on all faces. Pollen cones ovoid-cylindrical, 2–3 cm long, 8–10 mm wide, yellow. Seed cones solitary or rarely in pairs on stout, 3–4 cm long peduncles, maturing in 3 years, persisting to 5 years, massive, 10–16 cm long, broadly ovoid to ovoid-conical, opening slowly and only partially

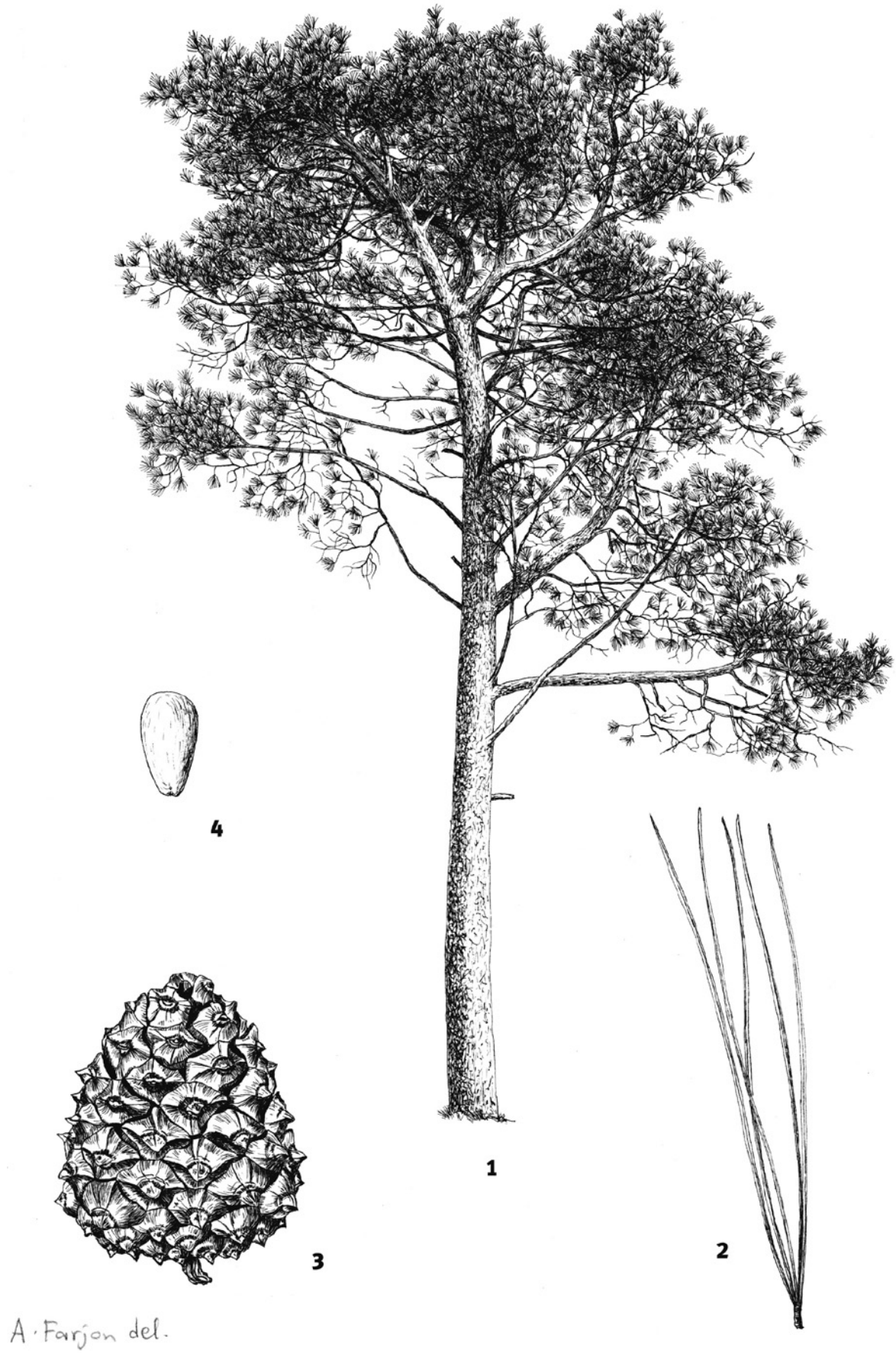

PLATE 34. *Pinus torreyana* subsp. *torreyana*. **1.** Habit of tree. **2.** Leaves. **3.** Seed cone. **4.** Seed.

to 8–17 cm wide, strongly resinous. Seed scales thick woody, rigid, cuneate, with 2 deep seed cavities adaxially; apophyses strongly developed, markedly raised, multi-angular or more or less rhombic, sharply transversely keeled or with 4–5 convergent ridges, lustrous light or red-brown; umbo dorsal and central, pyramidal or slightly curved, with an obtuse, hard apex. Seeds large, obovoid, slightly flattened, 17–24 mm long, 10–14 mm wide, light brown or darker mottled; wing reduced, up to 10 mm long, surrounding the seed like a partial ring, deciduous and sometimes remaining attached to the seed scale.

Distribution

USA: S California (San Diego and Santa Barbara Co.).
TDWG codes: 76 CAL

Ecology

Pinus torreyana is a relict species now confined to littoral habitat on the coast (up to 1.6 km inland) and on two small islands off the coast of southern California. It grows from immediately above the high tide mark to about 180 m a.s.l. on rocky or sandy slopes. On these sites it seems dependent on the daily fog that comes in from the ocean in the afternoon, mitigating the heat of the sun and the resulting excessive evapotranspiration. It grows with a sparse chaparral and few other trees; in ravines sometimes accompanied by a few oaks (*Quercus* sp.) and *Arbutus menziesii*.

Uses

Torrey pine is not used as a timber tree; at present the two disjunct populations are protected by law. It is in cultivation in California in gardens and some arboreta, but rare elsewhere. In the better growing conditions of gardens it can grow to a large tree; a specimen in New Zealand was 45 m tall with a d.b.h. of 1.5 m in 1982 (Grimshaw & Bayton, 2009: 626). Although its conservation seems more or less cared fore at present, growing this species more widely as an *ex situ* backup is to be recommended; it is also an interesting species to grow and requires a mild climate with warm, sunny summers and (near) absence of frost in winter.

2 subspecies are recognized:

Pinus torreyana Parry *ex* Carrière subsp. ***torreyana***. Type: USA: California, San Diego Co., Torrey Pines State Park, *J. R. Haller 10450* (neotype UCSB).
Pl. 34

Description

Trees with erect trunks commonly 15, sometimes more than 20 m tall. Seed cones ovoid when closed, less than 12 cm wide. Seeds more or less evenly brown, not or only lightly mottled.

Distribution

USA: S California (San Diego Co., on the coast N of San Diego).
TDWG codes: 76 CAL

Conservation

The small population on the mainland that constitutes this subspecies is in part (southern subpopulation) legally protected in the Torrey Pines State Park. However, the small overall size, fewer than 3500 mature trees covering ca. 320 ha in two subpopulations, and close proximity to major urban development, put the subspecies highly at risk of destructive events such as fires, pest epidemics and diseases. Trees outside the reserve are often not protected from development; they are sometimes incorporated in urban landscaping and sometimes felled (personal obs. 1992).
IUCN: CR [B2ab (ii, iii, v)]

Pinus torreyana Parry *ex* Carrière subsp. ***insularis*** J. R. Haller, Syst. Bot. 11 (1): 45. 1986. *Pinus torreyana* Parry *ex* Carrière var. *insularis* (J. R. Haller) Silba, Phytologia 68: 64. 1990. Type: USA: California, Santa Barbara Co., Santa Rosa Island, *J. R. Haller 10448* (neotype UCSB).

Description

Stunted trees commonly less than 10 m tall, with a flat crown (due to severe growing conditions). Seed cones broad when closed, usually over 12 cm wide, with strong, nearly straight umbos. Seeds with dark spots.

Distribution

USA: S California (Santa Barbara Co., Santa Catarina Island, Santa Rosa Island).
TDWG codes: 76 CAL

Conservation

This tiny population of ca. 1000 mature trees covering less than 100 ha in two subpopulations on two near-shore islands is at high risk from stochastic events such as fire, pest infestation, or disease, all of which could wipe out this subspecies easily. The trees enjoy legal protection, but that is not an effective buffer against these risks.
IUCN: VU (D2)

Pinus tropicalis Morelet, Rev. Hort. Côte d'Or 1: 106. 1851. Type: Cuba: Isla de la Juventud [Isla de Pinos], La Cañada, *N. L. Britton & E. G. Britton 14416* (neotype NY).

Etymology

The species epithet means that this pine occurs in the tropics.

Vernacular names

Tropical pine; pino blanco, pino hembra (Spanish)

Description

Trees to 30 m tall, d.b.h. to 1(?) m; trunk monopodial, erect. Bark thick, rough, scaly, breaking into irregular polygon plates, divided by deep longitudinal fissures on lower part of the trunk, reddish brown, weathering grey. Branches spreading to ascending, forming an irregular, open crown. Shoots uni-nodal, thick, very rough, lustrous orange-brown in 1st and 2nd year, then grey. Cataphylls subulate, recurved, scarious, brown. Vegetative buds ovoid-oblong, acute; terminal bud 15–25 mm long; lateral buds smaller, not resinous. Fascicle sheaths initially ca. 20 mm long, persistent but reduced to ca. 10 mm on mature leaf fascicles. Leaves in fascicles of 2 (rarely 3), persisting 2 years, very uniform, straight and rigid, (15–)20–30 cm long, 1.5 mm wide, with serrulate margins, acute, light or yellowish green. Stomata on all faces of leaves. Pollen cones ovoid-oblong to cylindrical, 2–3 cm × 5 mm, pink to yellowish. Seed cones subterminal, on short, thick peduncles, solitary, in pairs or whorls up to 6, remaining erect or spreading obliquely. Mature cones narrowly ovoid to ovoid-attenuate when closed, ovoid with a flattened base when opened, then 5–8 × 4–5.5 cm, persistent for some years, but falling with peduncle attached. Seed scales oblong, straight or strongly recurved. Apophysis flat or slightly raised, transversely keeled, rhombic to pentagonal in outline, radially striated, light brown or reddish brown. Umbo dorsal, flat or slightly raised, without a prickle. Seeds 5 × 4 mm, light grey-brown; wings 12–15 × 5–6 mm, yellowish with a grey or black tinge. Seedling: Suppressed terminal growth and a thick radicle produce a 'grass stage' as an adaptation to ground fires. Leaves are normal but less straight.

Distribution

West Indies: W Cuba (Pinar del Rio, Isla de la Juventud [Isla de Pinos]).
TDWG codes: 81 CUB

Ecology

Pinus tropicalis is a lowland pine, occurring on the coastal plains and low foothills between 1–150 (–300) m a.s.l., on nutrient-poor sandy or gravelly alluvial soils which are dry due to rapid drainage. The climate is tropical, with annual precipitation of around 1200 mm and a prolonged dry season. It is in part sympatric with *P. caribaea* var. *caribaea*, which has a greater altitudinal range. Pine savanna's are open, grass-dominated lowland areas which burn frequently; *P. tropicalis* has an advantage over *P. caribaea* through its 'grass stage' by which the seedling can survive successive fires. Thus it becomes frequently the only pine in this vegetation type.

Conservation

The previous (1998) assessment did not account for a decline that was already going on due to deliberate replacement of *Pinus tropicalis* with *P. caribaea* by foresters. The EOO and AOO are both within the threshold for Vulnerable.
IUCN: VU [B2ab (ii, iii, v)]

Uses

Pinus tropicalis is an important regional source of timber mainly used by local sawmills. Its wood is dense and durable, but resinous. It is also used in plantation forestry, mainly in Cuba, but also to a limited extent elsewhere.

Pinus uncinata Ramond *ex* DC., in Lamarck & Candolle, Fl. française, ed. 3, 3: 726. 1805. Type: Europe: [locality not mentioned], *K. I. Christensen F6*, 5/12 July 1980 (neotype G).

Pinus uncinata Ramond *ex* DC. var. *rostrata* Antoine, Conif.: 12. 1840; *Pinus mugo* Turra var. *rostrata* (Antoine) Hoopes, Ber. Deutsch. Bot. Ges. 58a: 20. 1941; *Pinus mugo* Turra subsp. *rostrata* (Antoine) E. Murray, Kalmia 13: 23. 1983.
Pinus uncinata Ramond *ex* DC. var. *ancestralis* Businský, Acta Pruhon. 88: 7. 2008.

Etymology

The species epithet comes from the Latin *uncinus* = barb, referring to the hooked apophyses on the cone scales.

Vernacular names

Mountain pine; pino negro (Spanish); pin à crochets (French); Aufrechte Bergföhre, Hakenkiefer (German).

Description

Trees to 20–25 m tall (often smaller); trunk to 50 cm d.b.h. Bark breaking into small, rectangular plates and sometimes curling scales on larger stems, dark brown. Foliage branches stout, rough with decurrent pulvini and small cataphylls, glabrous, at first orange brown, later reddish brown. Buds ovoid-cylindrical, acute, strongly resinous, 5–10 mm long. Leaves in fascicles of 2, held in 10–18 mm long, later much shorter, basal fascicle sheaths, densely set on branches, directed forward, persisting 4–8 years, (3–)5–6 cm long, curved and rigid, twisted, 1.5–1.8 mm wide, dark green; margins minutely serrulate; apex acute or pungent; stomata in fine lines on all sides. Pollen cones short cylindrical, 10–15 mm long, 5 mm wide, yellow. Seed cones solitary or in whorls of 2–3, sessile or on very short peduncles below shoot apex, patent or more or less reflexed, falling at maturity or persisting up to 4 years, mostly oblique when closed, 3–6.5 cm long, 3–5(–6) cm wide when opened, with an asymmetrical, flattened base. Seed scales thin woody, rigid, oblong, spreading wide, dark brown or blackish brown. Apophyses prominently raised, transversely keeled, on outer, sun-exposed side of cone much larger and recurved or longitudinally ridged (' barbed' or 'hooked'), lustrous yellowish or light brown. Umbo dorsal, conical or obliquely pyramidal, excentric, armed with a minute prickle. Seeds small, 3–4 mm long; wing articulate, 10–13 mm long.

Taxonomic notes

This species has often been considered to be a variety or subspecies of *Pinus mugo* and has been classified under all its synonyms and possible combinations at these ranks (see Farjon, 1998, [2001] for full synonymy under *P. mugo* subsp. *uncinata*). The principal distinction with *P. mugo* is the tree habit of *P. uncinata* and not the oblique cones with strongly developed apophyses on one side, as these are found in some of the shrubby mountain pines as well (see *P. mugo* subsp. *rotundata* on p. 718 and Christensen, 1987). I have maintained this taxon in this Handbook as a distinct species, as I did in the second edition of my book Pines (Farjon, 2005b). The tree habit is not attributable to ecological factors, as it is constant through the entire altitudinal range in which this pine occurs and is maintained when seeds are grown up under controlled conditions, as is the case with the shrubby habit of *P. mugo* and its subspecies or varieties. Both taxa can and do form hybrids in nature with *P. sylvestris* and probably with each other. One would hope that taxonomists could finally arrive at a consensus, but that hope seems idle and the 200–year old tangle of names and their synonyms is likely to be expanded with yet more new names and combinations applied to this group of European pines.

Distribution

Europe: NE Spain, Pyrenees, Auvergne Mts. (possibly introduced), Alps, Jura, Vosges, Böhmerwald, Erzgebirge.
TDWG codes: 11 AUT-AU CZE-CZ GER SWI 12 FRA-FR SPA-AN SPA-SP

Ecology

This is a pine of wet moors in W European mountains and typical for the association Pinetum uncinatae Kastn., Flössn. *et* Uhlig (= Vaccinio uliginosi-Mugetum Oberdorfer). This association has only *Pinus uncinata* as a characteristic species, but it is usually accompanied by various species of *Vaccinium*, by *Calluna vulgaris, Eriophorum vaginatum*, and some oligotraphent species of *Sphagnum* like *S. recurvum* and *S. magellanicum*, most of these with a high presence in the vegetation. *Pinus uncinata* occurs naturally at altitudes of between 600 and 1600 m a.s.l. In the Alps and Pyrenees it grows on moist slopes up to the tree line; in the Alps it is confined to the western and northwestern ranges that are much wetter than the central and southern Alps. Here it sometimes grows with *Picea abies* or *Pinus sylvestris*; in the Pyrenees the spruce is naturally absent.

Conservation

IUCN: LC

Uses

Mountain pine is not commercially important; its main value is ecological and it has some significance as an ornamental tree. The wood is used as fuel and is suitable for light construction, but as this species grows slowly and remains small the yield is limited. Its only commercial use is located in the Pyrenees, where fairly extensive stands exist. Some of the wood is excellent for special uses like turnery, woodware and musical instruments due to its relative density and hardness. It is uncommon in cultivation and restricted to local parks and further afield to some botanic gardens and arboreta.

Pinus virginiana Mill., Gard. Dict., ed. 8: Pinus No. 9. 1768. Type not designated. Fig. 251

Etymology

This species name indicates its native origin, Virginia, with which much of the eastern USA was designated in colonial times.

Vernacular names

Virginia pine, Scrub pine

Description

Trees to 15–18 m tall, rarely to 25 m; trunk to 50 cm d.b.h., straight or contorted, forked, or shrubby. Bark thin and scaly, irregularly fissured and ridged on lower part of larger trunks, grey-brown, becoming reddish higher up in the tree. Branches numerous, irregularly spreading and ascending, forming an irregular, often dense, rounded or flat-topped crown. Foliage branches slender, rough with pulvini from fallen leaf fascicles, new shoots glabrous, purplish brown, often glaucous, becoming red-brown to grey. Buds short and broad, ovoid, 5–10 mm long, shortly acute, resinous or not; cataphylls red-brown, with whitish fringed margins. Leaves in fascicles of 2, held by short, persistent sheaths, remaining 3–4 years on branches, spreading, rigid, 3–8 cm long, often strongly twisted, 1–1.5 mm wide, light or dark green or yellowish green; margins minutely serrulate; apex narrowly acute; stomata in inconspicuous lines on all surfaces. Pollen cones ellipsoid-cylindric, 10–15 mm long, red-brown turning yellow at anthesis. Seed cones solitary or in pairs, nearly sessile or on 1 cm long, tenacious peduncles, persistent but opening soon, spreading out or curved back, 3.5–7 cm long, slightly oblique to symmetrical, conical when closed, ovoid when open. Seed scales woody, rigid, oblong, dull red-brown with a purple-red sealing band; apophyses prominently raised or slightly thickened, transversely keeled, light brown; umbo dorsal and central, pyramidal, armed with a slender, strong, to 5 mm long, straight or curved prickle. Seeds obovoid, slightly flattened, 4–6(–7) mm long, pale brown with darker spots; wing 16–20 mm long, narrow.

Distribution

E USA: from New York State in the north to N Alabama and Mississippi in the south-west and South Carolina in the south of its range.

TDWG codes: 75 INI NWJ NWY OHI PEN WVA 78 ALA DEL GEO KTY MRY MSI NCA SCA TEN VRG

Ecology

Pinus virginiana is a species of the Piedmont and lower slopes of the Appalachian Mountain system, growing on the sea coast in the north, but only in the interior and at higher altitudes in the south of its range, up to 950 m a.s.l. The climate is humid and cool in most of its range and snowfall can be abundant at least in the northern parts. This species is naturally restricted to poorer soils and avoids calcareous substrates. It is a pioneer that now invades large tracts of abandoned farmland, invigorating its reputation as a weedy species. On these and other marginal or disturbed sites it is a shrubby tree, but it can attain taller tree stature in mixture with other trees in a forest environment. In such woods it is a minor component accompanying *Quercus* spp. and sometimes other species of pine, e.g. *P. echinata, P. rigida* and *P. taeda*, or it is part of a mixture of oaks and pines. Other conifers locally growing with *P. virginiana* are *Tsuga canadensis* and *Thuja occidentalis*. In the so-called pine barrens in the NE of its range sometimes lichens (*Cladina, Cladonia*) and a few oak shrubs (*Quercus ilicifolia*) provide the only undergrowth.

Conservation

IUCN: LC

Uses

Foresters dismissed this species as 'weedy' in the past, but it has the capacity to grow upright to a moderate size, especially when planted on abandoned farmland and former coal strip mines. It provides rough lumber and pulpwood on these sites especially in the SE of its range. It is also important as a Christmas tree and huge quantities are planted and sold each year. It finds little appreciation in horticulture, but the dense branching of some shrubby specimens would be ideal in garden landscaping. Dwarf forms (cultivars) from witches brooms have been produced by growers in the USA and can be used to advantage in rock gardens.

Pinus wallichiana A. B. Jacks., Bull. Misc. Inform., Kew 1938: 85. 1938.

Etymology

This species was named in honour of Nathaniel Wallich (1786–1854), a Danish botanist who amassed the famous Wallich Herbarium for the East India Company, now kept at K.

Vernacular names

Himalayan white pine, Blue pine, Bhutan pine; kail (Hindi); lamshing (Kumaon, Bhutan)

Description

Trees to 50–60(–70) m tall; trunk to 2 m d.b.h., bole straight and columnar. Bark becoming fissured and breaking into small scales that flake off in small chips, dark greyish brown. Branches whorled, spreading wide and curved downward, those of higher orders drooping but with upturned ends, forming a broadly pyramidal crown. Foliage branches glabrous, new shoots at first glaucous green, becoming pale green and then grey-brown. Buds ovoid-conical; terminal bud more or less conical, 10–15 mm long; lateral buds smaller and more ovoid, all slightly resinous. Leaves in fascicles of 5, held in deciduous, basal fascicle sheaths of orange-brown flimsy scales, persisting 2–3 years, slender and flexible, (6–)10–18(–20) cm long, drooping or sometimes pendulous, often with a sharp bend near base but otherwise straight, 1 mm wide; margins minutely serrulate, (dark) green abaxially, glaucous white adaxially; stomata in fine lines on the two adaxial faces. Pollen cones in small clusters at base of new shoots, with 8–12 basal perular scales remaining and partly covering the short cylindrical, yellow cones. Seed cones solitary or in whorls of 2–6, initially erect on stout, 2.5–4 cm long peduncles, becoming pendulous when growing, cylindrical, usually slightly curved, (10–)15–30 cm long, 3–4 cm wide when closed and 5–8(–9) cm wide when mature and opened, usually resinous, soon falling with peduncle after seeds have been released. Seed scales cuneate-oblong, widest just below the apophysis, thin woody, only slightly flexible, with two seed cavities near adaxial base. Apophyses more or less rhombic, slightly raised, with grooves converging

to the terminal, small, incurved, obtuse-triangular umbo, lustrous light brown with darker umbo. Seeds obliquely obovoid, (3–)5–9 mm long, 3.5–5 mm wide, yellowish brown or brown; wing (10–)20–35 mm long, (5–)8–10 mm wide, grey-brown.

Distribution

Himalaya: from Afghanistan (Hindu Kush) to NE India, SE Xizang [Tibet] and NW Yunnan; N Myanmar [Burma].
TDWG codes: 34 AFG 36 CHC-YN CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP PAK WHM-HP WHM-JK WHM-UT 41 MYA

Ecology

Pinus wallichiana grows in the Himalayas in the valleys and foothills, to a maximum altitude of 2700 m, but in Bhutan it reaches 3400 m a.s.l. Sometimes it forms pure stands or forests, in other places it appears as an important forest component mixed with broad-leaved trees, e.g. species of the genera *Quercus, Acer* and *Ilex*. In the western Himalayas, where conditions are drier, *P. wallichiana* forms mixed forests with *Cedrus deodara*. Other conifers with which it may be associated are *Pinus roxburghii, Abies spectabilis*, or *A. densa* and *Tsuga dumosa* in the wetter eastern part of its range.

Uses

Bhutan pine is an important timber tree in many parts of the Himalaya. It is of similar timber properties and quality to *P. strobus* and *P. monticola* in North America, with tall, straight trees producing straight grained wood of good strength. It is used for construction, carpentry and joinery, wall panelling, veneers, furniture, fences and gates, crates and boxes, and railway sleepers after treatment with preservatives. In India (Himachal Pradesh) resin tapping is an important use to obtain naval stores. A sweet liquid known as honey dew is secreted by aphids from the leaves and collected by local people of the mountain forests for consumption. Bhutan pine was introduced to England in 1823 and, unlike several other species of *Pinus* subsection *Strobi*, it turned out to be relatively immune to infections with blister rust (*Cronartium ribicola; Basidiomycota*) as well as to atmospheric pollution. In forestry it is also used in plantations and several hybrids with related species have been established with timber production in mind (e.g. the cross between *P. strobus* and *P. wallichiana* = *P.* ×*schwerinii* Fitschen). Bhutan pine is a widely used amenity tree and a number of cultivars have been selected and are in the trade.

2 varieties are recognized:

Pinus wallichiana A. B. Jacks. var. ***wallichiana***. Type: Illustration in Lambert, Descr. *Pinus* 2, t. 3 "*Pinus excelsa*". 1824 (lectotype designated here). Fig. 252

Pinus wallichiana A. B. Jacks. var. *manangensis* H. Ohba & M. Suzuki, [Himalayan Pl. 1] Univ. Mus. Univ. Tokyo Bull. 31: 350. 1988.

Description

Leaves 10–20 cm long. Seed cones 15–30 cm long. Seeds 4–9 mm long, with a 15–35 mm long and 8–10 mm wide wing.

Distribution

Himalaya: from Afghanistan (Hindu Kush) to NE India; China: SE Xizang [Tibet] and NW Yunnan; N Myanmar [Burma].
TDWG codes: 34 AFG 36 CHC-YN CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP PAK WHM-HP WHM-JK WHM-UT 41 MYA

Conservation

IUCN: LC

Pinus wallichiana A. B. Jacks. var. ***parva*** K. C. Sahni, Indian J. Forest. 12 (1): 40. 1989. Type: India: Arunachal Pradesh, Kameng District, Tawang, *R. N. Loganey 6* (holotype DD).

Description

Leaves 6–11(–13) cm long. Seed cones ca. 10 cm long. Seeds consequenly small, ca. 3 mm long, with a 10 mm long and 5 mm wide wing.

Taxonomic notes

This apparently high altitude form from NE India in an area also claimed by China as lying in Xizang [Tibet], see Flora of China 4: 24 (1999), was described from a type specimen only. A specimen in PE (Ying & Hong 759) from Tangmai in Xizang [Tibet] appears to belong to it as well.

Distribution

NE India: Arunachal Pradesh (Assam, Kameng District); China: SE Xizang [Tibet].
TDWG codes: 36 CHT 40 EHM-AP

Conservation

IUCN: LC

Pinus wangii Hu & W. C. Cheng, Bull. Fan Mem. Inst. Biol., ser. 2, 1 (2): 191. 1948. Type: China: Yunnan, Xichou Xian, Fadou, *C. W. Wang 85830* (holotype KUN).

Etymology

The species epithet commemorates the Chinese botanist C. W. Wang, who collected the type specimen in SE Yunnan, China.

Vernacular names

Wang pine; mao zhi wu zhen song (Chinese)

Description

Trees to 20 m tall; trunk to 60 cm d.b.h. Bark on young trees and branches smooth, thin, becoming scaly and flaking, brown, dark brown or grey-brown on trunks of larger trees. Branches spreading wide, forming broad, umbrella-shaped or irregular, flat-topped crowns. Foliage branches slender; young shoots red-brown, initially pubescent, glabrous or with remnants of pubescence in grooves in the second to third year, turning greyish brown. Buds ovoid to cylindrical, not resinous; cataphylls brown. Leaves in fascicles of 5, held by deciduous sheaths of flimsy, brown scales, spreading or curved slightly towards shoot, 2.5–6 cm long, pliant, straight or curved, 1–1.5 mm wide, green, with stomatal lines on the two adaxial surfaces; margins minutely serrulate. Pollen cones in small clusters, short cylindrical. Seed cones variable in size and shape, from short ovoid to long cylindrical, initially erect on stout peduncles, becoming curved down to pendulous, 4–10(–15) cm long, solitary or with 2–3 together. Seed scales soft woody, more or less flexible at base, cuneate to oblong; apophyses rhombic to oblong (at base and apex of cone), curved or more or less straight, not recurved or more commonly recurved near cone base, ripening to yellowish brown or dark brown, weathering grey-brown; apex thin and straight or slightly incurved, rarely upcurved; umbo terminal, small and sunken or obtuse. Seeds obovoid or ellipsoid, 8–10 mm long, ca. 6 mm wide, usually with a well developed wing ca. 16 mm long and 7 mm wide.

Taxonomic notes

Pinus wangii has been accepted as a distinct species in Flora of China 4 (1999) and in the World Checklist and Bibliography of Conifers (Farjon, 1998, [2001]) but was only tentatively accepted by Farjon (2005b) in the description of *P. fenzeliana* Hand.-Mazz. A complex of closely related taxa (among which also feature *P. kwangtungensis* and *P. dalatensis*) occurs in SW China and Viet Nam. The Czech botanist R. Businský (2008) has treated these taxa in a narrowly circumscribed concept of species and subspecies, recognizing more species than most. Hu & Cheng (*op. cit.*) compared their new species to *P. parviflora* of Japan, but we now consider that species more distantly related. The morphology is highly variable in some of these species and may not be sufficiently clear to resolve the taxonomy; additional DNA analysis may be needed, but could only help to resolve this species problem if based on sufficiently wide sampling. Ideally, clades resolved from DNA data should correlate with groupings based on distinct morphological character states, and only groups that are congruent on both criteria should be given species names.

Distribution

China: SE Yunnan (Malipo, Xichou, Maquan); Viet Nam (Mai Chou) [The taxonomic status in Viet Nam remains unclear, see Hiep *et al.*, 2004)]. It straddles the border between the two countries.
TDWG codes: 36 CHC-YN 41 VIE

Ecology

Pinus wangii is probably restricted to the 'limestone country' of S China and N Viet Nam, where it occurs on steep slopes and limestone ridges, associated with *Quercus variabilis* and other, mostly small-leaved, evergreen trees and shrubs. Its altitudinal range there is from 500 to 1800 m a.s.l.

Conservation

The subpopulations in China all appear to have been logged.
IUCN: EN [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Uses

Apparently used locally as a timber tree for house building. This species is rare in cultivation; there are a few, mostly young, trees in botanic gardens in China, the UK and the USA.

Pinus yunnanensis Franch., J. Bot. (Morot) 13 (8): 253. 1899.

Etymology

The species epithet denotes Yunnan, China, from where it was first described.

Vernacular names

Yunnan pine; yun nan song (Chinese)

Description

Trees to 30 m tall, rarely shrubs; trunk to 1 m d.b.h., in trees monopodial, sometimes forked in crown. Bark scaly, longitudinally fissured, breaking into irregular plates, greyish brown weathering grey, flaking in small or large chips. Branches spreading or curving down, forming a domed or flat-topped crown. Foliage branches stout, becoming rough with pulvini after shedding leaves, glabrous, new shoots thick, often vigorous, reddish brown, becoming brown or grey-brown. Buds ovoid-oblong, acute; terminal bud to 25 mm long; lateral buds smaller, not resinous; cataphylls appressed, red-brown. Leaves in fascicles of (2–)3, more or less remote, persisting 2–3 years, spreading, held in a 10–15 mm long, persistent basal sheath, 7–20(–30) cm long, straight and slender, pliant, only very long leaves drooping, 1–1.2 mm wide, often slightly twisted, light green; margins minutely serrulate; apex acute or acuminate; stomata in fine lines on all surfaces. Pollen cones short cylindrical, ca. 2 cm long, yellow. Seed cones in pairs or whorls of up to 5, short pedunculate or nearly sessile, usually persisting a few years but opening soon, ovoid-conical when closed, near-symmetrical, 5–10(–11) cm long and 3.5–4.5 cm wide, opening to 5–7 cm wide. Seed scales woody, rigid, oblong to obovate, except basal scales spreading wide. Apophyses raised, variously shaped, transversely keeled, ripening from green to light brown or chestnut-brown; umbo nearly flat or raised, armed with a short or minute prickle. Seeds ovoid, 4–5 mm long, brown; wing 12–15 mm long, 5 mm wide, light brown or grey-brown.

Taxonomic notes

This species resembles and hybridizes with *Pinus tabuliformis*, forming the hybrid taxon *Pinus ×densata* Mast. Some authors have considered it a subspecies of *P. kesyia* (or a variety of *P. insularis* = *P. kesiya* var. *langbianensis*). It would require detailed genetic (DNA) analysis to establish the true relationships of these taxa, and it seems more appropriate to retain this taxon at species rank at present. A form with very long, drooping needles up to 30 cm long was named *Pinus yunnanensis* var. *tenuifolia* and reported to occur in Guangxi and Guizhou, China, at 400–1200 m a.s.l. It is recognized as distinct in Flora of China 4: 15 (1999), but the characters stated to differentiate it from var. *yunnanensis* seem to be rather similar with those of the latter instead. Here var. *tenuifolia* is considered synonymous with *P. yunnanensis* var. *yunnanensis*.

Distribution

SW China: S Sichuan, Yunnan, E Guizhou, E Guangxi.
TDWG codes: 36 CHC-GZ CHC-SC CHC-YN CHS-GX

Ecology

Pinus yunnanensis grows from 400 m to 3300 m a.s.l. in valleys and deep river gorges and on the

high mountain slopes where it forms extensive forests. It is most abundant on dry and sunny slopes and it can locally reach to the tree line, forming an alpine shrub. It is adapted to survive on sites with infertile and shallow, rocky soils exposed to erosion. At high altitudes it can withstand severe frosts. It is most commonly gregarious in pure stands, but can be found growing with other pines, e.g. *P. armandii, P. tabuliformis* and *P. kesiya*, or with *Keteleeria evelyniana*, as well as with angiosperm trees and shrubs.

Uses

Yunnan pine is of considerable economic importance in China, with natural stands covering between 5.5 and 6 million ha and 275,000 ha in plantations. Its wood is used for fuel, as round wood for transmission poles and stakes, as sawn timber for construction, both exterior and interior, for fences and gates, pallets, crates and boxes, cooperage and vats, furniture, veneers, all kinds of plywood and boards, tool handles, pulp for paper, and to make chemical products like plastics and cellulose derivatives. Resin is tapped for naval stores, in particular turpentine, and the bark is used to extract tannins. The leaves (needle litter) provide fodder for animals and are distilled for oils and medicinal products. This species is much planted for wind breaks and erosion control. It is common in China as an ornamental tree, but is not widely planted in other countries, where it is mostly seen in arboreta and other collections. It has a tendency to become invasive as it is an aggressive pioneer species.

2 varieties are recognized:

Pinus yunnanensis Franch. var. ***yunnanensis***. *Pinus tabuliformis* Carrière var. *yunnanensis* Dallim. & A. B. Jacks., Handb. Conif., ed. 3: 563. 1948; *Pinus insularis* Endl. var. *yunnanensis* (Franch.) Silba, Phytologia Mem. 7: 52. 1984; *Pinus kesiya* Royle *ex* Gordon subsp. *yunnanensis* (Franch.) Businský, Acta Pruhoniciana 68: 24. 1999. Type: China: Yunnan, Lijiang Xian, Dapingzi, ["bois des montagnes au dessus de Ta pin tze"], *P. J. M. Delavay 569* (holotype P).

Pinus yunnanensis Franch. var. *tenuifolia* W. C. Cheng & Y. W. Law, Acta Phytotax. Sin. 13 (4): 85. 1975; *Pinus insularis* Endl. var. *tenuifolia* (W. C. Cheng & Y. W. Law) Silba, Phytologia 68: 51. 1990.

Description

Trees to 30 m tall. Leaves not or slightly pendulous, 10–20(–30) cm long, with 4–6 resin ducts. Seed cones opening at maturity, falling after seed dispersal.

Distribution

SW China: S Sichuan, Yunnan, E Guizhou, E Guangxi.
TDWG codes: 36 CHC-GZ CHC-SC CHC-YN CHS-GX

Conservation

IUCN: LC

Pinus yunnanensis Franch. var. ***pygmaea*** (J. R. Xue) J. R. Xue, Fl. Reipubl. Pop. Sin. 7: 258. 1978. *Pinus densata* Mast. var. *pygmaea* J. R. Xue, Acta Phytotax. Sin. 13 (4): 85. 1975; *Pinus tabuliformis* Carrière var. *pygmaea* (J. R. Xue) Silba, Phytologia 68: 63. 1990. Type: China: Yunnan [locality not stated], *Y. C. Hsüeh 156* (holotype PE).

Description

A shrub-like high mountain form to 2 m tall, branching from base. Leaves 7–13 cm long, rigid, not drooping, with 2–3 resin ducts. Seed cones persistent, more or less serotinous.

Distribution

China: SW Sichuan, Yunnan.
TDWG codes: 36 CHC-SC CHC-YN

Ecology

This variety occurs in the mountains at altitudes between 2200 m and 3100 m a.s.l.

Conservation

IUCN: DD

FIGURE 240. *Pinus pinaster* subsp. *pinaster* pollen cones

FIGURE 242. *Pinus pinea* in Algarve, Portugal

FIGURE 243. *Pinus pinea* seed cone

FIGURE 241. *Pinus pinaster* subsp. *pinaster* seed cones of two ages

FIGURE 245. *Pinus pungens* seed cones

FIGURE 244. *Pinus ponderosa* var. *ponderosa* pollen cones

FIGURE 246. *Pinus quadrifolia* in California, USA

FIGURE 247. *Pinus rzedowskii* tree in Michoacan, Mexico

FIGURE 248. *Pinus rzedowskii* seed cones

FIGURE 249. *Pinus sylvestris* var. *sylvestris* trees

FIGURE 251. *Pinus virginiana* seed cones

FIGURE 250. *Pinus taiwanensis* var. *taiwanensis* in Hehuan Shan, Taiwan

FIGURE 253. *Platycladus orientalis* foliage and seed cones (photo D. Mabberley)

FIGURE 254. *Platycladus orientalis* seed cones

FIGURE 252. *Pinus wallichiana* var. *wallichiana* seed cones

FIGURE 255. *Podocarpus acutifolius* foliage and pollen cones

FIGURE 257. *Podocarpus brevifolius* on the Mesilau River, Mt. Kinabalu, Borneo

FIGURE 256. *Podocarpus brassii* var. *brassii* seed cone (photo T. Waters)

FIGURE 259. *Podocarpus chingianus* foliage and seed cone

FIGURE 258. *Podocarpus brevifolius* leaves.

FIGURE 261. *Podocarpus cunninghamii* foliage and seed cones

FIGURE 262. *Podocarpus dispermus* leaves

FIGURE 260. *Podocarpus costalis* foliage

FIGURE 263. *Podocarpus elatus* foliage

FIGURE 264. *Podocarpus elatus* seed cone

FIGURE 266. *Podocarpus grayae* tree at Lake Eacham, Queensland

FIGURE 267. *Podocarpus grayae* trunk, Herberton Range, Queensland

FIGURE 265. *Podocarpus grayae* small sapling at Cape Tribulation, Queensland

FIGURE 269. *Podocarpus laubenfelsii* seedling on Mt. Kinabalu

FIGURE 268. *Podocarpus henkelii* leaves

FIGURE 270. *Podocarpus latifolius* in the Drakensberg, S.A. (photo J. Grimshaw)

FIGURE 272. *Podocarpus macrophyllus* var. *macrophyllus foliage*

FIGURE 277. *Podocarpus nakaii* foliage and seed cones

FIGURE 271. *Podocarpus lawrencei* seed cones

FIGURE 276. *Podocarpus nakaii* flushing leaves

FIGURE 273. *Podocarpus macrophyllus* var. *macrophyllus* foliage and pollen cones

FIGURE 279. *Podocarpus neriifolius* var. *neriifolius* seed cones (photo T. Utteridge)

FIGURE 274. *Podocarpus matudae* leaves and young seed cone

FIGURE 278. *Podocarpus neriifolius* var. *neriifolius* in P.N.G. (photo T. Utteridge).

FIGURE 275. *Podocarpus milanjianus* on Mt. Elgon, Uganda (photo D. L. Roberts)

FIGURE 280. *Podocarpus nivalis* in North Island, New Zealand

FIGURE 283. *Podocarpus novae-caledoniae* foliage and young seed cones

FIGURE 281. *Podocarpus nivalis* foliage and seed cones

FIGURE 284. *Podocarpus nubigenus* leaves (upperside)

FIGURE 285. *Podocarpus nubigenus* leaves (underside)

FIGURE 286. *Podocarpus polystachyus* pollen cones

FIGURE 282. *Podocarpus novae-caledoniae* in New Caledonia

FIGURE 287. *Podocarpus rumphii* seed cones

FIGURE 288. *Podocarpus salignus* foliage and young seed cones

FIGURE 289. *Podocarpus spinulosus* on North Stradbroke Island, Queensland.

FIGURE 295. *Podocarpus totara* foliage and pollen cones

FIGURE 290. *Podocarpus spinulosus* unripe seed cone (photo G. Garruthers)

FIGURE 291. *Podocarpus spinulosus* ripe seed cones (photo G. Garruthers)

FIGURE 293. *Podocarpus totara* tree in North Island, New Zealand

FIGURE 292. *Podocarpus sprucei* foliage buds (photo P. Cribb 1425)

FIGURE 294. *Podocarpus totara* bark

FIGURE 296. *Prumnopitys andina* foliage and pollen cones

FIGURE 297. *Prumnopitys andina* seed cones

FIGURE 298. *Prumnopitys ferruginoides* foliage on Mt. Mou, New Caledonia

FIGURE 299. *Prumnopitys ladei* trunk on Mt. Lewis, Queensland

FIGURE 300. *Prumnopitys ladei* foliage

FIGURE 301. *Pseudolarix amabilis* pollen cones

FIGURE 302. *Pseudolarix amabilis* seed cones

FIGURE 303. *Pseudotaxus chienii* foliage and buds of seed cones

Platycladus Spach, Hist. Nat. Vég. Phan. 11: 333. 1841. Type: *Platycladus orientalis* (L.) Franco [*Platycladus stricta* Spach (*nom. illeg.*) (*Thuja orientalis* L.)] (*Cupressaceae*).

Biota (D. Don) Endl., Syn. Conif.: 46. 1847, *non* Cassini (1825). Type: *Biota orientalis* (L.) Endl. [*Platycladus orientalis* (L.) Franco (*Thuja orientalis* L.)]

Greek: *platys* = broad, flat; *klados* = branch; referring to the flattened foliage branches.

Description

See the species description.

Distribution

As for the species.

Taxonomic notes

Detailed observations of the early stages of seed cone development in both *Microbiota* and *Platycladus* (Jagel & Stützel, 2001) demonstrated that these taxa are probably closely related. Both cones are quite variable (variation is greater in *Platycladus*) and are primarily distinct in size and in the number of bract-scale complexes and ovules. Extremely reduced cones of *Platycladus* resemble strongly developed cones of *Microbiota*; the latter seems merely a cone of *Platycladus* strongly reduced in size and number of parts, including seeds. Phylogenetic analyses of the genera in *Cupressaceae* (Brunsfeld *et al.*, 1994; Gadek *et al.*, 2000) based primarily on molecular data, confirmed the close relationship of these two taxa and their much greater distance from *Thuja*. A concise review of *Platycladus*, with botanical illustrations, was published by Morgan (1999) in Curtis's Botanical Magazine, hopefully with the effect that this genus will be recognized by all as truly distinct from *Thuja*.

Platycladus orientalis (L.) Franco, Portugaliae Acta Biol., sér. B, Sist. Vol. "Julio Henriques": 33. 1949. *Thuja orientalis* L., Sp. Pl. 2: 1002. 1753. Type: China: [locality unknown], *leg. ign. LINN 1136.2* (lectotype LINN). Fig. 253, 254

Thuja chengii Bordères & Gaussen, Bull. Soc. Hist. Nat. Toulouse 73: 284. 1939; *Platycladus chengii* (Bordères & Gaussen) A. V. Bobrov, 14. Symp. Biodiv. Evol. Biol. Jena 1999: 18. 1999.

Etymology

The species epithet means 'from the east', wherewith Linnaeus distinguished the species from his other species in *Thuja*.

Vernacular names

Oriental Arbor-vitae, Chinese Arbor-vitae; ce bai (Chinese)

Description

Trees to 20–25 m tall, evergreen, monoecious; trunk monopodial or multistemmed from low above ground, to 2–2.5(–4) m d.b.h., with stem(s) erect or ascending. Bark on large stems becoming fibrous, exfoliating in thin, long sheets, dull red-brown. Branches spreading, ascending or erect, contorted in old trees, higher order branches mostly spreading, forming a pyramidal, rounded or irregular crown. Foliage branches in flattened, more or less vertically disposed sprays, in older trees more horizontal or irregularly disposed, persistent. Leaves decussate, decurrent, scale-like, on lateral branchlets dimorphic, facials more or less rhombic to obtrullate, with appressed, obtuse apex; laterals bilaterally flattened, distal part spreading or reflexed, appressed or free, with incurved, obtuse apex; leaves on ultimate branchlets 1.5–2 × 1–1.5 mm, with facials slightly smaller than laterals; amphistomatic, stomata in

irregular lines; gland more or less linear, inactive or sometimes active; leaf colour green or greyish green. Pollen cones terminal on ultimate branchlets, solitary, subglobose, 2–3 × 2 mm; microsporophylls (6–)8–10(–12), decussate, peltate, bearing 3–6 abaxial pollen sacs. Seed cones terminal, maturing in one year to erect, ampulliform, glaucous or purplish cones 15–20(–25) × 10–18 mm which open widely and turn brown when the seeds have ripened. Bract-scale complexes 6–8, decussate, with mostly sterile upper pair, oblong to obtrullate, variable in size up to 15 × 8 mm, with a prominently recurved subapical spine 3–8 mm long, spreading wide, more or less woody, thick, exposing often persistent seeds. Seeds 6–10(–12?), ovoid to narrowly ovoid, 5–7 × 3–4 mm, greyish brown with a large, light brown hilum; wings absent or rudimentary as two narrow strips near seed apex.

Distribution

China: S Gansu, Hebei, Henan, Shaanxi, Shanxi, Nei Mongol [Inner Mongolia]; Korea; Russian Far East. [This is possibly the most widely introduced cupressaceous conifer in Asia. In many areas inside and outside China it has 'escaped' from cultivation and established spontaneous populations. Only its natural (indigenous) distribution is given here.]
TDWG codes: 31 AMU KHA 36 CHI-NM CHN-GS CHN-HB CHN-SA CHN-SX CHS-HE 38 KOR-NK KOR-SK

Ecology

Platycladus orientalis is most probably a species of the transitional open woodland zone between the steppes of Inner Mongolia and the deciduous oak, oak-birch, and oak-pine forests of NE China. Even within its natural range it is now almost invariably found in secondary vegetation or, nearest to its original habitat, in more or less degraded woodland and forest. As a pioneer species which is relatively long-lived, it can dominate certain slopes for a long time if further disturbances remain absent. Elsewhere it grows together with *Pinus tabuliformis*, less frequently with *P. armandii* and *Juniperus rigida; Betula chinensis* and *Populus tremula* are followed in the succession by *Quercus* spp. (some of which may be evergreen) and *Castanea*. The most arid and steepest slopes may only be covered with *Pinus tabuliformis* and *Platycladus*, accompanied by *Juniperus rigida* and other shrubs, and this vegetation may not represent a seral type, but an edaphically determined climax. The climate in NE China is above all characterized by very cold winters. As a pioneer of relatively dry, open vegetation on often unstable slopes, *P. orientalis* has found abundant opportunity over much of China, and even beyond (e.g. NE Iran), to establish itself and spread after introduction. It is much used in afforestation in NE and Central China and commonly planted in Central Asia. Buddhism has been instrumental in its spread especially in the SW of China, where it can be abundant on steep slopes of river valleys, but is usually never very far from settlements, monasteries or temples.

Conservation

IUCN: NT

Uses

The wood of Oriental Arbor-vitae is used for building and construction of houses and temples where there are still trees of good size left. The foliage is in some parts of China much used for incense burning, to which purpose the species has been introduced widely outside its natural range. It is also one of the most commonly planted amenity and ornamental conifers, a tradition that goes back many centuries. It is therefore a common tree in parks of towns and cities in much of temperate Asia; it appears to be tolerant of drought as well as the air pollution that occurs within the urban environment. In some parts of China (e.g. Yunnan) and in other countries (e.g. Iran) it has probably been naturalized. In NE China it is being used in afforestation schemes on deforested hills and mountains. A substantial number of cultivars has been raised in Europe since its introduction to France around 1700, many of which are now obsolete, while new cultivars continue to be selected and described.

Podocarpus L'Hér. *ex* Pers., Syn. Pl. 2 (2): 580. 1807 (*nom. cons.*). Type: *Podocarpus elongatus* (Aiton) L'Herit. *ex* Pers. [*Taxus elongata* Aiton] (*Podocarpaceae*)

Margbensonia A. V. Bobrov & Melikyan, Byull. Moskovsk. Obshch. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: *Margbensonia macrophylla* (Thunb.) A. V. Bobrov & Melikjan [*Podocarpus macrophyllus* (Thunb.) Sweet (*Taxus macrophylla* Thunb.)]

Greek: *podo* = foot, *carpus* = fruit; alluding to the receptacle and seed respectively of the female reproductive organ (cone + seed).

Description

(Decumbent) shrubs or more commonly trees, dioecious or rarely monoecious, much branched. Bark scaly or fibrous, peeling in vertical strips. Resin canals mostly in the leaves, none in the wood. Primary branching in pseudo-whorls, plagiotropic (Massart's model). Terminal buds distinctive, with imbricate and/or spreading primary and secondary scales. Leaves spirally inserted or subopposite on lateral foliage branchlets, relatively broad, bifacially flattened, usually linear-lanceolate or linear-elliptic, sessile to short petiolate, coriaceous, with a single raised, flat or sunken midrib and stomata in two broad bands on abaxial side, rarely on both sides and then only few stomata on adaxial side. Pollen cones axillary, solitary or clustered, sessile or on short peduncles, each cone subtended by bud scales, flexible and slender, catkin-like. Microsporophylls spirally attached to a slender rachis, triangular, with two basal pollen sacs containing bisaccate pollen. Seed cones axillary, pedunculate, solitary or rarely more together, consisting of 2–5 adnate bracts (upper 1–2 fertile); the sterile bracts fusing and greatly swelling to form a smooth, succulent, coloured receptacle. Seeds 1, sometimes 2, obliquely attached to the apical part of the receptacle, completely exposed, morphologically inverted, drupe-like, completely covered by a fleshy, green or sometimes reddish to bluish epimatium.

98 species

Distribution

Africa: S Nigeria, Cameroon, Angola; in E Africa from extreme S Sudan to South Africa down to the Cape; Madagascar. Asia: from E Nepal to Taiwan and southern Japan; from Indochina throughout Malesia (excluding Lesser Sunda Islands) to New Britain. Australia: SW corner of Western Australia, Northern Territory (Arnhem Land), Queensland, New South Wales, Victoria, Tasmania. SW Pacific: Solomon Islands, New Caledonia, Vanuatu, Fiji, Tonga, New Zealand. North America: S Mexico. Caribbean Islands (excluding Bahamas). Central America (all countries). South America: Colombia, Venezuela, Guyana, Ecuador, Brazil, Bolivia, N Argentina, S Chile.

Taxonomic notes

The taxonomy of the genus *Podocarpus*, after *Pinus* the most speciose (but not the most diverse) genus in the conifers, is perhaps the least well settled among the major coniferous genera. Whereas at the family level a limited number of phylogenetic studies have now been published, which appear to mostly corroborate the narrower circumscription of the genus established in recent decades on morphological grounds, no such studies have been attempted that more or less sampled the genus *Podocarpus* comprehensively. There are two revisions of the genus based on anatomy and/or morphology that need to be briefly assessed here, in order to establish whether they are useful for this Handbook. The first is by J. T. Buchholz and N. Gray and was published in a series of papers (variously authored by both or by Gray alone later) in the Journal of the Arnold Arboretum in 1948–1962. The circumscription of *Podocarpus* still included several other genera (as sections) and only their section "*Eupodocarpus*" (an illegitimate name under the Botanical Code) was equivalent to the genus *Podocarpus* as presently understood. This section was divided into six subsections, informally named A-F. The emphasis was on a detailed study of

leaf anatomy, but the subsections were mostly defined by geography and a few selected characters, indeed mostly anatomical. De Laubenfels (1985) followed an earlier suggestion by Pilger (1926) that the presence or absence of 'foliola' (lanceolate bracts) below the receptacle could be used to subdivide the genus *Podocarpus* (now in the narrower sense still in use) into two subgenera. Further "special characteristics" then helped De Laubenfels to further subdivide the genus into 18 sections "of from 1–10 species each" and the two subgenera and 18 sections were then formally named and described. In a phylogenetic context, it is unlikely that such a scheme, based as it is on a few selected characters, would be supported by a cladistic analysis of these and other anatomical or morphological characters or of molecular data. Simply put, a different classification would result from the choice of different characters, and without proper testing we do not know how 'artificial' or 'natural' such a scheme might be. It must therefore be concluded that neither of these two classifications has been tested, either by repeated (phenetic or phyletic) attempts using additional characters (as has been the case with *Abies* and *Pinus*) or by a comprehensive cladistic analysis of similar data or molecular data (as with *Abies* and especially *Pinus*). No classification of *Podocarpus* is therefore presented in this Handbook. The large number of species and the paucity of useful morphological characters make it impractical to construct a single key to all species. I therefore present keys to species of *Podocarpus* grouped on a geographical basis. An additional key is presented to help identify species that are more or less commonly found in cultivation.

Key to the species of *Podocarpus* in Africa and Madagascar

When using this key in the field only leaves on branches of mature shrubs or trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious shrubs and trees) are described as mature.

1a. Scales of terminal buds all imbricate or incurved **2**

1b. Scales of terminal buds with at least some outer scales spreading or recurved **6**

2a. Leaves 7–15 mm long, 2–4 mm wide, obovate to oblanceolate (widest above the middle) ***P. humbertii***

2b. Leaves usually longer than 15 mm (if smaller, only 1–2 mm wide), linear or widest below the middle **3**

3a. Leaves 7–36 mm long, 1–2 mm wide, narrowly lanceolate to linear **4**

3b. Leaves (1.5–)2–18 cm long, 2–16 mm wide, elliptic-oblong to linear **5**

4a. Seeds including the epimatium ca. 8 × 5 mm. Scales of terminal buds obtuse or acute. Leaves 7–20(–25) mm long ***P. perrieri***

4b. Seeds including the epimatium ca. 14 × 8 mm. Scales of terminal buds apiculate. Leaves (10–)15–30(–36) mm long ***P. rostratus***

5a. Leaves 2–5 mm wide, up to 7.5 cm long (mature trees!). Bud scales elongated ***P. capuronii***

5b. Leaves 3–16 mm wide, up to 18 cm long (but highly variable!). Bud scales rounded to ovate ***P. madagascariensis***

6a. Midrib on adaxial (upper) side of leaves distinct and continuously raised. Pollen cones always solitary ***P. milanjianus***

6b. Midrib on adaxial (upper) side of leaves indistinct and/or fading towards the apex. Pollen cones 2–5 together, rarely solitary **7**

7a. Shrubs or small trees to 6 m tall (occasionally to 20 m). Leaves (3–)4–5(–7) mm wide ***P. elongatus***

7b. Trees to 30–35 m tall (occasionally stunted on exposed mountain tops). Leaves (5–)6–12(–18) mm wide **8**

8a. Apex of leaves acute or acuminate. Pollen cones (1–)2–5 together. Receptacle below the seed rudimentary; seeds including the epimatium 17–22 mm long ***P. henkelii***

8b. Apex of leaves obtuse or mucronate. Pollen cones 1–2 together. Receptacle below the seed 8–14 × 8–12 mm, succulent; seeds including the epimatium 7–11 mm long ***P. latifolius***

Key to the species of *Podocarpus* in China (including Taiwan), NE India, Indochina, and Japan

When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male

(pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Buds globose to short conical, with imbricate, triangular scales **2**
1b. Buds variously shaped but not globose, with free, erect to spreading or recurved (outer) cales **3**
2a. Adult leaves (3–)5–10(–12) cm long, lanceolate to linear-lanceolate; midrib on adaxial (upper) side of leaves acutely raised ***P. nakaii***
2b. Adult leaves 9–14(–22) cm long, linear; midrib on adaxial side of leaves obtusely raised ***P. rumphii***
3a. Adult leaves 1.2–5(–7) cm long. Bud scales erect or slightly preading **4**
3b. Adult leaves (2.5–)4–12(–15) cm long. Bud scales spreading or recurved, sometimes more or less erect **6**
4a. Adult leaves 2.5–4.5 mm wide, not longer than 3.5 cm ***P. chingianus***
4b. Adult leaves (4–)5–8(–10) mm wide, often longer than 3.5 cm (maximum length 5–7 cm) **5**
5a. Pollen cones solitary, sessile, 8–25 × 6–8 mm. Small trees 1.5–10 m tall ***P. costalis***
5b. Pollen cones solitary, pedunculate, 15–30 × 3 mm. Shrubs or trees to 25 m tall ***P. pilgeri***
6a. Bud scales caudate, recurved. Midrib on adaxial (upper) side of leaves obtusely raised ***P. macrophyllus***
6b. Bud scales triangular-lanceolate to lanceolate, erect, spreading or sometimes recurved. Midrib on adaxial side of leaves acutely raised **7**
7a. Buds 1.5–3 mm long. Adult leaves from nearly oval to linear, with an acute or obtuse apex ***P. polystachyus***
7b. Buds (2–)3–5(–8) mm long. Adult leaves lanceolate to linear-lanceolate, with an acute or acuminate apex **8**
8a. Pollen cones 15–25(–30) × 2–2.5 mm. Receptacles when ripe 9–16 mm long; seeds including the epimatium ca. 9 × 7 mm ***P. fasciculus***
8b. Pollen cones 20–40(–60?) × 2–3.5 mm. Receptacles when ripe 7–12 mm long; seeds including the epimatium (8–)10–15 × 8–10 mm **9**
9a. Receptacles subtended by two 2–6 mm long bracts ('foliola'); epimatium around the seeds without a crest. New leaves flushing red ***P. neriifolius***
9b. Receptacles subtended by two 1–2 mm long bracts; epimatium around the seeds with a crest. New leaves flushing yellowish green ***P. subtropicalis***

Key to the species of *Podocarpus* in Malesia, excluding Borneo and New Guinea, and including the Andaman Islands (India)

Malesia is the phytogeographic region as defined in Flora Malesiana, and includes Peninsular Malaysia and Singapore and all the islands of the archipelago as far as New Guinea and the main chain of the Solomon Islands. Species which occur only in Borneo or New Guinea including the Bismarck Archipelago and/or the Solomon Islands are dealt with in two keys specific to these areas; species which are common to two or more of these areas appear consequently in more than one key. When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Buds short conical or subglobose; bud scales imbricate **2**
1b. Buds elongated, acute; outer bud scales free, erect or spreading **4**
2a. Bud scales rounded at apex. Midrib of leaves on adaxial (upper) side acutely raised, narrow, less than 1 mm wide ***P. teysmannii***
2b. Bud scales triangular, with an acute apex. Midrib of leaves on adaxial side obtusely raised, 1 mm wide **3**
3a. Buds up to 4 × 4 mm, short conical. Seeds including the epimatium ca. 10 mm long ***P. laubenfelsii***
3b. Buds (2.5–)4–5(–8) mm long, globose to short conical. Seeds including the epimatium 12–15 mm long ***P. rumphii***
4a. Adult leaves 0.8–3(–3.5) cm long, 3–6 mm wide. Shrubs or small trees **5**
4b. Adult leaves mostly longer. (Small) trees **6**

5a. Adult leaves elliptic to obovate; apex obtuse to abruptly rounded ***P. glaucus***

5b. Adult leaves elliptic to oblong; apex acute to obtuse ***P. lophatus***

6a. Adult leaves (4–)5–8(–10) mm wide **7**

6b. Adult leaves (6–)8–18(–20) mm wide **10**

7a. Buds 6–14 mm long; outer bud scales erect with recurved tips. Adult leaves 6–11 cm long ***P. atjehensis***

7b. Buds 2–5 mm long; outer bud scales erect or spreading, with straight tips. Adult leaves (2–)3–6(–7) cm long **8**

8a. Pollen cones solitary, sessile, 6–8 mm diam. ***P. costalis***

8b. Pollen cones solitary or more often with 2–3 together, pedunculate when solitary, otherwise sessile, 2.5–3.5 mm diam **9**

9a. Apices of adult leaves acute. Pollen cones solitary or often with 2–3 together, sessile. Receptacles 6–8 mm long when ripe; seeds including the epimatium 8–9 × 5–6 mm, red or purple ***P. rubens***

9b. Apices of adult leaves of various shapes, but often obtuse to rounded. Pollen cones solitary, pedunculate. Receptacles 10–22 mm long when ripe; seeds including the epimatium 10–12 × 8–9 mm ***P. pilgeri***

10a. Adult leaves (1.5–)2.5–5 cm long, elliptic to obovate, with an obtuse or rounded apex ***P. ramosii***

10b. Adult leaves (2.5–)4–15(–18.5) cm long, nearly oval to linear, rarely elliptic, with an acute, obtuse or rounded apex **11**

11a. Leaves linear, deflected at the petiolate base ***P. deflexus***

11b. Leaves nearly oval to linear-lanceolate or linear, not deflected **12**

12a. Adult leaves (8–)12–20 mm wide (5–10 cm long), with obtuse or rounded apex ***P. spathoides***

12b. Adult leaves 6–15(–18) mm wide, with acute or obtuse apex (if wider than 14 mm, apex acute) **13**

13a. Midrib on adaxial (upper) side of leaves indistinct, narrow; adult leaves very gradually tapering to a narrowly acute apex. Receptacle pink when ripe ***P. ridleyi***

13b. Midrib on adaxial side of leaves distinct, acutely or obtusely raised; adult leaves acute or obtuse, sometimes with a rounded apex. Receptacle red when ripe **14**

14a. Pollen cones solitary, 6.5–8 mm wide. Small trees as far as known ***P. palawanensis***

14b. Pollen cones solitary or more often with 2–3(–5) together, 2–4 mm wide. Potentially large trees **15**

15a. Midrib on adaxial (upper) side of leaves obtusely raised, fading towards the apex **16**

15b. Midrib on adaxial side of leaves acutely raised, always continuous to the apex **17**

16a. Buds 2–4 mm long. Pollen cones to 25 mm long. Receptacles 10–15 mm long; seeds including the epimatium 14–17 × 10–13 mm ***P. macrocarpus***

16b. Buds 3–9 mm long. Pollen cones 50–60 (–80?) mm long. Receptacles 8 mm long; seeds including the epimatium 8–11(–13?) × 7–8 mm ***P. levis***

17a. Buds 1.5–3 mm long. Pollen cones in clusters of 2–5, 15–30 mm long ***P. polystachyus***

17b. Buds 2–12 mm long. Pollen cones solitary or with 2–3 together, 25–50(–60) mm long **18**

18a. Adult leaves 3–7(–9) cm long, with an obtuse or rounded apex. Receptacles 6 mm long; seeds including the epimatium 6 × 5 mm, purple ***P. borneensis***

18b. Adult leaves (4–)8–12(–15) cm long, with an acute apex. Receptacles 8–14 mm long; seeds including the epimatium (8–)10–15 × 7–8 mm **19**

19a. Buds 2–5 mm long, sometimes with a few longer outer scales to 8 mm. Receptacles when ripe 8–10 mm long ***P. neriifolius***

19b. Buds 5–12 mm long, with all or most of the outer scales the same length. Receptacles when ripe 10–14 mm long ***P. bracteatus***

Key to the species of *Podocarpus* in Borneo

When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Bud scales imbricate **2**

1b. Bud scales free, erect or spreading **5**

2a. Buds 2–5 mm long, scales rounded **3**
2b. Buds 4–8 mm long, scales triangular **4**
3a. Buds 2–3 mm long. Leaves (2.5–)4–8(–9) cm long, (7–)9–15 mm wide ***P. globulus***
3b. Buds 3–5 mm long. Leaves 7–14 cm long, (10–)12–17(–20) mm wide ***P. teysmannii***
4a. Bud scales with recurved apex. Pollen cones 3–5 together, short pedunculate ***P. laubenfelsii***
4b. Bud scales entirely appressed. Pollen cones (2–)3–5 together, sessile ***P. rumphii***
5a. Leaves 1–7 cm long, rarely to 9 cm long, 3–13 mm wide; shorter leaves usually elliptical, sometimes obovate; longer leaves oblong or linear-lanceolate **6**
5b. Leaves (2.5–)5–15(–18) cm long, (5–)6–20 mm wide, usually linear-lanceolate, sometimes linear-oblong; shorter leaves sometimes elliptical or nearly oval **11**
6a. Buds 2–5 mm long **7**
6b. Buds 4–10 mm long **9**
7a. Buds 2–3 mm long. Leaves elliptical to obovate, 7–13 mm wide; apex obtuse or rounded ***P. ramosii***
7b. Buds 2–5 mm long. Leaves linear-elliptic to linear-lanceolate, (4–)5–8(–10) mm wide; apex acute, obtuse, or rounded **8**
8a. Leaves flushing green. Pollen cones always solitary, pedunculate. Receptacle when ripe 10–22 mm long ***P. pilgeri***
8b. Leaves flushing red. Pollen cones solitary or often 2–3 together. Receptacle when ripe 6–8 mm long ***P. rubens***
9a. Bud scales acuminate, spreading. Pollen cones solitary, rarely in pairs, ca. 15 × 3–4 mm ***P. gibbsiae***
9b. Bud scales triangular or lanceolate-linear, erect or spreading. Pollen cones solitary or often 2–3 together, 20–50 × 2.5–5 mm **10**
10a. Bud scales 4–6 mm long, triangular, spreading. Pollen cones solitary or in pairs, ca. 20 × 4–5 mm ***P. brevifolius***
10b. Bud scales 4–10 mm long, lanceolate-linear, erect or slightly spreading. Pollen cones solitary or with 2–3 together, 35–50 × 2.5–3.5 mm ***P. borneensis***
11a. Bud scales triangular, spreading. Leaves linear-oblong, shortest ones elliptical; apex obtuse or rounded ***P. spathoides***
11b. Bud scales narrowly triangular to lanceolate-linear or long acuminate, erect or spreading. Leaves linear-lanceolate, shortest ones lanceolate or nearly oval **12**
12a. Bud scales long acuminate, erect. Pollen cones solitary, rarely in pairs. Receptacle with a single basal bract 3–5 mm long ***P. confertus***
12b. Bud scales triangular to lanceolate-linear, erect or spreading. Pollen cones solitary or more often with 2–5 together. Receptacle with 2 basal bracts 1.5–6 mm long **13**
13a. Buds 1.5–3 mm long. Leaves nearly oval to linear-lanceolate. Pollen cones 2–5 together, 15–30 × 3 mm. Seeds including the epimatium 7–9 × 5–7 mm ***P. polystachyus***
13b. Buds (2–)3–15 mm long. Leaves linear-lanceolate or lanceolate. Pollen cones solitary or 2–3 together, (25–)30–75(–80?) × 2–4 mm. Seeds including the epimatium (6–) 8–15 × 6–8 mm **14**
14a. Buds 6–15 mm long, scales long linear-lanceolate, erect or spreading. Leaf apex acuminate or acute. Epimatium with a distal crest ***P. micropedunculatus***
14b. Buds (2–)3–9 mm long, scales lanceolate or rarely triangular, spreading. Leaf apex acute or obtuse. Epimatium smooth without a distal crest **15**
15a. Midrib on adaxial (upper) side of leaves obtusely raised, often fading towards the acute or obtuse apex. Seeds including the epimatium 8–11 mm long ***P. levis***
15b. Midrib on adaxial (upper) side of leaves usually acutely raised, continuous to the acute apex. Seeds including the epimatium (8–)10–15 mm long ***P. neriifolius***

Key to the species of *Podocarpus* in Papuasia

Papuasia is the phytogeographic region that includes New Guinea, the Bismarck Archipelago and the Solomon Islands (as on Plate 12 of the Times Atlas, 12th edition, but excluding the Santa Cruz Islands). When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Usually shrubs, only rarely (small) trees. Adult leaves not longer than 3 cm **2**

1b. Trees (can be stunted at high altitudes). Adult leaves usually longer than 3 cm **3**

2a. Buds 3–5 mm long. Pollen cones ca. 40 × 3–8 mm. Receptacles when ripe 12–15 mm long, thick, purple or purple-black; seeds including the epimatium 10–13 × 8–9 mm, without an apical crest ***P. brassii***

2b. Buds 2–3 mm long. Pollen cones 10–25 × 6–7 mm. Receptacles when ripe 6–8 mm long, purple; seeds including the epimatium 6–7 × 5 mm, with a small apical crest ***P. glaucus***

3a. Adult leaves (1.5–)2.5–6 cm long **4**

3b. Adult leaves mostly longer than 5 cm, only a few sometimes shorter **5**

4a. Pollen cones always solitary and pedunculate. Receptacles when ripe 10–22 mm long; seeds including the epimatium 10–12 × 8–9 mm ***P. pilgeri***

4b. Pollen cones solitary or often 2–3 together, sessile. Receptacles when ripe 6–8 mm long; seeds including the epimatium 8–9 × 5–6 mm ***P. rubens***

5a. Buds globose to conical, as wide as long, with imbricate scales. Leaves all linear ***P. rumphii***

5b. Buds variously shaped but not globose, including the free, erect or spreading outer scales longer than wide. Leaves variously shaped, not all linear **6**

6a. Leaves (strongly) deflected at the petiolate base ***P. atjehensis***

6b. Leaves spreading or sometimes drooping, not deflected **7**

7a. Apex of adult leaves obtuse or rounded, leaves 5–10 cm long, (8–)12–20 mm wide. Receptacles when ripe 5 mm long; seeds including the epimatium 7 × 5 mm, purple ***P. spathoides****

7b. Apex of adult leaves acute, acuminate or obtuse, never rounded, if adult leaves 20 mm wide (or wider), longer than 10 cm. Receptacles when ripe longer than 8 mm; seeds including the epimatium larger than 7 × 5 mm, variously (purplish) green **8**

8a. Midrib on adaxial (upper) side of leaves obtusely raised, often fading towards apex **9**

8b. Midrib on adaxial (upper) side of leaves acutely raised, continuous to apex **10**

9a. Pollen cones always solitary, 30–40 × 6–8 mm. Buds 3–5 mm long, with triangular to lanceolate, slightly spreading scales. Seeds including the epimatium 5–6 mm wide ***P. archboldii***

9b. Pollen cones often 2–3 together or solitary, 50(–80?) × 2–3.5 mm. Buds 3–9 mm long, with lanceolate, spreading outer scales. Seeds including the epimatium 7–8 mm wide ***P. levis***

10a. Buds 6–14 mm long; bud scales with a long, acuminate or caudate apex **11**

10b. Buds 1.5–7(–8) mm long; bud scales triangular to lanceolate **13**

11a. Adult leaves (11–)15–25 mm wide. Receptacles when ripe 10–16 mm long ***P. ledermannii***

11b. Adult leaves (5–)7–12 mm wide. Receptacles when ripe 8–11 mm long **12**

12a. All bud scales erect. Adult leaves (4–)6–15 cm long, leaf apices acute ***P. pseudobracteatus***

12b. Outer bud scales spreading. Adult leaves 10–25 cm long, leaf apices acute or obtuse ***P. salomoniensis***

13a. Buds on leading shoots (3–)4–8 mm wide and 4–7 mm long, onion-shaped or truncate, with strongly recurved outer scales. Pollen cones 6–7 mm wide ***P. crassigemma***

13b. Buds on leading shoots longer than wide, more or less conical, with erect or spreading outer scales. Pollen cones 2–3.5 mm wide… **14**

14a. Adult leaves 6–11 mm wide. Pollen cones always clustered with 2–5 together, 15–30 mm long. Seeds including the epimatium 7–9 mm long ***P. polystachyus***

14b. Adult leaves 8–15(–18) mm wide. Pollen cones solitary or often 2–3 together, 25–40(–50) mm long. Seeds including the epimatium (8–)10–15 mm long **15**

15a. Buds 2–5 mm long, sometimes with a few longer outer scales to 8 mm. New leaves flushing red ***P. neriifolius***

15b. Buds 2–3 mm long, without longer outer scales. New leaves flushing pale whitish green ***P. insularis***

* *Podocarpus spathoides* has been found to be limited to Malaysia and trees from Papuasia that would key out to belong here are not that species (Mill & Whiting, 2012).

Key to the species of *Podocarpus* in Australia

When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Shrubs. Adult leaves 2–5 mm wide **2**
1b. Trees. Adult leaves (5–)7–30 mm wide **4**
2a. Adult leaves 0.4–1.6 cm long; leaf apices obtuse. Bud scales imbricate, broadly triangular ***P. lawrencei***
2b. Adult leaves 2.5–9(–13) cm long; leaf apices acuminate or pungent. Bud scales free, (slightly) spreading, narrowly triangular **3**
3a. Apices of leaves apiculate, pungent; midrib on adaxial (upper) side of leaves acutely raised. Pollen cones 4–8 mm long. Receptacles when ripe 6–10 × 6–7 mm; seeds including the epimatium 8–10 × 5–7 mm ***P. spinulosus***
3b. Apices of leaves acuminate; midrib on adaxial side of leaves obtusely raised. Pollen cones (5–)10–20(–22) mm long. Receptacles when ripe 20–25 × 10–13 mm; seeds including the epimatium 12–20 × 8–12 mm ***P. drouynianus***
4a. Bud scales free, spreading. Adult leaves (13–)18–30 mm wide, oval to oblong ***P. dispermus***
4b. Bud scales imbricate, appressed. Adult leaves (5–)7–18(–20) mm wide, linear to linear-lanceolate **5**
5a. Adult leaves (6–)10–25(–30) cm long, linear ***P. grayae***
5b. Adult leaves (3–)5–11(–15) cm long, linear-lanceolate **6**
6a. Buds 1.5–2.5 mm long. Midrib on adaxial (upper) side of leaves obtusely raised but prominent. Pollen cones 10–20 × 2–3 mm. Receptacles when ripe 15–25(–30) × 15–20 mm, dark purple or blue-black ***P. elatus***
6b. Buds 3.5–8 mm long. Midrib on adaxial side of leaves obscure. Pollen cones 30–45 × 4–6 mm. Receptacles when ripe 5–7 × 5 mm, red ***P. smithii***

Key to the species of *Podocarpus* in the SW Pacific

The SW Pacific for the purposes of this key includes New Caledonia, Vanuatu, Fiji, and Tonga. When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Adult leaves 0.8–5 cm long **2**
1b. Adult leaves (2.5–)4–14(–15) cm long **3**
2a. Trees. Adult leaves 2.5–5 cm long, 6–9 mm wide ***P. affinis***
2b. Shrubs. Adult leaves 0.8–2.2 cm long, 1.7–2.3 mm wide ***P. gnidioides***
3a. Buds small (usually ca. 2 mm long); bud scales imbricate, obtuse or short triangular **4**
3b. Buds larger (usually more than 3 mm long); bud scales free, erect, spreading or outer bud scales recurved, triangular-lanceolate, elongated or acuminate **6**
4a. Shrubs. Adult leaves 3–5(–6) mm wide, with a central groove on adaxial (upper) side ***P. novae-caledoniae***
4b. Trees. Adult leaves (5–)7–18 mm wide, with an obtusely raised midrib on the adaxial side **5**
5a. Adult leaves (9–)11–18 mm wide. Seeds including the epimatium without a distal crest ***P. lucienii***
5b. Adult leaves (5–)7–11(–13) mm wide. Seeds including the epimatium with a (faint) crest ***P. sylvestris***
6a. Low, decumbent shrubs. Bud scales free, erect, not spreading. Adult leaves oblanceolate (widest beyond the middle) ***P. decumbens***
6b. Erect shrubs or more often trees. Bud scales free, spreading to recurved or reflexed. Adult leaves linear-lanceolate (widest at or below the middle) **7**
7a. Buds with distinctly elongated outer scales 4–15 mm long. Midrib on the adaxial (upper) side of leaves obtusely raised. Seeds including the epimatium 7–9 mm long **8**
7b. Buds with triangular or lanceolate, sometimes acuminate outer scales 2–6(–8) mm long.

Midrib on adaxial side of leaves acutely raised. Seeds including epimatium (8–)10–15 mm long **9**

8a. Pollen cones always solitary, 3.5–5 mm wide. Receptacles when ripe 10–13 × 8–9 mm. Adult leaves 6–8 mm wide ***P. polyspermus***

8b. Pollen cones with 2–3 together or sometimes solitary, 2.5–3.5 mm wide. Receptacles when ripe 8 × 4–5 mm. Adult leaves 5–10(–12) mm wide ***P. longefoliolatus***

9a. Shrubs or small trees. Adult leaves 5–11 mm wide. Pollen cones always solitary. Receptacles when ripe turning from red to blackish ***P. pallidus***

9b. Trees. Adult leaves (6–)8–15(–18) mm wide. Pollen cones solitary or more often with 2–3 together. Receptacles when ripe red **10**

10a. Buds 2–5 mm long, sometimes with a few longer outer scales to 8 mm. New leaves flushing red ***P. neriifolius***

10b. Buds 2–3 mm long, without longer outer scales. New leaves flushing pale whitish green ***P. insularis***

Key to the species of *Podocarpus* in New Zealand

When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Shrubs. Pollen cones 1–2.5 mm wide **2**

1b. Trees. Pollen cones 3–8 mm wide **3**

2a. Adult leaves (0.5–)0.8–2 cm long, 1.4–2 mm wide, acicular, pungent. Receptacles when ripe 5–7 mm long ***P. acutifolius***

2b. Adult leaves 0.3–1 cm long, 2–2.5 mm wide, naviculate (boat-shaped) to ovate-linear, obtuse or mucronate. Receptacles when ripe 8–10 mm long ***P. nivalis***

3a. Pollen cones solitary or more often in clusters of 2–5, 20–30 × 5–8 mm. Adult leaves (1.5–)2–3(3.5) cm long, 3–5(–6.5) mm wide, with a narrow but conspicuous groove on adaxial (upper) side ***P. cunninghamii***

3b. Pollen cones solitary, sometimes in pairs, 12–15(–20) × 3–4 mm. Adult leaves (0.5–)1–2.5(–3) cm long, (1.5–)2–3.5(–4.5) mm wide, with a faint groove on the adaxial side ***P. totara***

Key to the species of *Podocarpus* in Mexico, Central America, and the Caribbean Islands

When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Adult leaves (1–)1.5–3(–3.5) cm long, 3–5 mm wide **2**

1b. Adult leaves (1.5–)2–15(–20) cm long, (3–)5–20(–22) mm wide **3**

2a. Adult leaves narrowly lanceolate (widest below the middle), with apiculate-pungent or acute apex. Small trees to 16 m tall (often only 5–10 m) ***P. urbanii***

2b. Adult leaves oblanceolate to linear-oblanceolate (widest above the middle), with acuminate apex. Shrubs or small trees to 8 m tall ***P. ekmanii***

3a. Buds (on leading shoots) at least 5 mm long, often twice as long, with ovate-apiculate to long acuminate, more or less spreading (outer) scales **4**

3b. Buds (on leading shoots) not longer than 5 mm, with ovate to triangular, rounded to apiculate or short acuminate, mostly imbricate scales **6**

4a. Adult leaves (7–)10–18(–22) mm wide, lanceolate, with a grooved midvein on adaxial (upper) side ***P. costaricensis***

4b. Adult leaves 7–14 mm wide, linear-lanceolate to linear or narrowly lanceolate, with a raised but fading midrib (midvein) on adaxial side **5**

5a. Pollen cones solitary or in pairs, 50–60 × 3–4 mm. Bud scales ovate-apiculate, free at apex ***P. coriaceus***

5b. Pollen cones always solitary, 30–45 × 4–5 mm. Bud scales long acuminate, more or less spreading ***P. matudae***

6a. Adult leaves 1.5–5.5 cm long, with an acute-pungent or spinescent apex. Buds small, with ovate or rounded scales **7**

6b. Adult leaves (1.5–)3.5–15(–20) cm long, with an acute, acuminate or obtuse apex (if pungent, adult leaves longer than 6 cm). Buds up to 5 mm long, with triangular or acuminate, rarely ovate or rounded scales **8**

7a. Receptacles when ripe 10–15 mm long. Adult leaves 2–5.5 cm long, acute-pungent ***P. angustifolius***

7b. Receptacles when ripe 8–10 mm long. Adult leaves 1.5–4 cm long, spinescent ***P. buchii***

8a. Adult leaves (3–)7–15(–20) cm long, (12–)15–20 mm wide (juvenile leaves often substantially larger). Seeds including the epimatium 9–11 mm long ***P. magnifolius***

8b. Adult leaves (1.5–)3.5–9 cm long, (5–)6–14 mm wide. Seeds including the epimatium 7–8 mm long **9**

9a. Midvein on adaxial (upper) side of leaves forming a groove from base to apex **10**

9b. Midvein (midrib) on adaxial side of leaves prominently raised, sometimes fading towards apex, but not grooved **11**

10a. Adult leaves elliptic-linear (widest at the middle). Bud scales all imbricate ***P. hispaniolensis***

10b. Adult leaves lanceolate to linear-lanceolate (widest below the middle). Bud scales imbricate but some outer bud scales may be spreading ***P. oleifolius***

11a. Midrib on adaxial (upper) side of leaves slightly raised, fading towards the acute to apiculate, sometimes pungent apex ***P. purdieanus***

11b. Midrib on adaxial side of leaves prominently raised, continuous to the acute or obtuse (or weakly apiculate) apex **12**

12a. Bud scales all imbricate. Adult leaves 4–10 cm long, lanceolate to linear-lanceolate (widest below the middle) ***P. guatemalensis***

12b. Bud scales free at apex. Adult leaves (2.5–)4–6(–7) cm long, elliptic to oblanceolate (widest at or above the middle) ***P. trinitensis***

Key to the species of *Podocarpus* in South America

When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Buds longer than wide at base, with outer scales 9–15 mm long, acuminate or cuspidate, sometimes elongated to become more or less leaf-like **2**

1b. Buds (usually) not longer than wide at base, with outer scales up to 6 mm long, of various shapes but with a short apex and not elongated **7**

2a. Adult leaves (1.5–)2–5 cm long; midvein on adaxial (upper) side of leaves a continuous groove **3**

2b. Adult leaves (2–)4–13 cm long; midrib (midvein) slightly raised or obtusely raised, with or without a medial groove towards leaf apex **5**

3a. Adult leaves linear-lanceolate, 2–4(–5) mm wide, strongly spinescent (with a hard, spine-like apex) ***P. glomeratus***

3b. Adult leaves elliptic, linear-lanceolate or oblanceolate, 4–8(–10) mm wide, acute or obtuse **4**

4a. Adult leaves oblanceolate (widest above the middle) with an obtuse apex. Outer bud scales free but erect, the apices coming together ***P. aracensis***

4b. Adult leaves elliptic to linear-lanceolate (widest at or below the middle) with an acute apex. Outer bud scales spreading ***P. rusbyi***

5a. Adult leaves (7–)8–13 cm long, with an obtusely raised, not grooved midrib on adaxial (upper) side. Receptacles when ripe 8–12 mm long, dark purple ***P. salicifolius***

5b. Adult leaves (2–)4–9(–11) cm long, with a slightly raised and grooved midrib on adaxial side. Receptacles when ripe 6–8 mm long, red or purple **6**

6a. Buds 3–4 mm long, with a few elongated outer scales to 10 mm long. Leaf apices all acute. Seeds including the epimatium without an apical crest ***P. sellowii***

6b. Buds 5–15 mm long, with ovate-cuspidate outer scales all apically elongated. Leaf apices acute or obtuse. Seeds including the epimatium with a minute apical crest ***P. steyermarkii***

7a. Adult leaves (1.5–)2–4(–5) mm wide; apex angustate-acute or pungent **8**

7b. Adult leaves (3.5–)4–15(–20) mm wide; apex acute or obtuse, sometimes acuminate **11**

8a. Bud scales 4–6 mm long, apiculate or lanceolate, outer scales erect or slightly spreading, always free at apex **9**

8b. Bud scales shorter than 4 mm, broadly triangular, imbricate **10**

9a. Adult leaves 1.5–3 cm long ***P. nubigenus***

9b. Adult leaves (2.5–)4–8(–9) cm long ***P. parlatorei***

10a. Midrib (midvein) on adaxial (upper) side of leaves continuously raised. Small trees to 12 m tall ***P. lambertii***

10b. Midvein on adaxial side of leaves a continuous groove, not raised above general surface of leaf. Trees to 20 m tall but may be dwarfed at the highest altitudes ***P. sprucei***

11a. Bud scales acute, acuminate or cuspidate, erect and free at apex **12**

11b. Bud scales broadly triangular, ovate or rounded, imbricate or rarely some outer scales free at apex **14**

12a. Adult leaves 4.5–7.5 cm long, 8–15 mm wide. Trees to 30 m tall ***P. celatus***

12b. Adult leaves 2–4 cm long, 4–8 mm wide. Shrubs or small trees to 10 m tall **13**

13a. Adult leaves ovate to ovate-linear, 7–8 mm wide (widest below the middle), apex acuminate ***P. acuminatus***

13b. Adult leaves oblanceolate to elliptic, 4–7 mm wide (widest at or above the middle); apex acute or obtuse ***P. roraimae***

14a. Midrib on adaxial (upper) side of leaves initially raised but fading towards apex. Pollen cones long and very slender, 25–50 × 1.5–2 mm ***P. salignus***

14b. Midrib (midvein) continuously raised and/or grooved, or a continuous groove not raised above general surface of leaf. Pollen cones short and slender, or longer than 20 mm but then at least 3 mm wide **15**

15a. Pollen cones solitary or more often 2–6 together, pedunculate, 6–12 × 1.5–2 mm. Seeds including the epimatium 4–5 mm long, globose, without an apical crest. Buds smaller than 3 mm ***P. transiens***

15b. Pollen cones always solitary, sessile, more than 10 mm long. Seeds including the epimatium 6–11 mm long, not globose and with an apical crest (sometimes inconspicuous). Buds usually 3–5 mm long **16**

16a. Adult leaves oblanceolate or elliptic (widest at or above the middle), (1–)1.5–2.5(–3.5) cm long, 3.5–5 mm wide ***P. tepuiensis***

16b. Adult leaves lanceolate-linear to linear, sometimes narrowly oblanceolate (usually widest below the middle), (3–)4–13(–20) cm long, (5–)6–18(–20) mm wide **17**

17a. Adult leaves (12–)15–20 mm wide, highly variable in length but up to 20 cm or more long ***P. magnifolius***

17b. Adult leaves (5–)6–14(–18) mm wide, somewhat less variable in length and not longer than 12–13 cm **18**

18a. Midrib on adaxial (upper) side of leaves sharply and continuously raised, not lying in a (shallow) groove. Pollen cones 10–15 mm long ***P. guatemalensis***

18b. Midrib on adaxial side of leaves obtusely raised, lying in a groove or becoming grooved towards leaf apex. Pollen cones 20–30 mm long **19**

19a. Adult leaves pendulous. Pollen cones 6–7 mm wide ***P. pendulifolius***

19b. Adult leaves spreading. Pollen cones 3–4 mm wide **20**

20a. Adult leaves with a narrow midrib in a medial groove, not elevated above general adaxial (upper) surface of leaf. Bud scales rounded or ovate, all imbricate ***P. oleifolius***

20b. Adult leaves with an obtusely raised or more or less flat and dorsally grooved midrib. Bud scales (broadly) triangular, with some outer scales free at apex ***P. brasiliensis***

Key to the species of *Podocarpus* commonly in cultivation

The species of *Podocarpus* keyed out here can be found in cultivation within and without the areas in which they also occur naturally. If a species is only known to have been planted within the area (in the sense of the keys) in which it also occurs naturally, it is here excluded because then it can be found in the key to the species of that area. Species that are only known or assumed to be grown in a few botanic gardens and/or arboreta are also not included here. In cultivation means here: planted in an amenity, forestry or horticultural context. When using this key in the field only leaves on branches of mature trees, preferably from sun-exposed foliage, should be taken into account. Male (pollen) and female cones and seeds (they occur on dioecious trees) are described as mature.

1a. Adult leaves 0.3–3 cm long, 1.4–5 mm wide **2**
1b. Adult leaves (1.5–)2.5–14(–15) cm long, (3–)4–15(–18) mm wide (if shorter than 3 cm, usually wider than 4 mm) **6**
2a. Always shrubs with multiple stems **3**
2b. Always trees with single stems **5**
3a. Adult leaves acicular, 1.4–2 mm wide, pungent. Bud scales acute with free apices ***P. acutifolius***
3b. Adult leaves ovate-linear to linear, or naviculate (boat-shaped), obtuse or mucronate. Bud scales (broadly) triangular, imbricate **4**
4a. Adult leaves 4–5 mm wide, with a nearly absent (inconspicuous) midrib on adaxial (upper) side ***P. lawrencei***
4b. Adult leaves 2–2.5 mm wide, with a central groove on adaxial side ***P. nivalis***
5a. Bud scales lanceolate, to 6 mm long, erect or slightly spreading. Midrib on adaxial (upper) side of leaves raised but fading towards apex. Pollen cones 2–4 together, sessile. Receptacles when ripe 7–8 mm long; seeds including the epimatium 8–9 × 6–7 mm ***P. nubigenus***
5b. Bud scales obtuse or acute, 2–3 mm long, imbricate or a few with a free apex. Midvein (midrib) on adaxial side of leaves a faint groove. Pollen cones solitary or sometimes in pairs, short pedunculate. Receptacles when ripe 4.5–5.5 mm long; seeds including the epimatium 3–3.5 × 2–2.5 mm ***P. totara***
6a. Buds very small (< 3 mm), with imbricate scales **7**
6b. Buds larger, with outer scales longer than 3 mm and spreading or recurved (at least free at apex) **8**
7a. Adult leaves narrowly linear-lanceolate, (3–)4–7 mm wide. Pollen cones very slender, 25–50 × 1.5–2 mm. Receptacles when ripe 5–6 mm long; seeds including epimatium 7–8 × 4–5 mm ***P. salignus***
7b. Adult leaves linear-lanceolate, (5–)7–14(–17) mm wide. Pollen cones more robust, 10–20 × 2–3 mm. Receptacles when ripe 15–25(–30) mm long; seeds including the epimatium 15–20 × 12–15 mm ***P. elatus***
8a. Adult leaves (3–)4–5(–7) mm wide; midrib on adaxial (upper) side of leaves fading towards apex ***P. elongatus***
8b. Adult leaves (3–)4–15(–18) mm wide; midrib on abaxial side of leaves acutely raised and continuous (if indistinct or fading towards apex, leaves wider than 6 mm) **9**
9a. Bud scales on leading shoots long acuminate, 8–12 mm ***P. matudae***
9b. Bud scales on leading shoots not long acuminate, 2–5 (rarely to 8) mm long **10**
10a. Adult leaves (2–)3–5(–7) cm long. Bud scales erect, with free apices close together. Pollen cones solitary, 8–25 × 6–8 mm ***P. costalis***
10b. Adult leaves (2–)3.5–12(–15) cm long. Bud scales spreading or recurved, rarely erect. Pollen cones solitary or more often 2–5 together, 15–40(–60?) × 2–4 mm **11**
11a. Midrib on adaxial (upper) side of leaves indistinctly raised, leaf apices obtuse or mucronate. Pollen cones solitary or in pairs. Small bracts ('foliola') basal to receptacles absent ***P. latifolius***
11b. Midrib on adaxial side of leaves acutely raised. Leaf apices acute, acuminate or obtuse. Pollen cones 2–5 together (sometimes solitary). Small bracts basal to receptacles present **12**
12a. Adult leaves from nearly oval (the shortest) to linear (with parallel margins) in longer leaves ***P. polystachyus***
12b. Adult leaves linear-lanceolate or lanceolate (widest below the middle), the shortest leaves sometimes oblanceolate (widest above the middle) **13**
13a. Bud scales caudate, with a narrow, recurved apex. Shrubs or small trees. Small bracts ('foliola') basal to receptacles also recurved ***P. macrophyllus***
13b. Bud scales lanceolate or triangular, spreading with a more or less straight apex. Potentially large trees. Small bracts basal to receptacles not recurved **14**
14a. Adult leaves (4–)6–10 mm wide. Pollen cones 15–25(–30) × 2–2.5 mm. Receptacles when ripe 9–16 mm long; seeds including the epimatium ca. 9 mm long, green or glaucous ***P. fasciculus***
14b. Adult leaves (5–)6–15(–18) mm wide. Pollen cones 20–40(–60?) × 2–3.5 mm. Receptacles when ripe 7–12 mm long; seeds including the epimatium (8–)10–15 mm long, purplish green or blackish purple **15**

15a. Receptacles subtended by two 2–6 mm long bracts ('foliola'); epimatium around seeds without a crest. New leaves flushing red
P. neriifolius

15b. Receptacles subtended by two minute, 1–2 mm long bracts; epimatium around seeds with a crest. New leaves flushing yellowish green
P. subtropicalis

Podocarpus acuminatus de Laub., Novon 2 (4): 329. 1992. Type: Brazil: Amazonas, Serra da Neblina, Pico da Neblina, *C. Farney & B. F. E. Pesscoal 870* (holotype MO).

Etymology

The species epithet refers to the apex of the leaves, which tapers to a narrow point.

Vernacular names

No common names have been recorded for this species.

Description

Small trees 4–5 m tall; trunk to 20 cm d.b.h. Bark not described. Branches forming a dense crown. Foliage branchlets slender, short and ascending to erect, terete, with fine grooves between the leaf bases, terminating in small, globose buds with erect, 4–6 mm long, cuspidate scales that are free at apex. Leaves ovate to ovate-linear, 3–4 cm long, 7–8 mm wide, more or less abruptly narrowing to a short petiolate or sessile base, terminating in an acuminate apex; leaf texture coriaceous; leaf colour deep green above, dull green below. Midrib on adaxial (upper) side a continuous groove, on abaxial side obtusely raised. Stomata very small, in two bands of numerous intermittent lines on abaxial side. Pollen cones not observed. Seed cones axillary, solitary on a short peduncle; receptacles consisting of an axis with 3–4 partly fused bracts, one or two of which are smaller and sterile and occur below the usual (second) sterile bract, the whole swelling to ca. 6 mm long and 3–4 mm wide and green, becoming red or purple at maturity. Seeds solitary, sometimes 2 per receptacle, obliquely ovoid, including the epimatium ca. 7 mm long and 4 mm wide, with a prominent distal crest, green. Seed proper not observed.

Distribution

Brazil: Amazonas (Serra da Neblina); Venezuela: Amazonas (Sierra de la Neblina), Bolivar (Chimantá, SW Amuri-tepui).
TDWG codes: 82 VEN 84 BZN-AM

Ecology

Podocarpus acuminatus occurs on upper slopes and summits of some of the tepuis (table mountains) formed of sandstone in southern Venezuela and the border with Brazil. It is a sun-exposed shrubby tree in closed dwarf forest, often growing among rocks, at altitudes between 1900 m and 2400 m a.s.l.

Conservation

Podocarpus acuminatus is known only from two widely disjunct localities in remote areas. The area of occupancy (AOO) is less than 500 km² but the remoteness of the localities and relative or perhaps even completely undisturbed nature of the forests on the tepuis and mountains makes it likely that no immediate threats are present. However, road access to the Serra da Neblina area from Brazil has now been established and, as experience shows, may pose a threat to the forests in the mountains. It is therefore thought prudent to flag this rare species with NT.
IUCN: NT

Uses

No uses have been recorded of this species.

Podocarpus acutifolius Kirk, Trans. & Proc. New Zealand Inst. 16: 370. 1884. Type: New Zealand: South Island, Nelson, Buller Valley, near outflow of Lake Rotaiti, *T. Kirk s.n.* (lectotype WELT). Fig. 255

Etymology

The species epithet refers to the sharp pointed leaves.

Vernacular names

Needle-leaved totara

Description

Low decumbent or erect shrubs 50–150 cm tall, or small, bushy trees to 9 m tall with a trunk to 40 cm diam. Branches numerous, on larger shrubs and trees ascending, otherwise spreading, branching irregularly. Foliage branchlets lax and slender or more rigid in small trees, finely grooved between leaf bases, glabrous, light brown turning grey; terminal buds conical, 2–4 mm long, with free, acute scales. Leaves spirally arranged, spreading at wide angles from shoot, acicular, (5–)8–20 mm long, 1.4–2 mm wide, coriaceous, rigid, straight or slightly curved, flattened; narrowed base twisted and derurrent; apex pungent. Midrib inconspicuous on both sides; leaf leaf colour green to yellowish green or bronze green above, similar but with whitish stomatal lines below. Stomata on abaxial side in two bands of intermittent lines separated by a flat midrib. Pollen cones axillary on short peduncles, solitary or with 2–4 together, subtended by 3–4 scarious, acuminate bracts, slender cylindrical, 12–20 mm long, 2–2.5 mm wide at anthesis; microsporophylls triangular, with two globose pollen sacs. Seed cones axillary, solitary on ca. 5 mm long peduncles, consisting of an axis with 2 obtuse bracts which fuse to become a swollen, succulent, red receptacle 5–7 mm long, subtending a single, small, narrowly ovoid seed 4–5 mm long including the glaucous green epimatium. Seed proper not observed.

Taxonomic notes

It is commonly stated that Thomas Kirk discovered this species in the upper part of Buller Valley, Nelson, New Zealand (near the outflow of Lake Rotaiti), but his collection from there is only one element cited in the protologue, as he also acknowledges T. F. Cheeseman for further specimens. At Kew (K) is a sheet with a mixture of male and sterile (female?) branchlets collected by Cheeseman at Lake Rotaiti. Since the plant is dioecious, these constitute more than one collection and we do not know what Kirk saw of this (if any, they are likely duplicates). A specimen at WELT with acc. no. SP038257 collected by T. Kirk in January 1875 at this locality and selected by B. J. P. Molloy in 1991 is here designated as the lectotype.

Distribution

New Zealand: South Island (Marlborough Sounds to S Westland).
TDWG codes: 51 NZS

Ecology

Podocarpus acutifolius is a shrub or bushy tree occurring in lowland to montane forest and scrub. According to Allan in Flora of New Zealand 1: 108 (1982) the taller growing tree form is possibly of hybrid origin (other parent not stated, but likely *P. cunninghamii* or *P. totara*).

Conservation

IUCN: LC

Uses

Needle-leaved totara is rare in cultivation. Under garden conditions it sometimes grows into a small, bushy and open-crowned tree to 5 m tall, but provenances from low creeping shrubs may stay in that habit. It should be a species suitable to be trained and pruned into hedges, while the decumbent form with its often bronze foliage is an attractive shrub for rockeries.

Podocarpus affinis Seem., Fl. Vitiensis: 266. 1868. Type: Fiji: Western Division, Viti Levu, Voma Peak, *B. C. Seemann 574* (holotype K).

Etymology

The species epithet means 'allied to'; Seemann thought it was allied to *Podocarpus elatus*.

Vernacular names

kuasi (Viti Levu)

Description

Small to medium size tree to 15–20 m tall. Bark not described. Branches short and spreading; foliage branches towards ends of main branches slender, terete, terminating in small buds with more or less erect, free, narrowly triangular, acute scales. Leaves on seedlings similar to those on mature trees, 2.5–5 cm long, oblanceolate to elliptic or linear-elliptic, 6–9 mm wide, widest at or above the middle, coriaceous, gradually tapering to a petiolate base; apex obtuse to rounded; margins slightly revolute, lustrous green above, dull brownish green below. Midrib narrow (ca. 0.5 mm wide) and acutely raised on adaxial (upper) side, similar but fading towards apex on abaxial side. Stomata very small, in numerous irregular and intermittent lines on abaxial side. Pollen cones and seed cones remain unknown.

Taxonomic notes

Although the leaves of this species are distinct (but reminiscent of *P. pilgeri*) at least among the podocarps of Fiji and New Caledonia, to date no specimens have been collected with either pollen or seed cones. Apparently, this tree rarely bears these reproductive organs and all herbarium specimens cited by previous authors, as well as seen in the Kew Herbarium (K) are sterile. Acceptance of this taxon remains therefore more or less provisional.

Distribution

Southwestern Pacific: Fiji Islands (Viti Levu, Namosi, Voma Peak).
TDWG codes: 60 FIJ

Ecology

Podocarpus affinis has been found in rainforest on or near the summits of a few mountains in Viti Levu, where it is locally common growing in the understorey or dominant in the canopy of low forest. The altitudinal range is 900–1200 m a.s.l.

Conservation

Doyle (1998) has listed this species as Endangered (EN) on grounds of its very limited distribution and apparent decline and fragmentation of its habitat. It was listed as Vulnerable (VU) by the same author in the Global Redlist of Conifers (Farjon & Page, 1999) under the 1994 A-criterion which estimates decline only. Since these criteria have changed in 2001, a reassessment of this species in 2011 concluded that it does not meet them.
IUCN: NT

Uses

The wood of this species, according to Seemann, was used for outrigger canoes by "the natives"; presumably it was used for other purposes as well. Depletion of the resource has greatly diminished this use at present. The species is not known in cultivation.

Podocarpus angustifolius Griseb., Cat. Pl. Cubensis: 217. 1866. Type: Cuba, ["Cuba occidentalis"], Pinar del Rio, Charco Azul, *C. Wright 3188A* (lectotype GOET, isolectotypes BM, G-DC).

Podocarpus aristulatus Parl., in Candolle, Prodr. 16 (2): 513. 1868; *Podocarpus angustifolius* Griseb. var. *aristulatus* (Parl.) Staszk., Fragm. Fl. Geobot. 33: 77. 1988.
Podocarpus leonii Carabia, Caribbean Forest. 2: 92. 1941. *Podocarpus angustifolius* Griseb. var. *leonii* (Carabia) Staszk., Fragm. Fl. Geobot. 33: 77. 1988, ["*leonis*"].
Podocarpus victorinianus Carabia, Caribbean Forest. 2: 92. 1941 (*nom. illeg.*, Art. 52); *Podocarpus angustifolius* Griseb. var. *leonii* (Carabia) Staszk. f. *victorinianus* (Carabia) Staszk., Fragm. Fl. Geobot. 33: 77. 1988.

Etymology

The species epithet refers to the narrow leaves.

Vernacular names

sabina cimarrona, espuela de caballero (Cuba)

Description

Large shrubs or small trees to 12 m tall; trunk to 50 cm d.b.h. Bark thin, smooth, brown weathering grey. Branches on young trees subverticillate and spreading, ascending on multi-stemmed shrubs. Foliage branches slender, terete, with fine longitudinal grooves between the leaf bases, terminating in small, ovoid or subglobose buds with imbricate, ovate, carinate outer scales with scarious margins terminating in an acuminate apex. Leaves on saplings and mature trees similar, more or less remotely spaced especially on vigorous shoots, patent, narrowly elliptical (shortest and widest leaves) or lanceolate-linear to linear, 2–5.5 cm long, (3–)5–10(–12) mm wide, straight or curved downward, gradually narrowing to a short petiolate base and to an acute-pungent or spinaceous apex; margins revolute; leaf colour lustrous dark green above, dull green below. Midrib on adaxial (upper) side narrow, slightly raised but often fading towards apex, acutely raised on abaxial side and continuous almost to apex. Stomata very small, in intermittent lines on either side of the abaxial midrib. Pollen cones axillary, solitary, sessile, cylindrical, elongating to 15–20 mm, 2.5–3 mm wide at anthesis; microsporophylls broadly ovate, obtuse with minutely erose-denticulate margin, bearing two basal ovoid-oblong pollen sacs. Seed cones axillary, short pedunculate; receptacles with 2–3 unequal, fused bracts, swelling to 10–15 mm long and 7–10 mm wide, succulent and ripening to bright red. Seeds solitary, including the epimatium 7–10 mm long, narrowly ovoid with a small, 1–2 mm long crest, green. Seed proper ovoid, smooth, dark yellowish brown ('tawny').

Taxonomic notes

The distinction between *Podocarpus aristulatus* and *P. angustifolius* appears to be based on the (maximum) width of leaves. A comparison between the type collections (specimens at K) *Wright 1461* (*P. aristulatus*) and *Wright 3188* (*P. angustifolius*) gives a difference in maximum width of leaves of 3 mm (8 mm resp. 5 mm). The specimen at BM of *Wright 1461* has leaves to 12 mm wide and none narrower than 8 or 9 mm. Because *Wright 1461* at K is a male specimen and the one at BM female, they cannot have been taken from the same tree, which means that *Wright 1461* is a mixed collection. Carabia (*op. cit.*) described a new species *P. victorinianus* based on *Wright 1461* at GH. His observation that it has 1–1.2 cm wide leaves is in agreement with *Wright 1461* at BM, which, like the specimen he cites from GH, is female. Gray & Buchholz (1948) described the two species on the same page of their revision of American podocarps, but did not indicate any difference other than the width of leaves. Parlatore (1868) cited *Wright 1461* and *Wright 3788* (typographic error for *Wright 3188*) under *P. aristulatus* ["*aristulata*"] and wrote of the latter specimen that it has 4–5 mm wide leaves. Florin (1934) considered them synonyms. Other specimens at K from Cuba appear to fall more or less between leaf width measurements of 5–8 mm and are difficult to assign to either *P. angustifolius* or *P. aristulatus*.

Distribution

West Indies: Cuba (Granma, Holguín, Pinar del Rio, Sancti Spiritus).
TDWG codes: 81 CUB

Ecology

Podocarpus angustifolius occurs in montane rainforests of Cuba, often on laterite soils derived from serpentine. Its altitudinal range is undetermined, but several herbarium collections were made around 800 m a.s.l. It is associated with mostly angiosperm shrubs and trees, such as *Magnolia cubensis, Cojoba arborea, Beilschmiedia pendula, Octea* spp., *Laurocerasus occidentalis, Mataybe domingensis*, etc., and can occur in low forest canopy as well as in more open, sun-exposed vegetation on rocky sites. In some localities it has been found to be abundant, with regeneration representing all age classes in undisturbed forest, but nearly absent in disturbed areas.

Conservation

This species, now known not only from western Cuba but also from central and eastern parts of the island, is nevertheless uncommon. Its total area of occupancy (AOO) is less than 10 km² and populations are widely separated and/or fragmented and very small. Although not usually a timber tree, it is

declining mainly because of forest clearance to make way for agriculture. It regenerates poorly or not at all in disturbed areas, even if these are left for secondary forest regeneration, probably because of low competitiveness.
IUCN: CR [B2ab (ii–iv); C2a (ii)]

Uses

No commercial uses have been recorded of this species. Larger trunks of trees growing in forest may have been logged and used for timber, but probably only locally. It is locally planted in Cuba as an ornamental shrub or small tree.

Podocarpus aracensis de Laub. & Silba, Phytologia 65: 330. 1988. Type: Brazil: Amazonas, Serra Araca, ["margins of R. Serra Araca"], *N. A. Rosa & S. B. Lira 2317* (holotype MG).

Etymology

This species was named for the mountain, Serra Araca, where it was first found.

Vernacular names

No common names are known for this species.

Description

Shrubs or small trees 2–6 m tall; trunk diam. 10–20 cm or more. Branches spreading, in older plants forming a dense crown. Foliage branchlets slender, terete, finely grooved between leaf bases, terminating in conical buds with erect, elongated outer scales 4–9 mm long, ca. 2 mm wide at base, constricted to a 0.5 mm wide distal part. Leaves on saplings and juvenile (or shaded?) plants remotely placed along shoots, on older shrubs and trees and on sun-exposed branches crowded at the tips, spreading to nearly erect, lanceolate-linear on juvenile plants, oblanceolate (widest above the middle) on mature shrubs and trees, 5–8 cm long on juvenile plants, 2–4.5 cm long on mature shrubs and trees, 4–7(–9) mm wide (widest on juvenile plants), gradually narrowing to a 2–5 mm long petiolate base, more abruptly ending in an acute (juvenile plants) or obtuse apex. Margins revolute, leaf texture coriaceous; midrib on adaxial (upper) side a continuous narrow groove, on abaxial side raised, or nearly flat *in sicco*. Stomata on abaxial side in numerous intermittent lines on either side of midrib. Pollen cones axillary, solitary or in clusters of 2–3, with a scaly 7–9 mm long peduncle, cylindrical, 17–20 mm long, 2–2.5 mm wide; microsporophylls triangular, with two globose pollen sacs. Seed cones not observed.

Taxonomic notes

This species remains poorly known due to insufficient collecting. Some additional herbarium specimens, collected from the Cerro de la Neblina in Venezuela, were mentioned in the protologue (De Laubenfels & Silba, 1988) but these are doubtfully identified as having characters shared with *P. aracensis* as well as *P. buchholzii*, another of David de Laubenfels's poorly known species from Venezuela. An additional herbarium collection (*O. Huber 11873*, K), not cited in the protologue, but identified by De Laubenfels in 1992 as belonging to *Podocarpus aracensis*, was collected in 1986 on Cerro Yaví in Amazonas Territory, Venezuela, nearly 500 km to the north of Cerro de la Neblina and 550 km NNW of Serra Araca, the type locality in Brazil.

Distribution

Brazil: Amazonas (Serra Araca, Cerro Neblina?); Venezuela: Amazonas (Cerro Yaví).
TDWG codes: 82 VEN 84 BZN-AM

Ecology

This species has been found on sandstone massifs along streams in shrubby vegetation or dwarf forest at altidudes around 1200 m a.s.l. in Brazil and at 2100 m in Venezuela.

Conservation

IUCN: LC

Uses

No uses are known of this species, which occurs remote from human habitation.

Podocarpus archboldii N. E. Gray, J. Arnold Arbor. 39: 452. 1958. *Margbensonia archboldii* (N. E. Gray) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: Indonesia: Papua, Idenburgh River, Bernhard Camp, 4 km SW of camp, *L. J. Brass 13121* (holotype A).

Etymology

The species epithet commemorates Richard Archbold, who sponsored the botanical expedition to New Guinea on which this species was first found.

Vernacular names

mu, soa (Papua), sarau (PNG); probably many other names in local languages.

Description

Trees to 45 m tall, to 100 cm d.b.h., bole erect, straight, sometimes fluted at base. Bark smooth, thin, longitudinally and often more or less spirally fissured, brown weathering grey; inner bark cream, fibrous. Branches spreading, forming a narrow or rounded crown. Foliage branchlets terete, stout, more or less grooved, glabrous, terminating in 3–5 mm long, nearly globular buds with slightly spreading, triangular to lanceolate outer scales and imbricate, rounded inner scales. Leaves on juvenile plants short petiolate, linear-lanceolate, (3–)6–14(–18) cm long, 10–16 mm wide, straight or slightly curved, gradually narrowed at base, tapering to an acute apex. Leaves of mature trees usually shorter, linear-lanceolate, (3–)5–10(–12) cm long, 8–13 mm wide, straight or slightly curved, coriaceous, sometimes convex or with revolute margins, short petiolate at a gradually or abruptly narrowing base, tapering to an acute or obtuse apex. Midrib obtusely raised on both sides, usually narrower on adaxial side; leaf colour dark green above, pale green below, new leaves flushing light yellowish green. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, solitary, sessile or short pedunculate with several large basal bract scales, cylindrical, elongating to 30–40 mm, 6–8 mm wide; microsporophylls spreading, apical part elongated, with two globose pollen sacs. Seed cones axillary, solitary on a 5–10 mm long peduncle; receptacles with 2 minute bracts at base and often two protruding lateral bracts, obliquely bilobate, ca. 10 mm long, swelling with a truncate distal end, red or purple-black and succulent when ripe. Seeds enclosed in a smooth epimatium, light green when ripe, ovoid, 8–9 × 5–6 mm, with a distal crest. Seed proper not observed.

Distribution

New Guinea.
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

Podocarpus archboldii is a canopy tree occurring scattered or locally common in evergreen tropical montane forest. The altitudinal range is (720–) 1500 m to 2600 m a.s.l. The largest trees occur in closed forests dominated by *Castanopsis* spp. with a canopy to 50 m tall; trees become smaller and stunted in mossy forest which often occurs on mountain ridge tops over rocky terrain. Here soils are less well developed and other conifers, e.g. *Agathis labillardierei, Dacrydium novo-guineense, Falcatifolium papuanum, Papuacedrus papuana*, and *Retrophyllum vitiense*, may join *Podocarpus archboldii*, while angiosperms become less dominant.

Conservation

Logging of this species is causing a continuing decline in the number of mature trees left in the forest.
IUCN: VU [B2ab (v)]

Uses

Podocarpus archboldii is a valuable timber tree where it attains large sizes with a clear, straight bole. Its wood is used as roundwood for masts, spars and poles, in house construction as beams, in high-grade construction for flooring, joinery and other carpentry, for furniture and cabinet work, veneer, to

make boxes, and for match sticks. Its traditional uses include village house contruction, household utensils and wood carving. This species has been found either spared from the forest or planted in village dancing grounds.

Podocarpus atjehensis (Wasscher) de Laub. *ex* Silba, Phytologia Mem. 7: 60. 1984. *Podocarpus neriifolius* D. Don var. *atjehensis* Wasscher, Blumea 4 (3): 450. 1941; *Margbensonia atjehense* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: Indonesia: Sumatera, Aceh, Gunung Kemiri, *C. G. G. J. van Steenis 9614* (holotype L).

Etymology

The species epithet refers to Atjeh [now to be spelled Aceh], the semi-autonomous region of northern Sumatera in Indonesia.

Vernacular names

No common names have been recorded for this species.

Description

Small trees 8–15 m tall, to 25 cm d.b.h. Bark not described. Branches spreading and ascending, forming a pyramidal to rounded crown. Foliage branchlets terete, with narrow ridges from decurrent leaf petioles; leading branches terminating in large buds 6–14 mm long, 5–8 mm wide, with broadly triangular scales, the outer scales with apiculate, recurved tips, the inner scales shorter and more or less imbricate. Leaves of young plants linear, usually deflected, to 18 cm long and 9 mm wide; leaves of adult trees linear-lanceolate, petiolate at base, strongly deflected, 6–11 cm long, 5–8 mm wide, coriaceous, gradually narrowing at both ends; apex long acute; midrib on adaxial (upper) side less than 0.4 mm wide and acutely raised, on abaxial (lower) side ca. 1 mm wide and raised to a prominent flat ridge; leaf colour dark green above, light green below, flushing pink or rosa. Pollen cones axillary, solitary, sessile, subtended by broadly ovate-triangular bud scales, long cylindrical, 25–30 mm long, 4–4.5 mm wide at anthesis; microsporophylls with a small triangular apex and two large pollen sacs. Seed cones axillary, solitary, on a 8–15 mm long peduncle; receptacles with one (or two?) 2–4 mm long basal bract(s) ('foliola'), unequally bilobate with two bract tips, swelling to 9–11 × 6–7 mm, succulent and red at maturity. Seeds including the epimatium ovoid-globose, 9–11 × 7–8 mm, whitish or bluish pruinose, without a crest. Seed proper not observed.

Taxonomic notes

Formerly known as *Podocarpus neriifolius* D. Don var. *atjehensis* Wasscher, this taxon was elevated to species rank by David. J. de Laubenfels (1985), who classified the two species in different sections based on vegetative characters. Although De Laubenfels should be credited for the taxonomy, it was John Silba (*op. cit.*) who first validly published the new combination, citing the full reference to the basionym.

Distribution

Malesia: Sumatera (Aceh, Gajo Lands); Papuasia: New Guinea (Papua, Wissel Lakes).
TDWG codes: 42 SUM 43 NWG-IJ

Ecology

Podocarpus atjehensis was discovered and described (as a variety of *P. neriifolius*) from the summit area of a high mountain in northern Sumatera growing in mossy dwarf forest and shrubland. The type collection was gathered at 2900 m a.s.l. on a slope below the summit of Gunung Kemiri, and it may (or may not) occur near or on the summit of nearby Gunung Leuser, the highest mountain in the area at 3145 m. The other locality reported for this taxon is in New Guinea at 1800 m a.s.l.

Conservation

This species is only known from two very disjunct locations. This type of disjunction is also reported from other groups of organisms. In both locations there is a considerable human footprint on the landscape and although we do not know to what extent this affects this species, it is assumed that some decline has occurred. IUCN's Conifer Specialist

Group therefore wish to flag this species as Near Threatened.
IUCN: NT

Uses

No uses have been recorded of this poorly known species.

Podocarpus borneensis de Laub., Blumea 30 (2): 266. 1985. Type: Malaysia: Sabah, Sandakan District, Bukit Tawai, *D. J. de Laubenfels P 702* (holotype L).

Podocarpus polystachyus R. Br. *ex* Endl. var. *rigidus* Wasscher, Blumea 4 (3): 460. 1941.

Etymology

The species epithet refers to the island of Borneo, where it is endemic.

Vernacular names

bisit, bubung, buloh (local names in Sarawak)

Description

Small to medium sized trees 5–10(–23) m tall, up to 30 cm d.b.h. Bark not described. Branches spreading, forming a rounded or domed crown. Foliage branchlets terete, more or less grooved, glabrous, terminating in 4–10 mm long, 2–3 mm wide buds with erect or slightly spreading, lanceolate to linear outer scales. Leaves on juvenile plants short petiolate, linear, to 16 cm long and to 14 mm wide, straight or slightly curved, gradually narrowed at base, acute or obtuse. Leaves of mature trees often crowded at the distal end of branchlets, spreading or ascending, linear-ovate or elliptic, 3–7(–9) cm long, 8–13 mm wide, straight or slightly curved, short petiolate at a gradually narrowing base, tapering to an obtuse or rounded (rarely acute) apex, thick coriaceous. Midrib acutely raised on adaxial side, nearly flat on abaxial side, drying to a groove; leaf colour dark green above, pale green below. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, solitary or in clusters of 2–3, sessile or short pedunculate with several basal bract scales, cylindrical, elongating to 35–50 mm, 2.5–3.5 mm wide; microsporophylls triangular, spreading, with two pollen sacs. Seed cones axillary, solitary on a 2–3 mm long peduncle; receptacles with 2 bracts ('foliola') 1–2 mm long at base, obliquely bilobate, 6 mm long, swelling with a truncate distal end, green turning red and succulent when ripe. Seeds including the epimatium ovoid, 6 × 5 mm, the distal end cristate, green turning purple or dark brown when ripe. Seed proper not observed.

Distribution

Borneo: Indonesia: Kalimantan (including Karimata Island); Malaysia: Sabah, Sarawak.
TDWG codes: 42 BOR-KA BOR-SB BOR-SR

Ecology

Podocarpus borneensis occurs in mossy forest on mountain ridges, often in rocky, exposed sites as a small or stunted tree. Downslope, where the forest becomes taller and has a closed canopy, scattered trees may reach into the canopy and attain 20 m or more. It also occurs in 'keranga' forest on nearly white sand and it was once or twice collected from swamp forest at low altitude (ca. 350 m) on peaty soil. Its more common altitudinal range is from 700 m to 2100 m a.s.l. On the Meurong Plateau (sandstone), it may become the dominant tree in some localities, elsewhere it is mixed with various conifers (*Agathis, Dacrydium, Dacrycarpus, Podocarpus, Phyllocladus*) and angiosperm shrubs and trees.

Conservation

IUCN: LC

Uses

No economic uses have been recorded of this species. Its ecology and commonly low stature make it an unlikely target of timber logging. Where it is abundant, like on the Merurong Plateau, its wood is locally used for construction of houses and other carpentry work. It is not known to be in cultivation.

Podocarpus bracteatus Blume, Enum. Pl. Javae 1: 88. 1827. *Podocarpus neriifolius* D. Don var. *bracteatus* (Blume) Wasscher, Blumea 4 (3): 449. 1941. Type: Indonesia: Jawa, [locality not stated], *C. L. Blume s.n.* (holotype L).

Etymology

The species epithet describes the two conspicuous bracts at the base of the receptacle.

Vernacular names

ki marak, ki pantjar, ki putri (Jawa); kayu unung unung (Sumatera)

Description

Trees to 40 m tall, to 1 m d.b.h., bole straight, in large trees slightly fluted or rarely buttressed at base. Bark smooth, thin, on large boles with narrow, longitudinal flakes or strips, light brown weathering grey; inner bark pinkish or reddish brown, fibrous. Branches spreading, forming a rounded or domed crown. Foliage branchlets terete, more or less grooved, glabrous, terminating in 5–12 mm long buds with spreading, triangular to lanceolate outer scales. Leaves on juvenile plants short petiolate, linear-lanceolate, 15–23 cm long, 15–20 mm wide. Leaves of mature trees shorter and narrower, mostly linear-lanceolate or lanceolate, (6–)8–12(–14) cm long, 9–14 mm wide, straight or slightly falcate, gradually narrowing to a petiolate base, gradually tapering to an acute apex. Midrib acutely raised on adaxial (upper) side and 0.4 mm wide, flat or obtusely (sometimes acutely) raised abaxially; leaf colour dark green above, pale green below, new leaves flushing red. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, solitary or in clusters of 2–3, sessile with several basal, large, ovate-triangular, carinate bud scales, cylindrical, elongating to 25–50(–60) mm, 3.5–4 mm wide; microsporophylls spirally arranged, triangular, spreading, with two globose pollen sacs. Seed cones axillary, solitary on a 10–20 mm long peduncle; receptacles with 2 subulate bracts ('foliola') 4–5 mm long at base, swelling to become ellipsoid with a truncate distal end, 10–14 mm long, yellow turning orange-red or bright red and succulent when ripe. Seeds at truncate end of the receptacle, enclosed in a smooth epimatium, green turning purplish green when ripe, ovoid-oblong or ovoid, 10–14 mm long, ca. 7 mm wide. Seed proper ovoid, 7–10 mm long, slightly flattened.

Taxonomic notes

Podocarpus bracteatus is quite similar to *P. neriifolius*, of which Wasscher (*op. cit.*) considered it to be a mere variety. However, De Laubenfels (1985, 1988) not only kept it as a distinct species, but classified it in a different section: *Longifoliolatus* as opposed to *Foliolatus*. Both are named for the 'foliola', i.e. the two basal, subulate bracts below the receptacle. De Laubenfels held that these were about 2 mm long in species of sect. *Foliolatus*, which contains *P. neriifolius*, and "over 3 mm" in those of sect. *Longifoliolatus*. However, in the widespread species *P. neriifolius* basal bracts or 'foliola' as long as 5 or even 6 mm occasionally occur, and consequently this is a spurious character. To base divisions in the genus on this single feature amounts to 'artificial' classification (see taxonomic notes above under the genus).

Distribution

Indonesia: Flores, Jawa, N Sumatera.
TDWG codes: 42 JAW LSI-LS SUM

Ecology

Podocarpus bracteatus is a scattered canopy tree of evergreen montane tropical rainforest, most commonly found on forested volcanoes of Jawa at altitudes between 1000 m and 2600 m a.s.l. It has occasionally been collected from lower altitudes between 400 m and 1000 m a.s.l. Its ecology is similar to that of *P. neriifolius*.

Conservation

Logging of larger trees of this species probably has had an impact on its conservation status, but it seems too widespread and still reasonably common at least in western Jawa. If the botanical distinction with *P. neriifolius* is slight and not often made by

foresters in the field, it will be very difficult to know whether this species is declining or not. It is at present not considered to be threatened with extinction.
IUCN: LC

Uses

This species is an important timber tree in Jawa. Its excellent wood is used for house construction and carpentry and for making oars, spars and masts of sailing vessels. More specialized uses requiring high grade timber are veneer, furniture making, cabinet making, interior trim, household utensils, and wood carving. As far as known it is not in cultivation.

Podocarpus brasiliensis de Laub., Fl. Venezuela 11 (2): 31. 1982. Type: Brazil: Distrito Federal, Brasilia, Horto do Guará, *E. P. Heringer 8034* (holotype NY).

Podocarpus barretoi de Laub. & Silba, Phytologia 68: 65. 1990.

Etymology

The species epithet means 'from Brazil', where the type specimen was collected.

Vernacular names

pineirino-da-serra (Portuguese)

Description

Small trees to 15 m tall; trunk to 30 cm d.b.h. Bark not described. Branches spreading, forming a broad pyramidal to rounded crown. Foliage branchlets slender or stout, terete, with fine grooves between the leaf bases; terminating in subglobose buds 3–4 mm wide at base with (broadly) triangular scales, the inner ones imbricate and obtuse with scarious margins, the outer scales to 4 mm long with an acute or acuminate and erect, free apex. Leaves on mature trees elliptic-linear to narrowly oblanceolate, (3–)5–10(–13) cm long, (6–)9–14(–18) mm wide, mostly straight, gradually tapering to a petiolate base, gradually or more abrubtly narrowing to an acute or obtuse or slightly acuminate apex; margins flat or weakly revolute; texture coriaceous; leaf colour lustrous green above, dull green below. Midrib on adaxial (upper) side narrow (less than 1 mm), continuous or nearly so, obtusely raised or flat and with a central groove, on abaxial side wider, ca. 1 mm, obtusely raised or nearly flat but conspicuous to apex. Stomata small, in numerous intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary, sessile, elongating to ca. 30 mm, 3 mm wide at anthesis; microsporophylls broadly triangular, acute, with two globose pollen sacs. Seed cones axillary, solitary on 5–12 mm long, slender peduncles terminating in two minute scales ('foliola') subtending the eventually 7–8 mm long, 4–5 mm wide, succulent red receptacle consisting of an axis with two unequal bracts. Seeds solitary, including the epimatium 7–8 mm long, subglobose or broadly ovoid, with a weakly developed crest. Seed proper more or less ovoid, 4–5 mm long, grooved or pitted (*in sicco*).

Distribution

Brazil: Bahia, Distrito Federal, Goiás, Mato Grosso, Minas Gerais, Rondonia, Roraima; Venezuela.
TDWG codes: 82 VEN 84 BZC-DF BZC-GO BZE-BA BZL-MG BZN-RO BZN-RM

Ecology

Podocarpus brasiliensis is apparently widespread and occurs both north and south of the Amazon Basin (which is devoid of conifers in natural habitats). In Venezuela it is known from the tepuis, high and isolated sandstone plateaux and table mountains, where it is a component of dwarf forest above sandstone bluffs, or occupies the transition zone to lower altitude, taller evergreen rainforest. The altitudinal range is imperfectly known; where stated specimens were collected between 800 m and 1600 m a.s.l. In Brazil it occurs in the 'cerrado' which is mostly low, open, and bushy vegetation, but here it is limited to narrow strips of 'gallery forest' along streams, where ground water is more reliably available. In the Mato Grosso of Brazil a herbarium collection of this species was made in "high forest" but this habitat was not further characterized.

Conservation

IUCN: LC

Uses

No commercially significant uses have been recorded of this species. It occurs in remote localities and is too small a tree to be of much value for timber, but it may locally have been used for firewood. This species is not known in cultivation.

Podocarpus brassii Pilg., Bot. Jahrb. Syst. 68: 246. 1937. Pl. 35

Etymology

This species commemorates the plant collector L. J. Brass, who made six collecting expeditions to New Guinea sponsored by the American Museum of Natural History in New York.

Vernacular names

In Flora Malesiana ser. 1, 10 (3): 413–414 (1988) a number of local names for var. *brassii* are listed; still other names were seen mentioned on herbarium collections.

Description

Decumbent shrubs or small, often gnarled trees 0.15–15 m tall, rarely an erect forest tree to 30 m tall and 75 cm d.b.h. Bark thin and smooth, becoming stringy on largest stems, light brown weathering grey; inner bark pink, sometimes nearly white. Crown of trees often flat-topped, otherwise usually irregular. Foliage branches spreading to assurgent, profusely leaved distally, forming dense tufts of foliage. Terminal buds on leading shoots 3–5 mm wide, onion-shaped or truncate with triangular, spreading outer scales. Leaves on young plants 2.5–4 cm long, 5–7.5 mm wide, linear-lanceolate, straight, acute or short apiculate. Leaves on adult plants (0.5–)1–2(–2.5) cm long, (3–)4–6(–7) mm wide, oval or elliptical to oblong, coriaceous, spreading to erect and densely crowded, abruptly or in longer leaves gradually tapering to a sessile or short petiolate base; apex obtuse or obtuse-cuspidate; margins revolute; midrib raised on adaxial side, forming a narrow ridge less than 0.3 mm wide, ca. 0.5 mm wide and obtusely raised on abaxial (lower) side; leaf colour in flushing leaves pinkish or light green with reddish margins, in adult leaves dull dark green above, light or glaucous green below. Stomata very small, in numerous irregular lines on either side of abaxial midrib. Pollen cones axillary, solitary or rarely in pairs, sessile, elongating at anthesis to ca. 40 mm, slender or robust, 3–8 mm wide; microsporophylls short triangular or with an elongated 2–3 mm long reddish or pink apex, bearing two globose, greenish yellow pollen sacs. Seed cones towards ends of foliage branchlets, axillary on short peduncles; receptacles subtended by two 3–4 mm long bracts ('foliola'), 8–12 mm long, expanding at maturity to 15 mm long and wide and becoming dark purple to nearly black when ripe. Seeds including the covering epimatium ovoid, 10–13 × 8–9 mm, without a crest, olive green or purplish green or pruinose. Seed proper not observed.

Distribution

New Guinea.
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

Podocarpus brassii occurs in high montane evergreen forest, in subalpine mossy forest, in subalpine to alpine scrubland and on the margins of or occasionally in alpine grassland. It is a high altitude species; the two varieties, as noted by De Laubenfels in Flora Malesiana ser. 1, 10 (3): 413–414 (1988), although for the most part sympatric, occur at more or less separated altitudes. Var. *humilis*, a decumbent shrub or small, stunted tree, is found from 2510 m to 3600 m a.s.l.; the more abundant tree form, var. *brassii*, from occasionally around 2700 m, but more commonly between 3100 m and 4000 m a.s.l. In wet areas near pools var. *humilis* becomes decumbent and forms dense 'mats' of ca. 3 m^2 and only 15–30 cm tall. The (fuzzy) forest line is situated at 3600–3700 m in many places, so the highest growing trees of var. *brassii* are isolated individuals emergent above shrubbery or in acid, boggy subalpine to alpine grassland. The species is rather rare in tall forest, where it may attain 25–30 m with a straight bole. Associated taxa in the subalpine shrubbery or mossy forest are e.g. *Rhododendron* and *Rapanea*; in the upper montane forest we can also find the conifers *Araucaria cunninghamii, Dacrycarpus compactus* and *Podocarpus pilgeri*. Tree ferns are often abundant in the alpine grassland, which often forms mozaic vegetation patterns with shrubbery and patches of mossy forest.

The occurrence of *P. brassii* in grassland away from woody vegetation may be caused by past fires, which are often lighted by people.

Uses

This species is not recorded as being used commercially; its rarity as a tall tree makes exploitation for timber unlikely. Outside a few plants grown in botanic gardens, where it is usually a shrub, but only named to species, neither variety is in cultivation. Due to their high altitude provenance both forms should be perfectly hardy for gardens in cool temperate regions, and the decumbent form of var. *humilis* would make an attractive garden plant worth being tried.

2 varieties are recognized:

Podocarpus brassii Pilg. var. ***brassii***. Type: New Guinea: Papua New Guinea, Owen Stanley Range, Mt. Albert Edward, *L. J. Brass 4395* (lectotype K, here designated). Fig. 256

Description

Small trees, often stunted, to 15 m tall; rarely a tall tree to 30 m and 75 cm d.b.h. Pollen cones robust, 6–8 mm diam. at anthesis; microsporophylls with elongated, reddish or pink apex.

Distribution

New Guinea.
TDWG codes: 43 NWG-IJ NWG-PN

Conservation

IUCN: LC

Podocarpus brassii Pilg. var. ***humilis*** de Laub., Blumea 30 (2): 274. 1985. Type: New Guinea: Papua New Guinea, Telefomin District, Mt. Capella, *W. R. Barker LAE 67278B* (holotype L).

Description

Decumbent shrubs or stunted trees to 5–6 m tall. Pollen cones slender, 3–4 mm wide; microsporophylls small, with a triangular apex.

Distribution

New Guinea.
TDWG codes: 43 NWG-IJ NWG-PN

Conservation

IUCN: LC

Podocarpus brevifolius (Stapf) Foxw., Philipp. J. Sci. 6: 160. 1911. *Podocarpus neriifolius* D. Don var. *brevifolius* Stapf, Trans. Linn. Soc. London, Bot., ser. 2, 4: 249. 1894. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu, *G. D. Haviland 1093* (lectotype K, here designated). Fig. 257, 258

Etymology

The species epithet refers to the short leaves.

Vernacular names

No vernacular names are known for this species.

Description

Small, often gnarled trees 1.5–7.5 m tall. Bark becoming scaly on largest stems, brown weathering grey. Crown in more or less sheltered trees conical, becoming rounded with age, otherwise usually irregular. Foliage branches spreading to assurgent, densely leaved distally, forming tufts of foliage; shaded branches with more widely spaced leaves. Terminal buds on leading shoots 4–6 × 3–5 mm, onion-shaped or truncate with triangular, spreading outer scales. Leaves on young plants 4–8.5 cm long, 5–9 mm wide, linear-lanceolate, straight, narrowly acute. Leaves on adult plants (1.2–)2–5(–7) cm long, 4–6(–8) mm wide, elliptical or falcate-lanceolate to linear-lanceolate, coriaceous, spreading to erect and densely crowded, gradually tapering to a sessile or short petiolate base; apex acute or obtuse; margins slightly revolute; midrib acutely raised on adaxial side, forming a narrow ridge less than 0.4 mm wide, ca. 1 mm wide and obtusely raised on abaxial (lower) side. Stomata very small, in numerous irregular lines on either side of the abaxial midrib. Pollen cones axillary, solitary or rarely in pairs, sessile, elongating at anthesis to ca. 20 mm, 4–5 mm wide;

PLATE 35. *Podocarpus brassii*. **1.** Branch with foliage and pollen cones (var. *humilis*). **2.** Branchlet with leaves and pollen cones (var. *brassii*). **3.** Branch with foliage and seed cones (var. *brassii*). **4.** Branchlet with leaves and seed cone (var. *brassii*). **5.** Seed cone. **6, 7.** Leaves.

microsporophylls with narrowed 1–1.5 mm long apex, bearing two globose pollen sacs. Seed cones towards ends of foliage branchlets, axillary on short peduncles; receptacles subtended by two 3–4 mm long bracts ('foliola'), 6–8 mm long, distally bilobed or truncate when swollen and becoming dark purple. Seeds including the covering epimatium ovoid, 8–10(–12) × 6–7 mm, with a small distal crest, dark purple, glaucous or pruinose. Seed proper not observed.

Distribution

Malaysia: Sabah (Mt. Kinabalu and surrounding mountain ridges).
TDWG codes: 42 BOR-SB

Ecology

Podocarpus brevifolius is locally common in upper montane to subalpine dwarf forest on Mt. Kinabalu and other mountain ridges and heights in the vicinity. It grows most commonly on ultramafic substrate and also on granite, among boulders or from crevices. It has been found on ultramafic rock at 1350–1450 m a.s.l. near a copper mine and on the Bambangan Ridge at 1900 m in lower montane forest. Its altitudinal range on Mt. Kinabalu proper is between 2100 and 3800 m a.s.l., where it is a constituent of a dwarfed forest to 10 m tall, dominated by the conifers *Phyllocladus hypophyllus* and *Dacrycarpus kinabaluensis* and the umbrella-crowned angiosperm tree *Leptospermum recurvum* (*Myrtacea*). Other common woody plants in this zone are the conifer *Dacrydium gibbsiae* (on ultramafics) and the angiosperms *Eugenia* (*Syzygium*) *kinabaluensis*, *Rhododendron buxifolium* and *Schima brevifolia*. Near the summit of the mountain only dwarfed, shrub-like plants of *P. brevifolius* occur in granite crevices.

Conservation

IUCN: NT

Uses

No uses are recorded of this species. It can be assumed that provenances from high altitude (above 3000 m) may be hardy as they experience occasional frost. It will probably be a slow growing shrub in cultivation, but should be tried.

Podocarpus buchii Urb., Fedde's Repert. Sp. Nov. Regni Veg. 19 (16–21): 298. 1924. *Podocarpus angustifolius* Griseb. subsp. *buchii* (Urb.) Staszk., Fragm. Fl. Geobot. 33: 77. 1988; *Podocarpus aristulatus* Parl. var. *buchii* (Urb.) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 31. 2000. Type: Hispaniola: Haiti, near La Bellefontaine, *L. von Buch 2089b* (holotype B, destroyed?).

Podocarpus buchii Urb. var. *latifolius* Florin, Ark. Bot. 25-A (5): 3. 1934; *Podocarpus angustifolius* Griseb. subsp. *buchii* (Urb.) Staszk. var. *latifolius* (Florin) Staszk., Fragm. Fl. Geobot. 33: 77. 1988.

Etymology

This species was named after the German botanist Christian Leopold von Buch (1774–1853).

Vernacular names

No common names have been recorded for this species.

Description

Small trees 5–10 m tall, or larger (?); trunk d.b.h. to 30 cm (or to 100 cm?). Bark smooth, brown. Branches spreading, forming a dense crown. Foliage branchlets terete, finely grooved between leaf bases, terminating in globose buds with imbricate, rounded, keeled scales and apiculate, partly free outer scales. Leaves on saplings larger than on mature trees, to 5 cm long and 9 mm wide; leaves on mature trees crowded, directed forward at a narrower than 45° angle towards the distal parts of branchlets but more widely spreading lower down, 1.5–4 cm long, straight, elliptic to linear-oblanceolate, (4.5–)6–9 mm wide, gradually tapering to a near sessile to short petiolate base, abruptly narrowing to a spinescent apex, the spine 1–1.5 mm long; margins slightly revolute, texture coriaceous, stiff; leaf colour dark green above, paler green below. Midrib inconspicuous on adaxial (upper) side, slightly raised above leaf base but soon becoming a groove towards apex, continuous, obtusely raised and wider (0.7 mm) on the abaxial side. Stomata very small, in numerous

intermittent lines on either side of abaxial midrib. Pollen cones not observed. Seed cones axillary, solitary on 6–8 mm long peduncles; receptacles an axis with two fused, unequal bracts, growing to 8–10 mm long, becoming swollen and succulent, bright red. Seeds solitary, elliptical, including the epimatium 7–8 mm long, 4–4.5 mm wide, with a prominent, recurved distal crest. Seed proper not observed.

Taxonomic notes

The leaves of *P. buchii* var. *latifolius* in the type specimen at K (*E. L. Ekman 4913*, isotype K) from the Massif du Nord in Haiti are 1.5–4 cm long and 5–9 mm wide. This is overlapping the range of dimensions found in specimens of *P. buchii* Florin ascribed to the species, but reaching 2–3 mm wider. This does not seem to warrant taxonomic distinction, as the other charcters observed in the type specimen are similar to the species. Gray & Buchholz (1948) in their revision of American species of *Podocarpus* included material with much larger leaves in this variety, which appears to belong to *P. aristulatus*.

Distribution

West Indies: Hispaniola: Dominican Republic, Haiti.
TDWG codes: 81 DOM HAI-HA

Ecology

Podocarpus buchii occurs in the mountain forests of Hispaniola. The northern population in Haiti, described by Florin (*op. cit.*) as *P. buchii* var. *latifolius*, occurs on limestone massifs. In most populations in the south of this country the geological substrate is also a hard karst limestone with a lateritic thin soil. In the Dominican Republic the species is known from two locations in montane forest on metamorphic rock types. The forest is mostly evergreen tropical rainforest dominated by angiosperms with small leaves on steep, rocky slopes, ridges and summits at altitudes between 600 m and 2050 m a.s.l.

Conservation

This species is apparently scattered and is estimated to have declined by at least 50% while threats to its remaining population have not ceased.
IUCN: EN (A2a, c, d)

Uses

No uses have been recorded of this species. If reports about large trees with d.b.h. to 1 m are correct, such trees may well have been logged and the wood used for general construction, carpentry and furniture making.

Podocarpus capuronii de Laub., Adansonia 11 (4): 713. 1971. Type: Madagascar: Fianarantsoa Prov., Itremo Massif, Mt. Ambatomenaloha, *R. Capuron 11566* (holotype P).

Podocarpus woltzii Gaussen, Bull. Soc. Hist. Nat. Toulouse 110: 123. 1974; *Podocarpus capuronii* de Laub. var. *woltzii* (Gaussen) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 31. 2000.

Etymology

This species has been named after R. Capuron, who collected the type specimen.

Vernacular names

No common names have been recorded for this species.

Description

Shrubs or small trees to 20 m tall, usually less than 6 m. Bark breaking in small irregular flakes, brown. Foliage branchlets terete, with grooves and fine ridges between the leaf bases, terminating in small buds with elongated, incurved outer scales. Leaves crowded towards ends of branchlets, spreading forward at ca. 35–45° or some lower leaves spreading wider, linear, (1.5–)2.5–5(–7.5) cm long, 2–5 mm wide, straight or slightly falcate, gradually narrowing to a sessile or short petiolate base, more abruptly converging distally to an obtuse or minutely acuminate apex; margins mostly parallel, slightly revolute; texture coriaceous; leaf colour dark green above, flushing leaves bright glaucous blue. Midrib thin, raised proximally but fading towards apex on adaxial (upper) side, continuous and markedly visible on abaxial side. Stomata small, in numerous intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary or with 2–3 together on 4–8 mm long peduncles, subtended by scarious bud scales, cylindrical,

elongating to 1–2(–3) cm, 3–4 mm wide at anthesis; microsporophylls 1–1.5 mm long and ca. 1 mm wide, with minutely erose-denticulate margins, each bearing two subglobose pollen sacs. Seed cones axillary, solitary, on a short peduncle, receptacle formed of an axis with two unequal bracts, swelling only slightly to 3–4 mm long and 2.5 mm wide. Seeds including the epimatium 15–18 mm long, 10–12 mm wide, obliquely ovoid with a distal crest, brown to bluish pruinose or whitish pruinose. Seed proper not observed.

Taxonomic notes

Podocarpus woltzii was described by Gaussen (*op. cit.*) as a distinct species, but with characters said to be close to *P. rostratus*. The main difference stated seems to be the occurrence inside the leaves of horizontal sclereids, hard bodies that are sometimes interspersed between the mesophyll cells. Sclereids in leaves of conifers occur erratically and are not reliable taxonomic characters, although some species may never develop them. *Podocarpus woltzii* was also described with larger leaves than those of *P. rostratus*. The longer and wider leaves seem to be based on material belonging to *P. capuronii* de Laub. described two years earlier and, like *P. woltzii*, based on a collection made by R. Capuron on the same day but on a different mountain.

Distribution

Madagascar: Itremo Massif, Manandona.
TDWG codes: 29 MDG

Ecology

Podocarpus capuronii is found on skeletal sandy soil over quarzite or gneiss, along streams in ravines and on rocky slopes and ridges. It is a slow growing shrub or stunted tree in these depauperate sites; in forest it may attain 20 m. The altitude (from information with herbarium specimens) ranges from 1320–2000 m, but is reported to extend to 2800 m a.s.l.

Conservation

Probably now restricted to the Itremo massif, where all recent collections have been made. The disjunct occurrences are based on *Perrier de la Bathie 13163* and *R. Capuron 27065* (type of *P. woltzii*) in the Paris Herbarium (P), which were collected in the 1920's and 1960's. Habitat loss is considered to be very high in the whole of central Madagascar. Deforestation, habitat loss, cutting for firewood, fires, and grazing are the main threats to this species. This species is not known to occur in a protected area.
IUCN: EN [B2ab (i–v)]

Uses

No uses have been recorded of this species. It is likely to have been used as firewood when still abundant; perhaps the wood of larger trees was used in local construction and hand tool carpentry.

Podocarpus celatus de Laub., Fl. Venezuela 11 (2): 35. 1982. Type: Bolivia: Potosí, Morro, *R. W. Pearce s.n.* (lectotype K, specimens B, designated here).

Etymology

The species epithet (Latin: *celatus* = concealed, hidden) relates to the species previously not being recognized as distinct from *P. magnifolius*.

Vernacular names

'Cinqui-masé' (Peru); Ulcumanu (Andes)

Description

Trees to 25–30 m tall; trunk to 60 cm d.b.h., erect in tall forest habitat. Bark thin, fibrous, exfoliating in small strips and flakes, reddish brown, weathering grey. Branches sparse, forming an open, spreading crown. Foliage branchlets slender, terete, finely grooved between remote leaf bases. Terminal vegetative buds more or less conical, with short, triangular, acuminate scales 4–6 mm long, 3 mm wide at base; outer scales free at apex; inner scales more or less imbricate. Leaves on saplings and juvenile trees much larger than on mature trees, 12–18 cm long, 17–23 mm wide, lanceolate-acuminate, thin and lax, light green. Leaves on mature trees 4.5–7.5 cm long, 8–15 mm wide, elliptic to lanceolate, straight or slightly falcate, more or less abruptly narrowing to a short petiolate base, abruptly or gradually

tapering to an acute apex; margins flat, mostly not parallel; texture thin coriaceous; leaf colour deep green above, pale green below. Midrib on adaxial (upper) side a shallow groove, fading towards apex; obtusely raised and continuous to apex on abaxial side, ca. 1 mm wide. Stomata very small, in numerous intermittent lines forming two broad bands on either side of abaxial midrib. Pollen cones axillary, solitary, sessile, subtended by small, triangular perular scales, cylindrical, 20–35 mm long and creamish white when mature. Seed cones axillary, solitary on a 4–10 mm long peduncle; receptacles 7–9 mm long, slightly swollen and red when mature. Seeds including the epimatium subglobose to globose, 9–12 mm long, 8–10 mm wide, with a small apiculus, green. Seed proper globose, with a lustrous, finely pitted, brown seed coat.

Taxonomic notes

David de Laubenfels (*op. cit.*) cited as the holotype of *Podocarpus celatus* "Pearce en 1866 (K), Bolivia, Moro." The pertinent sheet at Kew contains a foliage branch with large leaves from a juvenile tree (Pearce: "leaves of young trees very large") and two branchlets, one fertile with a seed cone, with much smaller leaves from a mature tree. These are in effect two separate gatherings and cannot be both the holotype. I have marked them A (juvenile plant) and B (mature plant) and here designate the two branchlets marked B as the lectotype of this species. The juvenile foliage branch thereby becomes a paratype. This species differs in its foliage only slightly from *P. magnifolius*, with which the type specimens at Kew of *P. celatus* were provisionally equated by J. T. Buchholz in 1950. Several leaves of the juvenile foliage specimen on the 'type sheet' at K have acuminate leaves, similar to leaves of *P. magnifolius*. The buds of *P. celatus* have shorter scales and the seeds are nearly globular without a crest. The pollen cones, unknown when *P. celatus* was published, are similar to those of *P. magnifolius*, but slightly shorter at maturity.

Distribution

Bolivia: La Paz, Potosí; Brazil: Goiás, Mato Grosso; Colombia; Ecuador; Peru: Amazonas, Junin, Loreto, Montaña, Puno; Venezuela: Amazonas, Bolivar, Tachira.

TDWG codes: 82 VEN 83 BOL CLM ECU PER 84 BZC-GO BZC-MT

Ecology

Podocarpus celatus occurs in tropical evergreen lowland to low montane rainforests. Its altitudinal range as presently known from herbarium specimen data is between 130 m and 1930 m a.s.l.

Conservation

IUCN: LC

Uses

This species is undoubtedly being logged for its timber, as it grows in accessible forests to a considerable size. As with other wood of podocarps, it is used for general construction, carpentry and furniture making. It is not known to be in cultivation, or perhaps planted in a few botanic gardens as *P. magnifolius* or *P. oleifolius*.

Podocarpus chingianus (N. E. Gray) S. Y. Hu, Taiwania 10: 32. 1964. *Podocarpus macrophyllus* (Thunb.) Sweet var. *chingii* N. E. Gray, J. Arnold Arbor. 39: 474. 1958; *Margbensonia chingiana* (N. E. Gray) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 59. 1998. Type: China: Zhejiang, ["55 Chinese miles (li) west of Lung-sien"], *R. C Ching. 2477* (holotype A). Fig. 259

Etymology

The specific and varietal epithets commemorate the Chinese plant collector Ching Ren-chang.

Vernacular names

zhu guan luo han song (Chinese)

Description

Small trees to 8 m tall; trunk to 20 cm d.b.h. Bark smooth, fibrous, brown weathering to grey-brown. Branches ascending, foliage branches in mature plants dense, forming a (broad) columnar crown;

ultimate branchlets angular, glabrous, terminating in a small conical bud with carinate, somewhat tapered, to 3 mm long and occasionally spreading scales. Leaves densely crowded, spirally arranged, spreading to erect and rigid, sessile to short petiolate, leaf blade linear-lanceolate to oblanceolate, 1.2–3.5 cm long, 2.5–4.5 mm wide, gradually tapering to base, in adult leaves with an obtuse apex, midvein acutely raised adaxially, not raised and wider abaxially; leaf colour olive green above (adaxially), glaucous green below. Stomata conspicuous, in numerous regular lines on abaxial side on either side of the midvein. Pollen cones axillary, sessile, in clusters of (1–)2–3 per axil, subtended by several scarious, more or less triangular bracts, long cylindrical, 15–25 mm long, 1.5–2 mm wide; microsporophylls spirally arranged, imbricate, spreading at anthesis, the laminar part apiculate, 0.5–0.7 mm long, with two basal pollen sacs. Seed cones and seeds not known.

Taxonomic notes

This species was originally described as a variety of the wide-spread species *Podocarpus macrophyllus* (Thunb.) Sweet by N. E. Gray (*op. cit.*), based on the collection *R. C. Ching 2477* of which she had seen a specimen in the Herbarium of the Arnold Arboretum at Cambridge, Massachusetts. S. Y. Hu (*op. cit.*) described it as a new species, based on the same type collection (*R. C. Ching 2477*) so in fact elevating Gray's variety in rank to a species. Two more collections were cited by Hu (Gray only knew the type), *C. L. Tso 1477* from Jiangsu and *W. P. Fang 14261* from Sichuan. A duplicate of *C. L. Tso 1477* is in the Kew Herbarium (K); the collection from Sichuan could not be verified. This taxon was regarded as a cultivar of *Podocarpus macrophyllus* (cv. Chingii) by S. Y. Zhang in Flora of Zhejiang Province 1 (Lin & Zhang, 1993), but there is no evidence of it having been found (only) in cultivation.

Distribution

China: Jiangsu, Zhejiang, Sichuan(?).
TDWG codes: 36 CHS-JS CHS-ZJ

Ecology

Podocarpus chingianus occurs in woods and open thickets, i.e. secondary woodland or shrubby vegetation. Its altitudinal range is quoted as "near sea level to 1000 m", but this is based on no more than two (or three) localities cited in the literature. This habitat note is quoted from S. Y. Hu (1964), but was not specified with the collected specimens from Jiangsu and Zhejiang (the Sichuan specimen was not seen). It is apparently very rare.

Conservation

Too little is known about this taxon, apart from its apparent rarity, to evaluate its conservation status. It is with certainty known from two localities, one in Jiangsu and the other in Zhejiang; a third herbarium collection was mentioned by S. Y. Hu (*op. cit.*) to be from Sichuan. That would be far to the west of the other two, neither of which has been specified to modern topographic locality names, so they remain essentially located as to the provinces only.
IUCN: DD

Uses

No uses are known of this species; it may be in cultivation in China locally.

Podocarpus confertus de Laub., Blumea 30 (2): 271. 1985. Type: Malaysia: Sabah, Tawau District, Gunung Silam, *D. J. de Laubenfels P 691* (holotype L).

Etymology

The species epithet means 'pressed close together', but what is considered to be so is not clear from the original description or the specimens seen.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 35 m tall; trunk erect, terete, to 70 cm d.b.h. Bark soft, becoming flaky on largest stems, peeling in longitudinal strips, brown weathering grey. Crown becoming rounded with age in large trees, otherwise usually irregular or stunted. Foliage

branches spreading, mostly with widely spaced leaves. Terminal buds on leading shoots 6–10 mm long, 3–4 mm wide, narrowly conical, with erect, free, long acuminate outer scales. Leaves on young plants 10–15(–20) cm long, 9–12 mm wide, linear-lanceolate, straight or slightly curved, acute. Leaves on adult plants smaller (3.5–)5–10(–12) cm long, (5–)7–10(–12) mm wide, lanceolate to linear-lanceolate, coriaceous, spreading to ascending, gradually tapering to a petiolate base; apex acute, or slightly apiculate from extended midrib; margins flat; midrib obtusely raised and 0.8–1 mm wide on adaxial side, flattened and slightly wider on abaxial (lower) side. Stomata very small and inconspicuous in dense lines on abaxial side. Pollen cones axillary, solitary or occasionally in pairs, sessile, subtended by long acuminate bracts (bud scales), elongating at anthesis to 20–40 mm, 3–4 mm wide; microsporophylls with acute apex ca. 1 mm long, bearing two globose pollen sacs. Seed cones axillary on a 4–13 mm long peduncle; receptacles subtended by a 3–5 mm long bract, 8–12 mm long, formed of an axis with two unequal parts, swelling to become succulent and red. Seeds including the epimatium ovoid-globose, ca. 10 × 7 mm when mature, distally obtuse. Seed proper not observed.

Distribution

Malaysia: Sabah (Bukit Ampuan, Mt. Silam), Sarawak.
TDWG codes: 42 BOR-SB BOR-SR

Ecology

Podocarpus confertus occurs in kerangas forest on poor, sandy soils and in stunted forest on ultrabasic rocks, commonly at altitudes between 100 and 1200 m a.s.l. It can locally form dense populations, but commonly it is associated with various shrubs and trees, conifers as well as angiosperms.

Conservation

The rapid and ongoing deforestation related to oil palm plantations in the region has caused severe fragmentation of the population and contributes to its continuing decline.
IUCN: EN [B2ab (iii–v)]

Uses

Where it grows to a large tree this species will be valued and exploited for its timber; however, most trees do not attain large size as they occur on very poor soils or on exposed sites with ultrabasic rock. Its wood may be used for house construction, flooring, furniture making and cabinet work, carpentry and joinery, household utensils, matches, and toothpicks. This species is not known to be in cultivation.

Podocarpus coriaceus Rich., in A. Richard (ed.) Comm. Bot. Conif. Cycad.: 14, t. 1, f. 3. 1826.
Type: West Indies: Montserrat. *R. Brown s.n.* (holotype BM).

Etymology

The species epithet (Latin *corium* = skin) describes the thick, leathery leaves.

Vernacular names

Resinier moutaigue (Dominica); Caoba del país, Coabilla (Puerto Rico); Granadillo (Trinidad & Tobago)

Description

Shrubs or more commonly small, stunted trees 3–10 m tall, rarely to 20 m; d.b.h. to 50 cm. Bark thick, smooth, becoming fissured and scaly, exfoliating with shaggy strips, brown weathering grey. Branches much spreading and contorted in older trees. Foliage branchlets stout, terete, with longitudinal grooves and ridges on vigorous shoots, less marked on slow growing shoots, terminating in large, broadly ovoid buds with ovate-apiculate 3–6 mm long scales which are free towards apex, a few of the outer scales sometimes elongated to scale-like leaves 10 mm long or longer. Leaves on vigorous shoots of saplings larger than on mature trees, to 22 cm long and 17 mm wide. Leaves on mature trees (3–)5–12 cm long, 7–14 mm wide, straight or slightly falcate, linear-lanceolate to linear, narrowing to a near sessile or short petiolate base, gradually tapering to an acute or slightly acuminate apex, only in longer leaves the two sides running parallel in the

middle section of the leaf; margins mostly straight, sometimes slightly revolute; texture coriaceous; leaf colour dark green above, dull green below. Midrib on adaxial (upper) side thin, raised in proximal part of leaf, but fading towards apex, often grooved (*in sicco*), on abaxial side continuous to apex, wider (ca. 1 mm), but flattened. Stomata small, in numerous intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary or sometimes in pairs, sessile, subtended by scarious bud scales, long cylindrical, elongating to 50–60 mm, 3–4 mm wide at anthesis; microsporophylls ovate-triangular, obtuse with erose margins, each bearing two globose pollen sacs. Seed cones axillary, solitary on 4–8 mm long peduncles, 2 bracts at base of receptacle ('foliola') soon absent; receptacles composed of an axis with two unequal, fused bracts with free tips, swelling to a 7–9 mm long, 6–7 mm wide, succulent red body. Seeds solitary, including the epimatium 8–10 mm long, 6–7 mm wide, obliquely ovoid with a subapical beaked crest, green. Seed proper not observed.

Distribution

West Indies: Dominica, Guadeloupe, Martinique, Montserrat, Puerto Rico, Saint Lucia, Saint Kitts and Nevis, Trinidad and Tobago.
TDWG codes: 81 LEE-GU LEE-MO LEE-SK PUE TRT WIN-DO WIN-MA WIN-SL

Ecology

Podocarpus coriaceus occurs in lowland forest or woodland on poor sandy soils in Trinidad and Tobago and on the Leeward and Windward Islands of the Lesser Antilles and in Puerto Rico in 'elfin forest' on windswept mountain ridges and summits from 500 m to 1350 m a.s.l. This vegetation type does not exceed 10 m in height and is usually much lower and scrubby.

Conservation

IUCN: LC

Uses

No uses have been recorded of this species; where accessible it is probably cut for firewood. In the past, larger trees to 18 m tall may have existed, which were logged long ago and were probably used for construction and general carpentry.

Podocarpus costalis C. Presl, Epimel. Bot.: 236. 1851. Type: [orig. mat. coll. *T. Haenke* (1792), not located]. Fig. 260

Podocarpus costalis C. Presl var. *taiwanensis* Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 183. 1976 (*nom. inval.*, Art. 37.1).

Etymology

The species epithet refers to the coastal habitat of this species.

Vernacular names

lan yu luo han song (Chinese); no common names recorded in the Philippines.

Description

Small, often gnarled trees 1.5–10 m tall. Bark becoming scaly on largest stems, brown weathering grey. Crown usually spreading, dense and irregular. Foliage branches spreading to assurgent, densely leaved distally, forming tufts of foliage; shaded branches with more widely spaced leaves. Terminal buds on leading shoots 3–4 mm wide and 2–4 mm long, onion-shaped or truncate with triangular, erect and free outer scales. Leaves on young plants to 9 cm long, 10–13 mm wide, linear-lanceolate, straight, acute or more or less rounded at apex. Leaves on mature plants (2–)3–5(–7) cm long, 5–8(–10) mm wide, oblong to linear, coriaceous, spreading to erect and densely crowded, gradually tapering to a short petiolate and twisted base; apex obtuse to rounded, sometimes indistinctly apiculate; margins slightly revolute; midrib acutely raised on adaxial side, forming a narrow ridge less than 0.4 mm wide, ca. 1 mm wide and obtusely raised on abaxial (lower) side. Stomata very small, in numerous irregular lines on either side of abaxial midrib. Pollen cones axillary, solitary, sessile with rounded bud scales at base, (short) cylindrical, 8–25 mm long and 6–8 mm wide at anthesis; microsporophylls

with narrowed ca. 2 mm long apex, bearing two globose pollen sacs. Seed cones towards ends of foliage branchlets, axillary on slender peduncles; receptacles subtended by two 1–1.5 mm long, deciduous bracts ('foliola'), 10–14 mm long, distally bilobed or truncate when swollen and becoming reddish purple then dark purple-pruinose. Seeds including the epimatium ovoid, 8–10 × 6–7 mm, with a small distal crest, green or glaucous. Seed proper not observed.

Distribution

Philippines: NE Luzon coast?, Bucas Islands off NE Mindanao to Batan Islands in the Luzon Strait; Taiwan: Lanyu (Orchid Island).
TDWG codes: 38 TAI 42 PHI

Ecology

Podocarpus costalis occurs on islands in lowland evergreen scrub to low forest on karst limestone bluffs and ridges or sea-stacks, from near sea level to at least 300 m a.s.l. It may be native in similar habitat on the northern coast of Luzon.

Conservation

Podocarpus costalis has a very limited distribution in fewer than five localities (islands) and is restricted to a specific habitat. It is in decline because plants are taken from the wild to be planted in gardens in Luzon and Taiwan, and possibly elsewhere. It was listed on Appendix I of CITES in 1975, but deleted from the Appendices in 1990. Attempts should be made to grow this species from seed or scions in order to minimize the taking of plants from habitat.
IUCN: EN [B2ab (v)]

Uses

This attractive, shrubby dwarf tree is popular in cultivation for gardens in the Philippines and in Taiwan, where it has been confused with *P. polystachyus*. The pollen cones of *P. costalis* are much more robust (up to 3 times wider) and its leaves shorter and more crowded. The ripe receptacle of the seed cone is dark purple-pruinose, not red. *Podocarpus costalis* is also used in bonsai culture.

Podocarpus costaricensis de Laub. *ex* Silba, Phytologia 68: 67. 1990. Type: Costa Rica: San José, Tarrazu, San Pablo de Leon Cortes, 2 km W of cemetery, *D. J. de Laubenfels P 810* (holotype MO).

Etymology

The species epithet indicates Costa Rica, where the species is endemic.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 20–30 m tall, erect, monopodial, with a trunk to 1 m d.b.h. but most known trees are more slender. Bark reddish brown, scaly and exfoliating in longitudinal strips; inner bark pinkish. Branches spreading, forming a rounded crown. Foliage branchlets with prominent leaf scars and fine grooves from decurrent leaf bases. Terminal vegetative buds with spreading acuminate scales 10–15 mm long; axillary buds small, with triangular, keeled, acute to acuminate scales 2–3 mm long, with free tips. Leaves on juvenile plants larger than on mature plants. Leaves on mature trees lanceolate, flat, (4–)6–10(–13) cm long, (7–)10–18(–22) mm wide, straight, narrowing to a petiolate base, gradually tapering to a mostly acuminate apex. Midvein lying in a groove on the adaxial (upper) side, narrow (less than 0.5 mm wide), extending from base to apex, prominently raised and 1–1.5 mm wide on abaxial side and extending to apex. Stomata small, in numerous intermittent lines on either side of midrib on abaxial side only. Pollen cones axillary, solitary, sessile, subtended by triangular, acuminate, keeled bud scales, cylindrical, expanding to 20–55 mm long, 4–5 mm wide at anthesis; microsporophylls triangular-acuminate, with two basal pollen sacs. Seed cones axillary, not observed (the receptacle presumably succulent and red at maturity).

Taxonomic notes

According to De Laubenfels (in Silba, 1990) this species is the only species in Costa Rica with long

acuminate vegetative bud scales; its leaf apices are also (mostly) acuminate. The only other species with similar bud scales in Mesoamerica is *P. matudae*; its leaves are usually gradually tapering to an acute apex and only occasionally acuminate; they are also often narrower but there is considerable variation in this. The midvein has characteristics similar to that species. Although now known from a few more collections than the two made by De Laubenfels, the seed cones of *P. costaricensis* are still unknown; they are probably similar to those of *P. matudae*. The species is disjunct from *P. matudae*, which has not been recorded with certainty south of Guatemala, and at present remains only known from a limited area in Costa Rica; De Laubenfels mentions an additional locality (Parque Nacional de Darién) in Panama, but no specimens.

Distribution

Costa Rica (San José).
TDWG codes: 80 COS

Ecology

Podocarpus costaricensis occurs in lowland and lower montane tropical rainforest at elevations between 70 m and 1700 m a.s.l. Its distribution and ecology remain poorly known since it was described in 1990.

Conservation

This species is limited to four localities in Costa Rica within an extent of occurrence (EOO) of less than 100 km². The altitudinal range of 70 m to 1650 m a.s.l., taken from herbarium collections, indicates a probable decline because of deforestation and changes in land use at lower levels. The locality at 70 m was recently collected (1995). Only eight collections were found in the search of herbaria, indicating that the species is uncommon. This species is not recorded from any protected area.
IUCN: CR [B1ab (ii, iii, v)]

Uses

No economic uses are known of this species and it is not in cultivation.

Podocarpus crassigemma de Laub., Blumea 26 (1): 141. 1980 ["*crassigemmis*"]. Type: Papua New Guinea: Eastern Highlands, Goroka, Marafunga, *D. J. de Laubenfels P 743* (holotype L).

Etymology

The species epithet (Latin *crassus* = thick, *gemma* = bud) refers to the stout buds on leading foliage shoots.

Vernacular names

Numerous names are known for this species in the New Guinea Highlands; several are listed in Flora Malesiana, ser. 1, 10 (3): 413 (1988). These names are likely to be applied to *P. archboldii* and/or other podocarps as well.

Description

Trees to 40 m tall, close to tree line only 3–8 m tall; trunk erect, to 1 m d.b.h., sometimes fluted from base. Bark thin, longitudinally fissured and scaly on largest trunks, fibrous light brown; inner bark light orange. Crown usually spreading, open and irregular, on exposed ridges sometimes flat-topped. Foliage branches spreading to assurgent, stout; terminal buds on leading shoots (3–)4–8 mm wide and 4–7 mm long, onion-shaped or truncate with lanceolate, (strongly) recurved outer scales. Leaves on young plants to 20 cm long, 10–13 mm wide, linear-lanceolate, straight, acute at apex. Leaves on adult plants (2.5)4–9(–11) cm long, 5–8(–10) mm wide, elliptic to oblanceolate, coriaceous; margins slightly revolute, gradually tapering to a petiolate base; apex acute or obtuse, sometimes indistinctly apiculate; midrib acutely raised on adaxial side, forming a narrow ridge less than 0.4 mm wide, ca. 1 mm wide and obtusely raised on abaxial (lower) side; leaf colour lustrous dark green above, young leaves flushing yellow-green, glaucous or red. Stomata very small, in numerous irregular and intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary or sometimes in pairs, on a 3–6 mm long peduncle, with rounded bud scales at base, (short) cylindrical, 10–25 mm long and 6–7 mm wide at anthesis; microsporophylls with narrowed ca. 2 mm long apex, bearing two globose pollen sacs. Seed cones axillary

on slender peduncles; receptacles subtended by two 1–1.5 mm long, deciduous bracts ('foliola'), 13–18 mm long, truncate when swollen and becoming red then dark purple to shining black. Seeds including the covering epimatium ovoid, 10–14 × 9–10 mm, with a small distal crest, green or glaucous-pruinose. Seed proper not observed.

Distribution

Papuasia: New Guinea (central highlands), Bismarck Archipelago (New Ireland).
TDWG codes: 43 BIS NWG-IJ NWG-PN

Ecology

Podocarpus crassigemma is a common large canopy tree in montane rainforest with other *Podocarpus* spp. and angiosperms of the families *Cunoniaceae, Fagaceae, Lauraceae, Myrtaceae*, and others. It can be an emergent but smaller tree in upper montane mossy forest with *Nothofagus* spp., *Myrtaceae* and the conifer *Phyllocladus hypophyllus*, and may extend into the subalpine acid grassland zone with *Papuacedrus papuana* and tree ferns. Its altitudinal range is from (1800–)2100 m to 3400 m a.s.l. and it occurs most commonly on igneous or metamorphic rock with acidic soils.

Conservation

IUCN: LC

Uses

Podocarpus crassigemma is a valuable timber tree where it attains large sizes with a clear, straight bole. Its wood is used as roundwood for masts, spars and poles, in house construction as beams, in high-grade construction for flooring, joinery and other carpentry, for furniture and cabinet work, veneer, to make boxes, and for match sticks. Its traditional uses include village house construction, household utensils and wood carving. This species was formerly confused with *P. archboldii* (e.g. Van Royen, Alpine Flora of New Guinea 2: 30, t. 41. 1979) and is probably not distinguished from it by Papuans, who may use either species for the same purposes.

Podocarpus cunninghamii Colenso, Visit Ruahine Mt. Range: 58. 1884. Type: New Zealand: [locality unknown], *W. Colenso 1631* (lectotype K, designated here). Fig. 261

Podocarpus hallii Kirk, Forest Fl. New Zealand: 14. 1889; *Podocarpus totara* G. Benn. *ex* D. Don var. *hallii* (Kirk) Pilg., in Engler, Pflanzenr. IV.5 [18]: 84. 1903.

Etymology

This species was named after Allan Cunningham (1791–1839), who botanized in Australia and New Zealand.

Vernacular names

Hall's totara, montane totara; totara kiri (Maori)

Description

Trees to 20 m tall, with a straight trunk to 1.3 m d.b.h. Bark thin, scaly, exfoliating in thin, long strips, light orange-brown. Branches spreading, forming a dense, rounded crown. Foliage branchlets terete, glabrous, finely grooved; branching irregularly, ultimate branchlets more or less pectinate, terminating in small, subglobose buds with imbricate, acute or rounded scales. Leaves helically arranged, sessile or short petiolate, short decurrent, spreading at wide angles, lanceolate to lanceolate-linear, (1.5)2–3(–3.5) cm long, 3–5(–6.5) mm wide (on saplings and young trees to 5 cm long), straight or slightly curved, tapering to a narrow, twisted base and an acute-pungent or sometimes obtuse-mucronate apex, coriaceous, stiff; midvein a narrow groove through the middle adaxially (upperside) and an obtuse midrib abaxially; leaf colour mid green, slightly paler green below. Stomata in two broad bands of intermittent lines on abaxial side. Pollen cones axillary, solitary or with 2–5 on distinct peduncles, subtended by small, triangular scales, cylindrical, 20–30 mm long, 5–8 mm wide at anthesis, straight or curved after shedding pollen, yellowish green turning brown; microsporophylls helically arranged, imbricate, peltate-triangular, with denticulate upper margin and with two sublateral, globose, yellow pollen sacs. Seed cones axillary, solitary on a short peduncle; receptacles when growing narrowly

oblong, with two distal bracts subtending 1–2 ovules, swelling to 4.5–6 mm long and 3.5–4 mm wide, yellow ripening to scarlet, soft and succulent. Seeds including the epimatium ovoid-oblong, with a constricted distal part, 3.5–4 × 2–2.5 mm, light green or glaucous green. Seed proper ca. 3 mm long, narrowly ovoid, seed coat smooth and hard.

Taxonomic notes

Podocarpus hallii, a species described by Thomas Kirk (*op. cit.*), has turned out on careful examination of types and other material to be synonymous with the earlier described species *P. cunninghamii*. Colenso (*op. cit.*) published his species in a taxonomically obscure title, so it was often overlooked and the name coined by Kirk appears in much of the literature, including earlier handbooks of conifers. Brian Molloy in 1991 provisionally selected a single branchlet (which he marked with 'a') of *Colenso 1631* at Kew (K) as the lectotype of *P. cunninghamii* Colenso but never came round to publish that choice. There are three branchlets plus a packet with broken material on the sheet at K, all likely to have come from the same tree, and I take the view that therefore the entire sheet can serve as the lectotype, which is here designated as such.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Podocarpus cunninghamii occurs in evergreen coniferous and mixed forest from near sea level to 1000 m. In lowland forests up to ca. 500 m a.s.l. *P. cunninghamii* may occur together with *P. totara*; the latter rarely occurs above that elevation. Other common and large conifers in these lowland forest remnants are *Agathis australis* (in Northland), *Dacrycarpus dacrydioides, Dacrydium cupressinum*, and *Prumnopitys ferruginea*, locally *Halocarpus kirkii, Manoao colensoi* and *Phyllocladus trichomanoides*. In montane situations above 600 m conifers are fewer and angiosperms like *Metrosideros umbellata, Quintinia acutifolia* and *Weinmannia recemosa* become more prominent. Here other conifers are *Libocedrus bidwillii, Halocarpus biformis* and *Phyllocladus trichomanoides* var. *alpinus*. Especially in South Island *Nothofagus solandri* often forms dominant patches, but these are not long-lived and *Libocedrus bidwillii* and *Podocarpus cunninghamii* are both able to prevail as emergents.

Conservation

IUCN: LC

Uses

The use of Hall's (or montane) totara as a timber tree has virtually vanished with the legal protection of native trees against logging in New Zealand. Although potentially not as big a tree, its use would have been very similar to that of totara (*P. totara*).

Podocarpus decumbens N. E. Gray, J. Arnold Arbor. 36: 202. 1955. Type: New Caledonia: Grande Terre, Province Sud, Montagne des Sources, *L. Chevalier s.n.*, 1949 (holotype ILL).

Etymology

The species epithet means 'prostrate, lying on the ground'; such plants only raise the growing tip of the shoots.

Vernacular names

No common names have been recorded for this species.

Description

Decumbent or prostrate shrubs, sometimes semi-erect, rooting from stems, spreading over rocks or other shrubs. Bark thin, exfoliating with fibrous strips; outer bark yellowish brown; inner bark reddish brown. Foliage branches terete, finely striated; terminal buds ca, 4 mm long, with erect lanceolate outer scales to 10 mm long, but inner scales much shorter. Leaves often in tufts towards ends of brachlets, or inserted more remotely in shaded shoots, oblanceolate (widest above the middle part) to linear, 4.5–8 cm long, 6–9 mm wide, coriaceous,

gradually tapering to a petiolate base; margins revolute, straight; apex narrowing abruptly, obtuse or sometimes acutish. Midrib prominent, acute or obtuse on adaxial (upper) side, flattened on abaxial side, both ca. 1 mm wide. Leaf colour light green on both surfaces. Stomata small, in numerous intermittent lines forming bands on either side of abaxial midrib. Pollen cones axillary, solitary, sessile, subtended by triangular, keeled bud scales, elongating to 15–30 mm, 3–3.5 mm wide at anthesis; microsporophylls spirally arranged, triangular, bearing two sub-basal pollen sacs. Seed cones axillary, solitary on a 5–7 mm long peduncle; receptacles subtended by two 3–4 mm long, linear bracts ('foliola'), composed of an axis with 3–4 fused bracts with exserted tips, one of which is fertile, all swelling to a 8–10 cm long, red and succulent body. Seeds solitary, including the epimatium 6–7 × 4 mm (probably growing slightly larger but no completely mature seeds are known), with a small crest. Seed proper not observed.

Taxonomic notes

The botanical characteristics, apart from growth habit, are similar to those of *P. longefoliolatus*, but only single-seeded cones (receptacles) are reported for this decumbent taxon. The number of localities known and herbarium collections made are limited and it is necessary to expand the field knowledge of this peculiar species of *Podocarpus*.

Distribution

New Caledonia: Grande Terre, southern mountains.
TDWG codes: 60 NWC

Ecology

Podocarpus decumbens occurs in open woodland or scrubby dwarf forest on mountain ridges at 800–1000 m a.s.l., where it forms extensive colonies by layering. On open rocky terrain it does not normally rise above 40 cm, but with the support of other vegetation it can erect itself higher above the ground. It is not in any way a liane, as De Laubenfels (1972) suggested, because it neither entwines other plants, nor has it developed specialized climbing or holding devices or liane architecture (see Bell, 1991).

Conservation

Based on the very limited number of localities (only two are known thus far), this species is at risk. Due to fire hazard the quality of habitat is projected to decline, probably leading to a reduction of population size.
IUCN: CR [B2ab(iii)]

Uses

No uses have been recorded of this species. Its interesting habit may indicate potential in horticulture in countries with a warm, frost-free and humid climate.

Podocarpus deflexus Ridl., Fl. Malay Pen. 5: 283. 1925. Type: Malaysia: Peninsular Malaysia, Pahang, Gunung Tahan, *H. N. Ridley 16024* (lectotype K).

Etymology

The species epithet refers to the leaves and outer bud scales being abruptly turned downward (deflected).

Vernacular names

No vernacular names are known for this species.

Description

Small trees to 10 m tall, to 20 cm d.b.h., sometimes monoecious. Bark smooth, thin, brown; inner bark reddish brown, fibrous. Branches spreading, forming a rounded or irregular crown. Foliage branchlets with distinct decurrent ridges from the leaf bases, glabrous, terminating in broad, 2–3 mm long buds with spreading to reflexed, lanceolate outer scales to 10–12 mm long and much shorter, rounded inner scales. Leaves on juvenile plants petiolate, linear, 20–26 cm long, 12–15 mm wide, gradually narrowed at base and apex, acute. Leaves on mature trees nearly as long but narrower, linear, 10–22 cm long, 8–11(–13) mm wide, straight or (irregularly) curved, thick coriaceous, deflected at the gradually narrowing, petiolate base so as to all hang downward, tapering to an obtuse or sometimes acute apex. Midvein acutely (sometimes obtusely) raised adaxially, ca.

1 mm wide, flat, marginally wider and drying to a shallow groove abaxially. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, in clusters of 2–3, (nearly) sessile with several basal bract scales, cylindrical, elongating to 25–40 mm, 2–3 mm wide; microsporophylls spirally arranged, triangular, spreading, with two basal pollen sacs. Seed cones axillary, solitary on a 5–10 mm long peduncle; receptacles with 2 subulate bracts ('foliola') 2–5 mm long at base and 2 fertile and 1 sterile bracts distally, swelling to become ellipsoid with a truncate distal end, bright red and succulent when ripe. Seeds enclosed in a smooth epimatium, ovoid to subglobose, 10–12 mm long, 6–8 mm wide. Seed proper not observed.

Distribution

Malaysia: Gunong Tahan in Pennisular Malaysia; Indonesia: N Sumatera (Aceh).
TDWG codes: 42 MLY-PM SUM

Ecology

Podocarpus deflexus is a small tree rising above and locally dominant in dwarf mountain scrub at altitudes between 1500 m and 2100 m a.s.l. Field observations appear to indicate that this species is monoecious, unlike most species in the genus.

Conservation

This species is known only from two greatly disjunct populations, the one in Sumatera only known from one herbarium collection made in 1972. This species appears to be confined to summit areas of mountains. Based on these two locations its area of occupancy (AOO) is estimated to be less than 500 km² and is probably in the lower range between Endangered (EN) and Critically Endangered (CR) (10–500 km²). There are no collections known in institutional herbaria made after 1973; all were made within protected areas, yet habitat degradation remains a problem in these areas, mainly through fires. The known collections were recorded from the Taman Negara (Malaysia) and Gunung Leuser Reserves.
IUCN: EN [B2ab (iii)]

Uses

No economic uses have been recorded of this rare species.

Podocarpus dispermus C. T. White, Contr. Arnold Arbor. 4: 10. 1933. *Margbensonia disperma* (C. T. White) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Australia: Queensland, Atherton Tablelands, Gadgarra Forest Reserve, *S. F. Kajewski 1192* (holotype BRI). Fig. 262

Etymology

The species epithet refers to the two ovules (seeds) often found on a single receptacle.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 20–25 m tall; trunk erect, terete, to 40 cm d.b.h. Bark thin, smooth, on larger trunks becoming flaky, exfoliating in narrow strips, light brown to grey-brown; inner bark slightly fibrous, pinkish. Branches spreading, forming a broad crown. Foliage branchlets smooth or with fine grooves, terminating in small, narrowly conical buds with lanceolate, minutely denticulate, apically free, spreading or slightly recurved scales. Leaves on juvenile and mature trees similar in size ranges, spreading at a forward angle from branchlets, short petiolate, (5–)8–18(–20) cm long, (13–)18–30 mm wide, the shortest leaves nearly oval, the longer leaves oblong, with more or less abruptly tapering base and apex, flat and thin, acute or often cuspidate; leaf colour lustrous dark green; midrib on adaxial (upper) side prominently raised from base to apex, 1 mm wide, conspicuous but more flattened on abaxial side. Stomata small and inconspicuous, in numerous intermittent lines on abaxial (under) side of leaves. Pollen cones axillary, sessile, solitary or in groups of 2–3, narrowly cylindrical, 10–30 mm long, 2–3 mm diam. at anthesis; microsporophylls imbricate, broadly triangular,

acute, bearing to globose pollen sacs. Seed cones axillary, solitary on a stout peduncle ca. 10 mm long, consisting of an axis with one fertile scale subtended by two small, deciduous bracts ('foliola') with 1–2 fertilized ovules; receptacles 15–25 mm long, swelling to become flattened pyriform, succulent and red when ripe. Seeds when ripe solitary or in pairs (often with unequal development) at oblique distal end of receptacle, 17–22 mm long, 12–15 mm wide, elliptic to ovoid, with smooth green epimatium obliquely curved at base, olive green ripening to purple. Seeds proper 11–14 mm long, obliquely ovoid, with a curved apex, dark brown to nearly black, rugose with one side smooth.

Distribution

Australia: NE Queensland (Atherton Tableland, Bellenden Ker Range).
TDWG codes: 50 QLD-QU

Ecology

Podocarpus dispermus occurs in complex mesophyll vine forest (rain forest), in which it is a small to medium size understorey tree with large leaves. The elevation ranges from 57–971 m (GIS data), it is most common between 500–700 m a.s.l. and the soils (often sceletal) are derived from basalt or granite.

Conservation

The naturally restricted range (EOO = 170 km² and AOO = 170 km²) of this species with specific habitat requirements would justify the category Endangered (EN) if there was an ongoing decline of the population. Stochastic events like cyclones and fires are the main threats to this species. Only a limited part of the total population occurs within the 'Wet Tropics of Queensland' World Heritage Site; most known trees are outside this protected area.
IUCN: NT

Uses

No economic uses are recorded for this species at present. Most trees are relatively small and do not yield quantities of timber, even though the wood is of good quality, to make exploitation worthwhile. It was undoubtedly used in the past by settlers for light construction work, but no records have been found documenting this. Outside a few botanic gardens in Queensland, this species it not known in cultivation and is strictly tropical in its horticultural requirements.

Podocarpus drouynianus F. Muell., Fragm. 4: 86, t. 31. 1863–64. *Margbensonia drouyniana* (F. Muell.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Australia: Western Australia, Tone River, *[?] Maxwell s.n.* 1867 (holotype MEL[?], isotype K).

Podocarpus brownii C. E. Bertrand, Ann. Sci. Nat. Bot., sér. 5, 20: 64. 1874.

Etymology

This species was named after Edouard Drouyn de Lhuys (1805–1881), minister under Napoleon III and a member of the Institut de France.

Vernacular names

Emu berry, Emu bush

Description

Shrubs 1–3 m tall, multi-stemmed and sprouting from the rootstock, forming dense clumps a few meters across; stems erect. Bark thin, fibrous, green turning cinnamon brown. Foliage branches terete, finely grooved or striate, terminating in a conical, 2–4 mm long and 1.5–3 mm wide bud with narrowly triangular, slightly spreading scales. Adult and juvenile leaves similar, linear, sessile with a broad, decurrent base, 3–9(–13) cm long, 2–4(–5) mm wide, acuminate; midrib on adaxial (upper) side obtusely raised in proximal part, gradually becoming obscure towards apex, prominently raised along the full length of abaxial side; leaf colour green above, glaucous beneath. Stomata in intermittent lines arranged in two conspicious bands on either side of abaxial midrib. Pollen cones axillary, solitary or in groups of 2–6, with 10–25 mm long peduncles bearing small scale leaves, cylindrical, at anthesis

(5–)10–20(–22) mm long without peduncle, 2–4.5 mm wide; microsporophylls imbricate, small, apiculate, bearing two globose pollen sacs. Seed cones axillary, solitary, on a 10–20 mm long, slender and bare peduncle, with 1 fertile scale and 1–2 ovules of which usually only one develops; receptacles subtended by 2 deciduous, 2–10 mm long bracts ('foliola'), growing to 20–25 mm long and 10–13 mm wide, fleshy and swollen at maturity, becoming purple-pruinose when ripe. Mature seeds ovoid, 12–20 mm long, 8–12 mm diam., covered in a green or purplish green epimatium, distal part rounded without a crest; seed proper ovoid, 7–12 mm long.

Distribution

SW Western Australia (from Bunbury to Mt. Barker; Darling Ranges).
TDWG codes: 50 WAU-WA

Ecology

Podocarpus drouynianus occurs in the understorey of jarrah and karri (*Eucalyptus* spp.) forests on sandy soils, where it forms large or small patches by root suckering. It is a lowland species and does not occur in the mountains of the Stirling Range N of Albany. It regenerates after fire but is probably dependent on the microclimate of the forests for its long-time survival. However, it can re-establish in disturbed forests and persists in managed forests where logging creates temporary openings. It is one of the few species in the genus with this habit.

Conservation

IUCN: LC

Uses

This species is used in the cut flower trade as a foliage plant; it is not cultivated for that purpose. It may have some potential for horticulture in regions with a Mediterranean-type climate, but considering its growth habit it could become weedy and invasive.

Podocarpus ekmanii Urb., Fedde's Repert. Sp. Nov. Regni Veg. 18 (1–3): 17. 1922. Type: Cuba: Holguín Prov., Sierra del Cristal, near the Rio Lebisa, *E. L. Ekman 6790* (holotype S).

Etymology

The species epithet commemmorates E. L. Ekman, a Swedish botanist, who collected plants in the West Indies in the period 1915–1930.

Vernacular names

No common names have been recorded for this species.

Description

Shrubs or small trees to 8 m tall; d.b.h. to 30 cm. Bark thin, exfoliating in small flakes, light brown weathering dark grey. Branches numerous, spreading or ascending. Foliage branchlets slender, terete, finely grooved between the densely set leaf bases, terminating in small, ovoid-globose buds with imbricate, broadly ovate, carinate scales, the outer scales terminating in an acuminate apex. Leaves densely set towards distal end of branchlets, spreading at wide angles from shoot, oblanceolate to linear-oblanceolate, 1.5–2.7 cm long, straight or slightly curved downward, rarely slightly falcale, 3–5 mm wide, gradually narrowing to a short petiolate base, more abruptly to an acuminate apex, coriaceous, stiff, lustrous green or greyish green above, whitish green below. Midrib 0.5 mm wide, slightly raised from leaf base on adaxial (upper) side, often fading towards apex, more prominent and continuous on abaxial side. Stomata very small but conspicuous in numeous white lines on either side of abaxial midrib. Pollen cones axillary, not observed. Seed cones axillary, solitary on short peduncles 1–2 mm long; receptacles a short axis with two fused bracts, swelling to 10 × 6 mm, becoming succulent and bright red when ripe, still showing free acute bract apices. Seeds solitary, including the epimatium 6–7 mm long, 3.5–4 mm wide, narrowly ovoid to ovoid with a distal ridge culminating in a 1 mm high crest. Seed proper not observed.

Taxonomic notes

This species was treated as a synonym of *P. angustifolius* Griseb. in my World Checklist and Bibliography of Conifers (Farjon, 1998, [2001]). Its most obvious distinctive character is its shorter leaves (1.5–2.7 cm long in *P. ekmanii* versus 2.5–5 cm long in *P. angustifolius*), but most other characters appear to be similar. *Podocarpus angustifolius* (here including *P. aristulatus*), *P. buchii*, and *P. ekmanii* are closely similar and presumably related taxa. While *P. buchii* is only known from Hispaniola, *P. angustifolius* and *P. ekmanii* occur partly in the same general area of E Cuba and occupy similar forest formations and habitats.

Distribution

West Indies: Cuba (Holguín Province, Sierra de Nipe, Sierra del Cristal, Sierra de Moa; Santiago de Cuba Province, Loma Azul).
TDWG codes: 81 CUB

Ecology

Podocarpus ekmanii occurs in the mountains of E Cuba in sclerophyllous rain forest on serpentine or limestone, at altitudes between 450 m and 1000 m a.s.l. It is a shrub or at most a small, stunted tree typical of 'carrascales' which in Iberian Spanish refers to woods with Holm oak (*Quercus ilex*), but here merely to 'stony ground' occupied by sclerophyllous shrubs and small trees. It has also been found along streams in these mountains, indicating that it is not as drought tolerant as some of the other species in this formation. The habitat conditions in the disjunct populations in the Sierra del Cristal and the Loma Azul, where it occurs between 650 m and 1000 m a.s.l. and 500 m and 700 m resp., are similar to those in the larger area further east.

Conservation

This species is rare and has been collected in four disjunct areas; one is in the Sierra de Nipe, a second in the Sierra del Cristal, another on the Loma Azul and the fourth, with possibly 2–3 subpopulations, is located to the east of these in the Sierra de Moa. The Loma Azul ("Sierra Azul") population is only known from Ekman's herbarium specimens collected in the early part of the 20th century. Part of the Sierra de Moa population(s) is situated in a national park and here collections were made recently. The trees were regenerating well in that location. At present no information is available about the status of the two western populations.
IUCN: LC

Uses

No uses have been recorded of this species.

Podocarpus elatus R. Br. *ex* Endl., Syn. Conif.: 213. 1847. *Margbensonia elata* (R. Br. *ex* Endl.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Australia: New South Wales, Paterson River, *R. Brown [3117]* (lectotype BM, here designated).
Pl. 36, Fig. 263, 264

Etymology

The species epithet means 'tall' and refers to the size of the trees.

Vernacular names

Brown pine, Plum pine, Yellow pine

Description

Trees to 30 m tall, with erect trunk to 80 cm d.b.h. Bark thin, becoming longitudinally fissured and scaly on large trees, slightly fibrous, brown. Branches spreading to form a broad, dense crown. Foliage branchlets terete, smooth, finely grooved, terminating in small, conical buds 1.5–2.5 mm long and ca. 1 mm wide at base, with imbricate, mostly appressed, narrowly triangular and acute scales with free or recurved apices. Leaves on seedlings 2.5–6 cm long, 6–8 mm wide, on juvenile and mature plants much larger but variable, on some trees much smaller than on others, (3–)5–10(–15) cm long, (5–)7–14(–17) mm wide, linear-lanceolate, tapering gradually or in wider leaves more abrubtly to a short petiolate base; apex acute or sometimes obtuse, often cuspidate; midrib prominent but

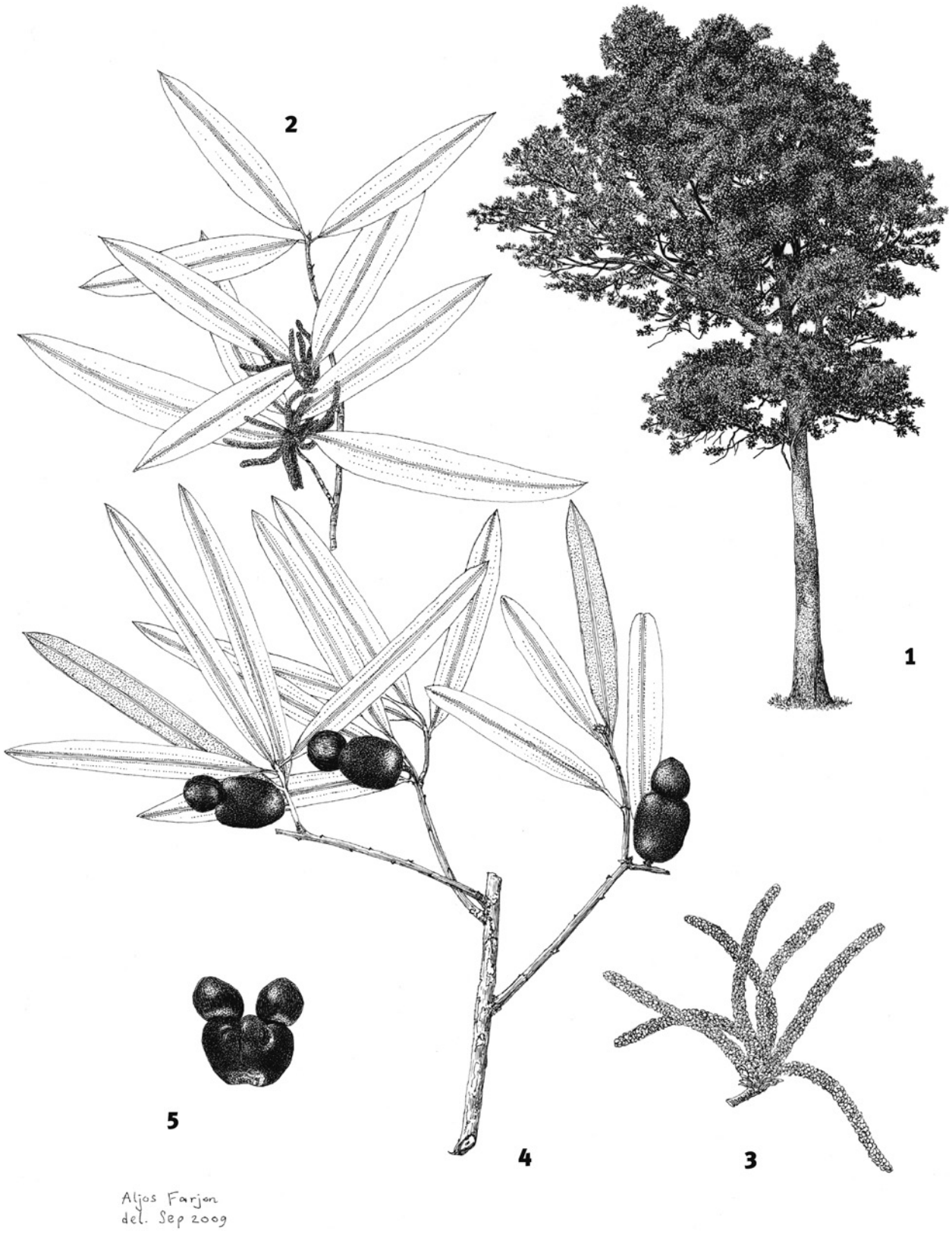

PLATE 36. *Podocarpus elatus*. **1.** Habit of tree. **2.** Branchlet with leaves and pollen cones. **3.** Pollen cones. **4.** Branchlet with leaves and seed cones. **5.** Seed cone with two seeds.

obtuse on adaxial (upper) side, varying in width with leaf but up to 1 mm wide, more flattened on abaxial side; leaf colour lustrous dark green above, pale green below. Stomata numerous, small, in two bands of intermittent lines on abaxial side. Pollen cones clustered, axillary with 2–4 together, sessile, cylindrical, 10–20 mm long, 2–3 mm wide; microsporophylls very small, imbricate, broadly triangular, with two basal globose pollen sacs. Seed cones axillary, solitary on stout, 3–10 mm long peduncles; receptacles subtended by two very small bracts ('foliola'), growing and swelling to 15–25(–30) mm long and 15–20 mm thick at the distal end, ripening from red to pruinose dark purple or blue-black, very succulent. Seeds 1(–2) on distal part of receptacle, obliquely attached, ovoid-globose with a short proximal beak and an obscure distal crest, 15–20 × 12–15 mm when mature; epimatium ripening from dark glaucous green to purplish black with a whitish bloom. Seed proper not observed.

Taxonomic notes

Ken Hill in Flora of Australia 48: 556 (1998) indicated a collection made by Robert Brown with *No. 3117*, with duplicates at BM and K, as syntype. Endlicher (1847) merely referred to Brown as the author of the species and "Habitat in Nova Hollandia orientali" but not to his collections of specimens. We do not know what Endlicher, who was based in Vienna, has seen, as the conifer specimens at W were all destroyed in World War II. Assuming *Brown 3117* is a collection of which Endlicher saw a duplicate at W and that he may have seen other material collected by Brown along the Hunter River as well, the BM duplicate is here designated as the lectotype of *Podocarpus elatus* R. Br. *ex* Endl., with an isolectotype at K.

Distribution

Australia: New South Wales, Northern Territory, Queensland.
TDWG codes: 50 NSW-NS NTA QLD-QU

Ecology

Podocarpus elatus occurs naturally in coastal and subcoastal rainforest in the region of the eastern Australian coast which receives ample rain and has a warm climate; it becomes rare in drier forest in the north of Queensland. These forests are regionally known as complex mesophyll vine forests, characterized by trees with medium-size, entire margined leaves, an abundance of climbing plants (lianas), and locally palms. The altitudinal range of this species is from near sea level to ca. 1000 m a.s.l. The soils are usually deep, alluvial sands and silts and this species is often found on river banks. Associated species are e.g. *Castanospermum australe, Grevillea robusta*, and nearer the coast in a type called mixed notophyll vine forest *Alphitonia excelsa*, *Cryptocarya triplinervis, Cupaniopsis anacardioides, Diploglottis cunninghamii*, and the palm *Livistona australis*, the latter often along streams.

Conservation

IUCN: LC

Uses

The wood of this species is resistant to termites and marine borers like barnacles, it is highly durable and strong. It is therefore valued and used for construction like jetties and boat pilings in salt water, for boat construction, packing cases, carpentry, joinery, and wood turning, and also for furniture, especially outdoor furniture. It takes a fine polish and is therefore used in high quality products that last long. This species is occasionally planted as a park or street ornamental tree; in deforested areas turned over to agriculture mature individuals may have been retained as amenity trees. It is obviously only suitable for these purposes in warm temperate to subtropical climates.

Podocarpus elongatus (Aiton) L'Herit. *ex* Pers., Syn. Pl. 2 (2): 580. 1807. *Taxus elongata* Aiton, Hort. Kew. 3: 415. 1789. Type: South Africa: Cape Province, ["Caput Bona Spei"], *F. Masson s.n.* (lectotype BM).

Etymology

The species epithet means 'elongated' and refers to the leaf shape.

Vernacular names

Breede River yellowwood; Breërivier geelhout (Afrikaans)

Description

Shrubs or small trees usually 3–6 m tall, but on occasion attaining 20 m, d.b.h. to 50 cm; bark on trees thin, exfoliating in narrow strips, light brown weathering grey. Shrubs spreading wide to 10–12 m, multistemmed, regenerating from fires. Foliage branchlets assurgent, slender, terete, with fine grooves, terminating in buds 2–3 mm diam. with oblong, narrowly triangular, 4–6 mm long outer bud scales with spreading tips. Leaves crowded in upper parts of branchlets, spreading to nearly erect, (1.5–)2.5–5(–7) cm long, (3–)4–5(–7) mm wide (to 12 cm long and 10 mm wide on juvenile plants or vigorous epicormic shoots), narrowly oblong-elliptic to linear, gradually tapering to a petiolate base, more abruptly to an acute or sometimes obtuse apex; margins flat to slightly revolute; leaf colour glaucous to greyish green above, dull whitish green below; midrib on adaxial (upper) side thin, raised in lower half and fading towards apex, on abaxial side continuous and distinctly raised. Stomata in two bands of many white lines separated by midrib on abaxial side, only occasionally a few short lines of stomata on adaxial side. Pollen cones axillary, solitary or sometimes in clusters of 2–5, sessile or sometimes pedunculate, cylindrical, 15–25 mm long, elongating to 30–40 mm at anthesis, 3–5 mm diam., subtended by ovate or broadly rounded, scarious, acuminate bud scales; microsporophylls spirally insertend, imbricate, outer part triangular, minutely denticulate or lacerate, each bearing two oblong basal pollen sacs. Seed cones axillary, solitary, on 4–12 mm long, stout (1 mm diam.) peduncles; receptacles an axis with two fused bracts, green but swelling to a scarlet, 9–15 mm long and 10–15 mm wide (at distal end) succulent body. Seeds including the epimatium 7–12 mm long, ellipsoid to ovoid with a slightly narrowed distal end, glaucous green. Seed proper ovoid with purple-mottled seed coat.

Taxonomic notes

The presence of stomata on the adaxial (upper) side of the leaves in "1 to several short rows…in shallow longitudinal grooves" was reported by Leistner in Flora of Southern Africa 1: 40 (1966) and repeated in several compilations on southern African trees. My observations of herbarium specimens at K with a powerful Leica MZ6 binocular microscope at 30–40 × magnification did reveal a few short lines of stomata on that side on only some specimens (e.g. *Pearson 5328* from near Oliphant's River). Nearly all stomata are confined to the abaxial side and most leaves observed did not have any stomata on the adaxial surface of the leaves.

Distribution

South Africa: Eastern, Northern and Western Cape Provinces; Malawi; Zambia; Zimbabwe.
TDWG codes: 26 MLW ZAM ZIM 27 CPP-EC CPP-NC CPP-WC

Ecology

Podocarpus elongatus is an uncommon species growing in woodlands in moist sites, usually along (intermittent) streams and in ravines, or on rocky sites with sparse vegetation. Woodland species in these ravines are *Cunonia capensis* and *Olea capensis*, among other trees, and sclerophyllous shrubs on the drier edges. In the Western Cape its habitat contacts with fire-prone vegetation types such as fynbos and as a consequence individual trees are frequently burnt. Resprouting from the base, they then develop into broad spreading shrubs or bushes, while only individuals that are protected from fire, e.g. by growing in a deep ravine, can develop into monopodial trees of some size. In the NE part of its scattered range it is usually a component of moist evergreen forest and grows more often into a tree.

Conservation

IUCN: LC

Uses

Due to its small size and usually bushy habit, this species is not of economic importance as a timber tree. It is rare in cultivation, but a few cultivars have been recorded.

Podocarpus fasciculus de Laub., Blumea 30 (2): 277. 1985. Type: Taiwan: Taichung Co., Tashue Shan, ["Tai-shu Shan"], *D. J. de Laubenfels P 675* (holotype L).

Podocarpus macrophyllus (Thunb.) Sweet var. *liukiuensis* Warb., Monsunia 1: 192. 1900; *Podocarpus macrophyllus* (Thunb.) Sweet f. *grandifolius* Pilg., in Engler, Pflanzenr. IV.5 [18]: 80. 1903.

Etymology

The species epithet (Latin *fasciculus* = cluster or fascicle) refers to the clustered pollen cones.

Vernacular names

Given in Flora of Taiwan, ed. 2, 1: 561 (1994) in Chinese characters.

Description

Trees to 20 m tall, with erect, terete trunk. Bark not described. Foliage branches terete, grooved, terminating in buds 4–5(–9?) × 2 mm, with lanceolate, keeled and spreading scales. Leaves linear-lanceolate, short petiolate, on juvenile plants up to 16 cm long and 14 mm wide; on adult plants 5–10(–12) cm long, (4–)6–10 mm wide, thin and easily bending, straight or more or less falcate, gradually tapering at both ends, acute or acuminate; midrib prominent on both sides, acutely raised adaxially, wider and not acute abaxially; leaf colour bright green above (adaxially), pale green below. Stomata on abaxial (under) side, very small, in numerous irregular lines on either side of midrib. Pollen cones axillary, sessile, in clusters of (1–)2–5, subtended by small (ca. 2 × 1 mm) scarious, keeled scales, cylindrical, elongating to 15–25(–30) mm × 2–2.5 mm; microsporophylls spirally arranged, with a triangular, spreading, 0.3–0.5 mm long apex and with two conspicuously protruding, globular pollen sacs. Seed cones solitary and axillary on 6–12 mm long, slender peduncles; receptacles 9–16 mm long, with two 2–3 mm long, obtuse basal bracts ('foliola'), swelling when ripe to a succulent, red 'fruit' 10–12 mm thick. Seeds single at truncate distal end of receptacle and partly enclosed by it, ovoid-globose, ca. 9 × 7 mm including the green epimatium, ripening to purple-green. Seed proper ca. 7 × 5 mm, slightly flattened, brown.

Taxonomic notes

De Laubenfels (*op. cit.*) described *P. fasciculus* as a new species based on his own collections from Taiwan, with one of these designated as the type. Similar plants were described from southern Japan (Kyushu: Nagasaki; Ryukyu Islands: Iriomote Island) as *P. macrophyllus* var. *liukiuensis* Warb. from Kyushu, and as *P. macrophyllus* f. *grandifolius* Pilg. from the Ryukyu Islands. Iriomote Island is close to Taiwan and apparently *P. fasciculus* occurs on several other islands in the Ryukyus, up to the main islands of Japan.

Distribution

Japan: Pacific side of Honshu, Shikoku, Kyushu, Nansei-Shoto (Ryukyu Islands); Taiwan.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH NNS TAI

Ecology

Podocarpus fasciculus is a small to medium size tree in evergreen, lower montane to montane forests. It is often found to grow as an understorey tree, but may reach the canopy in lower forest types on the oceanic islands of the Ryukyus. Its ecology remains poorly described in the available literature. In Taiwan, its altitudinal range is given as between 1500 and 2500 m a.s.l. by S. Y. Lu in Vol. 1 of Rare and Endangered Plants in Taiwan (1996). This six volume work in Chinese gives localities (with Pinyin transcription), a distribution map with altitudinal range, the IUCN rating of conservation status with criteria, selected herbarium specimens, and a set of colour photographs for each species. It does not describe habitats in any detail but these can be estimated from some of the photographs (not for *P. fasciculus*).

Conservation

This species is treated as endemic to Taiwan in Flora of Taiwan (ed. 2) 1: 561, pl. 219 (1994), following De Laubenfels's original description, but occurs also and more widely in southern Japan, including the Ryukyu Islands. The Japanese populations were considered

a variety of *P. macrophyllus* (var. *liukiuensis* Warb. or forma *grandifolius* Pilg.) in the past, but are here included in *P. fasciculus*. In Taiwan, it was assessed as Endangered (EN) in Rare and Endangered Plants in Taiwan 1 (Lu, 1996), with only five localities known and populations declining under threat from selective felling for its timber.
IUCN: VU (A2a, c, d)

Uses

In Taiwan this species has been exploited for its timber, but as most trees do not attain large size, its commercial importance is limited. The wood is used for light construction, carpentry, and sometimes furniture making. It may be planted in city parks as an ornamental, masquerading under the general name *P. macrophyllus*, to which it is superficially similar.

Podocarpus gibbsiae N. E. Gray, J. Arnold Arbor. 39: 429. 1958 ["*gibbsii*"]. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N. P., Marai Parai, near camp, *J. Clemens & M. S. Clemens 32021* (holotype A).

Etymology

The species epithet commemorates Lilian Suzette Gibbs (1870–1925), who collected and studied the flora of Mt. Kinabalu.

Vernacular names

No common names are recorded for this species.

Description

Small to medium sized trees 7–20 m tall. Bark becoming scaly on largest stems, brown weathering grey. Crown in more or less sheltered trees conical, becoming rounded with age, otherwise usually irregular. Foliage branches spreading to assurgent, densely leaved distally, forming tufts of foliage; shaded branches with more widely spaced leaves. Terminal buds on leading shoots 4–9 mm long, 2–3 mm wide, narrowly conical, with free spreading, acuminate outer scales. Leaves on young plants 3–6(–9) cm long, 4–7(–9) mm wide, linear-lanceolate, straight or slightly curved, acute. Leaves on adult plants (much) smaller 1–3.5(–4.5) cm long, 3–6(–7) mm wide, elliptical or obovate-oblong to linear-lanceolate (longer leaves in shaded foliage?), coriaceous, spreading to erect and densely crowded, gradually tapering to a petiolate base; apex obtuse to rounded, or slightly apiculate from extended midrib, rarely acute; margins slightly revolute; midrib acutely raised but fading distally on adaxial side, obtusely raised from base to apex on abaxial (lower) side; new leaves flushing pink. Stomata very small and inconspicuous on abaxial side. Pollen cones axillary, solitary or rarely in pairs, sessile, elongating at anthesis to ca. 15 mm, 3–4 mm wide; microsporophylls with acute apex ca. 1 mm long, bearing two large pollen sacs. Seed cones towards ends of foliage branchlets, axillary on short peduncles; receptacles subtended by a 3–4 mm long bract ('foliolum'), ca. 6 mm long when still immature, bilobed. Seeds in mature state not observed.

Distribution

Malaysia: Sabah (Mt. Kinabalu, Bukit Ampuan).
TDWG codes: 42 BOR-SB

Ecology

Podocarpus gibbsiae occurs on mountain ridges at altitudes between 1200 m and 2400 m a.s.l. in mossy forest within the cloud belt on Mt. Kinabalu. It appears to be confined to ultramafic soil derived from serpentine and similar rocks. This forest type has an open canopy up to 20–25 m tall and consists of a mixture of angiosperms and gymnosperms (mostly conifers); common conifers are *Phyllocladus hypophyllus* and *Dacrydium gibbsiae*. Epiphytes, from lichens, mosses, and ferns to orchids are numerous.

Conservation

The near endemic population known on Mt. Kinabalu of this species occupies an area (AOO) of less than 100 km² and the trees are restricted to a specific soil type, which is discontinuous within that area. Most trees are now within Mt. Kinabalu National Park. Although occurring within the cloud belt, exceptional spells of drought and the greatly

increased tourism on the mountain pose a potential fire hazard, to which the species is not adapted.
IUCN: VU (D2)

Uses

No uses have been recorded for this tree.

Podocarpus glaucus Foxw., Philipp. J. Sci. 2: 258. 1907. Type: Philippines: Mindoro, Parabatugan, Mt. Halcon, *E. D. Merrill 5672* [holotype PNH (destroyed?), isotypes K, NY].

Etymology

The species epithet refers to the bluish (glaucous) leaves of the type specimen; not all leaves of all plants of this species are so coloured.

Vernacular names

nipa (New Guinea)

Description

Decumbent or erect shrubs or small to medium size trees to 15 m tall; trunk of trees monopodial, erect, to 60 cm d.b.h. Bark of trees fibrous, flaky, brown weathering grey; inner bark pink. Branches spreading, in trees forming a spreading crown. Foliage branchlets terete, slender, terminating in small buds with erect or slightly spreading, triangular to lanceolate and narrowly acute scales up to 2 mm long. Leaves on saplings and young trees usually larger than on shrubs and sun-exposed branches of mature trees, to 3.5 cm long and 7 mm wide, elliptic. Leaves on shrubs and mature trees often densely crowded, when sun-exposed 0.8–1.8 cm long, 3–6 mm wide, elliptic to obovate, gradually or more abruptly tapering to a short petiolate, slightly twisted base; apex often obtuse to abruptly rounded, sometimes apiculate; margins slightly revolute. Midrib on adaxial (upper) side 0.2 mm wide, acutely raised, on abaxial side wider, to 0.5 mm, obtuse. Leaf colour variable; upperside dark green or glaucous; underside light green or grey-green; new leaves flushing red. Stomata very small, numerous on abaxial face. Pollen cones axillary, solitary, cylindrical, 15–20 mm long, 2–2.5 mm wide, with a few rounded scales (from the buds) on a 2 mm long peduncle; microsporophylls rounded at apex, with two globose pollen sacs at base. Seed cones axillary, solitary; receptacles with two 1.5 mm long basal bracts ('foliola'), 6–8 mm long and swollen when ripe, becoming purple. Seeds including the epimatium ovoid-globose, 6–7 × 5 mm, with a crest at maturity, glaucous green to purplish green; seed proper not observed.

Distribution

Malesia: Admiralty Islands (Manus), Maluku [Moluccas] (Seram), Philippines (Mindoro), Sulawesi; Papuasia: Bismarck Archipelago, New Guinea, Solomon Islands.
TDWG codes: 42 MOL PHI SUL 43 BIS NWG-IJ NWG-PN SOL-SO

Ecology

Podocarpus glaucus is most commonly a decumbent or erect shrub occurring in stunted mossy forest on mountain ridges. Sometimes it descends from these down into taller forest, where it can become a subcanopy tree. Its altitudinal range is from (600–)1000 to 2800 m a.s.l. Its substrates are acidic to neutral, e.g. sandstone or karst limestone; near the Danau Paniai [Wissel] Lakes in New Guinea it occurs on peaty soil on the slopes and on rocky terrain at the summit of a mountain. It is associated with numerous shrubs, among which are species of *Gymnostoma* (*Casuarinaceae*) and *Rhododendron* (*Ericaceae*).

Conservation

IUCN: LC

Uses

No uses have been recorded of this species. It is unlikely to be of much use for its timber and it is not known in cultivation.

Podocarpus globulus de Laub., Blumea 30 (2): 269. 1985. Type: Malaysia: Sabah, Tawau District, Gunung Silam, *D. J. de Laubenfels P 688* (holotype L).

Etymology

The species epithet means 'a little ball' and refers to the foliage buds.

Vernacular names

sapiro (Sabah)

Description

Trees to 27 m tall, commonly to 15 m, d.b.h. to 45 cm; trunk erect, terete. Bark smooth, eventually with small, powdery and flaky scales, brown; inner bark soft and fibrous, red-brown. Branches spreading, forming a rounded crown. Foliage branchlets terete, slightly grooved or ridged, terminating in globose compact buds 2–3 mm diam. with imbricate, rounded or apiculate scales with entire margins. Leaves on juvenile plants (broadly) lanceolate, to 15 cm long and 25 mm wide, straight, coriaceous, abruptly tapering to an acuminate apex. Leaves on mature plants linear-lanceolate, (2.5–)4–8(–9) cm long, (7–)9–15 mm wide, straight or slightle curved, coriaceous, gradually tapering to a petiolate base; apex acute-acuminate, obtuse or rounded; midrib on adaxial side narrow, to 0.8 mm, prominently raised from base to apex, on abaxial side wider, to 1.5 mm, nearly flat. Stomata very small, in numerous irregular lines on abaxial (under) side. Pollen cones axillary, solitary or in clusters of 2–3, sessile or sub-sessile, subtended by rounded bracts (bud scales), long cylindrical, 25–45 mm long, 3–4 mm wide; microsporophylls ca. 1 mm long, with triangular apex and two basal pollen sacs. Seed cones axillary, solitary on a 3–5 mm long, stiff peduncle; receptacles subtended by 2 minute, 1–2 mm long, early deciduous bracts, slender, ca. 10 mm long, consisting of two lobes (axes?) each with a distal bract, one of these being fertile, the lobes swelling mostly distally, ripening to red. Seeds including the epimatium 7–9 × 5–6 mm, ovoid-globose with a small crest, green turning dark brown. Seed proper not observed.

Distribution

Malaysia: Sabah (and on the border with Sarawak).
TDWG codes: 42 BOR-SB BOR-SR

Ecology

This species occurs in lower to middle montane rainforest on ridges and summits where the forest is not dominated by dipterocarps, in some localities on ultrabasic soil; altitudinal range 310–1530 m a.s.l. based on information on herbarium specimen labels.

Conservation

Only known from four disjunct localities, none of these is in a protected area. The area of occupancy (AOO) is calculated to be less than 500 km² based on these four localities and the fact that it is known from only a few herbarium collections, indicating that it is rare. Its altitudinal range places it in lower to middle montane rainforest, which is known to be in decline. None of the presently known collections originates from protected areas.
IUCN: EN [B2ab (ii, iii, v)]

Uses

It is not known whether this relatively rare (and unknown) species is specifically exploited as 'podocarp' timber; the modest size of most trees would indicate that it is not. Where forest is cleared, the more valuable trees will be 'salvaged' and put to uses commonly associated with this timber.

Podocarpus glomeratus D. Don, in Lambert, Descr. *Pinus* 2: [21]. 1824. Type: Peru: ["Chili. Herb: Pavon."], *R. Ruiz & J. A. Pavón y Jiménez s.n.* (holotype BM).

Podocarpus cardenasii J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 142. 1948.

Etymology

The species epithet refers to the clustered pollen cones, "collected closely together into a head" (Stearn, 1983).

Vernacular names

Intimpa, Huampo (Quechua); pino de monte (Spanish)

Description

Shrubs or stunted trees up to 12 m tall; trunk of trees to 35 cm d.b.h. Bark smooth, on larger trunks exfoliating in small flakes, dark brown weathering blackish grey. Branches spreading or ascending, forming a bushy crown. Foliage branches stiff, ascending or erect, terete, with fine grooves running down from slightly raised leaf bases, terminating in subglobose buds 3–5 mm wide at base, the scales triangular, carinate, with free, acuminate apices, the outer scale sometimes elongated to 7–10 mm. Leaves on juvenile plants similar to those on adult plants, spreading to erect, rigidly coriaceous, (1.5–)2–3.5(–5) cm long, 2–4(–5) mm wide, linear-lanceolate or sometimes slightly falcate, gradually narrowing to a short petiolate base; margins revolute; apex acuminate and strongly spinescent; leaf colour greyish green above, glaucous below. Midrib a continuous groove on adaxial (upper) side, inconspicuous and only raised near leaf base on abaxial side. Stomata very small, in numerous intermittent lines on abaxial side. Pollen cones axillary, clustered with 4–6 on a stalk to 10 mm long, sessile on this stalk, subtended by acuminate bracts of variable length up to 5 mm and with triangular, carinate bud scales at their base, 4–6 mm long, 1–1.5 mm wide; microsporophylls with scarious denticulate margins and obtuse apex, bearing two small, globose pollen sacs. Seed cones axillary, solitary, on short or longer peduncles to 10 mm; receptacles 5–6 mm long, becoming succulent and red. Seeds including the epimatium globose, ca. 5 mm long, with or without a minute crest. Seed proper not observed.

Distribution

Bolivia, Ecuador, Peru (Apurimac, Huánuco).
TDWG codes: 83 BOL ECU PER

Ecology

Podocarpus glomeratus is a species of the high Andes occurring in high montane to subalpine forests and woodland or scrub, at altitudes from 1800 m a.s.l. (but usually not below 2500 m) to 3600 m a.s.l. or perhaps higher. Above 3000 m this species is dwarfed and shrubby; below this it is a constituent of cloud forest rich in epiphytes, especially mosses and lichens.

Conservation

IUCN: LC

Uses

The wood of this species is exploited for the making of furniture and cabinets, the smaller and more crooked trunks and branches for firewood. It is not known to be in cultivation.

Podocarpus gnidioides Carrière, Traité Gén. Conif., ed. 2, 2: 656. 1867. *Podocarpus alpinus* R. Br. *ex* Hook. f. var. *arborescens* Brongn. & Gris, Bull. Soc. Bot. France 13: 425. 1866. Type: New Caledonia: [locality not stated], *F. von Mueller 70* (lectotype P).

Podocarpus alpinus R. Br. *ex* Hook. f. var. *caespitosus* Pancher *ex* Brongn. & Gris, Bull. Soc. Bot. France 13: 425. 1866; *Podocarpus gnidioides* Carrière var. *caespitosus* Pancher *ex* Carrière, Traité Gén. Conif., ed. 2, 2: 657. 1867.

Etymology

The species epithet refers to *Gnidia* (*Thymelaeaceae*), to which it is supposed to bear a resemblance.

Vernacular names

No common names have been recorded for this species.

Description

Spreading or decumbent shrubs to 2 m tall, branches assurgent to erect. Bark thin, fibrous, light

brown to reddish brown. Foliage branchlets terete, rough with persistent leaf bases, terminating in small, globose buds with at base a few free but otherwise imbricate, triangular, 1–2 mm long scales. Leaves densely crowded, remaining on branchlets for several years, oblanceolate (widest above the middle) to linear, 0.8–2.2 cm long (longest on juvenile plants), 1.7–2.3 mm wide, curved downward, gradually tapering to a short, petiolate and decurrent base; margins strongly revolute; apex obtuse or rounded. Midrib forming a groove on adaxial (upper) side, prominently elevated but obtuse on abaxial side. Stomata small, in two narrow bands on either side of abaxial midrib. Pollen cones axillary, solitary on a short peduncle lacking bud scales at base, subtended by 3–5 keeled bracts, cylindrical, 8–14 mm long, 2–2.5 mm wide at anthesis; microsporophylls triangular, with two sub-basal, semiglobose pollen sacs. Seed cones axillary, solitary on a short peduncle; receptacles formed of a short axis with two basally fused but distally spreading bracts of unequal to nearly equal size, swelling to become one or two distinct, succulent, bright red bodies, each ca. 7 × 4 mm (if one then slightly larger) in case of two only one of which bears the single seed. Seeds including the epimatium 6–7 mm long, obliquely ovoid, 3.5–4 mm wide, the green surface becoming grooved or rugose, terminating in a crest. Seed proper not observed.

Taxonomic notes

This species is similar to *Podocarpus nivalis* from New Zealand and *P. lawrencei* from SE Australia including Tasmania and is perhaps most closely related to the latter. The original description by Carrière (*op. cit.*) stated that this species is a tree, with the shrub as a variety, but this species never grows into a tree and only shrubs exist. De Laubenfels (1972) cited "*Mueller 70*" as the holotype of *P. gnidioides* Carrière and as the type of *P. alpinus* Hook. f. var. *arborescens* Brongn. & Gris, but these authors merely referred to an unidentified collection by Mueller of "*Podocarpus spec.*" (Carrière) and "Mueller, 1862" (referring to the year of collection). More than one specimen from Mueller in P are thus marked and none of these authors annotated them with their taxon names. For these reasons, *Mueller 70* at P is to be considered the lectotype chosen and designated by De Laubenfels of both names.

Distribution

New Caledonia: Grande Terre, Province Sud.
TDWG codes: 60 NWC

Ecology

Podocarpus gnidioides is a shrub of the higher mountains (above 600 m a.s.l.) of the southern part of New Caledonia (Grande Terre) and has been found close to the summit of Mont Humboldt at 1600 m a.s.l. It forms broad shrubs in rocky terrain with low vegetation on serpentine rock, where there is no competion from trees and where it grows with numerous other montane plants, among which are a number of ferns, that are adapted to nutrient poor and ultramafic soils.

Conservation

IUCN: NT

Uses

Although this species is very similar in habit and foliage to the Australian and New Zealand shrubby podocarps, it has not been taken into cultivation beyond a few botanic gardens. It is obviously less hardy than the other two, but cultivation of plants is not necessarily restricted to countries with frost and snow in winter and it is therefore to be recommended that it be tried for rock gardens in a mild climate.

Podocarpus grayae de Laub., Blumea 30 (2): 275. 1985 ["*grayii*"]. Type: Australia: Queensland, Cape York Peninsula, Parrot Creek (Annan River drainage), *L. J. Brass 20203* (holotype L). Fig. 265, 266, 267

Etymology

This species was named after Netta Elizabeth Gray (1913–1970), who (in part with J. T. Buchholz) published a serial monograph of the genus.

Vernacular names

No common names are known for this species.

Description

Trees to 40 m tall, with erect trunk to 1.5 m d.b.h. Bark thin, becoming scaly on large trees, flaking in narrow strips, slightly fibrous, brown; inner bark pinkish. Branches spreading to form a broad crown. Foliage branchlets terete, smooth, finely grooved, terminating in large, globose buds 3.5-.4.5 mm long and 4–5 mm wide, with imbricate, rounded or broadly triangular scales with appressed or sometimes a few free apices. Leaves on seedlings 3–4 cm long, 5 mm wide, on juvenile and mature plants much larger, (6–)10–25(–30) cm long, 7–18 mm wide, linear, straight or slightly curved, tapering gradually to a petiolate base; apex acute; midrib slightly raised and obtuse on adaxial (upper) side, ca. 1 mm wide, often more prominent on abaxial side; leaf colour dark green above, glaucous green below. Stomata numerous, small, in two bands of intermittent lines on abaxial side. Pollen cones axillary, solitary or with 2–4 together, sessile, subtended by imbricate, rounded scales, cylindrical, 25–45 mm long, 4–5 mm wide; microsporophylls very small, imbricate, broadly triangular, with two sublateral globose pollen sacs. Seed cones axillary, solitary on slender, 5–10 mm long peduncles; receptacles subtended by two very small, deciduous bracts ('foliola'), growing and swelling to 9–14 mm long and 7–9 mm thick at distal end, ripening to orange-yellow then red. Seeds solitary on distal part of receptacle, obliquely attached, ovoid-globose with a short proximal beak and an obscure distal crest, including the epimatium 12–15 × 9–12 mm when mature; epimatium ripening from glaucous green to dark red. Seed proper not observed.

Distribution

Australia: N Queensland, Northern Territory (Arnhem Land).
TDWG codes: 50 QLD-QU NTA

Ecology

Podocarpus grayae is widespread in the subcoastal warm subtropical to tropical rainforests of N Queensland, where it occurs from near sea level to ca. 750 m a.s.l. It can occur on coastal flats directly behind the mangroves, along streams, and on low mountain ridges. In Arnhem Land, Northern Territory, a few small, relict populations occur in patches of rainforest along streams.

Conservation

IUCN: LC

Uses

Large trees are a valuable source of timber but data on its exploitation are lacking, primarily due to the fact that it has been described as a new species relatively recently. It has been erroneouly identified as *P. neriifolius* in the past and its uses may therefore have been similar to those of that widespread (but not Australian) species. It is reported to be in cultivation in some botanic gardens.

Podocarpus guatemalensis Standl., Proc. Biol. Soc. Washington 37: 49. 1924. Type: Guatemala: Izabal, Puerto Barrios, *P. C. Standley 25090* (holotype US).

Podocarpus pinetorum Bartlett, Publ. Carnegie Inst. Washington 461: 21. 1935; *Podocarpus guatemalensis* Standl. var. *pinetorum* (Bartlett) J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 137. 1948.
Podocarpus allenii Standl., Ann. Missouri Bot. Gard. 28: 409. 1941; *Podocarpus guatemalensis* Standl. var. *allenii* (Standl.) J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 137. 1948.

Etymology

The species epithet indicates Guatemala, the country from which the species was first known.

Vernacular names

Mountain cypress (Belize); chaquiro, cipresillo, ocotillo de llano (Spanish)

Description

Trees to 20–35 m tall, erect; trunk up to 1–1.5 m d.b.h. Bark smooth, reddish brown turning dark grey and fissured on large trees. Branches spreading, forming a broad or sometimes pyramidal crown. Foliage

branchlets terete, finely grooved from decurrent leaf bases. Terminal vegetative buds semi-globose or ovoid, ca. 4 mm wide, with imbricate, broadly triangular, keeled, acute, sometimes apiculate scales 2–3 mm long; axillary buds small, with ovate scales. Leaves on young plants larger than on mature plants, to 16 cm long and 18 mm wide. Leaves on mature trees lanceolate to linear-lanceolate, straight or slightly curved, sometimes falcate, 4–10 cm long, 6–14 mm wide (largest on shaded lower branches), gradually or more abruptly narrowing to a short petiolate base; margins parallel or nearly parallel in middle part of leaf, gradually tapering to an acute to slightly acuminate or sometimes obtuse apex. Midrib continuously raised but narrow, not in a groove, on adaxial (upper) side, forming a more or less prominent and continuous ridge abaxially. Stomata in numerous intermittent lines in broad bands on either side of midrib on abaxial side. Pollen cones axillary, sessile, solitary, cylindrical, 10–15 mm long; microsporophylls triangular, acute, with two basal pollen sacs. Seed cones axillary, on short peduncles; receptacles 6–8 mm long, swelling and becoming succulent, reddish turning brown. Seeds including the epimatium ellipsoidal, 7–8 mm long, 5 mm wide, smooth with a small, apical crest, light brown or grey-brown. Seed proper not observed.

Taxonomic notes

Bartlett (*op. cit.*) described from Mountain Pine Ridge, Belize a new species *P. pinetorum*, comparing it with the type of *P. guatemalensis*, which apparently came from a shrubby young plant with longer, falcate leaves. He "reluctantly separated [it] from *P. guatemalensis*" because he realized that it might just represent the more mature form of that species. Likewise, Standley (*op. cit.*) expressed doubts about the distinction between his new species *P. allenii* from Panama and *P. guatemalensis* on similar grounds. Leaves of these large Panamanian trees measured only 3.5–4.5 cm long and 7–8 mm wide, but leaves of seedlings and saplings measured 9–12 cm long and 9–14 mm wide. These two species were reduced by Gray & Buchholz (1948) to varieties of *P. guatemalensis*, mainly on the basis of asserted differences in leaf anatomy, particularly the presence of sclereids and their position in the mesophyll. Orr (1944) found sclereids only in *P. oleifolius* among American species of *Podocarpus*, but he did not examine leaves of these two taxa and only juvenile leaves of *P. guatemalensis*. As Gray & Buchholz admit, there may be a correlation with leaf form (juvenile versus adult) as well as environment (lowland versus upland), and taxonomic distinction on the basis of these characters in limited samples may not be justified.

Distribution

Belize; Colombia; Costa Rica; Ecuador (Cordillera del Condor); Guatemala; Honduras; El Salvador; Mexico (Chiapas, Oaxaca); Panama; Venezuela (Cordillera Oriental, Selvas de Guatopo).

TDWG codes: 79 MXS-OA MXT-CI 80 BLZ COS ELS GUA HON PAN 82 VEN 83 CLM ECU

Ecology

Podocarpus guatemalensis occurs in mixed conifer-angiosperm forest or pine forest, often along streams. The altitudinal range calculated from data with herbarium specimens is 1–2615 m a.s.l., but it is most common below 1200 m a.s.l. It is therefore a species both from lowland and montane forests. In the lowlands it is often present in savanna type vegetation with *Pinus oocarpa, P. caribaea*, and many angiosperm shrubs; it there occupies stream sides. In evergreen broad-leaved tropical rainforests it is a canopy tree, apparently successfully competing with other trees. Little is known of the soil types in which this tree occurs in the latter vegetation type; often conifers are restricted to nutrient-poor substrates where they do better with the aid of mycorrhiza.

Conservation

IUCN: LC

Uses

No specific data could be found regarding the uses of this species. It will undoubtedly be logged with other trees and sold on a limited scale as podocarp wood, which is used for construction, carpentry, and, to a lesser extent, depending on size and quality, furniture, veneer, and tool making. It is not known to be in cultivation.

Podocarpus henkelii Stapf *ex* Dallim. & A. B. Jacks., Handb. Conif.: 47. 1923 ["*henckelii*"]. Type: South Africa: Kwazulu Natal, Bulembu Forest, Mt. Ayliff, Fort Donald Forest Station, *W. G. Cochrane s.n.* (lectotype PRE). Fig. 268

Podocarpus ensiculus Melville, Kew Bull. 1954: 566. 1955.

Etymology

This species was named after Heinrich Henkel, a German botanist who died in 1914.

Vernacular names

Henkel's yellowwood, Falcate yellowwood; Bastergeelhout (Afrikaans); nanjula (Malawi)

Description

Trees to 35 m tall; trunk to 1.8 m d.b.h. Bark thin, fibrous, smooth but on large trunks fissured, exfoliating in longitudinal strips and small or large flakes, light brown or tan weathering grey; inner bark pinkish red, drying to red-brown. Main branches spreading or ascending, forming a rounded crown. Foliage branches terete, finely grooved from decurrent leaf bases, usually stout, terminating in globose to short conical buds 3–5 mm wide with imbricate, apiculate inner scales and a few longer outer scales with recurved margins and spirally rolled apices. Leaves on seedlings and saplings to 22 cm long, 7–12 mm wide, linear, straight to falcate. Leaves on mature trees spreading wide or often drooping to nearly pendulous, (5–)8–12(–17) cm long, (5–)7–9(–10) mm wide, linear, straight or falcate, narrowing to a petiolate base and very gradually tapering to an acute or acuminate apex, thin coriaceous; margins slightly revolute; midrib indistinct and raised only in proximal two thirds of leaf on adaxial (upper) side, more distinct and continuous but narrow on abaxial side; leaf colour lustrous dark green above, dull green below. Stomata on abaxial side, in numerous intermittent lines on either side of midrib, small. Pollen cones axillary, solitary or in clusters of 2–5, sessile, subtended by rounded to ovate, scarious, keeled bud scales with lacerate margins, subglobose becoming cylindrical, elongating to 4–5 cm, 4–5.5 mm wide; microsporophylls spirally inserted on a stout rachis, imbricate, ovate-triangular, each bearing two oblong pollen sacs at base. Seed cones axillary, solitary on a 5–10 mm long, stout peduncle, initiated as a short axis with 2 bracts not or only very weakly enlarging to a clavate receptacle (hence a succulent, coloured receptacle is usually absent). Seeds single, enclosed in a thick epimatium, 17–22 × 14–18 mm, broadly ellipsoid, green or olive green ripening to yellowish or purplish and pruinose, exuding a whitish latex from distinct vescicles when cut. Seed proper not observed.

Taxonomic notes

Podocarpus henkelii is unusual in the genus, because its seed cone bracts, one of which is fertile and on which develops the large seed, do not or sometimes only slightly enlarge and never develop into a large, succulent and coloured receptacle. The epimatium is thicker than in other species and colours purplish pruinose (as in a damson or small plum) and presumably takes over the function of attraction to birds as food. This development and the resulting 'fruit' resembles that in *Afrocarpus*, which totally lacks a receptacle. The vegetative characters of *P. henkelii* are different from *Afrocarpus* (e.g. hypostomatic leaves) and (*in toto*) identical with other species of *Podocarpus*. In *Nageia*, commonly lacking a receptacle, one species (*N. wallichiana*) usually develops a small but succulent and coloured one, but the epimatium of the seed, given its size, colour, and texture, presumably remains the main food attraction. Apparently the development of a receptacle in these genera is not a completely fixed character.

Distribution

South Africa: Eastern Cape Province, Kwazulu Natal; Malawi; Tanzania; Zimbabwe.
TDWG codes: 25 TAN 26 MLW ZIM 27 CPP-EC NAT

Ecology

Podocarpus henkelii is a tree that occurs in montane evergreen rainforest, often on steep, rocky slopes, at altitudes between 1300 m and 2000 m a.s.l.; it is also present in coastal forests near sea level in Eastern Cape Province (where it is rare) and Kwazulu Natal.

Here it may be associated with *Afrocarpus falcatus*; both are in these forests emergents above a canopy of angiosperm trees. In Tanzania it occurs as a codominant in *Ocotea-Podocarpus* forest with a canopy 30–40 m tall and both *Afrocarpus usambarensis* and *P. milanjianus* are often also present as canopy trees.

Conservation

Unsustainable logging poses the major threat to this species, especially in Tanzania. Deforestation is also an issue in parts of its range, especially where it occurs in montane rainforest.
IUCN: EN [B2ab (ii, iii, v)]

Uses

This species is a valuable timber tree but not common enough to be of major economic importance. The wood is used for construction, carpentry and joinery, as well as furniture making. In South Africa and Zimbabwe it is commonly planted as an ornamental tree; outside the indigenous region of the species it is often planted in southern California. It is also in cultivation in England and Wales and young trees are offered to the trade from British nurseries (Grimshaw & Bayton, 2009: 641).

Podocarpus hispaniolensis de Laub., Moscosoa 3: 149. 1984. Type: Dominican Republic: Cordillera Central, Peravia, Rancho Arriba, near Finca de Los Suizos, *M. Mejía & J. Pimentel 444* (holotype JBSD).

Etymology

The species epithet refers to the island of Hispaniola, where this species is endemic.

Vernacular names

palo de cruz, palo de puntella (Spanish)

Description

Trees 15–20 m tall; trunk massive, d.b.h. 1–1.5 m in large specimens. Branches spreading and drooping, forming a wide, domed crown. Bark not described. Foliage branchlets slender, terete, with fine grooves between leaf bases, terminating in small, globose buds 2–3.5 mm diam. and 2–3 mm long with imbricate scales; outer scales keeled, with apiculate, erect or incurved apices. Leaves on saplings presumably larger than on mature trees. Leaves on mature trees spreading or somewhat drooping, 3.5–8 cm long, elliptic-linear, 6–11 mm wide, gradually narrowing to a short, 1–3 mm long petiole and to an acute or apiculate apex. Midrib on adaxial (upper) side lying in a distinct groove, on abaxial side prominently raised and continuous to apex. Pollen cones axillary, solitary, sessile, observed only in the immature state before elongation to full length. Seed cones axillary, solitary on a 7 mm long peduncle; receptacles formed of an axis with two fused, fleshy bracts, swelling to 8–10 mm long and 6 mm wide and becoming succulent and red. Seeds including the epimatium ca. 7 mm long and 4 mm diam. with a distinct distal crest.

Distribution

West Indies: Hispaniola, Dominican Republic (Cordillera Central, Prov. Puerto Plata).
TDWG codes: 81 DOM

Ecology

This species is found in tropical broad-leaved evergreen rainforest in the mountains of the Dominican Republic at altitudes between 750 m and 1200 m a.s.l. It grows with many different trees, one of which is the palm *Prestoea acuminata*, which has been found with it in several locations. Compared to its moderate height, trees have been found with massive trunks (one was blown by hurricane 'David' in 1984), which may indicate that it is a long-lived species of which the larger individuals have withstood high winds for a considerable time.

Conservation

This species is only known from five locations, all visited for collection of herbarium specimens in the 1980s. Its total area of occupancy (AOO) is estimated to be less than 500 km² and due to deforestation several populations are fragmented. Logging of large trees has had an impact on the number of mature trees, which have become scarce in some areas.
IUCN: EN [B1ab (i–v)]

Uses

This species is being logged together with other large trees in the forests where it occurs. The wood is used for general construction and carpentry. It is not known to be in cultivation.

Podocarpus humbertii de Laub., Adansonia 11 (4): 714. 1971. Type: Madagascar: Antsiranana Prov., Anjanaharibe Massif, Mont Anjanaharibe, slopes and north summit, west of Andapa, *H. Humbert et al. 24741* (holotype P).

Etymology

This species has been named after H. Humbert, who collected it in 1951.

Vernacular names

No common names have been recorded for this species.

Description

Small, shrubby trees 3–15 m tall or perhaps larger. Bark exfoliating in small flakes, brown weathering grey. Foliage branchlets spreading to erect, slender, terete, with persisting leaf bases, terminating in small, subglobose buds with imbricate, triangular, obtuse scales. Leaves small, crowded towards ends of branches, spreading at 50° or less from shoot, curved downward towards apex, overlapping each other particularly near ends of branchlets and concealing buds, obovate to oblanceolate (the widest part towards the apex), 7–15 mm long, 2–4 mm wide, gradually narrowing towards a petiolate base; margins flat or slightly revolute, abrubtly narrowing to form an obtuse, rounded or sometimes acuminate apex; texture coriaceous; leaf colour dark green above, dull green below. Midrib narrow, inconspicuous and discontinuous or in a groove on adaxial (upper) side, continuous and wider but flattened on abaxial side. Stomata small, in numerous intermittent white lines on either side of abaxial midrib. Pollen cones axillary, solitary or in pairs on a 3–6 mm long peduncle, cylindrical, 8–20 mm long, 2.5–3 mm wide; microsporophylls with a triangular, ca. 1 mm long apex and two basal, globose pollen sacs. Seed cones axillary on a short, 2–3 mm long peduncle; receptacles formed of an axis with two unequal bracts and enlarging to only 3–5 × 2.5–4 mm, becoming coriaceous. Seeds solitary, including the thick epimatium 11–15 mm long, 9–12 mm wide, ovoid-globose, with a small, inconspicuous crest below the apparent apex.

Distribution

Madagascar: Antsiranana Province.
TDWG codes: 29 MDG

Ecology

Podocarpus humbertii is reported from sub-humid forest, dry lowland deciduous forest, and ericoid thickets or wooded heath on mountain summits of gneiss and granite. The elevation ranges from 1600 m to 2410 m a.s.l. according to data on herbarium specimen labels. In the original description of the species it was reported to occur up to 2800 m a.s.l.

Conservation

This species is know from five to seven subpopulations (locations) and most of the herbarium collections were made between 1950–1960 with only one recent collection in 2001. Based on the mapped herbarium collections, the area of occupancy (AOO) is calculated as <150 km², which falls within the threshold of Endangered (EN). Its habitat is (in part) dry lowland deciduous forest, which is under pressure from grazing. A continuing decline is inferred from the collection dates and the degradation of parts of its habitat. This species has been collected in the following protected areas: Tsaratanana Reserve, Marojejy National Park, and Anjanaharibe-Sud Special Reserve. Only one collection, from Mont Tsaratanana, was made recently, in 2001.
IUCN: EN [B2ab (iii, iv)]

Uses

No economic uses have been recorded of this species. It is probably used for firewood locally.

Podocarpus insularis de Laub., Blumea 30 (2): 266. 1985. Type: Papua New Guinea: Louisiades Archipelago, Tagula Island [Sudest Island], *L. J. Brass 27987* (holotype L).

Etymology

The species epithet refers to its insular (on islands) distribution.

Vernacular names

In Papua New Guinea this species is known locally as 'dala' and 'tunum' (Milne Bay); in the Solomon Islands 'dengali' or 'dingale' and 'mou' were recorded by collectors.

Description

Trees to 25(–35) m tall, to 60 cm d.b.h., bole straight, to 20 m. Bark smooth, thin, on large boles with narrow, longitudinal flakes or strips, light brown weathering grey; inner bark pinkish or reddish brown, fibrous. Branches spreading, forming a rounded or domed crown. Foliage branchlets terete, more or less grooved, glabrous, terminating in 2–3 mm long buds with spreading, triangular to lanceolate outer scales. Leaves on juvenile plants short petiolate, linear-lanceolate, 10–15 cm long, (7–)12–18 mm wide, often curved and with undulating margins, gradually narrowed at base, long acuminate or acute. Leaves of mature trees shorter or of similar length, shade leaves 8–15 cm long, (7–)12–18 mm wide, acuminate; leaves more exposed to light mostly linear-lanceolate, 5.5–10(–13) cm long, 8–15(–18) mm wide, straight or slightly curved, petiolate at a more abruptly narrowing base, tapering to an acute or obtuse apex. Midrib acutely raised adaxially, flat or obtusely raised abaxially, usually narrower on adaxial side; leaf colour dark green above, pale green below, new leaves flushing pale whitish green. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, solitary or in clusters of 2–3, sessile or short pedunculate, cylindrical, elongating to 25–40 mm, 2–3 mm wide; microsporophylls spirally arranged, triangular, spreading, with two globose pollen sacs. Seed cones axillary, solitary on a 5–10 mm long peduncle; receptacles a short axis to 10 mm long with two fused bracts, swelling to become red and succulent when ripe. Seeds solitary at truncate end of receptacle, enclosed in a smooth epimatium, green turning purplish when ripe, ovoid to subglobose, 10–15 mm long, without a crest. Seed proper not observed.

Taxonomic notes

This species appears to be more variable in its leaf shapes and size than described by De Laubenfels (1985, 1988), at least in material seen at the Kew Herbarium (K) that seems to be best assigned to it. Unfortunately, most specimens are sterile, and both pollen cones and seed cones have been described here more or less provisionally.

Distribution

Papuasia: New Britain, New Guinea, D'Entrecastaux Islands, Louisiades Archipelago, Woodlark Island, Solomon Islands; Southwest Pacific: Vanuatu (Erromango, Tanna, Anatom [Aneityum]).
TDWG codes: 43 BIS NWG-PN SOL-SO 60 VAN

Ecology

Podocarpus insularis occurs as a canopy tree in submontane to montane rainforests mostly on islands in the Bismarck, Solomon, and Vanuatu Archipelagos. It is usually scattered, but locally common and attains considerably size in sheltered forests, but remains a low, stunted tree on exposed mountain ridges. It has been collected from near sea level to 1900 m a.s.l. It occurs mostly in angiosperm forest (e.g. with *Nothofagus* at higher altitudes in New Guinea and New Britain), but can be associated with a few other species of *Podocarpus*, among which are the similar *P. neriifolius* and the small-leaved *P. glaucus* on ridges. On ultramafic rock it grows often with *Gymnostoma* (Casuarinaceae).

Conservation

IUCN: LC

Uses

Larger specimen trees yield valuable timber, used for light construction, carpentry, boat building (especially oars), and flooring. This species is usually not recognized as distinct from *P. neriifolius* by foresters and loggers and simply taken as podocarp wood. It is not known to be in cultivation anywhere.

Podocarpus lambertii Klotzsch *ex* Endl., Syn. Conif.: 211. 1847. Type: Brazil: [locality not stated], *F. Sello s.n.* (holotype W, destroyed, isotypes BM, K).
Pl. 37

Etymology

This species was named after Aylmer Bourke Lambert (1761–1842), compiler and publisher of the famous elephant folio 'A Description of the Genus *Pinus*'.

Vernacular names

No common names have been recorded for this species other than the generic 'pinheirinho' which means little more than 'conifer'.

Description

Small trees to 10–12 m tall, d.b.h. to 30 cm. Branches spreading, forming a rounded or irregular crown. Foliage branchlets slender, terete, longitudinally grooved between leaf bases, terminating in small, subglobose buds with imbricate, broadly triangular, carinate, short apiculate scales. Leaves on saplings similar but slightly larger than on mature trees. Leaves on mature trees crowded, spreading at wide angles or more often at narrow angles to shoot and directed forward, (1–)2–4(–5) cm long, (1.5–)2.5–4 mm wide, lanceolate-linear to linear, straight or sometimes slightly falcate, or curved downward, gradually narrowing to a sessile or short petiolate base, gradually tapering to an acute or pungent apex; margins (nearly) parallel for most of the leaf length, slightly revolute; texture coriaceous or thin coriaceous; leaf colour green or grey-green above, whitish green below; flushing leaves reddish, subtended by enlarged perular scales. Midrib ca. 0.4 mm wide, continuous or sometimes fading towards apex, mostly forming a groove on adaxial (upper) side, more or less raised from a concave leaf surface and continuous to apex on abaxial side. Stomata small, in numerous intermittent lines forming two bands on abaxial side. Pollen cones axillary, on short shoots or slender peduncles up to 15 mm long in 1-several clusters of 2–8 or more, cylindrical, 5–12 mm long, 1.5–2 mm wide; microsporophylls ovate-triangular, with minutely denticulate margins, bearing two globose pollen sacs. Seed cones axillary, solitary on slender, 5–10 mm long peduncles; receptacles small, swelling to 6–7 mm long, 4–5 mm wide, succulent, reddish purple. Seeds solitary, globose, including the epimatium 4–5 × 4–5 mm, glossy without a crest. Seed proper globose with a smooth surface.

Distribution

NE Argentina: Missiones; Brazil: Sao Paulo, Rio de Janeiro, Paraná, Santa Catarina, Rio Grande do Sul, Minas Gerais.
TDWG codes: 84 BZL-MG BZL-RJ BZL-SP BZS-PR BZS-RS BZS-SC 85 AGE-MI

Ecology

The habitat type most commonly cited for *Podocarpus lambertii* is 'campo rupestre' ('rocky grassland') which is in actual fact a mozaic of different habitats, composed of usually stony fields with grasses and often also shrubs, wet or peaty areas, small and larger streams bordered with taller woody vegetation, or even with gallery forest. In the eastern States where this species occurs, it will be mostly gallery forest, which enters into the Atlantic Forest belt, especially in Santa Catarina and Rio Grande do Sul. Here *P. lambertii* approaches the Atlantic coast and may also occur, with or without *P. sellowii*, in the drier types of Atlantic Forest. *Podocarpus lambertii* is also found in rocky areas where rain runoff may provide sufficient moisture. Its small, narrow leaves are adapted to periods of drought. Few data are available indicating altitude: some collections were made from 900 m to 1800 m a.s.l.

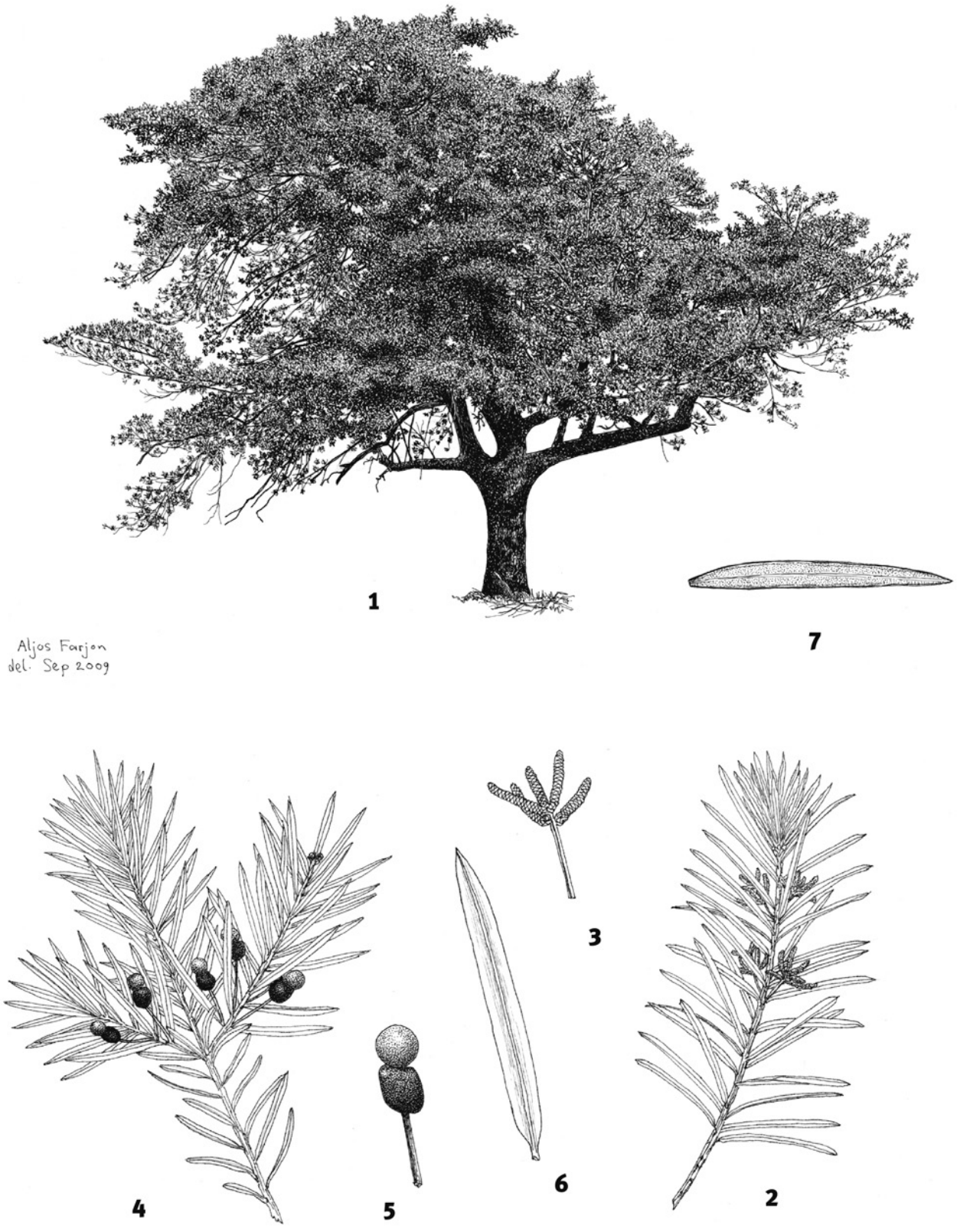

PLATE 37. *Podocarpus lambertii*. **1.** Habit of tree. **2.** Branchlet with leaves and pollen cones. **3.** Pollen cones. **4.** Branch with leaves and seed cones. **5.** Seed cone. **6.** Leaf, upperside. **7.** Leaf, underside.

Conservation

This species has a large range; the extent of occurrence (EOO) calculated from mapped herbarium specimens = 761,575 km². The human footprint factor is fairly high (45), especially near the coast, where habitat and individual trees are likely to have disappeared. The IUCN Conifer Specialist Group feels it is warranted to flag this species as NT. The species is not known to occur in any protected area.

IUCN: NT

Uses

No commercial uses have been recorded for this small tree, of which the timber has not much value. It may be used locally for fence posts and most likely for firewood. It is not known to be in cultivation.

Podocarpus latifolius (Thunb.) R. Br. *ex* Mirb., Mém. Mus. Hist. Nat. 13: 75. 1825. *Taxus latifolia* Thunb., Prodr. Pl. Cap.: 117. 1800. Type: South Africa: Cape Province, ["Houtniquas, Grootvadersbosch, aliis"], *C. P. Thunberg UPS 23780* (holotype UPS). Fig. 270

Podocarpus latifolius (Thunb.) R. Br. *ex* Mirb. var. *latior* Pilg., in Engler, Pflanzenr. IV.5 [18]: 90. 1903; *Podocarpus latior* (Pilg.) Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 66. 1976 (*nom. inval.*, Art. 33.2).

Etymology

The species epithet *latifolius* means 'with broad leaves'.

Vernacular names

Broad-leaved Yellowwood, True Yellowwood; Opregte geelhout (Afrikaans); 'umGeya' (Xhosa)

Description

Trees to 30 m tall or more in forests, or stunted small trees 2–3 m tall on exposed mountain slopes, bole of large trees to 1.2 m d.b.h. Bark thin, smooth, light brown, exfoliating in long strips, weathering grey. Crown relatively small in forest trees, low spreading in stunted trees. Foliage branchlets stout, terete or slightly angular, finely grooved from the decurrent leaf bases, terminating in obtuse buds 2–3.5 mm diam. with narrowly triangular, acuminate, sometimes recurved outer scales. Leaves on juvenile plants up to 17 cm long and 20 mm wide. Leaves on mature trees shorter but variable and often crowded towards ends of branchlets, (2–)3.5–8(–12) cm long, mostly straight, (5–)6–12(–18) mm wide, elliptic to linear-elliptic or linear, longer leaves with parallel sides in middle part, gradually or more abruptly narrowing to a petiolate base, abruptly narrowing to an obtuse or mucronate to apiculate apex; margins slightly revolute; leaf colour dark green to glaucous green above, dull green below; flushing leaves bright green or bronze. Midrib thin and inconspicuous on adaxial (upper) side, fading towards upper part, more prominent and continuous on abaxial side. Stomata in numerous intermittent lines on either side of abaxial midrib, rarely a few present on upper leaf surface. Pollen cones axillary, solitary or rarely in pairs, sessile or on very short peduncles, cylindrical, elongating to 20–30 mm long at anthesis, 3–4 mm wide, subtended by 3–4 mm long, narrowly triangular, keeled bud scales; microsporophylls triangular to broadly ovate, lacerate, bearing two oblong pollen sacs. Seed cones axillary, solitary on slender 5–15 mm long peduncles; receptacles composed of an axis with two bracts, one or sometimes both fertile, swelling to 8–14 mm long and 8–12 mm wide and becoming succulent, turning from glaucous green to pink and sometimes reddish or bluish purple when ripe. Seeds including the epimatium obovoid to subglobose, 7–11 mm long, slightly apiculate or crested, glaucous green turning purple or violet. Seed proper smooth, the seed coat containing resin cavities.

Distribution

South Africa: from the Cape to the Limpopo Province.

TDWG codes: 27 CPP-EC CPP-WC LES NAT OFS SWZ TVL-GA TVL-MP TVL-NP TVL-NW

Ecology

Podocarpus latifolius is a canopy forest tree in the coastal and midland primary forests where there is

sufficient rainfall and natural protection from fires to allow such forest types to develop. In open coastal bushland and on dry, rocky mountain slopes it only grows to a stunted tree a few meters tall at most. It occurs from near sea level to 2000 m a.s.l. In forested valleys near the coast it can be associated with *Afrocarpus falcatus* and both are there commonly emergents above a lower canopy of angiosperm trees, among which members of the families *Celastraceae, Araliaceae* and *Flacourtiaceae*, as well as *Olea capensis* are often seen.

Conservation

IUCN: LC

Uses

Broad-leaved Yellowwood is a valuable timber tree producing even-grained, light weight, pale yellow wood suitable for a variety of purposes. It was extensively used in colonial times for railway sleepers and construction, and many houses were built with it, such as the old Cape homesteads of which many still exist. It is still valued for indoor carpentry and floors, as in former times, but large trees have become much less common and smaller sizes are now used for furniture making, especially when well seasoned and nicely figured with darker streaks. Africans value the wood for coffins. In South Africa this species is commonly planted as an amenity tree in parks and along streets. Elsewhere it is uncommon and mainly represented by specimens in botanic gardens. It is too slow growing for profitable forestry plantation, which is unfortunate as that role is mostly taken by several species of *Eucalyptus*, some of which have turned out to be invasive pests.

Podocarpus laubenfelsii Tiong, Blumea 29 (2): 523. 1984. Type: Malaysia: Sabah, Ranau District, Mt. Kinabalu N. P., Bukit Burong, *D. J. de Laubenfels P 715* (holotype L). Fig. 269

Etymology

This species has been named in honour of David J. de Laubenfels, a long-time student of *Podocarpaceae*.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 40 m tall, bole erect, straight, to 80 cm d.b.h. Bark nearly smooth, soft, exfoliating in thin strips, light brown. Branches spreading, in mature trees forming a rounded crown. Foliage branchlets terete, glabrous, finely grooved or striated, terminating an a small, globose bud up to 4 × 4 mm, with triangular, imbricate scales forming a short conical apex, the tips of the scales at apex often recurved. Leaves on saplings and young trees usually larger than on mature trees; shaded leaves also larger than sun-exposed leaves on mature trees, to 25 cm long and 25 mm wide. Leaves on mature trees exposed to sun (7–)10–19 cm long, 10–20(–25) mm wide, long petiolate, linear-lanceolate to linear, straight or slightly curved, more or less abruptly widening above the 6–15 mm long petiole, more gradually tapering to an acute or more commonly acuminate apex. Midrib on adaxial (upper) side obtusely raised, ca. 1 mm wide, on abaxial side wider and flatter, fading towards apex. Stomata very small and indistinct, in numerous irregular lines on abaxial side. Pollen cones axillary, clustered with 3–5 on a short peduncle or sessile, raising from globular buds with rounded scales, cylindrical, elongating to 20–40 mm or longer, 2,5–3.5 mm wide; microsporophylls with an elongated apex, bearing two elongated pollen sacs. Seed cones axillary, solitary on slender peduncles (3–)10–15 mm long; receptacles with 2 very short (1–2 mm) bracts ('foliola') at base, ca. 10 mm long. Seeds including the epimatium at least 10 mm long but fully mature phase not observed.

Distribution

Borneo: Malaysia: Sabah (Mt. Kinabalu, Mt. Trusmadi), Sarawak (Lawas); Indonesia: Kalimantan Timur (Gunung Palimasan).
TDWG codes: 42 BOR-KA BOR-SB BOR-SR

Ecology

Podocarpus laubenfelsii occurs scattered in 'keranga' forest with *Agathis borneensis, Nageia wallichiana,*

Sundacarpus amarus, Dacrydium gracile, and *Falcatifolium falciforme*, often on nutrient-poor and/or water-logged, acidic soils. The species is also scattered in primary rainforest and mossy forest; growing as a large emergent tree on rocky ridges; it may be more common in 'heath forests' at higher elevations. Altitude of *P. laubenfelsii* ranges from 920 m to 1650 m a.s.l. This species occurs with scattered individuals in the forest, but can be dominant in 'heath forests' at higher altitudes.

Conservation

Most collections of this species are from Mt Kinabalu National Park. Deforestation is widespread outside of protected areas in the region, indicating a considerable decline in the past that has not abated. Outside Mt. Kinabalu National Park it is known from only three locations, one just outside the park, the other two at considerable distance. Its total range is probably incompletely known as the species was only described and named in 1984. It is a large forest tree with considerable timber value. Its only protected location so far known is in Mt. Kinabalu National Park.
IUCN: EN [B2ab (ii, iii, v)]

Uses

This species attains large sizes in primary lower montane rainforest and is consequently a valuable timber tree logged and traded as other 'podocarp' trees, without distinction to species or even genus. Its excellent wood is used for house construction and carpentry and for making oars, spars and masts of sailing vessels. More specialized uses requiring high grade timber are veneer, furniture making, cabinet making, interior trim, household utensils, and wood carving. It is not known to be in cultivation.

Podocarpus lawrencei Hook. f., London J. Bot. 4: 151. 1845., ["*lawrencii*"] *Podocarpus alpinus* R. Br. *ex* Hook. f. var. *lawrencei* (Hook. f.) Hook. f., Fl. Tasmania 1 (5): 356. 1857. Type: Australia: Tasmania, *R. W. Lawrence 218* (holotype K). Fig. 271

Podocarpus alpinus R. Br. *ex* Hook. f., London J. Bot. 4: 150. 1845.

Etymology

This species was named after Robert William Lawrence (1807–1833), who collected plants in Tasmania around 1826.

Vernacular names

Mountain plum pine, Plum pine

Description

Procumbent or more or less erect shrubs to 4 m tall, usually creeping and prostrate, forming 4–5 m wide clumps. Branching often profuse, with densely set foliage branchlets and in creeping shrubs with long leaders (whip shoots), terminating in small, globose buds 1–2 mm diam. with broadly triangular, imbricate scales. Leaves sessile, decurrent, 4–16 mm long, linear-oblong, the shortest leaves nearly oval, 4–5 mm wide, gradually tapering to a slightly twisted, narrow base; apex obtuse, sometimes minutely apiculate; midrib nearly absent on adaxial (upper) side, prominent but obtuse on abaxial side; leaf colour mid-green or dark green above, light green below with two grey-green stomatal bands. Stomata small, in intermittent, wavy lines on either side of abaxial midrib. Pollen cones axillary and solitary or in groups of 2–3(–6) at distal end of foliage branchlets, sessile or on short peduncles, cylindrical, 4–7 mm long, 2–2.5 mm wide; microsporophylls imbricate, very small, broadly triangular, enclosing towards their base two relatively large, globose pollen sacs. Seed cones axillary, solitary, sessile or shortly pedunculate; receptacles while growing ca. 3 mm long, swelling strongly at maturity to 5–6 mm, becoming subglobose, succulent and dark red. Seeds solitary at distal end of receptacle, narrowly ovoid, 4.5–5 mm long, 2.5–3 mm wide, with a narrowing distal end; epimatium olive green. Seed proper not observed.

Distribution

Australia: New South Wales, A. C. T., Victoria, Tasmania.
TDWG codes: 50 NSW-NS TAS VIC

Ecology

Podocarpus lawrencei is a subalpine to alpine shrub limited to the highest mountains in the southern part of the Great Dividing Range and in Tasmania. Its altitudinal range is between 1100 m and 2030 m a.s.l. and it grows mostly in rocky terrain, e.g. scree slopes, broken rocky plateaus and ridges formed by acidic igneous or metamorphic rock types. In the Great Dividing Range it may also occur in wet sclerophyll forest with *Acacia* spp., *Eucalyptus* spp., and *Telopea* sp., where it can reach to 4 m tall; above the tree line it is found in subalpine/alpine dwarf scrub mixed with alpine herbaceous grassland, some associated species there are *Prostanthera cuneata, Grevillea australis* and *Eucalyptus australis*. In Tasmania, three endemic conifers are often associated with *Podocarpus lawrencei: Diselma archeri* (*Cupressaceae*), *Microcachrys tetragona*, and *Pherosphaera hookeriana* (*Podocarpaceae*). The angiosperm flora is also distinct, with e.g. *Orites revoluta, Richea scoparia, Epacris serpyllifolia*, and *Leptospermum ruprestre*.

Conservation

IUCN: LC

Uses

Mountain plum pine is suitable as a low, hardy shrub in countries with mildly cold winters. It is planted in rockeries or as undergrowth in park-like tree plantings and provides an evergreen, spreading shrub with attractive, red 'fruits' (the ripe receptacles) topped by a shiny, green seed. It is uncommon in Europe, North America and Japan probably because it is not easy to germinate; in Australia and New Zealand gardeners seem to have a preference for conifers from the northern hemisphere, too.

Podocarpus ledermannii Pilg., Bot. Jahrb. Syst. 54: 210. 1916. Types: Papua New Guinea: West Sepik, Sepik River, ["Lordberg"], *C. L. Ledermann 9943, C. L. Ledermann 10064a* (syntypes K, lectotype not designated).

Podocarpus idenburgensis N. E. Gray, J. Arnold Arbor. 39: 447. 1958.

Etymology

This species was named after the German botanist Carl Ludwig Ledermann (1875–1958), who first collected it in the Sepik River delta.

Vernacular names

sua (Papua); babako (Papua New Guinea mainland); neleel, nelil (New Britain)

Description

Trees to 25(–30) m tall; trunk to 60 cm diam., erect. Bark more or less fibrous, dark brown. Branches spreading, forming a rounded crown. Foliage branchlets terete, glabrous, finely grooved or striate, terminating in an elongated bud 6–12 mm long, 3–4 mm wide at base, with free, erect to slightly spreading lanceolate scales drawn out in a caudate apex. Leaves lanceolate to linear-lanceolate, 8–20(–22) cm long, (11–)15–25 mm wide, straight or slightly curved, distinctly petiolate, more or less abrubtly widening at base, with parallel sides for most of their length, gradually tapering to an acuminate or sometimes acute apex. Midrib distinctly raised and narrow on adaxial (upper) side, wider and flattened on abaxial side; leaf colour lustrous green on both sides. Stomata very small, in numerous irregular lines on abaxial side on either side of midrib. Pollen cones axillary, on a 3–4 mm long peduncle, in groups of 1–3, subtended by 4–5 mm long acuminate bracts (bud scales), elongating to 3.5–4.5 cm, 4 mm wide at anthesis; microsporophylls apiculate, bearing two elongated pollen sacs at base. Seed cones axillary, solitary, on a 5–15 mm long peduncle; receptacles subtended by 2 recurved, 2 mm long bracts ('foliola') and with one apical bract visible when still growing, at maturity 10–16 mm long, ripening to a swollen, succulent, orange then red imitation fruit. Seeds including the epimatium ovoid, 10–13 × 8–10 mm, with a distal, barely elevated crest.

Distribution

Papuasia: New Guinea, Bismarck Archipelago.
TDWG codes: 43 BIS NWG-IJ NWG-PN

Ecology

Podocarpus ledermannii occurs as a scattered and locally common tree in tropical evergreen rainforests, from near sea level to 2300 m a.s.l. It has been found in forests in river deltas (e.g. Purari, Sepik) as well as in upland lower montane forests dominated by *Castanopsis*. It often grows in the understorey, but can attain canopy height in medium-high forests or in more open (disturbed?) forests.

Conservation

IUCN: LC

Uses

This species is relatively uncommon and is probably not distinguished from the more common species like *P. neriifolius*. Therefore it can be assumed to be logged when occurring in accessible forest and attaining suitable size. The uses of the wood are similar to that of *P. neriifolius*, i.e. primarily light construction and carpentry, and in the delta areas where it occurs boats, oars, masts, and spars. As far as known this species is not in cultivation.

Podocarpus levis de Laub., Blumea 24 (2): 496. 1979. Type: Indonesia: Papua, Yapen Island, Mariatu, *L. J. van Dijk bb 30484* (holotype L).

Etymology

The species epithet means 'with a smooth surface'; it refers to the upper surface of the leaves from which the midrib scarcely protrudes.

Vernacular names

marisa, sanru (Sulawesi); wasiwarare (Yapen Island, New Guinea)

Description

Trees to 25(–35?) tall, usually with a straight bole; trunk d.b.h. 40 cm or more. Bark smooth, thin, on large boles with narrow, longitudinal flakes or strips, light brown weathering grey; inner bark pinkish or reddish brown, fibrous. Branches spreading, forming a rounded crown in large trees. Foliage branchlets slender, terete, finely grooved between remote leaf bases. Terminal buds 3–9 mm long, outer scales lanceolate, terminating in an acuminate, slightly spreading apex. Leaves on saplings and young trees larger than on mature trees, 12–22 cm long, ca. 15 mm wide, acute, obtuse or truncated at apex. Leaves on mature trees linear-lanceolate, (5–)6–11 (–14) cm long, (7–)10–14 mm wide, straight or slightly falcate, narrowing at base to a 4–9 mm long petiole; margins often somewhat wavy; apex acute, obtuse or narrowly rounded. Midrib on adaxial (upper) side obtusely raised, especially near base, mostly less than 0.5 mm wide and often fading towards apex, raised and continuous on abaxial side, 0.5–1 mm wide. Stomata small, in numerous intermittent lines in two bands on either side of abaxial midrib. Pollen cones axillary, solitary or in clusters of 2–3, sessile, with several basal, carinate bud scales, cylindrical, elongating to 50–60(–80?) mm, 2–3.5 mm wide; microsporophylls triangular, spreading, with two globose pollen sacs. Seed cones axillary, solitary on a short peduncle; receptacles subtended by two 2–4 mm long bracts ('foliola'), consisting of an axis with 1–2 fertile bracts and 1–2 sterile ones, fusing and swelling, initially 5–6 mm long, becoming ca. 8 × 6 mm and red when ripe. Seeds single, sometimes two on a receptacle, including the epimatium 8–11(–13?) mm long, 7–8 mm wide, ovoid-globose with a rounded distal end. Seed proper not observed.

Taxonomic notes

This species is rather similar to *P. neriifolius*, from which it is distinct in its often bluntly rounded leaf apices. That character is, however, variable even on the same branch, with truncate and acute leaf apices e.g. on *C. B. Robinson 309* (K) from Amboina, which was cited in the protologue of this species, but the variation was not commented upon. *Podocarpus levis* does not have acuminate leaves, as seen in juvenile plants of *P. neriifolius*, and the midrib on the adaxial side is only prominent near the leaf base and soon flattens or even fades out towards the apex (at least *in sicco*). Whether to recognize such leaf differences as character states of a distinct species is a moot point; we need more and better material to decide, and this species is here merely given the benefit of doubt.

Distribution

Malesia: Borneo (Kalimantan Timur), Sulawesi, Maluku [Moluccas], Talaud Islands; Papuasia: New Guinea (Papua).
TDWG codes: 42 BOR-KA MOL SUL 43 NWG-IJ

Ecology

Podocarpus levis is a scattered tree, locally common, in evergreen primary rainforest. It has been found to grow from near sea level to 1650 m a.s.l. It occurs on various substrates; in Borneo (one locality known) it was found on limestone.

Conservation

IUCN: LC

Uses

This species is a valuable timber tree and logged with other species where large trees occur and are accessible. The wood is used for general construction, carpentry and furniture making. This species is not known to be in cultivation.

Podocarpus longifoliolatus Pilg., in Engler, Pflanzenr. IV.5 [18]: 79. 1903 ["longefoliolatus"]. Type: New Caledonia: Grande Terre, Province Sud, Mt. Mou, *J. A. I. Pancher s.n.*, 1870 (holotype P).

Etymology

The species epithet refers to the two (not very long!) bracts at the base of the growing receptacle of the seed cone.

Vernacular names

No common names are recorded for this species.

Description

Trees to 20 m tall with a monopodial trunk to 60 cm d.b.h. Bark longitudinally striated or fissured, fibrous, exfoliating in strips, brown or reddish brown, weathering grey. Branches spreading, forming a rounded or irregular crown. Foliage branchlets terete, more or less ridged from decurrent leaf bases; terminating in obtuse-conical buds with several elongated, spreading to recurved outer scales 4–10 mm long. Leaves on juvenile plants (including seedlings) similar to leaves on mature plants but sometimes longer, to 14 cm. Leaves on mature trees linear-lanceolate, 5–10(–13) cm long, 5–10(–12) mm wide, straight or slightly falcate, gradually widening from a petiolate base with parallel sides for most of their length; apex acute or sometimes obtuse. Midrib on adaxial (upper) side conspicuous but obtuse, sometimes obscure towards apex, on abaxial side flattened but well visible. Leaf colour lustrous green above, light dull green below. Stomata very small, forming numerous intermittent lines in two bands on abaxial side. Pollen cones axillary, nearly sessile or short pedunculate, solitary or with 2–3 together, subtended by short, triangular bud scales, cylindrical, elongating unequally to 15–25 mm, 2.5–3.5 mm wide; microsporophylls triangular, with an obtuse apex and bearing two partly hidden, subglobose pollen sacs. Seed cones axillary, solitary on slender peduncles 8–17 mm long; receptacles subtended by two spreading bracts ('foliola') 2.5–3.5 mm long, consisting of an axis with 3–4 bracts, 2 often fertile and spreading distally, swelling and amalgamating to an 8 × 4–5 mm large, succulent and red body. Seeds 1–2, rarely 3 on distal part of receptacle, including the covering epimatium 7–9 mm long, obliquely ovoid, with a small distal crest fading at maturity. Seed proper not observed.

Distribution

New Caledonia: Grande Terre (Province Sud, Île des Pins).
TDWG codes: 60 NWC

Ecology

Podocarpus longifoliolatus has been found on a few summits above 1100 m a.s.l. in the southern part of Grande Terre, the main island of New Caledonia. It occurs on serpentine rock in montane rainforest with both angiosperms and conifers, the latter dominated by *Araucaria* spp. Rainfall is high and cloud cover or mist frequent throughout the year. The rarity of this species, although real, is in part artificial as it is difficult to find or even recognize. More recently (1982) it was found on the Île des Pins at ca. 180 m a.s.l. in a moist ravine on Mt. N'ga.

Conservation

This species appears to occur in montane forests at or near the summits of mountains; some are in protected reserves. Due to deforestation its few populations are severely fragmented and not more than 2500 mature trees are estimated to be left.
IUCN: EN [B1ab (iii, v), 2ab (iii, v); C2a (i)]

Uses

No uses have been recorded of this species.

Podocarpus lophatus de Laub., Kalikasan 7 (2): 137. 1978. Type: Philippines: Luzon, Zambales Mountains, Mt. Tapulao, *H. M. Curran & M. L. Merritt PFB 9511* (holotype US).

Etymology

The species epithet is derived from Greek (prefix in compound words: *lopho-*) and means crested; it refers to the seed.

Vernacular names

No common names are recorded for this species.

Description

Shrubs or small trees to 6 m tall. Bark not described or observed. Branches ascending or spreading, forming a dense crown. Foliage branchlets ascending, terete, slender, terminating in small buds 3 mm long and 2 mm wide, usually hidden among crowded leaves. Leaves on shrubs and mature trees densely crowded, (1.2–)1.5–3(–3.5) cm long, 4–5(–6) mm wide, elliptic to oblong, greatest width usually at the middle, gradually tapering to a short petiolate, slightly twisted base; apex acute or nearly obtuse; margins slightly revolute. Midrib on adaxial (upper) side 0.2–0.3 mm wide, acutely raised, on abaxial side wider, to 1 mm, obtuse or nearly flat. Leaf colour on upperside dark glossy green, underside light green or dull green. Stomata very small, numerous, in two broad bands on abaxial side. Pollen cones axillary, solitary, sessile, becoming cylindrical (details of mature cones not observed). Seed cones axillary to uppermost leaves, solitary; receptacles with two 1.5–2 mm long basal bracts ('foliola'), 7–10 mm long and swollen when ripe, glaucous, becoming bright red or purple. Seeds including the epimatium ovoid-globose, 7 × 4–5 mm, with a distinct crest at maturity, glaucous green to purplish green; seed proper not observed.

Distribution

Philippines: Luzon (Mt. Tapulao), Mindoro (Mt. Halcon).
TDWG codes: 42 PHI

Ecology

Podocarpus lophatus is a species of mountain summits and upper slopes, where it occurs in 'heath', scrubland and upper montane, low canopy mossy forest. Its altitudinal range is from 1800 m to 2585 m (the summit of Mt. Halcon) a.s.l. On Mt. Halcon it is very common; its abundance in the type locality at Mt. Tapulao is not mentioned.

Conservation

Although no immediate threats are putting this species in danger of extinction, the fact that it is still only known from two separate mountains in the Philippines, at one of which at least it was said to be abundant in 1995, puts it under the D criterion as within a threatened category. This species remains poorly known and may well occur on other mountains; it may not have been recognized as distinct from e.g. *P. pilgeri*, which has similar leaves and can be a shrub as well as a large tree.
IUCN: VU (D2)

Uses

No uses have been recorded of this species. It may have some merit for horticulture, but is not known to be in cultivation.

Podocarpus lucienii de Laub., Brittonia 12 (1): 80. 1960. Type: New Caledonia: Grande Terre, Province Sud, Rivière Bleue, *D. J. de Laubenfels P 137* (holotype GH).

Etymology

This species was dedicated to René Lucien, an amateur botanist in New Caledonia.

Vernacular names

No common names are known for this species.

Description

Small trees to 15 m tall and 30 cm d.b.h. Bark fibrous, fissured longitudinally and exfoliating in long strips, yellowish brown weathering grey; inner bark reddish brown. Branches spreading to form a broad crown, spreading out wide. Foliage branchlets terete, finely grooved or ridged, terminating in small, globose or ovoid buds with 1–2 mm long, appressed and obtuse scales. Leaves on juvenile plants sometimes larger than on mature plants, to 18 cm long and 20 mm wide. Leaves on mature trees and shrubs variable in length, (3–)4.5–14 cm long, (9–)11–18 mm wide, oval-linear (widest at midpoint) to linear, tapering abruptly down to a more or less petiolate base and to an obtuse or rounded apex, coriaceous, straight or only slightly curved. Midrib obtusely raised or fading to a groove on adaxial (upper) side, 1–1.4 mm wide, flat or forming a groove in dried leaves on abaxial side. Leaf colour lustrous grey-green above, dull light green below. Stomata very small, in two bands forming numerous intermittent lines on abaxial side. Pollen cones from clustered buds in axils of leaves or below these, sessile, solitary or 2–3 together, subtended by small, rounded, imbricate bud scales, cylindrical, 10–20 mm long, 3 mm wide, yellow turning brown; microsporophylls imbricate, peltate, minutely apiculate, bearing two basal, globose pollen sacs. Seed cones axillary and solitary on slender, 12–20 mm long peduncles; receptacles subtended by two small bracts ('foliola'), growing to 9–11 mm long, swelling to 5–6 mm thick, maturing to red or red-brown. Seeds including the epimatium relatively large, 13–15 × 9–10 mm, obliquely ovoid without a crest, smooth, olive green turning brown. Seed proper ovoid, smooth, ca. 10 × 7 mm.

Taxonomic notes

Specimens at K belonging to this species were originally named *P. sylvestris* and the two species are indeed similar. The leaves of *P. lucienii* are wider and terminate more abrubtly at both ends even in leaves on juvenile plants; the seeds are also larger than those of *P. sylvestris*, and the receptacles are on longer peduncles.

Distribution

SW Pacific: New Caledonia.
TDWG codes: 60 NWC

Ecology

Podocarpus lucienii is a scattered small tree in moist forest occurring at middle elevations (altitudinal range of specimens seen 250–1350 m a.s.l.) in more or less open situations on ridges and rocky slopes. In the south it is restricted to serpentine and its ultramafic derivatives, but two localities in the north, on the eastern slopes of Mont Panié and on the western slope of the Roches d'Ouaième, are on micaschist.

Conservation

The habitat is under threat from various causes and the species is in decline despite recent discoveries of new locations.
IUCN: EN [D2ab (ii, iii, v)]

Uses

No uses have been recorded of this species.

Podocarpus macrocarpus de Laub., Kalikasan 7 (2): 140. 1978. Type: Philippines: Luzon, Benguet Province, *H. M. Curran PFB 10894* (holotype US).

Etymology

The species epithet refers to the large seed (Latin *macro* = large; Greek *carpos* = fruit).

Vernacular names

Malakawayan (Philippines).

Description

Trees to 20 m tall, d.b.h. to 30 cm. Bark peeling in fibrous strips, brown weathering grey; inner bark soft fibrous, pink. Branches spreading, forming an irregular crown in most trees. Foliage branchlets terete, slightly grooved or ridged, terminating in 2–4 mm long and 2–4 mm wide, conical or subglobose buds with triangular to lanceolate, erect to spreading outer scales. Leaves on juvenile plants linear to linear-lanceolate, 9–15 cm long, 10–14 mm wide, gradually tapering to a petiolate base and with an acute apex. Leaves on mature trees linear to linear-lanceolate, (4–)6–10 cm long, 8–13 mm wide, short petiolate, abruptly or more gradually narrowed at base, tapering to an acute or obtuse apex, straight or slightly curved, coriaceous; margins flat or nearly so; midrib obtusely raised adaxially (above), only slightly raised and wider abaxially (below); leaf colour lustrous green above, dull and pale green below. Stomata on abaxial side, very small and in numerous irregular lines in two broad bands divided by midrib. Pollen cones axillary, clustered with (2–)3(–4) together, sessile, with a few small scales at base, cylindrical, to 25 mm long and 3 mm wide; microsporophylls imbricate, slightly spreading at anthesis, apiculate, with two oblong pollen sacs. Seed cones axillary, solitary on a 5–10 mm long peduncle; receptacles with 2 very small basal bracts ('foliola') to 1.5 mm long (deciduous), 10–15 mm long, swelling to 10 mm thick, pruinose, becoming orange-red to red when ripe. Seeds including the epimatium 14–17 × 10–13 mm, globose-ovoid, without a crest, glaucous green. Seed proper not observed.

Taxonomic notes

Although De Laubenfels (*op. cit.*) mentions some distinctions between *Podocarpus macrocarpus* and *P. rumphii*, and in Flora Malesiana ser. 1, 10 (3) (1988) even places these two species in different sections, they appear to be rather similar. The bud scales of his own specimens of *P. macrocarpus* (e.g. *P 721*) are not spreading and some seeds in *P. rumphii* are of similar size to those of *P. macrocarpus*. The leaves of mature trees of *P. rumphii* are longer than those of *P. macrocarpus*. In the key to the species given by De Laubenfels (*op. cit.*) pollen cones were said to be in groups of three, yet they were "in clusters of up to at least four" in Flora Malesiana, which is similar to the grouping in *P. rumphii*. Both species are known from Luzon, albeit cited from different localities, with *P. macrocarpus* more to the north. The latter should perhaps be considered a variety or subspecies of *P. rumphii*.

Distribution

Philippines: N Luzon.
TDWG codes: 42 PHI

Ecology

Podocarpus macrocarpus occurs as a scattered tree in tropical montane, evergreen cloud forest (mossy forest) at 2000–2100 m a.s.l.

Conservation

None of the four known localities are in protected areas and deforestation is encroaching on most of these.
IUCN: EN [B2ab (ii–v)]

Uses

In the Philippines, the wood of this species is used in the construction of small aeroplanes as a substitute for Sitka spruce; in musical instruments for sounding boards, for tennis rackets, and for pencils. It is not known to be in cultivation.

Podocarpus macrophyllus (Thunb.) Sweet, Hort. Sub. Londin.: 211. 1818.

Etymology

The species epithet means 'with large leaves'; under *Taxus* as originally placed by Thunberg (see below) the leaves would indeed be large.

Vernacular names

Buddhist pine; kusamaki (Japanese); luo han song (Chinese)

Description

Trees (or shrubs) to 20 m tall; trunk to 60 cm d.b.h. Bark smooth, peeling off in thin flakes, grey-brown. Branches spreading or ascending, foliage branches in mature plants dense, forming a spreading crown; ultimate branchlets angular, glabrous or rarely pubescent, terminating in a bud with elongated, caudate and recurved scales. Leaves spirally arranged, sessile to short petiolate, leaf blade linear-lanceolate, slightly falcate-lanceolate or (oblong-)oblanceolate, (2.5–)4–10(–14) cm long, (3–)4–10(–13) mm wide, gradually tapering to base, in juvenile leaves with an acute apex, in adult leaves with an acute or acuminate apex or more abruptly converging to an obtuse or apiculate apex; midvein acutely raised adaxially, obtusely raised abaxially; leaf colour lustrous dark green above (adaxially), pale yellowish or whitish green below. Stomata very small, in numerous irregular lines on abaxial side on either side of midvein. Pollen cones axillary, sessile, in clusters of (2–)3–5 per axil, subtended by several scarious, more or less triangular bracts, long cylindrical, 20–40(–50) mm long, 2.5–3 mm wide; microsporophylls spirally arranged, imbricate, spreading at anthesis, the laminar part cordate, with two basal pollen sacs. Seed cones axillary, solitary, on slender, 5–15 mm long peduncles; receptacles subtended by 2 recurved bracts ('foliola'), columnar and glaucous when unripe, 10–15 mm long, 2–3 mm thick, swelling to 10–12 mm thick and becoming yellow, then red or purplish red to purple and succulent when ripe. Seeds enclosed in an epimatium, subglobose, 10–12 × 8–9 mm, from green ripening to purplish black, sometimes pruinose. Seed proper ovoid, ca. 10 × 8 mm, with a smooth surface, light brown.

Taxonomic notes

A number of varieties have been described and were recognized in Flora of China 4: 83–84 (1999), but of these only var. *maki* has here been retained, while var. *chingii* is recognized as a distinct species *P. chingianus*. The only difference which seems more or less consistent between *P. macrophyllus* var. *macrophyllus* and var. *maki* is the leaf width; other measurements, while statistically perhaps significant (not tested), show much overlapping. The receptacles of living *P. macrophyllus* var. *maki* seen in Taiwan were ripening to red, not purple; those of var. *macrophyllus* may turn to purple.

Distribution

China: Anhui, Chongqing, Fujian, Guangxi, Guizhou, Hong-Kong, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Yunnan, Zhejiang; Japan; Myanmar [Burma]; Taiwan.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HK CHS-HN CHS-JX CHS-ZJ 38 JAP-HN JAP-KY JAP-SH TAI 41 MYA

Ecology

Podocarpus macrophyllus is a forest species but also occurs in secondary vegetation (thickets and scrub on mountain slopes and hill sides), often along streams. It is one of numerous species in a mixed mesophytic forest formation, largely constituted of deciduous angiosperm trees and shrubs. *Podocarpus macrophyllus* occurs from near sea level to around 1000 m a.s.l.; in Yunnan it was recorded (*G. Forrest 4665*) growing at 2400 m and higher (–3000 m?) as a low shrub. Many forests at lower elevations have been cut over and have a secondary vegetation of remnant forest trees and pioneer species. In this vegetation and in remnants of undisturbed forest *Podocarpus macrophyllus* occurs with *Cunninghamia lanceolata, Pinus* spp., *Podocarpus neriifolius*, *Cephalotaxus fortunei, Fokienia hodginsii, Taxus chinensis*, and where not logged, *Pseudotsuga sinensis* and *Tsuga chinensis*, as well as numerous angiosperms, among which genera in the *Fagaceae* like *Castanopsis* and *Quercus* are conspicuous. Especially *Podocarpus macrophyllus* var. *maki* has been widely planted in China and Japan and has probably been spread by birds into vegetation in which it may not have occurred previously.

Uses

Podocarpus macrophyllus (especially var. *maki*) is widely planted in China and Japan as well as in parts of SE Asia as an amenity tree. In Japan, this species is planted for hedges; var. *maki* is a popular pot plant and is occasionally seen as bonsai. A few cultivars, one a compact shrub, others also shrubs but with narrow or variegated leaves, are known. The species and its var. *maki* are also commonly planted in other E Asian countries and find use as an ornamental as far away as Puerto Rico. The species was introduced from China in England in 1804; from Japan (var. *maki*) in the Netherlands in 1830. Apparent shrub forms which occur at higher altitude in Yunnan would be suitable as ornamentals in large rock gardens; George Forrest collected such a plant from the ranges near Dali in 1906 (*Forrest 4665*), but this provenance appears not to be in cultivation in Europe at the present time.

2 varieties are recognized:

Podocarpus macrophyllus (Thunb.) Sweet var. ***macrophyllus***. *Taxus macrophylla* Thunb., in Murray, Linn. Syst. Veg., ed. 14: 895. Mai-Jun 1784; *Margbensonia macrophylla* (Thunb.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type not designated.
Fig. 272, 273

Podocarpus macrophyllus (Thunb.) Sweet var. *piliramulus* Z. X. Chen & Z. Q. Li, Bull. Bot. Res. North-East. Forest. Inst. 9 (3): 69. 1989.

Description

Adult leaves (3–)5–10(–11) cm long, (5–)7–10(–13) mm wide, abruptly converging to an obtuse or apiculate apex, sometimes subacute.

Distribution

China: Anhui, Chongqing, Fujian, Guangxi, Guizhou, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Yunnan, Zhejiang; Japan: Honshu, Shikoku; Taiwan (extreme S and Lanyu or Orchid Island).
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JX CHS-ZJ 38 JAP-HN JAP-SH TAI

Conservation

IUCN: LC

Podocarpus macrophyllus (Thunb.) Sweet var. ***maki*** Siebold & Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4 (3): 232. 1846. *Podocarpus macrophyllus* (Thunb.) Sweet subsp. *maki* (Siebold & Zucc.) Pilg., in Engler, Pflanzenr. IV.5 [18]: 80. 1903; *Podocarpus maki* (Siebold & Zucc.) Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 214. 1976 (*nom. inval.*, Art. 33.2); *Margbensonia maki* (Siebold & Zucc. *ex* Endl.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type not designated.

Juniperus chinensis Roxb., Fl. Ind. 3: 840. 1832, *non* L. (1767). *Podocarpus chinensis* Wall. *ex* J. Forbes, Pinetum Woburn.: 212. 1839.
Podocarpus chinensis Wall. *ex* J. Forbes var. *wardii* de Laub. & Silba, Phytologia 65: 331. 1988.

Description

Adult leaves (2.5–)3.5–7(–8) cm long, 4–7(–8) mm wide; apex obtuse, acute or acuminate.

Distribution

China: Anhui, Chongqing, Fujian, Guangdong, Guangxi, Guizhou, Hong-Kong, Hunan, Jiangxi, Yunnan, Zhejiang; N Myanmar [Burma]; S Japan; Taiwan.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-YN CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HK CHS-HN CHS-JX CHS-ZJ 38 JAP-HN JAP-KY JAP-SH TAI 41 MYA

Conservation

IUCN: LC

Podocarpus madagascariensis Baker, J. Linn. Soc., Bot. 21: 447. 1885.

Etymology

The species epithet refers to Madagascar, where this species is endemic.

Vernacular names

Hetatra, Tsindrodravina (Malagasy)

Description

Trees to 25 m tall, but often much smaller and shrubby; trunk to 60 cm d.b.h. Bark thin, exfoliating in strips on larger trunks, in small flakes on small trees, light brown weathering grey. Branches numerous, spreading; foliage branchlets spreading or ascending, stout, terete, finely ridged and grooved, terminating in robust, subglobose buds 4–6 mm wide, with imbricate, rounded to ovate scales; lower scales carinate and weakly acuminate, with scarious upper margin. Leaves highly variable in size, on the type specimen 3–6 cm long, 5–7 mm wide, but ranging from 2–18 cm long and 3–16 mm wide on other specimens, elliptic-oblong to linear, mostly thick coriaceous, rigid, but in one variety more lax and drooping, tapering towards a petiolate base and to an acute, acuminate (or long attenuate) or obtuse apex; margins slightly revolute; leaf colour lustrous green above, dull green below. Midrib inconspicuous or obtuse on adaxial (upper) side, continuous or petering out distally, more distinct and continuous, with abruptly raised edges, on abaxial (lower) side. Stomata in numerous intermittent lines on either side of midrib on abaxial side. Pollen cones axillary, solitary or with 2–3 together on short peduncles, subtended by imbricate, rounded bud scales, cylindrical, elongating to 1.5–2.5(–3) cm long, 4–5 mm wide; microsporophylls imbricate, with triangular, minutely denticulate apex, each bearing two basal, oblong pollen sacs. Seed cones axillary, solitary on 15–23 mm long, slender peduncles, consisting of an axis with 2–3 fused bracts which retain free bract tips at distal widest end, only swelling slightly to a 4–5 mm long receptacle (sometimes virtually absent). Seeds large, ovoid-globose or nearly globose, including the epimatium 15–23 mm long , smooth, weakly crested, glaucous at first, olive green, ripening to brownish black. Seed proper not observed.

Taxonomic notes

Baker (*op. cit.*) cited three collections as seen by him in the protologue of this species: *R. Baron 2794, R. Baron 3129* and *G. W. Parker s.n.* All three are represented by specimens in the Kew Herbarium (K) and are therefore syntypes. However, whereas the two collections made by Baron are sterile foliage representing young trees (or a single tree), the Parker specimen is an adult foliage branch and has a seed. This latter specimen also bears a note from R. Baron (*in litt*. July 1884) about the uses of the wood and the native name of the tree, which Baker also cites in the protologue. It is therefore appropriate to designate the specimen at K collected by G. W. Parker as the lectotype of *Podocarpus madagascariensis* Baker.

Distribution

Madagascar, along eastern plateaus and mountains.
TDWG codes: 29 MDG

Ecology

Podocarpus madagascariensis occurs in moist forests or forest remnants from level plains near sea level to forested ridges and escarpments at 2000–2400 m a.s.l. In the lowland forest it can attain 20–25 m and become a canopy tree with mostly evergreen tropical angiosperms; on exposed rocky ridges it is a shrub or a stunted tree occurring in sclerophyllous low forest or scrubland rich in lichens, often on relatively dry sites. The drooping leaved variety *procerus* occurs from near sea level to about 1000 m a.s.l. on sand or sandstone; the small leaved var. *rotundus* occurs at altitudes between 1500 m and 1800 m a.s.l. on igneous rock outcrops. The variety *madagascariensis* is much more widespread and occurs on diverse substrates, usually above 800 m a.s.l.

Uses

According to one of the collectors of the original material of this species, the Reverend R. Baron, its wood was "extensively used in house building, for flooring, etc." in the latter decades of the 19th century.

These uses have diminished with many of the larger and more accessible trees now logged. The species and its varieties are not recorded in cultivation.

3 varieties are recognized:

Podocarpus madagascariensis Baker var. ***madagascariensis***. Type: Madagascar: ["central Madagascar"], *G. W. Parker s.n.*, Aug 1880 (lectotype K, here designated).

Description

Leaves coriaceous, more or less rigid and spreading, (2–)3–15(–18) cm long, (3–)5–14(–16) mm wide; apex acute or obtuse. Seeds including the epimatium ovoid-globose.

Distribution

Madagascar, along the eastern plateaux and mountains.
TDWG codes: 29 MDG

Conservation

IUCN: NT

Podocarpus madagascariensis Baker var. ***procerus*** de Laub., Adansonia 11 (4): 715. 1971. Type: Madagascar: Toliara Prov., Fort Dauphin, Forêt de Bemangidy, *R. Capuron SF 11774* (holotype P).

Description

Leaves mostly lax and drooping, linear, 5–13 cm long, 4–6.5 mm wide, thin coriaceous; margins revolute; apex acute or sometimes obtuse.

Distribution

Madagascar: near Tolanaro [Fort Dauphin] and Massif de Bekolosy.
TDWG codes: 29 MDG

Conservation

This variety was listed as Endangered in a pre-1994 IUCN Categories and Criteria listing on the grounds of its rarity and restricted distribution near Tolanaro [Fort Dauphin] in the SE of Madagascar. However, it is also known from the Massif de Bekolosy in the far north of the island, and from a locality in Fianarantsa Province. Logging and deforestation are the main threats.
IUCN: EN [B2ab (ii, iii, v)]

Podocarpus madagascariensis Baker var. ***rotundus*** L. Laurent, Ann. Fac. Sci. Marseille 23: 59. 1915. Type: Madagascar: Massif du Manongarivo, 1500–1800 m alt., *J. M. H. A. Perrier de la Bathie* (P, not designated).

Description

Leaves (3–)5–7 cm long, 4–6 mm wide, acuminate or with a long attenuate apex. Seeds including the epimatium nearly globular.

Taxonomic notes

Only known from the Massif de Bekolosy (Bekolosy River) and Massif du Manongarivo (river) in the far NW of Madagascar, but taxonomically perhaps doubtfully distinct and in need of critical revision.

Distribution

Madagascar: Massif de Bekolosy, Massif du Manongarivo.
TDWG codes: 29 MDG

Conservation

A conservation assessment of this variety is difficult, because very few collections are known in the herbaria, and its taxonomic distinction is somewhat doubtful.
IUCN: DD

Podocarpus magnifolius J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 133. 1948. Type: Venezuela: Bolivar, La Gran Sabana, Ptari-tepui, *J. A. Steyermark 59989* (holotype F).

Etymology

The species epithet describes the large leaves.

Vernacular names

'Cinqui-masé' (Peru)

Description

Trees to 30 m tall; trunk erect, d.b.h. to 60 cm. Bark of larger trunks becoming fissured, with longitudinally exfoliating strips 3–5 cm wide, dark brown; inner bark pink. Branches spreading to form a broad, rounded crown in mature trees. Foliage branches robust, terete, finely grooved between leaf bases, terminating in subglobose buds 3–5 mm wide at base, with imbricate, broadly triangular to ovate, carinate scales with a short acuminate or obtuse apex; axillary buds smaller, globose. Leaves variable in size especially on different trees, generally largest on saplings and young trees, commonly 7–13 cm long and 15–20 mm wide, but as small as 3 cm long and 12 mm wide and as large as 27–29 cm long and 27–30 mm wide, on saplings acuminate, on mature trees acute, acuminate or sometimes more or less obtuse in a few leaves, lanceolate to nearly linear from a short petiolate base, straight or slightly falcate, lustrous green above, dull pale green below. Midrib on adaxial (upper) side slightly raised, with a groove in the centre, on abaxial side obtusely raised, to 1 mm wide, continuous to apex on both sides. Stomata very small, in numerous intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary, sessile, at base with spreading perular scales with scarious margins, cylindrical, elongating to 30–40 mm, 3–4 mm wide; microsporophylls triangular, with two relatively large, oval pollen sacs at base. Seed cones axillary, solitary on 10–20 mm long peduncles; receptacles formed of an axis with two unequal bracts, exposing acute bract tips after swelling, 8–12 mm long, 6–7 mm wide at distal end, green ripening to succulent and bright red. Seeds single on the largest bract, including the epimatium 9–11 mm long, 5–6 mm wide, obliquely ovoid, with a crest. Seed proper not observed.

Distribution

Central America: Panama; South America: Bolivia (La Paz), Colombia, Peru (Huánuco, Pasco, San Martín), Venezuela (Cordillera de Merida, Venezuelan Highlands, Pico de Neblina).
TDWG codes: 80 PAN 82 VEN 83 BOL CLM PER

Ecology

Podocarpus magnifolius is a species of tropical montane, evergreen rainforests at altitudes from 850 m a.s.l. to ca. 1800 m a.s.l. and of cloud forests to an altitude of 2900 m a.s.l. at least in the Cordillera do Merida of Venezuela. Not much information has been recorded with herbarium collections, so we don't yet know with what other tree species *P. magnifolius* is commonly associated. The extraordinary large leaves encountered in some trees point to a shade tolerant tree that can hold its own with most large-leaved angiosperms and its maximum height would certainly take it into the forest canopy.

Conservation

Conservation assessment of this (and other) species of *Podocarpus* is hampered by the fact that we do not know which species are involved in logging operations of several that occur within the large range of *P. magnifolius*. Based upon that range, and assuming that it is more common than the fairly limited number of herbarium collections suggest, it might be considered of Least Concern (LC), since extensive forests still remain in the region. On the other hand, the decline may be more serious. The species was recognized as distinct in 1948 and for many years it remained only known from Bolivia and Venezuela, now we know it from Colombia, Peru and Panama as well.
IUCN: LC

Uses

This species is widespread but uncommon in the forests of Panama and NW South America, where it is undoubtedly logged when encountered for its

valuable timber. The wood is used in construction and carpentry, and perhaps also in furniture making. This species is not known in cultivation, but would be of interest in botanic gardens to show to the public that conifers can have really large leaves, like broad-leaved trees (angiosperms). Its leaf size is perhaps only surpassed among conifers by the very rare species *Nageia maxima* from Borneo.

Podocarpus matudae Lundell, Phytologia 1 (6): 212. 1937, ["*matudai*"]. Type: Mexico: Chiapas, Cerro Pasitar, *E. Matuda 698* (holotype MICH). Fig. 274

Podocarpus reichei J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 131. 1948; *Podocarpus matudae* Lundell var. *reichei* (J. T. Buchholz & N. E. Gray) de Laub. & Silba, Phytologia 68: 69. 1990.
Podocarpus matudae Lundell var. *macrocarpus* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 132. 1948.
Podocarpus matudae Lundell var. *jaliscanus* de Laub. & Silba, Phytologia 68: 68. 1990.

Etymology

This species was named after its discoverer E. Matuda.

Vernacular names

palmito, sabino (parts of Mexico).

Description

Large trees to 30 m or taller, up to 1.5 m d.b.h.; trunk monopodial, erect. Bark thin, smooth in young trees, eventually becoming scaly, light brown weathering grey. Branches spreading or ascending, forming a domed crown in large trees. Foliage branchlets slender, straight, terete, with fine grooves from decurrent leaf bases. Terminal vegetative buds 8–12 mm long, with more or less spreading, long acuminate scales; axillary buds smaller, 3–4 mm long, with acuminate scales. Leaves of saplings larger than of mature trees, to 20 cm long and 17 mm wide; leaves on mature trees narrowly lanceolate, straight or slightly falcate, flat, 5–14 cm long, 8–13 mm wide (smallest on canopy branches of old, slow growing trees), coriaceous, gradually narrowing to a short petiolate base, very gradually tapering to an acute or more or less acuminate apex. Midrib prominent but narrow (less than 1 mm wide) at least in proximal half of adaxial (upper) side, sometimes lying in a shallow groove or depression, fading towards apex, thin and inconspicuous, sometimes grooved in the middle (*in sicco*) on abaxial side. Stomata small and in numerous intermittent lines on abaxial side. Pollen cones axillary, solitary, sessile, cylindrical, expanding to 30–45 mm long, 4–5 mm wide when full-grown; microsporophylls with two globose pollen sacs. Seed cones axillary, solitary on short peduncles; receptacles 6–12 mm long, swelling and becoming succulent, red turning purplish brown. Seeds including the epimatium 8–12 mm long, broadly ovoid, with an inconspicuous crest, drying dark brown. Seed proper ovoid, 6–*8* mm long, slightly flattened.

Taxonomic notes

Lundell (*op. cit.*) briefly described *P. matudae* as a new species from Chiapas, Mexico, based on *E. Matuda 698* with rather short and broad leaves. No mention was made of the vegetative buds, while apparently the seed cones were not present in Matuda's specimens seen by Lundell. Buchholz and Gray (*op. cit.*) added a new species from south-central Mexico, *P. reichei*, but also cited this new species from a collection made in Costa Rica. The leaves are similar, if we ignore their observations about presence or absence of sclereids in the mesophyll as an informative character, but the seed cones (seeds) are larger than those in *P. matudae*. However, Buchholz & Gray also described, from Chiapas and Guatemala, a new variety *P. matudae* var. *macrocarpus*, with (maximum) seed dimensions exceeding those of *P. reichei* and with 4–6 cm long pollen cones. Maturity of these organs is crucial for proper comparison, as often they are not full grown on the specimens examined. In all this material the buds with their long acuminate scales are most characteristic and I consider it to belong to a single species occurring from central Mexico to Costa Rica. De Laubenfels & Silba (*op. cit.*) described a variety *jaliscanus* with leaves up to 20 cm long from Jalisco, Mexico, but no information is given about the range of sizes found in leaves from

this area or whether these long leaves occurred only on vigorous shoots of shaded plants or not.

Distribution

Mexico: Chiapas, Jalisco, Michoacán, Nayarit, Oaxaca, Puebla, Queretaro, San Luis Potosí, Tamaulipas, Veracruz; El Salvador; Guatemala (Huehuetenango); Honduras.
TDWG codes: 79 MXC-PU MXE-QU MXE-SL MXE-TA MXG-VC MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 GUA ELS HON

Ecology

Podocarpus matudae is found in mixed pine forest, pine-oak forest, montane rain forest, and evergreen cloud forest, with an altitudinal range from (600–)1100 m to 2600 m a.s.l. Most trees in the broad-leaved forests are oaks (*Quercus* spp.) but also abundant are other deciduous trees such as *Liquidambar, Magnolia, Ostrea, Clethra*, and, especially in Chiapas, Puebla and Veracruz, species of northern genera like *Fagus*, *Carpinus* and *Platanus*. It grows often in ravines near streams. Precipitation is high, with annual rainfall of 1500–3000 mm and frequent fog at high altitudes.

Conservation

The range of this species is extensive, based on the mapping of herbarium collections the extent of occurrence (EOO) exceeds 600,000 km², but its distribution is apparently disjunct and scattered. It has been found in a variety of forest types, most of which are under pressure from logging, deforestation, habitat degradation etc., but to what extent this affects *P. matudae* is not known, but there is no doubt that it is declining. This species occurs in the following protected areas: El Trunfo Reserve, Reserva de la Biósfera El Cielo, Cuenca Hidrografica del Rio Necaxa and the Pico Pijol Reserves in Mexico and Honduras.
IUCN: VU [B2ab (ii, iii, v)]

Uses

The wood of this tree is fine grained, yellow, and of high quality for building and construction purposes. *Podocarpus matudae* is slow growing and can only be harvested sustainably at very long rotations, while successful regeneration requires a forest habitat with a mixture of other trees (microclimate) as well as the animal vector for its dispersal. It is therefore not suitable for plantation forestry. In warm temperate to subtropical countries it would be a suitable amenity tree for streets and parks. It is occasionally seen in cultivation, mainly restricted to arboreta and other living plant collections, and in the western USA usually under its synonym *P. reichei*.

Podocarpus micropedunculatus de Laub., Blumea 30 (2): 268. 1985. Type: Malaysia: Sarawak, 4th Division, Marudi F. R., *D. J. de Laubenfels P 564* (holotype A).

Etymology

The species epithet refers to the very short peduncle of the seed cone.

Vernacular names

kayu china (Sarawak); kayu tjina (Sabah)

Description

Shrubs or small trees 1–7(–13) m tall, stems 5–20 cm diam., vegetatively reproducing from rhizomes. Foliage branchlets terete, glabrous, finely grooved or striate, terminating in an elongated bud 6–15 mm long, 2–3 mm wide at base, with free, erect to slightly spreading linear-lanceolate scales drawn out in a caudate apex. Leaves lanceolate to linear-lanceolate, (6–)8–14(–18) cm long, 10–15(–20) mm wide [somewhat larger and wider in juvenile plants than in adult plants, but the distinction is vague due to vegetative reproduction] petiolate, more or less abrubtly widening at base, with parallel sides for most of their length, gradually tapering to an acuminate or sometimes acute apex. Midrib acutely raised and narrow on adaxial (upper) side, wider and almost flat to sunken (*in sicco*) on abaxial side. Stomata very small, in numerous irregular lines on abaxial side on either side of midrib. Pollen cones axillary, sessile or on a very short peduncle, solitary or in groups

of 2–3, subtended by 4–5 mm long acuminate bracts (bud scales), elongating to 35–75 mm, 3–4 mm wide at anthesis; microsporophylls apiculate, bearing two elongated pollen sacs at base. Seed cones axillary, solitary, on a 1 mm long peduncle; receptacles subtended by 2 recurved, 3–4 mm long bracts ('foliola'), 8–10 mm long, ripening to a swollen, succulent, red 'fruit'. Seeds including the epimatium ovoid, 8–10 × 6–7 mm, with a distal, curved crest.

Distribution

Malaysia: NW Sabah, N Sarawak, Brunei.
TDWG codes: 42 BOR-BR BOR-SB BOR-SR

Ecology

Podocarpus micropedunculatus is known to occur as an understorey tree in *Agathis* forest, where it is accompanied by other podocarpaceous conifers and by angiosperms adapted to poor sandy soil ('kerangas' forest). It is more abundant and may form a major element in the vegetation in shrubby thickets along the margins of forest clearings, again mostly on sandy, podzolic soils, or on sandstone. It also occurs in peaty soils, usually podzolic, of raised beaches, and in peat-swamp forest, from sea level to around 500 m a.s.l. Sometimes this species is associated with *Dryobalanops rappa* and *Shorea albida* (both *Dipterocarpaceae*), again as an understorey tree. This species shares the rare habit of rhizomatous propagation with *Podocarpus drouynianus* in SW Australia; the latter however never develops into a tree.

Conservation

This species is insufficiently known and since its description and naming in 1985 few collections have been made, so that an assessment using herbarium based data was not possible. Its growth habit and occurrence on the edges of forest clearings seem to indicate that it may have declined but is probably not in danger of extinction.
IUCN: NT (A2)

Uses

No uses have been recorded for this shrubby species. It could perhaps be suitable as a shrub in tropical to subtropical gardens.

Podocarpus milanjianus Rendle, Trans. Linn. Soc. London, Bot., ser. 2, 4: 61. 1894. Type: Malawi: Mulanje District, Mulanje Highlands, Mt. Mulanje, *A. Whyte s.n.*, Oct 1891 (lectotype BM, here designated). Fig. 275

Etymology

The species epithet refers to Mt. Mulanje in Malawi, where Alexander Whyte collected it in 1891.

Vernacular names

lusamina (Swahili)

Description

Trees to 35 m tall; trunk to 1.8(–3.5) m d.b.h., but small and stunted at highest altitudes. Bark thin, smooth or shallowly fissured longitudinally, exfoliating with small, thin flakes or strips, light or dark brown, weathering grey. Branches spreading, forming a broadly domed crown in large trees. Foliage branches terete, finely grooved or ridged, in slow growing (exposed) crowns with old leaf markings, terminating in 3–4 mm wide, obtuse buds with a few spreading and recurving outer scales. Leaves on seedlings and young trees similar to those on mature trees, but variable in size mostly in relation to exposure and/or altitude, 1.5–5 cm long on small, stunted trees above 3000 m altitude, 5–17 cm long on trees in forests at lower altitudes, 5–16 mm wide, elliptic, lanceolate-linear to linear, straight or slightly falcate, coriaceous; margins flat or slightly revolute, gradually tapering down to a petiolate base and to an acute apex. Midrib raised at least from leaf base to beyond the middle, situated in a shallow groove, ca. 0.5 mm wide on the adaxial (upper) side; continuous to apex, wider and flattened on abaxial side. Leaf colour lustrous green above, dull green or sometimes glaucous green below. Stomata small, in numerous intermittent and wavy lines on either side of abaxial midrib. Pollen cones axillary, solitary, sessile or nearly sessile, subtended by imbricate, broadly rounded, carinate bud scales, cylindrical, elongating to 30–40 mm, 3–3.5 mm wide at anthesis; microsporophylls spirally arranged, imbricate, with slightly elongated apex and minutely erose-denticulate margin, bearing two basal pollen sacs. Seed cones axillary, solitary on slender ca. 10 mm

long peduncles, the two bracts ('foliola') at base small and early deciduous; receptacles consisting of an axis with two bracts fusing and swelling to a 10–13 × 7–9 mm, succulent red body. Seeds normally solitary at oblique distal end of receptacle, including the epimatium ca. 8 × 10 mm, ovoid-globose without a distal crest, green or whitish pruinose, turning dark purple. Seed proper ca. 6 × 8 mm with a smooth, hard seed coat, brown.

Taxonomic notes

According to the protologue, the type should be from original material cited as "Habitat in Milanji, 6000 ft, Oct. [1891] Nos. 34 & 39" of Alexander Whyte's collections, which are kept at BM. In that herbarium, the only original material now extant is a specimen collected by Whyte in October 1891 on Mt. Mulanje, but without a number mentioned on the original sheet fragment; it was separated from another person's collection and remounted, stating it is "part of Type". It is here designated as the lectotype of *Podocarpus milanjianus*.

Distribution

Tropical Africa: Angola, Burundi, Cameroon, Congo Republic, Kenya, Malawi, Mozambique, Nigeria, Rwanda, S Sudan, Tanzania, Uganda, Dem. Rep. Congo [Zaire], Zambia, Zimbabwe.
TDWG codes: 22 NGA 23 BUR CMN RWA ZAI 24 SUD 25 KEN TAN UGA 26 ANG MLW MOZ ZAM ZIM

Ecology

Podocarpus milanjianus is a montane to high montane species occurring in tropical evergreen rainforest, cloud forest, or at its highest limit in dwarf forest dominated by *Ericaceae*, interfacing with subalpine grassland. The altitudinal range is (900–)1300–3000(–3250) m a.s.l. and about as great in west tropical as in east tropical Africa. It does not form conifer forest, although it can occur in forest dominated by *Juniperus procera* in e.g. Kenya, and is usually accompanied by angiosperm trees; however it will often become more abundant on exposed, thin-soiled mountain ridges where the forest becomes low and, at high altitudes, even stunted. In tall forest it is often restricted to stream sides in deep ravines. In eastern Africa common associated angiosperm tree genera in the forests are *Albizia, Croton, Macaranga, Ocotea, Olea, Schefflera*, and *Syzygium*; in Cameroon *Agauria, Albizia, Ilex, Nuxia, Olea, Pyseum, Schefflera*, and *Syzygium* are common with *P. milanjianus*, e.g. on Mt. Oku. 'Elfin' forest occurs at the highest altitudes above ca. 2800 m and can consist largely of *Erica arborea* in eastern Africa, or is mixed, with e.g. *Agauria, Cussonia, Myrica, Myrsine, Philippia, Syzygium*, and *Tecomaria*. Interfaces with grassland (*Arundinaria alpina*) occur here, often with poor drainage and *P. milanjianus* concentrated along rocky streams.

Conservation

IUCN: LC

Uses

This species is an important timber tree in many parts of tropical Africa. Its wood is valued for carpentry and joinery as it is light coloured, even grained, easily worked, and large trees yield good sizes of sawn timber. More specialized uses requiring high grade timber are veneer, furniture making, cabinet making, interior trim, household utensils, and wood carving. It has been used in afforestation on a small scale in several African countries, within and perhaps without its natural range. It is not known to be used in horticulture and is probably restricted to a few botanic gardens in Africa and/or other tropical countries or in glasshouses in cooler regions. Provenances from high altitudes may well be hardy enough to survive in European and other countries with mild winters and abundant rainfall, but no one seems to have tried it.

Podocarpus nakaii Hayata, Icon. Pl. Formos. 6: 66. 1916. *Podocarpus macrophyllus* (Thunb.) Sweet var. *nakaii* (Hayata) H. L. Li & Keng, Taiwania 5: 39. 1954. Type: Taiwan: Nantou Co., Holisha, Ta-shu-ku, ["Toshoko"], *S. Nakai s.n.* (holotype TI). Fig. 276, 277

Etymology

This species was named after the Japanese plant collector S. Nakai.

Vernacular names

tai wan luo han song (Chinese)

Description

Trees to 20 m tall, with erect, terete trunk. Bark not described or observed. Foliage branchlets terete, grooved, glabrous, terminating in globose buds ca. 4 mm diam. with imbricate, triangular scales. Leaves lanceolate to linear-lanceolate, (3–)5–10(–12) cm long, 8–15 mm wide, straight or slightly curved towards apex, tapering gradually to a petiolate and slightly twisted base ca. 5 mm long and an obtuse or sometimes acute apex; margins entire and smooth; midvein acutely raised adaxially, slightly raised or nearly flat abaxially; leaf colour mid green above (adaxially), pale green below; flushing leaves reddish pink or sometimes light green. Stomata on abaxial side, very small, in numerous irregular lines on either side of midrib. Pollen cones axillary, sessile, solitary or in clusters of 2–3, becoming long cylindrical and lax at anthesis, 20–40 mm long, 2–3 mm wide; microsporophylls arranged in steep spirals, triangular-apiculate, spreading, yellowish green, with two sublateral, globular, yellow pollen sacs. Seed cones axillary, solitary on 2–10 mm long peduncles; receptacles subtended by (1–)2 small, more or less linear bracts ('foliola'), 10–14 mm long, swelling to 10 mm thick, succulent, changing colour from glaucous green to yellow to crimson red when ripe, subtended by two small, leaf-like, deciduous bracts. Seeds solitary, obliquely ovoid, 8–9 × 6 mm, slightly flattened, covered by a pruinose epimatium, ripening blackish blue, crested distally. Seed proper ovoid, 7 × 5 mm.

Taxonomic notes

Podocarpus nakaii is similar to *P. macrophyllus* and has been treated as a variety of it. The pollen cones are solitary or with 2–3 together, not in clusters of 3–5 as in *P. macrophyllus*, and the leaves are usually wider, but the ranges of these measurements overlap. *Podocarpus macrophyllus* var. *macrophyllus* is cultivated in Taiwan, but its var. *maki* occurs in natural forests at low to middle elevations along the steep eastern coast of the island.

Distribution

Taiwan (Chianghua Co.?, Nantou Co., Taichung Co.).
TDWG codes: 38 TAI

Ecology

Podocarpus nakai occurs scattered in broad-leaved (angiosperm) forests in the central mountains of Taiwan. These forests are dominated by the families *Fagaceae* and *Lauraceae*, with *Theaceae* and *Magnoliaceae* also prominent. Characteristic genera of trees are *Cyclobalanopsis* (= *Quercus*), *Lithocarpus, Machilus* (= *Persea*), *Cryptocarya, Schima*, and *Magnolia*. The altitudinal range of this species rich evergreen forest type is from 700 to 1800 m a.s.l. and it exists under a markedly monsoonal subtropical climate.

Conservation

This species although not specifically targeted by loggers as it is generally of only small to moderate size, has suffered greatly from general deforestation in the period after World War II. Much of the primary forest where *P. nakaii* occurred has gone, or it has been turned into secondary vegetation unsuitable for this species. A locality in Chianghua where W. R. Price collected the species in 1912 probably no longer has it growing there; Flora of Taiwan, ed. 2, 1: 565 (1994) only mentions Nantou for its distribution. Fewer than 250 mature trees are now thought to exist.
IUCN: EN (A1a, D)

Uses

No uses have been recorded for this species; its wood was logged with other trees, and if of good size and shape would have been used for construction, carpentry, etc. It is probably in cultivation, but it may masquerade under the name *Podocarpus macrophyllus*.

Podocarpus neriifolius D. Don, in Lambert, Descr. *Pinus* 2: [21]. 1824.

Etymology

The species epithet means 'leaf like that of the genus *Nerium*' [oleander].

Vernacular names

Brown pine; podo bukit (Malay); numerous local names are in use in Malesia (see De Laubenfels, Flora Malesiana, ser. 1, 10 (3): 401. 1988); bai ri qing (Chinese); Thông tre lá dài (Vietnamese). Pilger (1903) cites kimerah and kiputri as names for the Indonesian island of Jawa, but these seem to apply to several species of 'podocarps' now in different genera. In Vanuatu the name 'nuhuoto' was recorded; in Fiji (Viti Levu) 'asimbolo', (Vanua Levu) 'kuasi'.

Description

Shrubs or trees to 45 m tall, to 75(–100) cm d.b.h., bole straight, in large trees slightly fluted or rarely buttressed at base. Bark smooth, thin, on large boles with narrow, longitudinal flakes or strips, light brown weathering grey; inner bark pinkish or reddish brown, fibrous. Branches spreading, forming a rounded or domed crown. Foliage branchlets terete, more or less grooved, glabrous, terminating in 2–5(–8) mm long buds with spreading, triangular to lanceolate outer scales. Leaves on juvenile plants short petiolate, linear-lanceolate, 15–20(–25) cm long, 17–26 mm wide, often curved and with undulating margins, abrubtly narrowed at base, long acuminate or acute. Leaves of mature trees usually much shorter and narrower, shade leaves (6–)8–15 cm long, (8–)12–18 mm wide, acuminate; leaves more exposed to light mostly linear-lanceolate or lanceolate, (4–)8–12(–15) cm long, 6–15 mm wide, straight or slightly curved, petiolate at a more gradually narrowing base, tapering to an acute apex. Midrib acutely (sometimes obtusely) raised adaxially, flat or obtusely (sometimes acutely) raised abaxially, usually narrower on adaxial side; leaf colour dark green above, pale green below; new leaves flushing red. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, solitary or in clusters of 2–3, sessile with several basal, carinate bud scales, cylindrical, elongating to 25–40(–50) mm, 2–3.5 mm wide; microsporophylls spirally arranged, triangular, spreading, with two globose pollen sacs. Seed cones axillary, solitary on a 5–20 mm long peduncle; receptacles with 2 subulate bracts ('foliola') 2–6 mm long at base, swelling to become ellipsoid with a truncate distal end, 8–10 mm long, yellow turning orange-red or bright red and succulent when ripe. Seeds solitary at truncate end of receptacle, enclosed in a smooth epimatium, green turning purplish green when ripe, ovoid-oblong or ovoid-globose, (8–)10–15 × 7–8 mm. Seed proper ovoid, 6–10 mm long, slightly flattened.

Taxonomic notes

In Flora of China 4: 83 (1999) and in the World Checklist and Bibliography of Conifers (Farjon, 1998, [2001]) *P. annamiensis*, described by N. E. Gray (*op. cit.*) from Indochina, Myanmar [Burma] and Hainan Island, is recognized as a distinct species, in China restricted to Hainan. However, the stated differences with *P. neriifolius* are very small and seem to be inconsistent. It appears that these differentiating character states (e.g. apiculate leaf apex, conspicuously raised midvein on both sides of the leaf in *P. annamiensis*) can be found in *P. neriifolius* from parts of its range beyond the areas where *P. annamiensis* is supposed to occur. *Podocarpus annamiensis* is therefore here treated as synonymous, in agreement with recent treatments of the two taxa especially concerning the conifers of Viet Nam (Nguyen Tien Hiep & Vidal, 1996; Nguyen Tien Hiep *et al.*, 2004). See also the Taxonomic notes under *P. subtropicalis* for an opposite view on which taxa to exclude from or include with the widespread and variable species *P. neriifolius*. Gray (1958) described *P. neriifolius* var. *degeneri* from Fiji (Viti Levu) as a distinct variety. Silba (1984) elevated it to a species, while De Laubenfels (1985) separated the two species into different sections, apparently based on slightly different sizes of the 'foliola' or basal bracts on the receptacles. Such minutiae hardly justify classifications at the species level, considering variations, and are not evident in the specimens seen at Kew (K). In a revision of Fijiian conifers, Doyle (1998) has treated *P. neriifolius* var. *degeneri* as a synonym of *P. neriifolius*. The narrower leaves appear to justify

varietal distinction and I follow Netta Gray in this case. Yet another new species, *P. epiphyticus*, was described from Myanmar [Burma] by De Laubenfels and Silba (1988). In the protologue it is said to be "an epiphytic shrub" which was taken from the type specimen label. The isotype specimen (*J. Keenan 3081* at K) is a branchlet with typically broad juvenile foliage leaves belonging to *P. neriifolius*. It was probably a young plant germinated and growing upon a tree, as conifers (and other trees) sometimes do, but it can be categorically stated that there are no obligate epiphytes among conifers.

Distribution

From E Nepal and Bangladesh through Myanmar [Burma] and Indochina (including the Andaman Islands), S and SW China, Malesia, Papuasia, Vanuatu and Fiji.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-SC CHC-YN CHH CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JX CHS-ZJ CHT 40 ASS-ME ASS-MI BAN NEP 41 AND-AN CBD LAO MYA THA VIE 42 BOR-BR BOR-KA BOR-SB BOR-SR JAW LSI-BA LSI-ET LSI-LS MLY-PM MOL PHI SUL SUM 43 BIS NWG-IJ NWG-PN SOL-NO SOL-SO 60 FIJ VAN

Ecology

Podocarpus neriifolius is the most widespread species in the genus. It occurs as a scattered tree in evergreen primary broad-leaved forests, either in the understorey or more commonly (and eventually) as a canopy tree. Its altitudinal range in China is from 100 m to 1500 m a.s.l., but in tropical Malesia it occurs from near sea level to 2900 m a.s.l. It is usually confined to well drained sites away from rivers, but occasionally it occurs in swampy forest. The soils vary from nutrient-poor sands ('kerangas' in Borneo), sandy clay or sandstone, to andesitic laterites (latosols) and ultrabasic soils over serpentine in New Guinea. In China and Indochina it is a component in *Lithocarpus-Castanopsis* mixed evergreen forest. In Malesia this conifer is commonly associated with other podocarps e.g. *Dacrycarpus imbricatus, Dacrydium* spp. and *Podocarpus* spp., and occasionally with *Agathis* spp. and/or *Phyllocladus trichomanoides*, especially on mountain ridges, and with numerous angiosperm trees of the families *Fagaceae, Myrtaceae, Sapindaceae, Guttiferae* (*Clusiaceae*), *Cunoniaceae, Rutaceae*, and many others.

Conservation

This species, while logged extensively as a valuable timber tree, is too widespread and common in most areas to be classified as threatened with extinction under the IUCN criteria. Locally, its status may be more severe depending on rates of logging and levels of general deforestation. The species is listed on CITES Appendix III (at the request of Nepal in 1975), which means that certificates or permits are required to export its timber from that country.

IUCN: status listed under varieties.

Uses

This widespread species is an important timber tree in several countries where it is common. Its excellent wood is used for house construction and carpentry and for making oars, spars, and masts of sailing vessels. More specialized uses requiring high grade timber are veneer, furniture making, cabinet making, interior trim, household utensils, and wood carving. In New Guinea, Highland tribes use the bark to insulate walls of round houses. As far as known it is not in cultivation; in China and several countries where plants under this name are introduced and/or cultivated, these commonly belong to *P. subtropicalis* originating from Emei Shan [Mt. Omei] in Sichuan, China, or perhaps to yet other similar species. This identity may also apply to a cultivar with variegated leaves that is occasionally seen labeled under *P. neriifolius*.

2 varieties are recognized:

Podocarpus neriifolius D. Don var. ***neriifolius***. *Margbensonia neriifolia* (D. Don) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Nepal ["Legi ad Sankoo,…Napaliae 1821"], *N. T. Wallich 6052A* (lectotype BM, isolectotype K-W). Fig. 278, 279

Podocarpus neriifolius D. Don var. *polyanthus* Wasscher, Blumea 4 (3): 455. 1941; *Podocarpus polyan-*

thus (Wasscher) Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 191. 1976 (*nom. inval.*, Art. 33.2).
Podocarpus decipiens N. E. Gray, J. Arnold Arbor. 36: 204. 1955; *Podocarpus neriifolius* D. Don var. *decipiens* (N. E. Gray) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 35. 2000.
Podocarpus annamiensis N. E. Gray, J. Arnold Arbor. 39: 451. 1958.
Podocarpus annamiensis N. E. Gray var. *hainanensis* Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 175, 210. 1976 (*nom. inval.*, Art. 37.1).
Podocarpus epiphyticus de Laub. & Silba, Phytologia 64: 290. 1988.
Podocarpus neriifolius D. Don var. *penibukanensis* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 34. 2000.
Podocarpus neriifolius D. Don var. *staintonii* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 36. 2000.

Description

Trees to 45 m tall. Terminal buds small, 2–4 mm long, with spreading, triangular to lanceolate outer scales. Leaves on mature trees 8–15 cm long, 12–18 mm wide, acuminate; leaves more exposed to light mostly linear-lanceolate or lanceolate, (4–)8–12(–15) cm long, 6–15 mm wide. Leaves on juvenile plants 15–20(–25) cm long, 18–26 mm wide

Distribution

From E Nepal and Bangladesh through Myanmar [Burma] and Indochina (including the Andaman Islands), S and SW China, Malesia, Papuasia, Vanuatu and Fiji.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-SC CHC-YN CHH CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JX CHS-ZJ CHT 40 ASS-ME ASS-MI BAN NEP 41 AND-AN CBD LAO MYA THA VIE 42 BOR-BR BOR-KA BOR-SB BOR-SR JAW LSI-BA LSI-ET LSI-LS MLY-PM MOL PHI SUL SUM 43 NWG-IJ NWG-PN SOL-NO SOL-SO 60 FIJ VAN

Conservation

IUCN: LC

Podocarpus neriifolius D. Don var. ***degeneri*** N. E. Gray, J. Arnold Arbor. 39: 467. 1958. *Podocarpus degeneri* (N. E. Gray) de Laub. *ex* Silba, Phytologia Mem. 7: 61. 1984; *Margbensonia degeneri* (N. E. Gray) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Fiji: Viti Levu, Mba, Nandarivatu, *O. Degener DA 14272* (holotype A).

Description

Shrubs or small trees. Terminal buds large, to 8 mm long, ovoid, outer scales acuminate to long attenuate or apiculate. Leaves on mature trees 6–12 cm long, 6–10 mm wide, linear, acute. Leaves on juvenile plants to 18 cm long and 17 mm wide.

Distribution

Fiji: Vanua Levu, Viti Levu.
TDWG codes: 60 FIJ

Ecology

Podocarpus neriifolius var. *degeneri* occurs in evergreen forests, at altitudes between 40 m and 1050 m a.s.l. In one locality it was found growing with *Musa, Casuarina, Myrtaceae*, etc. in dense forest; other records mention "dry forest, along stream", so it is dependent on a permanent supply of water. Where precipitation increases with altitude, this podocarp will be mixed with other rainforest trees away from streams.

Conservation

Podocarpus neriifolius was assessed as "LRlc" (Least Concern) for Fiji by M. F. Doyle in Farjon & Page (1999) and this pertains to both varieties.
IUCN: LC

Podocarpus nivalis Hook., Icon. Pl., n.s., 2: t. 582. 1843. Type: New Zealand: [locality unknown], *W. Colenso s.n.* (holotype K). Fig. 280, 281

Etymology

The species epithet means 'growing in or near snow' and refers to the alpine habitat of this species.

Vernacular names

Alpine totara, Mountain totara, Snow totara

Description

Decumbent, sprawling or more or less erect shrubs, 20–40 cm to 2 m tall, multi-stemmed. Foliage branches spreading or ascending, in decumbent shrubs with creeping whip shoots, forming matted shrubs of a few square meters in extent. Terminal buds very small, with imbricate scales, hidden among leaves. Leaves crowded, spirally arranged, spreading at narrow to wide angles from shoot, 3–10 mm long, 2–2.5 mm wide, boat-shaped (naviculate) to ovate-linear, curved outwards or down on some branchlets, narrowly decurrent at base, obtuse or mucronate at apex, thick coriaceous, rigid, canaliculate (grooved) adaxially (above), with an obtuse midrib abaxially. Stomata on abaxial (lower) side of leaf, on either side of midrib below, in intermittent white lines. Pollen cones axillary, on short peduncles with several small, obtuse bracts, solitary or with 2–3 or more together, very slender cylindical, 10–15 mm long, 1–1.5 mm wide at anthesis; microsporophylls peltate, apiculate, very small, with two relatively large, globose pollen sacs. Seed cones axillary, nearly sessile, solitary; receptacles originating from a short axis with two fused bracts, swelling to sub-globose, 8–10 × 8 mm, becoming succulent and scarlet. Seeds including the epimatium ovoid with a constricted distal end, 4–5 × 3 mm, lustrous light green. Seed proper not observed.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Podocarpus nivalis occurs at higher altitudes in the sub-alpine to alpine scrubland and tussock grassland of the New Zealand mountains. Its altitudinal range varies from 800 m to 2500 m a.s.l. depending on local climate and exposure. It is a species that commonly creeps low over rocks, but when competing with tall grasses or in tall scrubland it may grow to a more erect bush, sometimes several meters wider than tall. In open tussock grassland (*Chionochloa rubra*) it is often associated with *Hebe, Olearia, Dracophyllum, Gleichenia*, and the moss *Racomitrium*, etc. In scrubland it can be found with the conifers *Halocarpus bidwillii* and *Phyllocladus trichomanoides* var. *alpinus*, often interspersed with ericoid dwarf shrubs and scattered grasses in a lichen-rich ground cover.

Conservation

IUCN: LC

Uses

Mountain totara is fairly common in cultivation, especially for rock gardens where prostrate forms will grow readily over rocks, banks and low walls. The more upright forms are suitable for hedges lower than 1 m and take regular clipping well. This shrub is quite hardy depending on provenance and grows on almost any soil. No cultivars are known of this species and plants in the trade are propagated from cuttings; as the species is dioecious these usually do not produce receptacles ('berries').

Podocarpus novae-caledoniae Vieill., Ann. Sci. Nat. Bot., sér. 4, 16: 56. 1862. Type: New Caledonia: Grande Terre, Province Sud, Païta, *E. Vieillard 1266(b)* (holotype P). Fig. 282, 283

Podocarpus beecherae de Laub., New Zealand J. Bot. 41: 715. 2003.

Etymology

The species epithet refers to New Caledonia, where the species is endemic.

Vernacular names

No common names have been recorded of this species.

Description

Shrubs 1–2 m tall, rarely a small tree to 6 m tall; densely branched, erect and rounded or more

elongated in small trees. Bark fibrous, light brown weathering grey. Foliage branchlets numerous, slender, terete, glabrous with minute grooves between leaf bases, terminating in small, ovoid or subglobose buds with imbricate, appressed, triangular, weakly keeled, 1–2 mm long bud scales. Leaves on juvenile plants longer than on mature plants, up to 12 cm. Leaves on mature plants (2.5–)4–8(–10) cm long, 3–5(–6) mm wide, linear, straight or slightly falcate, gradually or sometimes more abruptly widening from a petiolate base, mostly with two parallel sides up to a gradually tapering, acute or obtuse apex. [Shortest leaves may differ in being either narrowly lanceolate and acute or sometimes slightly wider above the middle and then obtuse.] Midrib on adaxial (upper) side often running in a shallow V-shaped depression, forming a groove or a faint raised rib only proximally, on abaxial side obtusely raised; leaf texture coriaceous; leaf colour lustrous light green above, dull light green below. Stomata numerous, small, in two wide bands of intermittent lines on abaxial side. Pollen cones axillary, sessile, solitary or 2–3 together, narrowly cylindrical, 7–18 mm long, 2–2.5 mm wide at anthesis, yellow turning brown; microsporophylls very small, triangular, with two sublateral, globose pollen sacs. Seed cones axillary on slender peduncles 5–15 mm long, solitary; receptacles subtended by two small, recurved bracts ('foliola') and consisting of an axis with 2–3 fertile bracts which amalgamate and become swollen and succulent, 9–12 mm long, 6–8 mm wide, yellowish green to orange or (dark) red. [In some populations receptacles seem to stay greenish but it is not clear if they do not become more coloured eventually.] Seeds solitary or two on a receptacle, including the epimatium irregularly ovoid, 6–8 × 5–6 mm, with or without a small crest, whitish green or pruinose, ripening to light brown, smooth and lustrous. Seed proper not observed.

Taxonomic notes

De Laubenfels (*op. cit.*) described a new species, *Podocarpus beecherae*, from a locality at the Col de Yaté (Djuru Déré, near a Catholic shrine marked by a large cross) growing in 'maquis minier' on eroded serpentine. It has according to the protologue "light greenish yellow and glaucous" receptacles, distinct from the red receptacles of *P. novae-caledoniae*. The leaf shapes of the two species are also said to differ, with more lanceolate leaves in *P. beecherae* and more linear shapes in *P. novae-caledoniae*. They are claimed to occur in different habitats, with *P. novae-caledoniae* termed a "semi-rheophyte" while *P. beecherae* occurs in maquis on dry rocky sites. Closer scrutiny of these stated differences in herbarium specimens at K has shown that these distinctions either do not hold or are at best unconfirmed (colour of receptacle). A collection not known to De Laubenfels from the Île des Pins (Pic N'Ga) was found away from any stream in maquis and had red receptacles. The yellowish green receptacles found at the type locality of *P. beecherae* could well be a fully grown but yet unripe stage [when I visited the site in November 2005 the small receptacles were glaucous but immature]; this is seen in several other species in the genus, where the colour turns from yellowish green to yellow, orange, red and even purple eventually. Receptacle colour is not a sufficient character to base a species on. Besides, a mature greenish yellow receptacle would be unlikely in the genus; its colour is an adaptation to bird dispersal and therefore has to be quite distinct from the foliage when the seed is ripe to be effective. The leaf shapes of the type of *P. beecherae* and other collections cited by De Laubenfels fall entirely within the variation seen in those specimens of *P. novae-caledoniae* he did not include in his new species. *Podocarpus beecherae* is therefore considered a synonym of *P. novae-caledoniae*.

Distribution

New Caledonia: Grande Terre (Province Sud), Île des Pins
TDWG codes: 60 NWC

Ecology

Podocarpus novae-caledoniae is restricted to the ultramafic rock formations of the southern part of New Caledonia. It occurs often along streams and small rivers, but not in regular contact with their waters, and is also but less frequently found on rocky slopes away from streams, at altitudes from near sea level to ca. 700 m a.s.l. It is associated with shrubs and dwarfed trees in the 'maquis minier' vegetation, where it normally stays a low, dense shrub often

forming bushy thickets. Among trees like *Agathis ovata*, and to a lesser extent *Dacrydium araucarioides* and *Casuarina* sp., it may be forced up to a small tree 4–6 m tall, with a narrow crown. Rainfall is high in most areas, especially on SW exposed mountain slopes, but the vegetation remains mostly open due to extreme soil conditions not suitable for high plant density, giving this undemanding conifer an opportinity to thrive.

Conservation

IUCN: LC

Uses

No uses have been recorded of this species; it should be anemable to cultivation for gardens in warm climate regions, requiring very little in the way of soil fertility.

Podocarpus nubigenus Lindl., J. Hort. Soc. London 6: 264. 1851. Type: Chile: Los Lagos, Isla de Chiloé, *W. Lobb 80* (holotype not located, isotype K). Fig. 284, 285

Etymology

The species epithet is a compound adjective from Latin *nubilus* = 'dark, cloudy' and *genus* = 'born' or 'produced', and refers to the dark purple seed (and perhaps receptacle).

Vernacular names

Chilean totara; Manío, Manío macho, Manío hembra, Pino amarillo (Chile)

Description

Trees to 25 m tall or more; trunk to 2 m d.b.h., monopodial, erect. Bark smooth in young trees, on large trunks shallowly fissured, scaly, exfoliating in elongated flakes, cinnamon or purplish brown, weathering grey. Branches in younger trees ascending, forming a pyramidal crown, in old trees fewer heavy branches form a more open, irregular crown. Foliage branches stout or slender, terete, grooved between leaf bases. Terminal buds small, up to 6 mm long on vigorous shoots, with erect or slightly spreading, free, lanceolate scales with acute apices. Leaves on saplings and vigorous shoots slightly larger than on lateral twigs of mature trees. Leaves on mature trees patent, 1.5–3 cm long, linear-lanceolate, straight or very slightly falcate, 2–4 mm wide, more or less abruptly narrowing to a decurrent base, rigidly coriaceous, gradually tapering to a pungent apex, dark green with a lighter midrib above, two white bands below. Midrib raised but fading towards apex on adaxial (upper) side, obtusely raised or nearly flat on abaxial side. Stomata very small, in intermittent lines forming two white bands separated by a green midrib on abaxial face. Pollen cones axillary towards ends of leafy shoots, in groups of 2–4 per leaf, sessile with small perular scales at their base, cylindrical, 10–20(–25) mm long, 2.5–3.5 mm wide, cream coloured; microsporophylls deltoid, with an acute, erose-denticulate apex, each bearing two large, globose pollen sacs. Seed cones axillary, solitary on short peduncles; receptacles formed of an axis with two unequal bracts, fused and swelling to 7–8 × 6–8 mm, red ripening to dark purple, succulent. Seeds including the epimatium ovoid, 8–9 × 6–7 mm, not crested, dark purplish green ripening to purple. Seed proper not observed.

Distribution

S Argentina: Chubut, Neuquén, Santa Cruz; S Chile: Aisén, Los Lagos, Magellanes.
TDWG codes: 85 AGS-CB AGS-NE AGS-SC CLS-AI CLS-LL CLS-MG

Ecology

Podocarpus nubigenus is a component of mixed temperate rainforest, occurring from sea level to 1000 m a.s.l. It may grow in a forest type dominated by conifers, e.g. *Fitzroya cupressoides* forest with *P. nubigenus, Saxegothaea conspicua* and *Pilgerodendron uviferum*, or in forest dominated by angiosperms, in particular *Nothofagus nitida*. Other angiosperm trees with which it frequently occurs are *Drymis winteri*, *Laureliopsis philippiana, Nothofagus betuloides*, and various species in the family *Myrtaceae. Podocarpus nubigenus* is often found in water-logged soil or near streams on acidic substrates, particularly

in the coastal mountains and on the islands in the southern archipelago. It may also occur in montane shrub vegetation including *Embothrium coccineum*, *Ovidia andina*, and *Desfontainia spinosa*, on a substrate of volcanic ash in the Andes.

Conservation

Although widespread, this species is still at risk from logging, both for firewood and its high quality timber; while young trees are often cut as Christmas trees. Changes in land use, especially conversion of natural forest to plantations of *Eucalyptus* and Radiata pine, further reduce its extent of occurrence (EOO) and area of occupancy (AOO). Due to its wide distribution and large subpopulations still in existence, *Podocarpus nubigenus* does not at present meet the criteria for a threatened species.
IUCN: NT

Uses

This species is a valuable timber tree and is being logged for its timber of larger size, but also cut for firewood by the rural population. Young trees are cut from the forest to be used as Christmas trees. It is in cultivation in the milder Atlantic parts of Europe, especially in large gardens with tree collections in Ireland and southern England. It should be used more in horticulture, also in view of potential threat to the species in the wild; instructions for propagation can be found in Gardner *et al.* (2006).

Podocarpus oleifolius D. Don, in Lambert, Descr. Pinus 2: [20]. 1824. Type: Peru: ["in Peruvia ad Pillao et Panao"], *R. Ruiz & J. A. Pavón y Jiménez s.n.* (lectotype BM, designated here).

Podocarpus macrostachyus Parl., in Candolle, Prodr. 16 (2): 510. 1868; *Podocarpus oleifolius* D. Don var. *macrostachyus* (Parl.) J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 140. 1948.
Podocarpus oleifolius D. Don var. *costaricensis* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 140. 1948.
Podocarpus oleifolius D. Don var. *trujillensis* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 141. 1948.
Podocarpus oleifolius D. Don var. *equadorensis* Silba, Phytologia 68: 69. 1990.
Podocarpus monteverdeensis de Laub., Brenesia 33: 120. 1991.
Podocarpus ingensis de Laub., Bol. Lima 73: 58. 1991.
Podocarpus ballivianensis Silba, J. Int. Conifer Preserv. Soc. 15 (1): 1. 2008.

Etymology

The species epithet *oleifolius* compares the leaves with those of olives (*Olea* L.).

Vernacular names

pino de pasto (Colombia); pinete (Venezuela); saucecillo (Peru); chilca (Honduras); many other names are used

Description

Trees to 20–25(–30) m tall, to 1.5 m d.b.h., monopodial, erect, branching densely, at high altitudes a stunted bush or tree. Bark thin, eventually scaly, yellowish brown weathering light grey. Foliage branches terete, with prominent leaf scars and decurrent grooves. Terminal vegetative buds initially subglobose, 3–5 mm wide with imbricate, short, rounded or ovate scales 3–4 mm long which often spread out later; axillary buds globose, with imbricate, thick, rounded, carinate scales 2–3 mm long. Leaves on saplings often much larger than on mature trees, to 15 cm long and 20 mm wide, linear-lanceolate, often slightly falcate. Leaves on mature trees lanceolate to linear-lanceolate, straight (sometimes slightly curved), petiolate at base, gradually narrowing towards base as well as the acute or more or less obtuse apex, extremely variable in size dependent on growth of shoot, usually 4–9 cm long and 7–12 mm wide, but as small as 1.5 cm long and 5 mm wide on some trees. Midrib on adaxial (upper) side not elevated above surface of lamina but forming a narrow medial rib in a groove, on abaxial side a more or less prominent ridge, often with a central groove continuing to apex. Pollen cones axillary, solitary, sessile, expanding to 25–30 mm long, 3–4 mm wide; microsporophylls imbricate, with rounded or apiculate apex, bearing two pollen sacs near the base. Seed cones axillary, on short peduncles; receptacles

6–10 mm long, swelling to become succulent and red. Seeds including the epimatium ovoid-globose, 7–8 mm long, with an inconspicuous crest, olive green. Seed proper not observed.

Taxonomic notes

This species was mentioned by D. Don in Lambert (1824) to be found in Chile based on a collection by R. Ruiz & J. A. Pavon y Jiménez, but it is not known from further south than Peru and Bolivia. The original material is in BM and was collected by Ruiz & Pavon in Peru at "Pillas"; of two sheets the one labeled "in Peruvia ad Pillas et Panao" is here designated the lectotype. Buchholz & Gray (*op. cit.*) described *P. oleifolius* var. *costaricensis* from Volcan Poas; the type (*H. Pittier 822*) as well as other collections from there have short leaves and small, crested seeds. Similar specimens with small leaves are known from other localities in Central America and it is doubtful that they all belong to a single taxon distinct from the more common form of the species. They are known from both high and middle elevations. The relatively recently described new species *P. monteverdeensis* de Laub., from the reserve Monteverde in Costa Rica and found in a "mountain top swamp forest" appears to be merely a form with narrow leaves with a more or less attenuate apex. This taxon and *P. macrostachyus* Parl. have the same overall leaf shape variation and very similar midvein morphology as well as vegetative buds, and with no other characters to differentiate them, they are here treated as synonyms of *P. oleifolius*. Another species, *P. ingensis*, was described by De Laubenfels (*op. cit.*) from Bolivia and Peru, said to differ from *P. oleifolius* in foliage buds with more or less free scales and with lanceolate leaves widest below the middle. The pollen cones were unknown and the seed cones only seen as immature. Despite several more recent collections made by A. Fuentes and others (MO) under this name, this situation has not improved. This species is doubtfully distinct and its described characters likewise fall within the morphological variation of *P. oleifolius* that can be observed in much of its wide geographical range.

Distribution

S Mexico; Central America; Bolivia; Colombia; Equador; Peru; Venezuela.

TDWG codes: 79 MXC-PU MXG-VC MXS-GR MXS-MI MXS-OA MXT-CI 80 COS ELS GUA HON NIC PAN 82 VEN 83 BOL CLM ECU PER

Ecology

Podocarpus oleifolius is a montane to high montane species occurring in primary semi-deciduous and evergreen forests. Its altitudinal range is (825–)1200–3300 m a.s.l. and it is most frequent above 2000 m a.s.l. In some high valleys and on mountain summits at moderate elevation it grows in swamp forest. In tall montane forests it is associated with e.g. *Cedrela, Persea, Quercus, Podocarpus, Magnolia*, and *Symplocus* and various species in *Lauraceae*. At a higher altitude in Central America it was found in cloud forest with the dominants *Quercus xalapensis* and *Q. cortezii*, also with *Magnolia* sp., *Persea* sp., *Cornus diciflora, Ilex* sp., *Cyatheaceae*, and many bromeliad epiphytes and an epiphytic cactus. At the highest mountain ridges *P. oleifolius* occurs in an evergreen elfin forest with a canopy only 2–8 m tall and here it is also a stunted bush or tree. In Venezuela it has also been found on the tepuis, high sandstone table mountains with on their summit plateaus a mozaic vegetation of grasses, herbs and ferns, and dwarf forest or scrub.

Conservation

IUCN: LC

Uses

Only larger trees of this species growing in montane rainforest are being logged for timber, which is used in construction of houses and in furniture making. This species is very rare in cultivation and restricted to a few botanic gardens.

Podocarpus palawanensis de Laub. & Silba, Phytologia 64: 291. 1988. Type: Philippines: Palawan, Pagdanan Range, Ibangley ["Brookside Hill"], *C. E. Ridsdale SMHI 1502* (holotype L).

Etymology

The species epithet refers to the island of Palawan, Philippines.

Vernacular names

No common name has been recorded for this species.

Description

Trees to 7 m tall. Buds on vegetative branchlets 4–6 mm long and 4–5 mm wide at their base, with triangular, erect or slightly spreading outer scales. Leaves linear-lanceolate, 10.5–18.5 cm long, 8–11 mm wide, narrowing to a 5–7 mm long petiolate base and an acute apex.. Midrib on adaxial (upper) side acutely raised. Pollen cones axillary, sessile, solitary, cylindrical, 35–45 mm long, 6.5–8 mm wide; microsporophylls with a 4 mm long, lanceolate apex and two basal pollen sacs. Seed cones not observed.

[This brief description has been translated from the Latin description given in the protologue; no other information being available.]

Taxonomic notes

This species was first described and named in 1988, based on a single collection, *C. E. Ridsdale SMHI 1502* (holotype L, isotype K) with aberrant pollen cones. This is unsatisfactory and a critical comparison with other species in the region is needed, but hampered by the lack of collections particularly from Palawan. It is a species that has here been given the benefit of the doubt, but may be synonymous with *P. polystachyus*.

Distribution

Philippines, Palawan (Pagdanan Range).
TDWG codes: 42 PHI

Ecology

Closed tropical evergreen rain forest dominated by angiosperms.

Conservation

Not known from any other than the type location, which is called Ibangley Brookside Hill in the Pagdanan Range at only 40 m altitude. A map in the Philippines Red Data Book showing the extent of natural forest cover on the island of Palawan at present demonstrates an extreme rate of deforestation, much of which has occurred in recent decades. It is not known if this has affected the type location, and thereby this species, but assuming that it was present in places outside the type location, it is likely to have suffered serious decline. This species is not within a protected area.
IUCN: CR [B1ab (iii)]

Uses

No uses are specifically known of this species. Presumably it will have been used or is being used for firewood locally.

Podocarpus pallidus N. E. Gray, Bishop Mus. Bull. 220: 46. 1959. Type: Tonga: Tongatapu Group, ʻEua, ʻOhonua, ["western side of plateau region"], *H. E. Parks 16212* (lectotype F).

Etymology

The species epithet means 'pale' and probably refers to the pale green leaves.

Vernacular names

uhiuhi (Tongan name)

Description

Shrubs or small trees to 10 m tall, usually monopodial or branching low; trunk to 25 cm d.b.h. Bark light brown weathering grey; inner bark reddish brown. Foliage branchlets ascending or spreading, terete, with fine grooves or ridges, terminating in small ovoid-conical buds with 2–6 mm long, spreading or recurving and acuminate outer scales. Leaves on juvenile plants 10–15 cm long, 12–17 mm wide. Leaves on mature plants linear-lanceolate to linear, (2.5–)4–12 cm long (very variable on the same branch), 5–11 mm wide, straight or slightly falcate, gradually tapering to a petiolate base and to an acute or acuminate, sometimes mucronate apex; margins occasionally slightly revolute; leaf colour lustrous light green above, pale green below. Midrib on adaxial (upper) side narrow (0.3–0.4 mm wide), acute but sometimes fading towards leaf apex, on abaxial side wider (to ca. 1 mm) and obtuse or flattened. Stomata small, in numerous intermittent

lines on abaxial side on either side of distinct midrib. Pollen cones axillary, solitary, sessile, subtended by triangular bud scales, long cylindrical, 25–40 mm long, 3–4 mm wide at anthesis, pale yellowish white; microsporophylls triangular, acute, with scarious margins and two sub-basal pollen sacs. Seed cones axillary, solitary on 5–15 mm long, stout peduncles; receptacles subtended by two ca. 2 mm long, curved bracts ('foliola'), and formed of an axis with 2–3 fused bracts of unequal size, swelling to a succulent, red to blackish red body 10–13 mm long, ca. 10 mm wide at distal end. Seeds single, including the epimatium ovoid to subglobose, 10–13 × 8–10 mm, with or without an obscure distal ridge, blue to brown with a glaucous bloom. Seed proper not observed.

Distribution

SW Pacific: Tonga ('Eua and 'Uta Vava'u).
TDWG codes: 60 TON

Ecology

Podocarpus pallidus occurs in tropical low forest, dominated by angiosperms. This species is usually scattered in forest patches along the plateau escarpment and in ravines or gullies of two islands in the Tonga Archipelago situated some 325 km apart. It has been found on limestone cliffs on 'Uta Vava'u and occurs from around 50 m to ca. 250 m a.s.l.

Conservation

This species appears to occur on two islands, 'Eua and 'Uta Vava'u, of the Tonga Archipelago. No collections are known from Tongatapu, Tofua or Late, other islands in the archipelago with low forested mountains and plateaux. Because this species is a minor component in broad-leaved tropical forest, it is assumed there are fewer than 500 mature trees on each island. We have no information about possible decline. This species is not known from any protected area.
IUCN: VU (D1, 2)

Uses

No uses have been recorded of this species.

Podocarpus parlatorei Pilg., in Engler, Pflanzenr. IV.5 [18]: 86. 1903. *Podocarpus angustifolius* Parl., in Candolle, Prodr. 16 (2): 512. 1868, *non* Griseb. (1866. Type: Bolivia: [locality not stated], *T. Bridges s.n.* (holotype not located, isotype K).

Etymology

This species has been named after the Italian botanist Filippo Parlatore (1816–1877).

Vernacular names

pino del cerro, pino blanco (Argentina, Bolivia)

Description

Shrubs or stunted trees to 12 m tall, occasionally to 20 m tall; trunks of trees to 1.5 m d.b.h. Bark slightly fissured on larger stems, brown weathering grey. Branches often ascending from near the ground, but in closed forest trees have a clear bole to some height, forming a broad crown. Foliage branches sub-verticillate, ascending to erect, slender, terete, with fine grooves running down from slightly elevated leaf bases, yellowish green turning light brown. Terminal buds broadly ovoid to subglobose, 4–6 mm long and wide, with numerous apiculate scales with minutely denticulate margins and free tips, giving buds a bristly appearance; axillary buds smaller, globose. Leaves on juvenile plants or saplings larger than on mature plants, to 12 cm long and 5 mm wide. Leaves on mature plants patent to more or less erect, (2.5–)4–8(–9) cm long, 2–3 mm wide, narrowly linear, straight or slightly falcate, with a short petiolate base; margins slightly revolute, very gradually tapering to an acute-pungent apex, thin coriaceous, green above, pale green below; flushing leaves light green. Midrib on adaxial (upper) side of leaves a shallow groove often fading towards apex, on abaxial side a narrow ridge, continuous or raised in lower part of leaves only. Stomata very small, in numerous intermittent lines on abaxial side. Pollen cones in clusters of (3–)4–6 or more due to corymbose branching, on axillary, slender, angular stalks 5–15 mm long; individual cones axillary to a 2–3 mm long, lanceolate, acute bract, sessile and subtended by small, triangular, carinate-apiculate bud scales,

cylindrical, 5–10 mm long, 1.5–2 mm wide; microsporophylls triangular, with minutely denticulate margins and two globose pollen sacs. Seed cones axillary, appearing with new leaves, solitary on 3–8 mm long peduncles; receptacles composed of an axis with 2–3 fused, swollen bracts, 4–5 mm long and red when mature. Seeds globose, including the epimatium 5–6 mm long, 4–5 mm wide, with or without an inconspicuous crest.

Distribution

Argentina (Catamarca, Jujuy, Salta, Tucumán); Bolivia (Chuquisaca, Cochabamba, La Paz, Santa Cruz, Tarija).
TDWG codes: 83 BOL 85 AGW-CA AGW-JU AGW-SA AGW-TU

Ecology

Podocarpus parlatorei occurs in montane scrubland and forest at altitudes between 1000 m a.s.l. and the upper limit of trees between 2400 m and 3150 m a.s.l. This species may grow into a tree of maximal 20 m height in riverine forest at lower altitudes, but it is more often a shrub or stunted tree, branching near the base. It is commonly associated in the forest with *Meliaceae, Myrtaceae* (typically with *Alnus -Betulaceae-* in NW Argentina and S Bolivia) and other angiosperm trees; on cliff sides and in steep rocky gullies it is often the dominant shrub and can be quite abundant. In valleys it is locally abundant on old river terraces or on river banks, often now in forest relicts. It is a pioneer species with a key role in the forest dynamics. Its seeds or fruits are a food resource for endangered and of restricted range bird species, such as *Penelope dabbenei* (Cracidae) and *Amazona tucumana* (Psittacidae).

Conservation

This species was listed as Data Deficient in the Global Red List of Conifers (Farjon & Page, 1999). It has in the past been considered threatened with extinction and it was listed in 1975 on CITES Appendix I, which prohibits export of any of its parts, including timber. In NW Argentina this species was heavily used for paper pulp in the 1970's and 80's. Now this use has been stopped. Trade in this species, if it exists, is unlikely to involve timber in any quantity that could be of commercial importance. This species rarely attains tree sizes over 15 m tall, but in Argentina trees from 15–20 m have been recorded. It is a species with high ability to recruit. For example, it is common in secondary forest along roads, abandoned farms, and grazing areas where the use of fire was diminished or halted. Deforestation of a general kind, in which this species, where it occurs as a tree, will be logged with the rest, could be of conservation concern, as could increased domestic use of its timber when alternative sources become scarcer.
IUCN: NT

Uses

The wood of this species is at present used locally for firewood, fence posts and domestic articles, e.g. simple furniture and tool handles. In Argentina it was heavily used for paper pulp in the 1970's and 80's; now (1990's–2000's) it is occasionally logged for local (domestic) uses only. In Bolivia there is a programme to exploit the species to use the wood for local housing.

Podocarpus pendulifolius J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 138. 1948. Type: Venezuela: Cordillera do Mérida, Paramo de la Negra, above La Grita, *J. A. Steyermark 57115* (holotype F). Pl. 38

Etymology

The species epithet refers to the drooping or pendulous leaves.

Vernacular names

pino carbón, pino hayuco (Venezuela)

Description

Trees to 20 m tall, often smaller (2 m tall trees can be found fertile), d.b.h. to 50 cm. Bark thin, with horizontal and vertical shallow fissures, reddish brown. Branches spreading, forming a dense crown. Foliage branchlets stout, spreading or ascending, terete, grooved between remote leaf bases, yellowish green

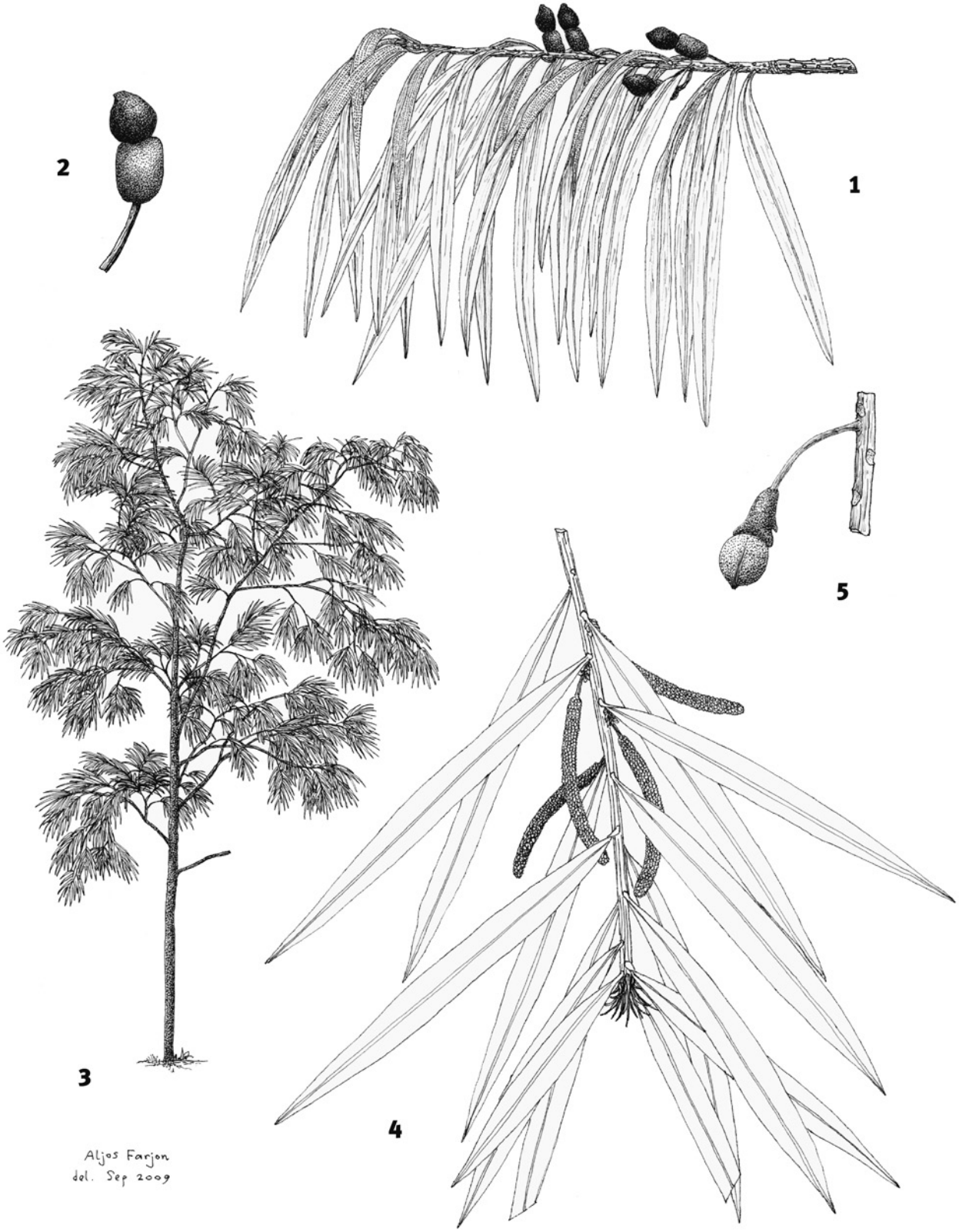

PLATE 38. *Podocarpus pendulifolius; Podocarpus salicifolius*. **1.** Branch with leaves and seed cones. **2.** Seed cone. **3.** Habit of tree. **4.** Branch with leaves and pollen cones. **5.** Seed cone. 1–2 = *P. pendulifolius;* 3–5 = *P. salicifolius*.

turning light brown. Terminal buds subglobose, 3–5 mm wide, often shorter than wide, with imbricate, broadly ovate, carinate scales with scarious margins. Leaves strongly drooping or pendulous; leaves on the upperside of the shoot curved down above a petiolate base, 5–12 cm long, lanceolate-linear, 7–11 mm wide, straight or slightly falcate, gradually tapering at both ends; margins nearly flat; apex acute; texture thin coriaceous; leaf colour green on both sides. Midrib obtusely raised and continuous to apex on both sides of leaf. Stomata very small, in wavy, intermittent lines on abaxial side in broad bands on either side of midrib. Pollen cones axillary, solitary, sessile, with obtuse perular scales at base, cylindrical, 20–40 mm long, 6–7 mm wide at anthesis; microsporophylls broadly ovate, obtuse with erose-denticulate margin, bearing two globose pollen sacs. Seed cones axillary, solitary on 7–10 mm long peduncles; receptacles 8–9 mm long, swelling and becoming red to dark purple, often pruinose. Seeds single, attached at distal end of receptacle, including the epimatium 8–9 mm long, 6–7 mm wide, ovoid-globose, glaucous-pruinose, with a small apiculate crest or nearly obtuse. Seed proper not observed.

Distribution

NW Venezuela: Cordillera de Merida.
TDWG codes: 82 VEN

Ecology

Podocarpus pendulifolius occurs in montane mixed low-canopy rainforest at elevations between 1400 m and 3000 m a.s.l. At the highest elevations it is part of a dwarfed forest on slopes immediately below the paramo vegetation, an alpine grassland rich in herbs. Young trees are said to be locally abundant in this habitat. It is less common in the taller forests below these stunted forests, where it can occasionally attain a height of 20 m.

Conservation

Based on distribution data from herbarium specimens, the extent of occurrence (EOO) is less than 3000 km² and the area of occupancy (AOO) is less than 100 km²; the species is only known from two (sub)populations ca. 100 km apart. Trees of some size are known to be valued and used for building houses, so there must be logging targeted at this species. No (sub)populations have been reported in protected areas.
IUCN: EN [B1ab (ii, iii, v), B2 ab (ii, iii, v)]

Uses

The wood of this species is considered to be of good quality for construction of houses. The pendulous or drooping habit of the foliage would make an attractive feature for horticulture and provenances from the highest altitudes may even prove more or less hardy. It is not known to be in cultivation.

Podocarpus perrieri Gaussen & Woltz, Bull. Soc. Hist. Nat. Toulouse 111: 319. 1975. *Podocarpus rostratus* L. Laurent var. *perrieri* (Gaussen & Woltz) Silba, J. Int. Conifer Preserv. Soc. 7 (1): 39. 2000. Type: Madagascar: Antananarivo Prov., Toamasina, Forêt d'Andasibé, *J. M. H. A. Perrier de la Bathie 17109* (holotype P).

Etymology

This species was named after Henri Perrier de la Bathie, who collected the type specimen.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 30 m tall; trunk to 80 cm d.b.h. Bark thin, becoming scaly on large trunks, light brown, weathering grey. Branches ascending and spreading, in old trees forming an umbrella-shaped crown. Foliage branchlets numerous, ascending, slender, terete, finely grooved between leaf bases, terminating in small buds with imbricate, obtuse outer scales and acute or apiculate inner scales with free but incurved apices. Leaves on saplings and young trees similar to those on mature trees, more remotely placed on branchlets and at the larger end of the size range. Leaves on mature trees crowded, spreading to nearly

erect, 0.7–2(–2.5) cm long, rigid, linear, straight or slightly curved, 1–2 mm wide, irregularly oval in cross-section, narrowing slightly to a decurrent base; apex pungent. Midrib absent or a very shallow groove on adaxial (upper) side, an obtuse keel on abaxial side. Stomata small, in intermittent white lines forming narrow bands on either side of abaxial midrib. Pollen cones axillary, solitary or with 2–3 on slender, 3–4 mm long peduncles, with a few triangular perular scales at their base, cylindrical, 8–15 mm long, 3 mm wide at anthesis; microsporophylls with an elongated, rostrate apex, bearing two ovoid-globose pollen sacs at base. Seed cones axillary, solitary on short peduncles; receptacles subtended by two minute, deciduous bracts ('foliola'), consisting of a short axis with two unequal bracts which become fused and coriaceous, 2–3 mm long. Seeds solitary with fertile bract, including the epimatium ca. 8 × 5 mm, obliquely ovoid with a minute crest.

Taxonomic notes

In the herbarium, this species could be confused with *Podocarpus rostratus*. Gaussen (1976) emphasised leaf anatomical characters as the distinction of the two species: *Podocarpus perrieri* has only 3 resin canals, while *P. rostratus*, with slightly larger and wider or flatter leaves, has many. To observe this character, microtome-cut cross-sections of fresh leaves have to be prepared for microscopic observation.

Distribution

Madagascar: Fianarantsoa Province (Andringitra Massif), Antanarivo Province (Toamasina, Forêt d'Andasibé).
TDWG codes: 29 MDG

Ecology

Podocarpus perrieri occurs in the eastern subhumid forest, at elevations between 1200 m and 2000(–2500?) m a.s.l. In one of the two known locations the terrain is described as "pentes rocailleuses", i.e. rocky slopes, at an altitude of 2000 m, and the rocks are silicious. At the type locality, at 1200 m a.s.l., this species was said to attain 30 m in height; this would have been in tall forest. No mention of tree size was made with the collection made at 2000 m a.s.l.

Conservation

This species is only certainly known from the type location and one other location and from GIS data it appears to be a deforested area. The type collection was made in 1925, the most recent collection dates from 1951. Surveys in this area are urgently required to determine if this species is still extant. Deforestation is serious in this region and this species is not known from any protected area.
IUCN: CR [B1ab (ii, iii, v), B2ab (ii, iii, v)]

Uses

No commercial uses are recorded of this species, but it is undoubtedly used locally for firewood and, if trees are large enough, for construction timber, such as flooring of houses.

Podocarpus pilgeri Foxw., Philipp. J. Sci. 2: 259. 1907. *Podocarpus celebicus* Warb., Monsunia 1: 192. 1900, *non* Hemsl. (1896). Types: Indonesia: Sulawesi, Wawo-Kraeng, *O. Warburg 16433, 16890* (syntypes B, destroyed, duplicates may exist in other herbaria).

Podocarpus pilgeri Foxw. var. *thailandensis* Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 185. 1976 (*nom. inval.*, Art. 37.1).
Podocarpus tixieri Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 21): 155. 1976 (*nom. inval.*, Art. 37.1); *Podocarpus tixieri* Gaussen *ex* Silba, J. Int. Conifer Preserv. Soc. 15 (2): 34. 2008.

Etymology

This species was named in honour of the German botanist Robert Pilger (1876–1953).

Vernacular names

In western New Guinea (Papua) this species is known by the name bempop; several names are recorded in eastern New Guinea (Papua New Guinea) and listed in Flora Malesiana ser. 1, 10 (3): 410–411 (1988). In

the Philippines it is called lubang-lubang (Manobo) and in Thailand phayamai-baisan.

Description

Decumbent or erect shrubs or medium size trees to 25 m tall; trunk of trees monopodial, erect, to 60 cm d.b.h., sometimes fluted at base. Bark of trees fibrous, flaking in strips, brown weathering grey; inner bark pink. Branches ascending or spreading, in trees forming a narrow or spreading crown. Foliage branchlets terete, slender, terminating in small buds 3–4 mm long with erect or slightly spreading, triangular to lanceolate and narrowly acute scales up to 4 mm long. Leaves on seedlings and young trees and/or shaded branches of mature trees usually larger than on shrubs and sun-exposed branches of mature trees, to 7 cm long and 12 mm wide, tapering at both ends. Leaves on shrubs and mature trees when sun-exposed (1.5–)2.5–4.5(–5) cm long, (4–)5–7(–10) mm wide, linear-elliptic to oblong, greatest width usually above middle, gradually tapering to a short petiolate, slightly twisted base; apex variable, often obtuse to abruptly rounded, sometimes acute or cuspidate especially in exposed leaves of shrubs; margins slightly revolute. Midrib on adaxial (upper) side 0.2–0.3 mm wide, acutely raised, on abaxial side wider, to 1 mm, obtuse or nearly flat. Leaf colour variable; upperside dark glossy green, dull green or glaucous; underside light green or grey-green. Stomata very small, numerous, in two broad bands on abaxial side. Pollen cones axillary, solitary, cylindrical, 15–30 mm long, ca. 3 mm wide, with a few rounded scales (from buds) on a 2–4 mm long peduncle; microsporophylls triangular-apiculate, with two globose pollen sacs at base. Seed cones axillary, solitary; receptacles with two 1.5–2 mm long basal bracts ('foliola'), 10–12 mm long and much swollen when ripe, greenish yellow, becoming bright red or purple. Seeds including the epimatium ovoid-globose, 10–12 × 8–9 mm, smooth without a crest at maturity, glaucous green to purplish green. Seed proper ovoid-globose, 8–10 mm long; micropylar end slightly elongated and curved.

Distribution

S China: Hainan Island, Guangxi, S Yunnan; Indochina: Kampuchea [Cambodia], Lao PDR, N Viet Nam; Malesia: Admiralty Islands, Borneo (Sarawak), Maluku [Moluccas] (Obi), Philippines, Sulawesi; Papuasia: New Guinea; Solomon Islands (Santa Isabel).

TDWG codes: 36 CHC-YN CHH CHS-GX 41 CBD LAO VIE 42 BOR-SR MOL PHI SUL 43 NWG-IJ NWG-PN SOL-SO

Ecology

Podocarpus pilgeri occurs in montane forests (often mossy forest) and in low scrub on exposed mountain ridges and summits. Its altitudinal range is (700–)1200 to 3000(–3300) m a.s.l. This species is in some localities a decumbent shrub not taller than 1 m, elsewhere it attains tree sizes. Apparently this is not correlated with altitude, since a tree 10 m tall was sampled at 3300 m on Mt. Wilhelm in Papua New Guinea and low shrubs have been found at around 1000 m altitude. It becomes dwarfed on exposed mountain ridges and summits amongst rocks. Trees are often limited to only reaching subcanopy height, in which case the forest is usually open, but it survives as well under canopy for a time. In New Guinea it is often associated with Southern beech (*Nothofagus* sp.), while another common conifer in this 'beech forest' is *Phyllocladus hypophyllus*. Low mossy *Xanthomyrtus-Podocarpus* forest dominates the crests and summit areas of Mt. Hunstein (Papua New Guinea) and Mt. Nettoti (Papua, Arfak Mts.) where *Podocarpus pilgeri* is a decumbent shrub. At its highest point (3300 m) it grows on the edge of low, open 'heath forest' and subalpine grassland on peaty soil.

Conservation

IUCN: LC

Uses

Where it grows as a medium-size forest tree it will be logged and used in similar ways as other 'podocarp' trees, i.e. for construction (house building) and other carpentry. Its scattered occurrence and often shrubby habit make it less important in the timber trade, so most uses will be rather local. It is not known to be in cultivation outside a few collections in botanic gardens.

Podocarpus polyspermus de Laub., Fl. Nouv. Calédonie Dépend. 4: 60. 1972. Type: New Caledonia: Grande Terre, Province Sud, Mé Maoya [Mt.], ridge north of the Col des Roussettes, *D. J. de Laubenfels P 424* (holotype P).

Etymology

The species epithet refers to the multiple seeds that are found on many receptacles, instead of the single seed in most species.

Vernacular names

No common names are known for this species.

Description

Small trees 5–15 m tall, monopodial, to 25 cm d.b.h. Bark fissured and scaly, dark or light brown; inner bark slightly fibrous. Branches spreading and assurgent, forming an irregular and open crown. Foliage branches terete, stout, ridged between leaf bases, with leaves mostly at distal parts, terminating in obtuse conical buds surrounded by elongated and spreading or reflexed outer scales 10–15 mm long and 2 mm wide at base. Leaves on juvenile plants not known; on mature trees crowded, more or less erect or spreading at a small angle to shoot, linear-lanceolate, 5–12 cm long, 6–8 mm wide, straight or slightly falcate, gradually tapering to a petiolate base, coriaceous; apex acute or obtuse. Midrib prominent on both sides, on adaxial (upper) side obtuse, on abaxial side flattened but with sharp sides. Leaf colour lustrous grey-green or dark green above, dull green below, flushing glaucous green. Stomata small, in numerous intermittent lines in two broad bands on either side of abaxial midrib. Pollen cones axillary, solitary, sessile; from scaly, subglobose buds sometimes persisting after leaves have fallen; bud scales triangular, keeled; cones elongating to cylindrical, 20–25 mm long, 3.5–5 mm wide; microsporophylls spirally arranged, imbricate, with an elongated apex and two basal pollen sacs. Seed cones axillary, solitary on 5–10 mm long, stout peduncles; receptacles formed of an axis with 3–5 bracts subtended by two spreading or recurved bracts ('foliola') 3–4 mm long, fusing and swelling to 10–13 × 8–9 mm, becoming succulent and red. Seeds often 2 per receptacle, sometimes 1 or 3, including the epimatium 8 × 6 mm, obovoid-globose without a crest. Seed proper not observed.

Distribution

New Caledonia, on several mountains in the central part of Grande Terre.
TDWG codes: 60 NWC

Ecology

Podocarpus polyspermus has been found on mountains at altitudes between 650 m and 950 m a.s.l. in low forest or transitions between 'maquis minier' and forest, on serpentine or ultramafic rocks derived from this. On mountain ridges the forest is often open and low and this species forms a canopy tree with a maximum height of 5–7 m and a characteristic flat candelabra crown; on less exposed sites it remains below the canopy formed often by angiosperms, with emergent *Araucaria* spp.

Conservation

In several parts of its presently imperfectly known range this species is under threat by nickel mines and their expansion. Only one population is in a protected area.
IUCN: EN [B1ab (iii, v), B2ab (iii, v)]

Uses

No uses have been recorded of this species.

Podocarpus polystachyus R.Br. *ex* Endl., Syn. Conif.: 215. 1847. *Margbensonia polystachya* (R. Br. *ex* Endl.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Singapore: ["Legi in Singapore ad libra"], *N. Wallich 6052B* (lectotype K-W, designated here). Fig. 286

Podocarpus thevetiifolius Zipp. *ex* Blume, Rumphia 3: 213. 1847 ["*thevetiaefolius*"]; *Podocarpus polystachyus* R. Br. *ex* Endl. var. *thevetiifolius* (Zipp. *ex* Blume) Silba, Phytologia 68: 70. 1990; *Margbensonia thevetiifolia* (Blume) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998.

Etymology

The species epithet means 'with many spikes' and refers to the clustered pollen cones.

Vernacular names

podo laut (Malay); jati bukit (Peninsular Malaysia); landin (Sarawak); kandabang (Sabah) and several more locally used names as listed in Flora Malesiana ser. 1, 10 (3): 418 (1988).

Description

Trees to 20(–40) m tall, d.b.h. to 45 cm (commonly a monopodial or multi-stemmed small tree ca. 6 m tall). Bark shallowly fissured, peeling in long, fibrous strips, brown weathering grey; inner bark soft fibrous, pink. Branches spreading, forming an irregular to rounded and dense crown in most trees. Foliage branchlets terete, slightly grooved or ridged, terminating in 1.5–3 mm long buds with narrowly triangular to lanceolate, erect to spreading outer scales. Leaves on juvenile plants linear to linear-lanceolate, 7–11 cm long, 8–13 mm wide, more or less abruptly tapering to a petiolate base and more gradually to an acute or apiculate apex. Leaves on mature trees linear to linear-lanceolate or nearly oval when very short, (2.5–)5–11 cm long, 6–11 mm wide, short petiolate, abruptly narrowed at base, more gradually tapering to an acute or obtuse apex, straight or slightly curved, coriaceous; margins flat or nearly so; midrib acutely raised and narrow adaxially (above), only slightly raised and wider abaxially (below); leaf colour deep green above, pale green below. Stomata on abaxial side, very small and in numerous irregular lines in two broad bands divided by midrib. Pollen cones clustered axillary with 2–5, sessile or very short pedunculate, with a few small scales at base, cylindrical to 15–30 mm long and 3 mm wide; microsporophylls imbricate, slightly spreading at anthesis, apiculate, with two oblong pollen sacs. Seed cones axillary, solitary on a 2–6 mm long peduncle; receptacles with 2 very small basal bracts to 1.5 mm long (deciduous), 7–10 mm long, swelling to 8 mm thick, pruinose, becoming orange-red to red when ripe. Seeds including the epimatium 7–9 × 5–7 mm, globose-ovoid, smooth, glaucous green. Seed proper not observed.

Distribution

Indochina: southernmost peninsular Thailand; Malesia: Borneo, Peninsular Malaysia, Maluku [Moluccas] (Obi & Waigeo Islands), Philippines, Singapore, Sulawesi, Sumatera (Bangka & Belitung Islands); Papuasia: New Guinea (Papua: Bird's Head Peninsula).

TDWG codes: 41 THA 42 BOR-BR BOR-KA BOR-SB BOR-SR MLY-PM MLY-SI MOL PHI SUL SUM 43 NWG-IJ

Ecology

This species occurs primarily on sandy beaches and bluffs, often on the land side of mangrove thickets at or just above the high tide mark. It can even occur within the mangroves on slightly raised, sandy ridges (probably old beaches). Here it is a stunted tree not exceeding 6–7 m in height. On coastal limestone and granitic rocks the trees are gnarled and shrubby, not exceeding 2–3 m. A second important habitat is coastal lowland kerangas, a low forest on almost pure sand, and 'pandangs', i.e. degraded heath forest; in these vegetations *Myrtaceae* have an important presence besides the conifers. In the interior of Peninsular Malaysia, the Philippines, and elsewhere it occurs on limestone hills and plateaus at altitudes between 150 m and 550 m (in Palawan at ca. 1000 m) a.s.l. Here trees may be taller; in Obi (Moluccas) trees are reported to reach 40 m tall with slender, buttressed boles clear of branches to 25 m. This can only occur in competition with other tall forest trees, where *P. polystachyus* is striving to reach the canopy. It appears therefore to be a highly adaptable species and the nearest to a mangrove-inhabiting conifer in existence.

Conservation

This species although widespread is declining due to habitat loss both past and future in various parts of its range.

IUCN: VU (A4)

Uses

Where this species grows into a tall tree, e.g. in Maluku [Moluccas], it is a fairly important source

of 'podocarp' timber. It has pale yellowish brown, leight-weight wood used for construction, window frames, boat building including masts, spars and oars, flooring, veneer, furniture making and cabinet work, carpentry and joinery, household utensils, matches, and toothpicks. *Podocarpus polystachyus* is one of few species in the genus commonly planted as an ornamental tree in tropical countries, mostly within its area of natural distribution but at least as far away as the Congo Republic.

Podocarpus pseudobracteatus de Laub., Blumea 26 (1): 142. 1980. Type: Papua New Guinea: Southern Highlands, Tari Subdistrict, Mt. Ambua, *C. Kalkman 5189* (holotype L).

Podocarpus archboldii N. E. Gray var. *crassiramosus* N. E. Gray, J. Arnold Arbor. 39: 453. 1958.

Etymology

The species epithet means 'seemingly but not actually like *bracteatus*' and refers to the similar species *P. bracteatus* Blume from Jawa, the Lesser Sunda Islands and Sumatera.

Vernacular names

kaip, kebu, puling (Papua New Guinea)

Description

Trees to 15(–20) m tall, but usually smaller; trunk short, to 40 cm d.b.h. Bark fibrous, becoming flaky on largest stems, peeling in longitudinal strips, cinnamon brown or dark brown. Crown usually irregular or stunted. Foliage branches spreading, mostly with widely spaced leaves. Terminal buds on leading shoots 6–14 mm long, 3–4 mm wide, narrowly conical, with free, long acuminate outer scales. Leaves on young plants 15–22 cm long, 12–17 mm wide, linear-lanceolate, straight or slightly curved, acute. Leaves on mature plants shorter and narrower, (4–)6–15 cm long, (5–)7–11 mm wide, lanceolate to linear-lanceolate, the shortest leaves elliptic, more or less abruptly tapering to a petiolate base, gradually tapering to an acute apex; margins flat; midrib acutely raised and less than 0.5 mm wide on adaxial side, obtuse and ca. 1 mm wide on abaxial (lower) side. Stomata very small and inconspicuous in dense lines on abaxial side. Pollen cones axillary, solitary or occasionally in pairs, short peduncuate, subtended by short obtuse bracts (bud scales), elongating at anthesis to 30–45 mm, 3–4 mm wide; microsporophylls with acute apex ca. 1 mm long, bearing two globose pollen sacs. Seed cones axillary on a 2–4 mm long peduncle; receptacles subtended by a 3 mm long, thick bract ('foliolum'), 8–11 mm long, formed of an axis with two unequal bracts, swelling to become succulent and first orange, then red. Seeds including the epimatium ovoid-globose, 10–11 × 8–9 mm when mature, distally obtuse. Seed proper not observed.

Distribution

New Guinea.
TDWG codes: 43 NWG-IJ NWG-PN

Ecology

Podocarpus pseudobracteatus is a species of montane to high montane mossy *Castanopsis-Nothofagus* forest, where it is commonly a canopy tree. At higher altitudes and on exposed ridges and summits, this forest becomes low and stunted and trees attain only 5–10 m, but in more protected sites where the forest grows taller it may attain larger size. Its altitudinal range is from 1700 m at the lowest limit to more commonly 2200–2850 m a.s.l. At high altitudes this species can occur in swamp forest with *Dacrycarpus* and *Dacrydium*, or it may enter the alpine shrubbery dominated by *Ericaceae, Myrtaceae*, and sometimes *Podocarpaceae*.

Conservation

IUCN: LC

Uses

Being usually a stunted tree, this species has no commercial value for timber; other uses are not known.

Podocarpus purdieanus Hook., Icon. Pl. 7: t. 624. 1844. Type: Jamaica: ["woods on the estate of Dunrobin Castle, … 8 miles north of White Hall"], *W. Purdie s.n.* (holotype K).

Etymology

This species was named by William Hooker after W. Purdie, who collected the first known specimens in 1843–44.

Vernacular names

No common name has been recorded for this species.

Description

Trees to 40 m tall or more, monopodial, erect; trunk d.b.h. to 1 m. Bark thin, smooth becoming scaly with longitudinal strips, brown weathering grey. Branches spreading, forming a rounded crown in large mature trees. Foliage branches slender or stout, terete, longitudinally grooved between leaf bases, terminating in more or less ovoid buds 3–4 mm wide with imbricate, thick, strongly acuminate scales with scarious thin margins and free apices. Leaves on saplings and vigorous shoots up to 14 cm long and 17 mm wide. Leaves on mature trees 4–7(–9) cm long, (6–)8–12(–14) mm wide, linear-lanceolate to sub-spathulate (widest above the middle), straight or nearly straight, coriaceous, lustrous green above, pale green below; margins flat or slightly revolute, narrowing gradually to a short petiolate base and gradually or more abruptly to an acute, apiculate or apiculate-pungent apex. Midrib on adaxial (upper) side raised only near base in most leaves, often in a shallow groove, continuous to apex but flat or with a central groove (*in sicco*) on abaxial side. Stomata very small, in numerous intermittent lines on abaxial surface. Pollen cones axillary, solitary, sessile, cylindrical, 15 mm or more long (fully elongated cones not observed); microsporophylls more or less ovate, obtuse, bearing two basal pollen sacs. Seed cones axillary, on 2–4 mm long peduncles; receptacles with two deciduous basal bracts ('foliola') and with spreading bract tips apically, swelling to a succulent, red, 7–8 mm long body (pseudo-fruit). Seeds obliquely ovoid, including the epimatium 8 × 5 mm, with a small conical, obtuse crest. Seed proper not observed.

Distribution

West Indies: Jamaica: parishes of Saint Ann (Mt. Diablo, Sander's Hill), Trelawny and St. Catherine.
TDWG codes: 81 JAM

Ecology

Podocarpus purdieanus occurs in wet tropical evergreen forest on limestone. The elevation is 800 m a.s.l. at the Mt. Diablo subpopulation; the highest record gives 2000–2500 m on Holly Mount at the crest of the Blue Mountains.

Conservation

A region measuring 60 km × 30 km is the area where it might be found, giving an extent of occurrence (EOO) of 1800 km². Mt. Diablo has the best known subpopulation, but it may be little more than 10 mature trees. Another sub-population, on Sander's Hill, has 15 trees found in dense forest, with many seedlings and saplings seen. There are probably other small subpopulations in the area. At present, only two locations are known; in the past it has been collected near Moneague, Troy in Trelawny Parish, and elsewhere. In the 19th century it was said to grow in "woods on mountain ridges" and to be "one of the noblest trees in the island." Historically, it was probably used for rebuilding ships; some logging continues. Present day threats are deforestation and cutting saplings for yam sticks. One million yam sticks are required per year, not just made from *Podocarpus*, but saplings and small trees are taken from the forest where *P. purdieanus* grows. There is no legislation that regulates the logging or cutting of this species and it has not been found to occur within any protected area.
IUCN: EN [B1ab (i–v), B2ab (i–v); C2a (i); D]

Uses

Trees of large size of this species have been logged extensively in the past. The wood of this species is

more highly prized for timber than mahogany. The wood was used for ship building, house construction, floors, furniture making, and numerous other uses by the European settlers. Large trees in accessible places became scarce and logging diminished to occasional instances. More recently, saplings of this and other tree species are being cut on a large scale as sticks (props) for the cultivation of yams (*Dioscorea* sp.), a tuberous twining plant and a staple food. This species is not known in cultivation.

Podocarpus ramosii R. R. Mill, Edinburgh J. Bot. 63 (1): 81. 2006. *Podocarpus rotundus* de Laub., Kalikasan 7 (2): 136. 1978 (*nom. illeg.*, Art. 53.1). Type: Philippines: Luzon, Laguna Prov., Mt. Banáhao, *M. Ramos BS 19581* (holotype US).

Etymology

The species epithet commemorates Maximo Ramos (d. 1932), who made extensive plant collections in the Philippines.

Vernacular names

No common names are recorded for this species.

Description

Small trees to 15 m tall; trunk monopodial, erect, to 30 cm d.b.h. Bark smooth, becoming scaly, brown weathering grey; inner bark pink. Branches spreading, forming a spreading crown. Foliage branchlets terete, slender, finely grooved, terminating in small buds 2–3 mm long with erect or slightly spreading, triangular to lanceolate and narrowly acute scales up to 3 mm long. Leaves on seedlings and young trees and/or shaded branches of mature trees usually larger than on sun-exposed branches of mature trees, to 7(–10?) cm long and 15 mm wide, linear-lanceolate; apex obtuse to acute. Leaves on mature trees when sun-exposed (1.5–)2.5–5 cm long, 7–13 mm wide, elliptic to obovate, greatest width usually above middle, gradually or abruptly tapering to a short petiolate base; apex obtuse to abruptly rounded; margins slightly revolute. Midrib on adaxial (upper) side 0.2–0.3 mm wide, acutely raised, on abaxial side wider, to 1 mm, obtuse or nearly flat. Leaf colour on upperside dark glossy green, on underside light green. Stomata very small, in intermittent, wavy lines in two broad bands on abaxial side. Pollen cones axillary, solitary, cylindrical, 20–30 mm long, ca. 3 mm wide, with a few lanceolate to linear scale leaves on a 5–10 mm long peduncle; microsporophylls less than 1 mm long, with two large globose pollen sacs at base. Seed cones axillary, solitary, on a 5–10 mm long peduncle; receptacles with two 2 mm long basal bracts ('foliola'), 7–10 mm long and swollen when ripe, greenish yellow, becoming red. Seeds including the epimatium ovoid-globose, 8–10 × 6–7 mm, smooth without a crest at maturity, glaucous green. Seed proper not observed.

Taxonomic notes

There is some doubt about the taxonomic distinctiveness of this species. The type collection is from Mt. Banahao in Luzon, Philippines, as are most other gatherings; only one sampling (*W. Meijer 903*) was taken from Mt. Beratus in Borneo. The most similar species is *P. pilgeri*, which mainly differs in having narrower and more pointed leaves at least in sun-exposed branches. De Laubenfels (*op. cit.*) stated, when he described this species with the illegitimate name *P. rotundus* (a later homonym), that *P. pilgeri* had not been found in Borneo or in Luzon. However, it has been collected in Sarawak as well as in NW Luzon with specimens that, based on their morphological characters, could not be included with *P. ramosii* (*P. rotundus*) without making the latter synonymous to *P. pilgeri*. Perhaps *P. ramosii* is a subspecies or variety of *P. pilgeri* with broad, apically rounded leaves. *Podocarpus costalis*, another name given to some specimens of *P. ramosii*, is indeed a very different species and occurs in a very different habitat as well.

Distribution

Indonesia: Kalimantan Timur (Mt. Beratus); Philippines: Luzon (Mt. Banahao).
TDWG codes: 42 BOR-KA PHI

Ecology

Podocarpus ramosii occurs in dwarf mossy forest, ant an altitude of ca. 1000 m a.s.l. on Mt. Beratus, up to ca. 2100 m on Mt. Banahao in Luzon. Mt. Beratus

is only 1223 m and Mt. Banahao in Luzon peaks at 2170 m, so in both localities this species occurs near the summit. The geographical disjunction may be real, but could well be an artifact of poor collecting, or poor recognition as a distinct species.

Conservation

Podocarpus ramosii is only known from two very disjunct populations. We are unsure of the threats to the habitat in either of these and neither of them are within protected areas. They will probably not be subject to logging or deliberate deforestation due to respectively small sizes of trees and unsuitability of the localities for agriculture. The conservation status of this species is therefore still unknown. More information is also needed to confirm (or reject) its status as a distinct species.
IUCN: DD

Uses

No uses have been recorded of this species.

Podocarpus ridleyi (Wasscher) N. E. Gray, J. Arnold Arbor. 39: 435. 1958. *Podocarpus neriifolius* D. Don var. *ridleyi* Wasscher, Blumea 4 (3): 453. 1941; *Margbensonia ridleyi* (Wasscher) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Malaysia: Peninsular Malaysia, Johore, Gunung Ledang [Mt. Ophir], *H. N. Ridley 10016* (holotype S).

Etymology

This species commemorates the plant collector H. N. Ridley, who collected the type specimen.

Vernacular names

No vernacular names are recorded for this species, which was originally described as a mere variety of the widespread *P. neriifolius*.

Description

Trees to 25 m tall, in stunted forests less than 10 m tall, d.b.h. to 40 cm. Bark soft, flaky or scaly, pale brown; inner bark dark red-brown. Branches spreading, forming an irregular crown in most trees. Foliage branchlets terete, slightly grooved or ridged, terminating in 4–8 mm long buds with narrowly triangular to lanceolate, erect to spreading scales. Leaves on juvenile plants linear-lanceolate, 11–20 cm long, 10–16 mm wide, gradually tapering to a petiolate base and to a narrowly acute apex. Leaves on mature trees lanceolate to linear-lanceolate, (4–)6–12(–14) cm long, 8–15 mm wide, distinctly petiolate, gradually narrowed at base, very gradually tapering to a narrowly acute apex, straight or slightly curved, coriaceous; margins somewhat revolute; midrib indistinctly raised and narrow adaxially (above), more prominently raised and wider abaxially (below); leaf colour yellowish green above, pale green below. Stomata on abaxial side, very small and in numerous irregular lines in two broad bands divided by midrib. Pollen cones clustered axillary with (1–)2–4 or several on small lateral leafless shoots, sessile or very short pedunculate, with papery scales at base, cylindrical to 15–20 mm long and 3 mm wide; microsporophylls imbricate, slightly spreading at anthesis, apiculate, with two oblong pollen sacs. Seed cones axillary, solitary on a 3–12 mm long peduncle; receptacles with 2 small basal bracts ('foliola') to 2.5 mm long (sometimes lacking in early stages, so not deciduous), 8–10 mm long, swelling to 8 mm thick, becoming pink when ripe. Seeds including the epimatium 7–8 × 4–5 mm, obliquely ovoid, without a crest, glaucous. Seed proper not observed.

Distribution

Malaysia: Peninsular Malaysia.
TDWG codes: 42 MLY-PM

Ecology

Podocarpus ridleyi occurs localized on several mountain summits and ridges in somewhat stunted rain forest; it may attain greater size when it occurs in forest on slopes below these summits. Its altitudinal range is from 480 m to 1500 m (possibly to 2100 m) a.s.l. It grows in impoverished soils derived from sandstone or granite (Mt. Ophir) and can be the dominant tree in these localities.

Conservation

Rapid change in land use involving the conversion of rainforest into rubber tree plantations have had an impact on the trees that occurred on the lower slopes of at least the southern subpopulations, reducing them to the higher summit areas.
IUCN: VU [B2ab (ii, iii, v)]

Uses

No uses have been recorded of this species.

Podocarpus roraimae Pilg., Notizbl. Bot. Gart. Berlin-Dahlem 5: 299. 1913. Type: Guyana: Cuyuni Mazaruni, Pakaraima Mountains, Mt. Roraima, *E. H. G. Ule s.n.* (holotype B).

Podocarpus buchholzii de Laub., Fl. Venezuela 11 (2): 31. 1982.
Podocarpus buchholzii de Laub. var. *neblinensis* Silba, Phytologia 68: 66. 1990.

Etymology

The species epithet refers to Mt. Roraima, on the border between Guiana and Venezuela.

Vernacular names

Ai-yek (Venezuela)

Description

Shrubs or small trees 1–3 m or 7–10 m tall; trunk diam. to 30 cm. Branches spreading, in older plants forming a dense, often straggling crown. Foliage branchlets slender or more robust, terete, finely grooved between leaf bases, terminating in subglobose buds 3–5 mm wide, with free, erect, acute scales, the outer scales often transformed into or accompanied by reduced leaflets (much) longer than normal bud scales. Leaves on vigorous shoots of juvenile plants remotely placed, spreading, on exposed, slower growing branches crowded, spreading at narrow angles to shoot to nearly erect, oblanceolate (widest beyond the middle) to elliptic, on juvenile plants somewhat linear and to 6 cm long, on mature plants 2–3(–3.8) cm long, 4–7 mm wide, gradually narrowing to a short petiolate base, more abruptly ending in an acute or obtuse apex. Margins revolute; leaf texture coriaceous; leaf colour deep green above, pale or glaucous green below. Midrib on adaxial (upper) side obtusely raised or nearly flat with a central groove, on abaxial side prominently raised. Stomata on abaxial side very small, in numerous intermittent lines on either side of the midrib. Pollen cones axillary, solitary, sessile with perular scales at base, cylindrical, 15–20 mm long, 2.5–3 mm wide; microsporophylls triangular, with two globose pollen sacs. Seed cones axillary, solitary on a 5–10 mm long, slender peduncle; receptacles small, 6–8 mm long, formed of a short axis with two unequal bracts, slightly swelling and ripening red. Seeds single, including the epimatium ca. 8 mm long, ca. 5 mm wide, ovoid with a distal crest. Seed proper not observed.

Taxonomic notes

Podocarpus buchholzii was described as a distinct species by David de Laubenfels (*op. cit.*) differing from *P. roraimae* in its leaf midrib, described as a groove on the adaxial side, instead of having a raised midrib as described in *P. roraimae*. The specimens actually show variation in this character, with many leaves having a slightly raised midrib with a groove in the middle, others have a raised midrib from the leaf base which turns into a grooved midrib towards the apex and still others have a groove on a flat midrib along the entire leaf length. In all other morphological characters, the two taxa are entirely similar and they occur in similar habitats, from bog margins to low woodland in ravines. It is therefore considered that *P. buchholzii*, and the variety under that name described by John Silba (*op. cit.*), are taxonomic synonyms of *P. roraimae*.

Distribution

Guyana (Mt. Roraima); Venezuela (several isolated mountains in Amazonas and Bolivar).
TDWG codes: 82 GUY VEN

Ecology

Podocarpus roraimae is found on isolated table mountains (tepuis), mostly on sandstone, at altitudes between 1800 m and 2700 m a.s.l. This species occurs in small stands of shrubs and trees in a mozaic vegetation of ombrotrophic bogs dominated by grasses and herbs and interspersed low scrub and woodland. It also occurs in ravines near streams and on wet plateaux and summits with boggy vegetation characterized by various ferns, pitcher plants and orchids. Shrubs of this species occur in more open terrain, while in forest it can attain small tree size. It can be associated with *P. steyermarkii* and *P. tepuiensis*, which are distinct in having larger, respectively smaller, leaves with a midvein groove on the adaxial side. There is high rainfall and frequent mist, and temperatures can fluctuate strongly from day to night and depending on weather conditions.

Conservation

This species, originally described from Mt. Roraima, has since been found in several isolated tepuis in Bolivar and Amazonas, Venezuela. Due to the remoteness of this region and its mostly undisturbed montane rainforests, it is believed that this species may occur on yet other mountains and is not threatened. One known location is within Roraima National Park.
IUCN: LC

Uses

No uses have been recorded of this species.

Podocarpus rostratus L. Laurent, Ann. Fac. Sci. Marseille 23: 60. 1915. Type not designated.

Etymology

The species epithet (Latin *rostrum* = beak) means 'provided with a beak' and refers to the apical shape of the microsporophyll.

Vernacular names

No common names have been recorded for this species.

Description

Small, usually stunted trees 8–10 m tall. Bark exfoliating in small strips and flakes, light brown weathering grey. Foliage branchlets slender, terete, finely grooved on vigorous shoots of young plants, ridged between decurrent leaf bases on older, slow growing trees, terminating in small ovoid-globose buds with imbricate, apiculate scales. Leaves on young plants linear, 2.5–6 cm long, 2–3 mm wide, straight or curved downward. Leaves on mature trees narrowly lanceolate to linear, (1–)1.5–3(–3.6) cm long, straight or sometimes slightly falcate towards apex, 1–2 mm wide, only slightly narrowing to a sessile, decurrent base; margins entire, mostly parallel but in the distal part tapering to an acute apex. Midrib absent or inconspicuous on adaxial (upper) side by a shallow central groove, continuous but flat or obtusely raised on abaxial side. Stomata on abaxial side in several intermittent lines on either side of midrib. Pollen cones axillary, solitary or in pairs, rarely 3 on 1–6 mm long stalks, subtended by a few keeled bud scales, cylindrical, 10–15(–20) mm long, 2.5–3 mm wide; microsporophylls more or less triangular, with an elongated, 1 mm long rostrate apex and two relatively large basal pollen sacs. Seed cones axillary, solitary, pedunculate, formed of an axis with two unequal bracts, subtended by two spreading or recurved 1 mm long bracts ('foliola'), fusing and slightly enlarging to a cuneate, 3–4 × 2–4 mm, coriaceous receptacle with divergent bract tips. Seeds solitary, including the epimatium ca. 14 × 8 mm, obliquely ovoid, with a small crest slightly below the apparent apex. Seed proper not observed.

Distribution

Madagascar: Antsiranana Prov., Fianarantsoa Prov., Mahajanga Prov., Toamasina Prov.
TDWG codes: 29 MDG

Ecology

Podocarpus rostratus is recorded from rocky slopes on silicious rocks; the elevation is given as 1800–2400 m a.s.l. (herbarium data), but the range may be greater according to GIS calculations and information from literature. It occurs in ericaceous

scrubland near the summits of mountains, a vegetation type prone to fires. It is not well adapted to fires and therefore occupies either open, rocky places with little vegetation, or wetter sites along streams.

Conservation

This species is known from three highly disjunct populations. The greater number of herbarium collections is from the northern population and only one from each of the eastern and southern populations (to over 1000 km away), made in 1924–25 at locations which have probably been deforested. All but one collection are older than 50 years. The area of occupancy (AOO) of the northern population is less than 500 km² and only one sub-population is inside a protected area, a collection was made there recently (2005). Serious decline of small populations is therefore inferred for this species, which is susceptible to fires.
IUCN: EN [B2ab (ii, iii, v)]

Uses

No uses have been recorded of this species. It is not known to be in cultivation, but should be attempted in the context of *ex situ* conservation to back-up the remaining fragmented populations in the wild.

Podocarpus rubens de Laub., Blumea 30 (2): 266. 1985. Type: Papua New Guinea: Western Highlands, Wahgi-Sepik Divide, *J. S. Womersley & A. N. Millar NGF 6980* (holotype L).

Podocarpus neriifolius D. Don var. *timorensis* Wasscher, Blumea 4: 451. 1941.
Podocarpus indonesiensis de Laub. & Silba, Phytologia 64: 292. 1988.
Podocarpus rubens de Laub. var. *pabinamaensis* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 37. 2000.
Podocarpus rubens de Laub. var. *sumatrana* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 37. 2000.

Etymology

The species epithet means 'red' and refers to the colour of the flushing leaves.

Vernacular names

A number of local names have been recorded for New Guinea in Flora Malesiana, ser. 1, 10 (3): 402 (1988); in Indonesia this species is probably not distinguished by non-botanists and known under names used for more common, earlier described species.

Description

Trees to 45 m tall, to 80 cm d.b.h., bole erect, straight. Bark smooth, thin, exfoliating in long strips, pale brown weathering grey; inner bark reddish brown, fibrous. Branches spreading, forming a rounded or domed crown. Foliage branchlets terete, more or less grooved, glabrous, terminating in 2–4 mm long buds with erect or slightly spreading, triangular to broadly lanceolate outer scales. Leaves on juvenile plants short petiolate, linear-lanceolate, 6–8 cm long, 10–14 mm wide, straight or slightly curved, gradually narrowed at base, acuminate or apiculate. Leaves of mature trees usually shorter and narrower, linear-lanceolate or elliptical, 3–6 cm long, 5–8(–10) mm wide, straight or slightly curved, short petiolate at a gradually narrowing base, tapering to an acute apex. Midrib acutely raised on both sides, usually narrower on adaxial side; leaf colour dark green above, pale green below; new leaves flushing bronze or bright red. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, solitary or in clusters of 2–3, sessile or short pedunculate with several basal bract scales, cylindrical, elongating to 20–35 mm, 2.5–3.5 mm wide; microsporophylls triangular, spreading, with two globose pollen sacs. Seed cones axillary, solitary on a 4–9 mm long peduncle; receptacles with 2 bracts ('foliola') 1–2 mm long at base, obliquely bilobate, 6–8 mm long, swelling with a truncate distal end, yellow-green turning red or purple and succulent when ripe. Seeds enclosed in a smooth epimatium, green turning red or purple when ripe, ovoid, 8–9 × 5–6 mm, distal end obtuse. Seed proper not observed.

Taxonomic notes

The species *P. indonesiensis* de Laub. & Silba (*op. cit.*), based on a few collections by P. J. Eyma in

Sulawesi and an additional specimen from Amboina (Maluku), is perhaps only a high altitude form of *P. rubens* in Sulawesi (2500–3000 m a.s.l.) with shorter and thereby more elliptical leaves. In New Guinea *P. rubens* has been collected from as high as 2750 m, a similar altitude as in Sulawesi. Shorter leaves tend to be elliptical, longer leaves linear-lanceolate, and both occur on the same specimens (*J. F. Veldkamp 8318*, K, L). The specimen from Amboina was said to be from around 1000 m a.s.l. All other characters are identical with *P. rubens* and *P. indonesiensis* is here considered a taxonomic synonym.

Distribution

Malesia: Borneo, Flores, Maluku [Moluccas] (Seram), Sulawesi, Sumatera, Timor; Papuasia: New Britain, New Guinea.

TDWG codes: 42 BOR-KA BOR-SB BOR-SR LSI-LS MOL SUL SUM 43 BIS NWG-IJ NWG-PN

Ecology

Podocarpus rubens is a constituent of lower montane to high montane primary rain forests. Its lower altitude is around 800 m a.s.l. (but sometimes lower to 150 m) and it reaches optimum growing conditions between that altitude and 1500 m. At higher altitudes it reappears on exposed ridges between 2000 m and 3200 m a.s.l. as a small, often stunted tree in mossy forest, especially in New Guinea accompanied by *Nothofagus* spp. and other 'fagaceous' trees. It is much less common in lowland swamp forest, where it may grow as an occasional tree with *Dacrydium* spp.

Conservation

IUCN: LC

Uses

Where it grows to a large tree, this species will be valued and exploited for its timber. It has pale yellowish brown, lightweight wood used for construction, window frames, boat building including masts, spars and oars, interior uses such as flooring, veneer, furniture making and cabinet work, carpentry and joinery, household utensils, matches, and toothpicks. It is not known to be in cultivation.

Podocarpus rumphii Blume, Rumphia 3: 214. 1847. *Margbensonia rumphii* (Blume) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Indonesia: Papua ["Nov. Guinea"], *leg. ign. s.n.* (holotype L, barcode L0050854). Fig. 287

Podocarpus koordersii Pilg. *ex* Koord. & Valeton, Meded. Lands Plantentuin 68: 268. 1904; *Margbensonia koordersii* (Pilg. *ex* Koord. & Valeton) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998.

Podocarpus philippinensis Foxw., Philipp. J. Sci. 6: 149. 1911; *Margbensonia philippinense* (Foxw.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998.

Podocarpus rumphii Blume var. *arbainii* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 38. 2000.

Podocarpus rumphii Blume var. *aruensis* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 38. 2000.

Etymology

This species was named in honour of Georg Eberhard Rumphius (1628–1702), author of an early Flora of Amboina.

Vernacular names

Numerous local names are in use for this species; several are listed by region in Flora Malesiana ser. 1, 10 (3): 416 (1988); in Maluku (Moluccas) and in Sabah it is called kayu china; in Vanuatu it is called nimsal (Sie language).

Description

Trees to 45 m tall, to 80 cm d.b.h., bole straight, in forest clear of branches 10–20 m. Bark scaly, whitish brown or brown; inner bark pinkish to red-brown. Crown spreading, rounded or domed and fairly dense. Foliage branchlets terete, finely grooved, terminating in a globose to (short) conical bud (2.5–)4–5(–8) mm long, outer scales imbricate, meeting at the papex, triangular, only at the tip sometimes bent outward. Leaves on juvenile plants 19–26 cm long, 18–25 mm wide, broad linear, straight; apex acute or slightly acuminate. Leaves on adult trees on lower branches or in shade 12–22 cm long,

10–20 mm wide, linear, straight or slightly curved, (long) petiolate and slightly twisted at base, gradually tapering towards base and towards acute apex, coriaceous and stiff; leaves in exposed crown parts of large trees still shorter and narrower, 9–14 cm long, 10–15 mm wide. Midrib on adaxial (upper) side conspicuous from base to apex, obtuse, ca. 1 mm wide, often collapsing in dry leaves, midrib on abaxial side prominently raised. Stomata on abaxial side in numerous lines on either side of midrib, small and inconspicuous. Pollen cones axillary, in clusters of (2–)3–5, sessile, subtended by imbricate, papery scales, long cylindrical, 35–45 mm long, 4 mm wide at anthesis; microsporophylls initially imbricate, then parting, small and apiculate, with two large, oblong pollen sacs. Seed cones axillary, solitary on a short peduncle; receptacles subtended by 2 minute bracts ('foliola') 1–1.5 mm long, bilobed, with 3 lateral bracts, one of which is smaller, ca. 10 mm long, swelling at maturity to 20–23 × 9–11 mm, turning yellow then red to purple. Seeds including the epimatium glaucous or pruinose, turning blackish at maturity, subglobose, 12–15 × 10–12 mm, with a curved distal crest or beak. Seed proper subglobose, with a hard and smooth seed coat, ca. 10 mm long.

Distribution

China: Hainan Island; Malesia: Peninsular Malaysia, Sabah, Sarawak, Jawa, Sumatera, Sulawesi, Lesser Sunda Islands (Flores, Timor), Philippines (Luzon), Maluku [Moluccas] (Aru, Obi, Weda); Papuasia: New Guinea (including Misool and Numfoor Islands), Bismarck Archipelago, Louisiade Archipelago.
TDWG codes: 36 CHH 42 BOR-SB BOR-SR JAW LSI-ET LSI-LS MLY-PM MOL PHI SUL SUM 43 BIS NWG-IJ NWG-PN

Ecology

Podocarpus rumphii is a constituent of lowland to lower montane tropical rainforests, where it can be locally common. It is likely to be confused with the similarly widespread but more ubiquitous species *P. neriifolius*, which can have similarly large leaves (but usually narrower) and differs in characters not always observable in specimens. The altitude ranges from sea level to 1600 m, but most collections are from below 500 m a.s.l. In Jawa it is found on limestone, on other islands also on soils ranging from clay to sand derived from acidic rock types. In tall forest (40–50 m) it can reach into the canopy, successfully competing with angiosperms. The large leaves of saplings to pole stage trees could be an adaptation to growing in shade under other trees; they become smaller, narrower and more leathery and stiff in sun-exposed crowns of larger trees.

Conservation

Exploitation has been extensive and in the Philippines this has reportedly led to the situation that this easily exploited tree survives over much of its range only in protected spots. Due to its vast extent of occurrence (EOO) and the existence of numerous localities where *P. rumphii* remains undisturbed, this species does not meet any of the criteria for a threatened category.
IUCN: NT

Uses

Podocarpus rumphii is a valuable timber tree where it attains large sizes with a clear, straight bole. Its wood is used as roundwood for masts, spars, and poles, in house construction as beams, in high-grade construction for flooring, joinery and other carpentry, for furniture and cabinet work, veneer, to make boxes, and for match sticks. In traditional use it was sought after for (dugout) canoes, used in coastal house construction, for household utensils, and wood carving. It is not known to be in cultivation, either as a forestry plantation tree or as an ornamental tree; the species is present in a few tropical botanic gardens and arboreta.

Podocarpus rusbyi J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 134. 1948. Type: Bolivia: La Paz, *H. H. Rusby 2463* (holotype NY).

Etymology

This species was named after the botanist and plant collector Henry Hurd Rusby (1855–1940).

Vernacular names

pino blanco (Bolivia)

Description

Trees to 25 m tall; trunk to 60 cm d.b.h. Bark on larger trees becoming fissured and scaly, brown weathering grey. Branches spreading or ascending, forming a broad open crown in the forest, more bushy in open terrain at high altitudes. Foliage branches slender or stout, terete, grooved between remote leaf bases, terminating in broad conical buds, on stout branchlets 5–7 mm wide at base, with lanceolate-acuminate outer scales 5–10(–16) mm long and spreading out, the inner scales smaller and erect or converging, buds on slender lateral branchlets smaller, with shorter scales. Leaves on saplings and shaded branches (in forest) larger than on mature trees and exposed small trees, 4–9 cm long, 6–10 mm wide. Leaves on mature and exposed trees (2–)3–5 cm long, (4–)5–8(–10) mm wide, patent, elliptic to linear-lanceolate, widest in middle part, gradually or sometimes more abrubtly narrowing to a short petiolate base; margins slightly revolute, gradually tapering to an acute apex, coriaceous, deep green above, pale green below. Midrib a continuous narrow groove on adaxial (upper) side, raised but narrow (0.4 mm wide) and continuous to apex on abaxial side. Stomata small, in numerous intermittent lines on abaxial side. Pollen cones not observed, presumably solitary. Seed cones axillary, solitary on 3–10 mm long peduncles; receptacles composed of an axis with two unequal, spreading bracts, fusing and swelling to 6–8 mm long with exserted, triangular bract tips, green becoming red. Seeds single between bract tips, ovoid-globose, including the epimatium ca. 7 mm long with an obtuse distal crest, dark green. Seed proper not observed.

Distribution

Bolivia: Cochabamba, La Paz, Santa Cruz; Peru: Cusco (Machu Pichu).
TDWG codes: 83 BOL PER

Ecology

Podocarpus rusbyi occurs in tropical montane rainforest and high montane cloud forest up to the tree line. In Peru it was found near Machu Pichu in high montane forest at 2900 m a.s.l. In Bolivia, where the species is much more common and widespread, its altitudinal range is between 1500 m and 3350 m a.s.l. It is commonly associated in the forest with *Meliaceae, Myrtaceae* and other angiosperm trees; at high altitudes it forms thickets with other dwarfed trees and shrubs. It occupies similar habitats as *P. parlatorei* within the same altitudinal range, but in Bolivia the two species are geographically separated.

Conservation

There is evidence of forest decline in the region, but we cannot quantify its impact upon this species. This species appears to have a limited distribution within Bolivia, with an estimated extent of occurrence (EOO) of 22,500 km² and an area of occupancy (AOO) below 2000 km² and with one location in Peru at ca. 300 km distance. Two localities from where collections were made are within protected areas: Parque Nacional de Choquecamiri in Bolivia and Machu Pichu National Park in Peru.
IUCN: VU [B2ab ii, iii, v)]

Uses

No commercial uses are recorded of this species. Its wood is used locally for construction purposes. This species is not known to be in cultivation.

Podocarpus salicifolius Klotzsch & H. Karst. *ex* Endl., Syn. Conif.: 209. 1847. Type: Venezuela: Cordillera de la Costa, Distrito Federal, Gran Colombia, ["Habitat in Colombia"], *H. Karsten s.n.* (holotype W, destroyed, isotype LE). Pl. 38

Podocarpus pittieri J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 130. 1948.

Etymology

The species epithet compares the leaves with those of willows (*Salix*).

Vernacular names

pinabete (Venezuela)

Description

Trees to 30 m tall (often much smaller); trunk to 80 cm d.b.h. Bark thin, smooth in young trees, eventually becoming shallowly fissured and exfoliating in small strips, brown, weathering grey; inner bark pinkish. Branches spreading or ascending, forming a broad crown in large trees. Foliage branches stout, terete, grooved between leaf bases; terminating in broad-based, conical buds with spreading, long acuminate scales, the outer scales to 12 mm long, up to 4 mm wide above their base, with scarious margins, a few sometimes elongated to leaf-like appendices 20–25 mm long, the inner scales usually shorter. Leaves on saplings spreading on vigorous shoots, to 23 cm long and 17 mm wide. Leaves on mature trees usually drooping but sometimes spreading, (7–)8–13 cm long, 8–12 mm wide, straight or falcate (drooping leaves curved above the short, twisted, petiolate base), lanceolate-linear, gradually narrowing at both ends; margins flat; apex acute; leaf texture lax; leaf colour green above, paler green below. Midrib on adaxial (upper) side obtusely raised, continuous or fading towards apex, raised at least near base on abaxial side. Stomata very small, in numerous intermittent lines on abaxial face of leaf. Pollen cones axillary, sessile, solitary from buds with short acuminate scales, long cylindrical, 40–80 mm long, 3.5–4.5 mm wide; microsporophylls broadly ovate with mucronate apex, bearing two globose pollen sacs. Seed cones axillary, solitary on 10–25(–30) mm long, slender, pendulous peduncles; receptacles formed of an axis with two unequal, fused bracts with free, curved bract tips, swelling to 8–12 mm long and 5–7 mm wide distally, ripening from dark green to dark purple. Seeds solitary on largest fertile bract, including the epimatium ca. 10 mm long, ovoid-globose with a distal crest terminating in a small protrusion. Seed proper not observed.

Distribution

Bolivia; NW Brazil; Colombia; Peru; N Venezuela.
TDWG codes: 82 VEN 83 BOL CLM PER 84 BZN

Ecology

Podocarpus salicifolius occurs in the Andes ranges in montane to upper montane rain forest or cloud forest, at altitudes between 1200 m and 2150 m a.s.l. When growing in dense rainforest it can attain 30 m as a canopy tree, but in cloud forest on steep slopes it usually remains much smaller, up to 12 m tall.

Conservation

Although uncommon in most areas where it occurs, *Podocarpus salicifolius* has a wide range in the Andean Cordillera from Venezuela to Bolivia. Despite its early description, this species seems to be under-collected, except in northern Venezuela, and it is likely to be discovered in other localities than presently known within its extent of occurrence (EOO). It is therefore not considered to be threatened at present.
IUCN: LC

Uses

No commercial uses are reported of this species, but large trees will undoubtedly be logged for their timber, as are other podocarps. The wood is suitable for construction, general carpentry, and furniture making. It is not known to be in cultivation.

Podocarpus salignus D. Don, in Lambert, Descr. *Pinus* 2: [20]. 1824. Type: Chile: ["Gen. novum de Chile"; (on reverse) "Chili. Herb: Pavon"], *R. Ruiz & J. A. Pavón y Jiménez s.n.* (holotype BM). Fig. 288

Etymology

The species epithet compares the species with willows (*Salix*).

Vernacular names

Willowleaf podocarp; mañio, manique (Chile)

Description

Trees to 20 m tall; trunk monopodial or branching low, up to 1 m d.b.h. Bark thin, smooth in young trees, becoming ragged with exfoliating strips on older stems, light brown weathering whitish grey. Branches in young trees forming a pyramidal crown, in larger trees spreading out more widely, forming a broadly domed, often dense crown. Foliage

branchlets slender, often drooping, terete, with fine grooves between decurrent leaf bases, terminating in small, globose buds with imbricate, ovate-triangular scales. Leaves on seedlings and saplings similar to those on mature trees, narrowly linear-lanceolate, straight or (slightly) falcate, (3–)5–9(–12) cm long, (3–)4–7 mm wide, lax, narrowing to a short petiolate base, gradually tapering to an acute apex, lustrous light green above, pale green below. Midrib on adaxial (upper) face less than 0.4 mm wide, raised from base but fading towards apex, similarly narrow but continuous to apex on abaxial side. Stomata very small, in numerous intermittent lines on abaxial side. Pollen cones axillary, sessile, solitary or grouped with two or more, often from flushing leaves, or from older leaves, 25–50 mm long, very slender, the longest almost filiform, 1.5–2 mm wide at anthesis, yellow; microsporophylls minute, triangular, bearing two globose pollen sacs. Seed cones axillary, solitary on slender, 1–2 cm long peduncles; receptacles formed of an axis with 2–3 fused bracts, one or two of these fertile, swelling to 5–6 × 4–5 mm, succulent deep red to violet. Seeds solitary or sometimes two on a receptacle, including the epimatium 7–8 × 4–5 mm, obliquely ovoid, green maturing to reddish, with an obtuse crest. Seed proper not observed.

Distribution

S Chile: Biobio, La Araucania, Los Lagos, Maule.
TDWG codes: 85 CLC-BI CLC-LA CLC-MA CLS-LL

Ecology

In the north of its range (Mediterranean climate) *Podocarpus salignus* follows water courses in the Roble-Hualo forest type (Bosque Maulino Costero); in the Andes higher than 1000 m a.s.l. it can form pure stands in wetter areas away from water courses, or it occurs in moist ravines. Here it is a minor component of *Nothofagus obliqua* forests. The altitudinal range of this species is between 20 m and 1200 m a.s.l., with the highest localities in the Andes on S-facing slopes.

Conservation

In the northern part of its range there has been substantial decline due to conversion of natural forest to plantation forest with *Eucalyptus* and *Pinus radiata*. Increased fires have destoyed many other stands there. Cutting for firewood has also reduced the number of mature trees. In the south of its range it is doing better, but there is a continuing decline of its habitat resulting in reduced extent of occurrence (EOO) and area of occupancy (AOO) and, especially in the north, fragmented subpopulations. Habitat degradation is probably the most serious and widespread menace to the survival of this species, which does not react well to the opening up of forest cover and concomitant dehydration in summer.
IUCN: VU (A2a, c, d)

Uses

The fine-grained wood of this species is used locally in the craft industry and was in the past of importance for house building. More important now perhaps is its use in horticulture. Its date of introduction in Europe is uncertain, but it has been very successful and is quite common in large gardens and parks in regions with mild winters and abundant rainfall. It usually forms a bushy tree with dense, pendulous foliage.

Podocarpus salomoniensis Wasscher, Blumea 4 (3): 430. 1941. Type: Solomon Islands: San Cristobal, ["Hinuahaoro"], *L. J. Brass 2881* (holotype B, destroyed, isotypes A, BM, L).

Etymology

The species epithet refers to the Solomon Islands, where this species is endemic.

Vernacular names

dengali tolo (Malaita)

Description

Trees to 25 m tall, with a straight bole in forests to 35 cm d.b.h., stunted on poor growing sites; trunk at base not buttressed. Bark usually smooth, in larger trees flaking with thin, curling strips, pale yellowish brown; inner bark weakly fibrous. Branches spreading in tiers, sinuous, often drooping, forming

a diffuse, conical crown, in old trees more irregular and rounded. Foliage branches terete, stout, grooved between leaf bases, terminating in a large conical bud with subulate-acuminate, keeled scales to 11 mm long with spreading or curved tips. Leaves on saplings and young trees broader than on mature trees, to 20 mm wide, thin and flexible. Leaves of mature trees on distal parts of branches only, spreading wide or more or less drooping, 10–25 cm long, 7–12 mm wide, linear-lanceolate, gradually tapering to a narrow petiolate, twisted base (leaving crescent-shaped pulvini on the shoot when fallen) straight or slightly falcate, tapering to an acute or obtuse apex, thick coriaceous. Midrib prominent on both sides of leaf, extending the full length, more or less acute on adaxial (upper) side, 0.5–0.7 mm wide, obtuse, becoming flattened distally and to 1 mm wide on abaxial side. Leaf colour lustrous green above, dull green below. Stomata small and inconspicuous, in numerous intermittent lines on either side of abaxial midrib. Pollen cones unknown. Seed cones in upper leaf axils on slender 10–15 mm long peduncles; receptacles subtended by 2 subulate, ca. 4 mm long, acute bracts ('foliola'), obconical, slightly flattened, 8–10 mm long and broad, ca. 5 mm thick at apex, swelling to succulent red. Seeds 1, sometimes 2 per receptacle, including the epimatium subelliptical, 11 × 8 mm, narrowed at base and rounded at apex, smooth and glaucous green. Seed proper not observed.

Distribution

Solomon Islands, known from three main islands: Choiseul, Santa Isabel and San Cristobal, and on some of their 'satellites' such as San Jorge and Pawa.
TDWG codes: 43 SOL-SO

Ecology

Tropical rain forest or swamp forest, the latter on ultramafic soil and with codominant *Casuarina* sp. Elevation from herbarium specimen labels 10–900 m a.s.l.

Conservation

This species is only known from three main islands and two small ones, one of which (San Jorge) is a low-lying small island, where it may have disappeared. The other subpopulations are represented by several herbarium collections from San Cristobal and one from Choiseul. Deforestation has mainly affected the lower elevations on the islands of the archipelago. Most collections date from before 1970, but recently it was collected from Choiseul and Santa Isabel. This species is not known from any protected areas.
IUCN: EN [B2ab (iii)]

Uses

This species, where it develops into a tree of moderate size with a straight bole, is a useful timber tree producing soft, light wood suitable for light construction, interior finishing and boxes or cases. Locally it is being used to make oars. This species is not known to be in cultivation.

Podocarpus sellowii Klotzsch *ex* Endl., Syn. Conif.: 209. 1847.

Etymology

This species was named after the German botanist Friedrich Sellow [Sello] (1789–1831).

Vernacular names

No common names have been recorded for this species other than the generic 'pinheirinho', which means little more than 'conifer'.

Description

Small trees to 10–12 m tall, d.b.h. to 30 cm. Branches spreading, forming a rounded or irregular crown. Foliage branchlets stout, terete, longitudinally grooved between leaf bases, terminating in conical buds 3–4 mm wide at base, with free, erect or spreading, apiculate outer scales which are sometimes much elongated (to 10–15 mm) and leaf-like. Leaves on saplings larger than on mature trees, 8–15 cm long, 12–20 mm wide, straight or slightly falcate, linear to lanceolate-linear. Leaves on mature trees (2–)4–9(–11) cm long, (3–)7–11(–13) mm wide, narrowly elliptic, or lanceolate, lanceolate-linear to

more or less linear, straight or slightly falcate, gradually or more abruptly narrowing to a petiolate base, gradually tapering to an acute apex; margins only in the longest and narrowest leaves parallel for some distance, flat or slightly revolute; texture coriaceous or thin coriaceous; leaf colour more or less equally green on both sides. Midrib narrow (–0.5 mm), continuous or sometimes fading towards apex, raised in a shallow groove on adaxial (upper) side or forming a groove, more acutely raised from a flat leaf surface and continuous to apex on abaxial side. Stomata small, in two bands of intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary, sessile with obtuse perular scales near base, narrowly cylindrical, 10–20 mm long, 1–2 mm wide; microsporophylls ovate-acuminate, with minutely denticulate margins, bearing two globose pollen sacs. Seed cones axillary, solitary on slender, to 10 mm long peduncles; receptacle small, swelling to 6–8 mm long, 4–6 mm wide, succulent reddish purple turning dark brown. Seeds solitary, subglobose, including the epimatium 7–9 × 5–8 mm, without a crest. Seed proper globose with a smooth surface.

Distribution

Brazil: Paraná, Rio Grande do Sul, Rio de Janeiro, Santa Catarina, Sao Paulo.
TDWG codes: 84 BZL-RJ BZL-SP BZS-PR BZS-RS BZS-SC

Ecology

Podocarpus sellowii has a coastal distribution in S Brazil and occurs in the Atlantic Forest (Mata Atlantica). The remnants of this forest are situated in the coastal mountains. These forests are evergreen subtropical and grow on acidic soils derived from granite and gneiss. *Podocarpus sellowii* is found in the montane forests at altitudes between 800 m and 1800 m a.s.l. The forest type in which *P. sellowii* mostly occurs is relatively open and has an average canopy height of 10–15 m. In the northern half of its range this occurs predominantly on eastern slopes, which receive less rainfall, and in the south on most slopes between 1100 m and 1500 m a.s.l. *Podocarpus sellowii* may be associated with *P. lambertii* in the south of its range, where gallery forest along rivers becomes more prominent and intercalates with the Atlantic Forest. Palms and numerous dicots (both shrubs and trees) grow with it in most locations and epiphytes on trees are mostly mosses and lichens.

Uses

As a small tree this species has little commercial value for timber. It may locally be used for firewood or sometimes for fence posts. It is not known in cultivation.

2 varieties are recognized:

Podocarpus sellowii Klotzsch *ex* Endl. var. ***sellowii***, Syn. Conif.: 209. 1847. Type: Brazil: [locality not known], *F. Sello s.n.* [holotype B, destroyed, isotypes F, GH, NY, UC).

Description

Leaves of mature trees larger than in var. *angustifolius*, (3–)4–9(–11) cm long, (5–)7–11(–13) mm wide, lanceolate to lanceolate-linear or nearly linear. Pollen cones ca. 20 mm long, 2 mm wide. Seeds 8–9 × 6.5–8 mm.

Distribution

Brazil: Paraná, Rio Grande do Sul, Rio de Janeiro, Santa Catarina, Sao Paulo.
TDWG codes: 84 BZL-RJ BZL-SP BZS-PR BZS-RS BZS-SC

Conservation

Var. *sellowii* has a patchy occurrence in an area that has a very high human footprint factor (GIS-AVG = 51) and where deforestation has been serious, indicating continuous decline. The extent of occurrence (EOO) calculated on the basis of herbarium specimen distributions is 188,608 km² but there is a very scattered occurrence in coastal areas eastwards where the Atlantic Coastal Rain Forest has been decimated. Only one of 23 herbarium collections (from 16 localities) checked for the assessment has been recorded from a protected area, the Atlantic Forest Southeast Reserves.
IUCN: EN (A2c, d)

Podocarpus sellowii Klotzsch *ex* Endl. var. ***angustifolius*** Pilg., in Engler, Pflanzenr. IV.5 [18]: 88. 1903. Type: Brazil: Rio de Janeiro, Nova Iguaçu, Pico do Tingua, *A. F. M. Glaziou 17778* (lectotype K, here designated).

Description

Leaves of mature trees smaller than in var. *sellowii*, (2–)3–5 cm long, 3–8 mm wide, narrowly elliptic to lanceolate. Pollen cones ca. 10 mm long, 1 mm wide. Seeds 7–8 × 5–6 mm.

Distribution

Brazil: Rio de Janeiro (Cerro dos Orgaos, Pico do Tingua).
TDWG codes: 84 BZL-RJ

Conservation

This rare variety is known from only two localities next to a metropolis. The locality Pico do Tingua is in a biological reserve (Reserva Biologica Tingua) and this variety occurs here frequently and has been regularly collected (specimens in herbarium RB at Rio de Janeiro seen by Dr Nicholas Hind of the Royal Botanic Gardens, Kew, April 2008) since its discovery more than a century ago. The status of it in the other locality is unknown. Deforestation has probably greatly reduced the area of occupancy (AOO) but the reserve seems to be well protected.
IUCN: CR [B1ab (iii)]

Podocarpus smithii de Laub., Blumea 30 (2): 257. 1985. Type: Australia: Queensland, Atherton District, Mt. Lewis, *D. J. de Laubenfels P 464* (holotype A).

Etymology

This species was named after Lindsay Stuart Smith (1917–1970), plant collector in Queensland and New Guinea.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 30 m tall, with erect trunk to 80 cm d.b.h. Bark thin, becoming scaly on large trees, slightly fibrous, brown. Branches spreading to form a broad crown. Foliage branchlets terete, smooth, finely grooved, terminating in large, conical to fusiform buds 3.5–8 mm long and 2–4 mm wide at or above base, with imbricate, appressed, triangular or ovate, acute or obtuse and often mucronate scales. Leaves on mature trees (3–)5–11(–13) cm long, (8–)10–18(–20) mm wide, linear-lanceolate, usually straight but sometimes slightly curved, tapering gradually or in wider leaves more abrubtly to a short petiolate base; apex acute or sometimes obtuse; midrib obscurely raised on adaxial (upper) side, slightly less than 1 mm wide, more conspicuous on abaxial side; leaf colour lustrous dark green above, pale green below. Stomata numerous, small, in two bands of intermittent lines on abaxial side. Pollen cones axillary, solitary or with 2–3 together on 2–9 mm long peduncles, cylindrical, 30–45 mm long, 4–6 mm wide; microsporophylls spreading, falcate, to 2 mm long with two basal globose pollen sacs. Seed cones axillary, solitary on slender, 6–9 mm long peduncles; receptacles subtended by two very small bracts ('foliola'), growing and swelling to 5–7 mm long and 5 mm thick at distal end, ripening to deep red, succulent. Seeds solitary on distal part of receptacle, obliquely attached, ovoid with a short proximal beak and an acute distal crest, 12–18 × 8–13 mm when mature; epimatium ripening from green to dark red. Seed proper globose, with a thick wall.

Distribution

Australia: Queensland (Atherton Tableland, Mt. Lewis).
TDWG codes: 50 QLD-QU

Ecology

Podocarpus smithii is a rare species occurring in a few localities in montane rainforest on the eastern Atherton Tableland and on Mt. Lewis at elevations between 900 m and 1200 m a.s.l. It is most often found growing along mountain creeks in acidic soils derived from granitic rock.

Conservation

Podocarpus smithii was originally described from Mt. Lewis in northern Queensland and it was believed to be restricted to that locality. Since 1985 other localities have become known in the Atherton Tableland and further north in Queensland, but it is still considered to be a rare species occurring in small and scattered populations. General deforestation in the area through logging and land use conversion of forested areas are likely to have reduced its area of occupancy (AOO), but it remains difficult to estimate to what extent this has taken place. The populations are at present believed to be stable.
IUCN: LC

Uses

Logging for timber would almost certainly have included this species, as podocarp wood was and is considered valuable as construction material. At present, native woodland in Queensland, and more particularly rare species of trees in it, are considered for protection and logging has therefore been substantially reduced. This species may occur in a few botanic gardens, but is otherwise not known to be in cultivation.

Podocarpus spathoides de Laub., Blumea 30 (2): 267. 1985. Type: Malaysia: Peninsular Malaysia, Johore, Gunung Ledang [Mt. Ophir], *D. J. de Laubenfels P 600* (holotype L).

Etymology

The species epithet comes from Latin *spatha* = a broad flat wooden or metal blade and refers to the shape of the leaves.

Vernacular names

No common names are recorded for this species.

Description

Small trees 3–6 m tall, up to 20 cm d.b.h. Bark not described. Branches spreading, forming a rounded or domed crown. Foliage branchlets terete, more or less grooved, glabrous, terminating in 2–4 mm long, 2–3 mm wide buds with triangular outer scales with recurved tips. Leaves on juvenile plants petiolate, elliptic to oblong, to 10 cm long and to 20 mm wide, straight, abrubtly narrowed at base, acute or obtuse at apex. Leaves of mature trees more or less crowded at distal end of branchlets, spreading or ascending, elliptic to linear-oblong, (3–)5–8.5 cm long, (8–)9–13 mm wide, straight or slightly curved, petiolate at an abruptly narrowing base, with an obtuse or rounded (sometimes mucronate) apex, more or less coriaceous. Midrib obtusely raised on adaxial side, 1.3–1.5 mm wide, prominent and wider (to 2 mm) on abaxial side; leaf colour dark green above, pale green below. Stomata very small, in numerous irregular lines on abaxial (under) side on either side of midrib. Pollen cones axillary, in clusters of 3, short pedunculate with several basal bract scales, cylindrical (mature cones not observed). Seed cones axillary, solitary on a 2–6 mm long peduncle; receptacles with 2 bracts ('foliola') 1–2 mm long at base, obliquely bilobate, 5 mm long, swelling with a truncate distal end, turning red and succulent when ripe. Seeds including the epimatium ovoid, 7 × 5 mm, distal end obtuse, green turning purple or dark brown when ripe. Seed proper not observed.

Taxonomic notes

Podocarpus spathoides, first described and named by De Laubenfels in 1985 (*op. cit.*), was based on his collection *P 600* from Gunung Ledang [Mt. Ophir] in Peninsular Malaysia. The isotype specimen at K from a mature but small tree has elliptic to linear-oblong, obtuse or obtuse-mucronate to apically rounded leaves 5–8 cm long and 12–13 mm wide, with a raised midrib on the upperside of the leaf and a flat to shallowly grooved midrib on the lower (abaxial) side. On that mountain it occurs from the upper limit of *P. ridleyi* (a species with lanceolate, acute leaves) at ca. 1000 m to the summit at 1276 m. It is a poorly known species based on very few collections.

Distribution

Malesia: Peninsular Malaysia (Gunung Ledang = Mt. Ophir), Sarawak (Lawas).
TDWG codes: 42 BOR-SR MLY-PM

Ecology

On Gunung Ledang [Mt. Ophir] this species occurs at altitudes from ca. 1000 m to the summit at 1276 m a.s.l. in low shrubby vegetation and stunted forest. It is apparently rare there as on a visit in September 2008 with staff from FRIM I did not find it in the summit area.

Conservation

The only certain locality of this species is the type locality, Gunung Ledang (Mt. Ophir) in Peninsular Malesia. Another possible locality is in Lawas, N Serawak, Borneo. The natural vegetation on Gunung Ledang has been influenced by development, involving a road and television transmission towers and their infrastructure. It is apparently rare on this mountain. If taken as the only locality known then P. spathoides would be Endangered on the basis of its very restricted EOO in a partly disturbed mountain forest habitat. As the identity and status of the Sarawak occurrence are unknown but may belong here, the actual status remains DD.
IUCN: DD

Uses

No uses have been recorded of this species.

Podocarpus spinulosus (Sm.) R. Br. *ex* Mirb., Mém. Mus. Hist. Nat. 13: 75. 1825. *Taxus spinulosa* Sm., in Rees, Cyclopaedia 35, *Taxus* No. 7. 1819; *Margbensonia spinulosa* (Sm.) A. V. Bobrov & Melikyan, Bjull. Moskovsk. Obsc. Isp. Prir., Otd. Biol. 103 (1): 60. 1998. Type: Australia: New South Wales, Sydney Harbour, ["Port Jackson"], *A. Philip s.n.* (holotype LINN). Fig. 289, 290, 291

Etymology

The species epithet refers to the spiny leaf tips.

Vernacular names

No common names have been recorded for this species.

Description

Shrubs to 3 m tall, usually sprawling and not more than 1.5 m tall, layering. Bark thin, fibrous, brown. Foliage branchlets slender, terete, finely grooved, terminating in small, 2–4 mm long buds with narrowly triangular scales ending in fine, spreading apices. Leaves on young and adult plants similar, narrowly linear-lanceolate to linear, 2.5–7 cm long, 2–4.5 mm wide, straight or slightly curved, short petiolate or subsessile, gradually tapering to base and to an apiculate, pungent apex. Midrib acutely raised but narrow (0.3 mm wide) on adaxial (upper) side, prominently raised and slightly wider on abaxial side. Leaf colour yellowish green or lustrous green above, glaucous green below. Stomata in two conspicuous bands on either side of abaxial midrib, forming intermittent lines. Pollen cones axillary, solitary or in clusters of 2–5 on 1–4 mm long peduncles with minute scale leaves, short cylindrical, 4–8 mm long, 1.5–2.5 mm wide; microsporophylls minute, imbricate, finely apiculate, bearing two basal, globose pollen sacs. Seed cones axillary to reduced leaves, full-grown leaves or subterminal, solitary on slender, 5–10 mm long peduncles; receptacles subtended by two narrowly lanceolate, curved or revolute 3–5 mm long bracts ('foliola'), growing and swelling to 6–10 mm long, 6–7 mm wide, succulent and purple when ripe. Seeds obliquely attached to distal end of receptacle, ovoid when mature, 8–10 mm long, 5–7 mm wide, often distally crested; epimatium glaucous, becoming dark purple. Seed proper not observed.

Distribution

Australia: New South Wales, Queensland.
TDWG codes: 50 NSW-NS QLD-QU

Ecology

Podocarpus spinulosus is a shrub growing on nutrient-deficient soils derived from sandstone and on sandy old beaches and dunes along the coast as well as farther inland on plateaux (Blackdown Tableland in Queensland). The altitude range is 1–900 m a.s.l. On the coast it occurs in 'heath shrubland' while in the interior it is found scattered in dry sclerophyll forest dominated by *Angophora* spp. and *Casuarina*

spp. or with *Eucalyptus gummifera, E. sieberi, Acacia* spp., *Angophora bakeri, Dillwynia retorta, Lambertia formosa, Leptospermum attenuatum*, etc., in sandy soil derived from sandstone, or on the rocks themselves. On the islands in Moreton Bay, Queensland, it grows on stabilized dunes covered in shrubs and scattered eucalypts.

Conservation

IUCN: LC

Uses

This shrubby species of the genus *Podocarpus* appears not to be in cultivation outside a few collections in botanic gardens. Its ability to grow well in poor sandy substrates near the sea and its layering habit would make it a useful stabilizer of drifting sand in warm temperate to subtropical climate. Research into its potential for invasiveness in alien countries and habitats should be conditional if introduction is considered in this context.

Podocarpus sprucei Parl., in Candolle, Prodr. 16 (2): 510. 1868. Type: Ecuador: ["Valle de Pangor, ad 11,500' ascendit"], *R. Spruce 5519* (holotype not located, isotypes BM, K). Fig. 292

Etymology

This species was named after Richard Spruce (1817–1893), who collected extensively in Ecuador and distributed specimens to many herbaria.

Vernacular names

Huapsay, Guabisay (Quechua); romerillo (Spanish)

Description

Trees to 20 m tall (dwarfed at highest altitudes); trunk to 50 cm d.b.h. Bark becoming scaly, reddish brown. Branches ascending or spreading, forming a bushy crown. Foliage branchlets slender, terete, finely grooved between leaf apices; terminating in clusters of small, verticillate buds or single, subglobose buds with imbricate, broadly triangular, carinate scales with denticulate margins and acuminate apex, the outer scales enclosing the inner scales. Leaves on saplings similar but slightly larger than on mature plants, erect to patent, densele set on exposed branches of older trees and more remote on shaded young trees, 2–4(–7) cm long, elliptical to linear or oblanceolate-linear, straight, 3–5 mm wide, gradually narrowing to a short petiolate or subsessile base, gradually or more apruptly narrowing to an angustate-acute or pungent (occasionally obtuse) apex; margins slightly revolute; texture rigidly coriaceous; leaf colour lustrous dark green above, pale green below; flushing leaves glaucous green. Midrib on adaxial (upper) side a continuous (shallow) groove, sometimes raised proximally within this groove, on abaxial side raised but fading towards apex. Stomata very small, in numerous intermittent lines on abaxial face. Pollen cones in clusters of 3–8 or more due to corymbose branching at the end of 10–20 mm long, scaly or leafy stalks, sessile, subtended by short triangular bud scales, cylindrical, up to 10 mm long, 2 mm diam.; microsporophylls broadly obtuse, with a scarious margin, bearing 2 small, globose pollen sacs. Seed cones axillary, solitary on 3–7 mm long peduncles; receptacles 6–7 mm long, consisting of an axis with two unequal bracts, swelling only slightly to become more or less succulent and purplish red. Seeds globose, including the epimatium 5–7 mm diam., with a minute, ridge-like crest.

Distribution

Equador, N Peru (Piura).
TDWG codes: 83 ECU PER

Ecology

Podocarpus sprucei is a high montane to subalpine species growing in cloud forest up to the tree line, at altitudes from 1800 m to 3900 m a.s.l. Only in forests at lower altitudes does it become a tree to 20 m tall.

Conservation

Overexploitation for timber, logging the larger trees, was observed in the field by the plant collector W. H. Camp (vicinity of Cuenca, Province of Azuay,

Ecuador) in 1945, resulting in scarcity of the resource in that area. Continuing exploitation is causing further decline of this species, which has an area of occupancy (AOO) of less than 500 km² with a now severely fragmented population.
IUCN: EN [B2ab (ii, iii, v)]

Uses

The wood of this species is much in demand and trees are logged from primary forest often unsustainably due to scarcity and slow growth. It is used in house construction and to make furniture as it takes a fine polish. This species is also planted as an ornamental in parks in Ecuador.

Podocarpus steyermarkii J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 133. 1948. Type: Venezuela: Bolívar, Rio Carrao, Carrao-tepui, *J. A. Steyermark 60876* (holotype F). Pl. 39

Etymology

This species was named after Julian A. Steyermark (1909–1988) of the Field Museum of Natural History in Chicago, who hugely contributed to the botany of Central and South America.

Vernacular names

No common names have been recorded for this species.

Description

Small trees to 12 m tall, usually stunted in habit; trunk to 30 cm d.b.h. Bark undescribed, probably thin, smooth, becoming somewhat scaly on larger trunks, brown. Crown densely branched. Foliage branches stout, rigid, terete, with grooves running down from slightly raised leaf bases, terminating in large buds 4–7 mm wide at base, with broadly ovate, scariously margined outer scales terminating in a 5–15 mm long, cuspidate and erect or spreading apex (sometimes one or more scales becoming even longer and leaf-like); inner scales shorter with converging apices. Leaves more or less remotely inserted, patent, (3–)4–8 cm long, straight or slightly falcate, (6–)8–11 mm wide, thick coriaceous, lanceolate to lanceolate-linear, narrowing to a petiolate, often twisted base, slightly V-shaped transversely or nearly flat; margins slightly revolute, gradually tapering to an acute or obtuse apex; leaf colour lustrous dark green above, paler green below. Midrib on adaxial (upper) side slightly raised with a central groove, or only a groove continuous to apex, obtusely raised and 1 mm wide on abaxial side. Stomata small, in numerous intermittent lines on either side of abaxial midrib. Pollen cones axillary, solitary, sessile, subtended by acuminate bud scales, cylindrical, length at mature stage not observed. Seed cones axillary, solitary on 7–18 mm long peduncles; receptacles composed of an axis with two unequal, fused and slightly swollen bracts, 7–8 mm long, becoming red or purple. Seeds including the epimatium ovoid-globose, ca. 8 mm long, with a minute crest.

Distribution

Guyana: Pakaraima Mts.; Venezuela: Bolivar (Carrao-tepui, Uaipan-tepui, Cerro Jaua), Amazonas (Neblina Massif), Cordillera de Merida.
TDWG codes: 82 GUY VEN

Ecology

Podocarpus steyermarkii is a rare species occurring on the upper slopes and summits of the tepuis (table mountains) of Guyana and Venezuela. Its altitudinal range, as known from as yet limited collections in herbaria, is from 1850 m to 2430 m a.s.l. This species has now been found in cloud forest with a canopy to 20–25 m tall, as well as in low herbaceous or scrub vegetation in areas with blanket bogs with grasses, ferns, pitcher plants, orchids, mosses, and low scattered shrubs to 1.5 m tall, interspersed with thickets and dwarf forest including palms. Here the podocarps (*P. roraimae* and *P. tepuiensis* also occur in this habitat) occur mostly in the dwarf forest patches along small streams, which are the sources of large river systems. The substrate is acidic peat or peaty forest soil over sandstone. Levels of precipitation are very high and there is frequent, long lasting fog (clouds surrounding the tepuis), causing low temperatures in the daytime.

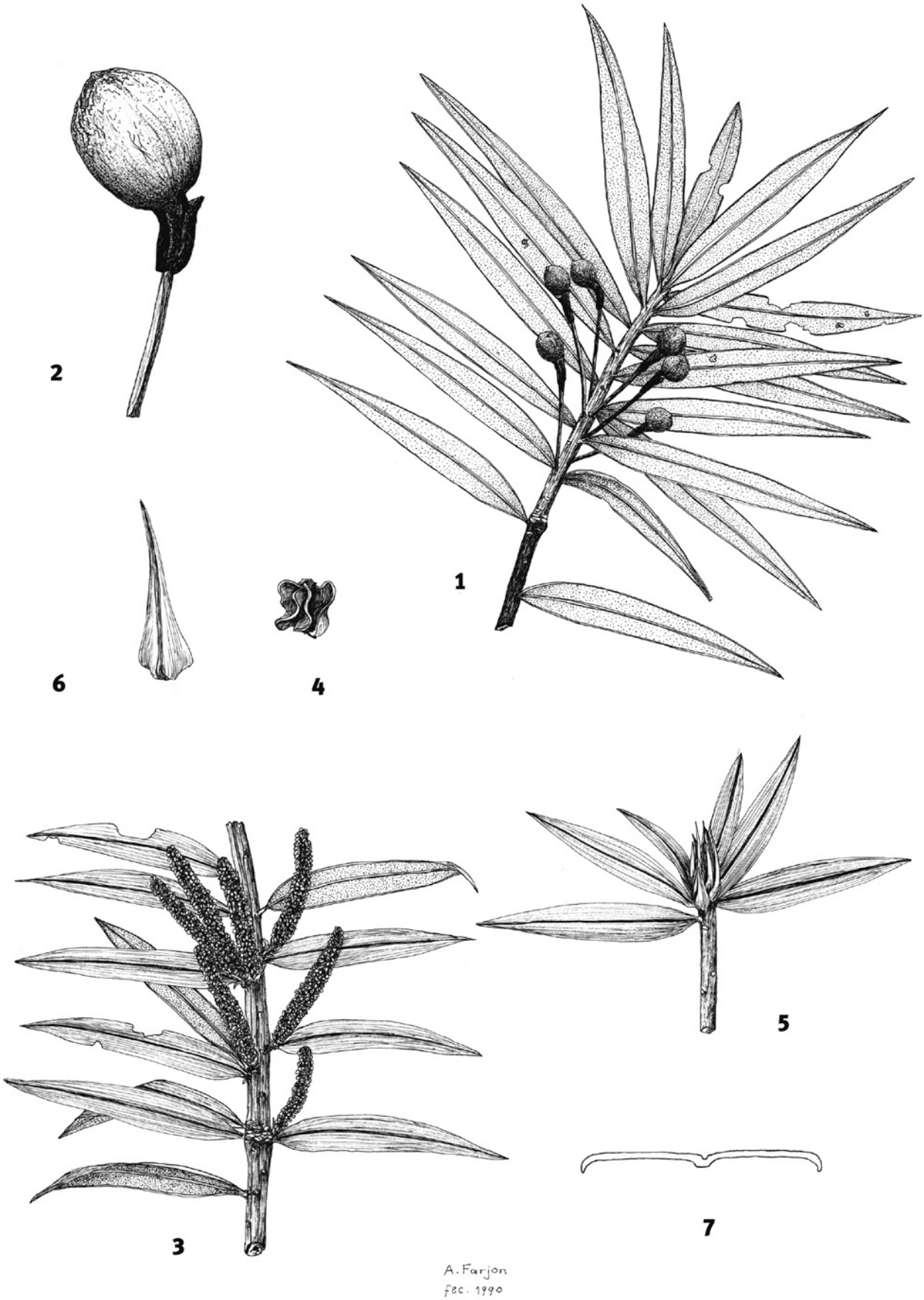

PLATE 39. *Podocarpus steyermarkii*. **1.** Branch with leaves and seed cones. **2.** Seed cone. **3.** Branch with leaves and pollen cones. **4.** Microsporophyll (dried). **5.** Foliage bud and leaves. **6.** Bud scale. **7.** Cross-section of leaf.

Conservation

This species, which was described and known from only a single locality in 1948, is still known from only six or seven localities. It is likely to turn up in more places with continuing botanical surveys, but is obviously scattered and uncommon. Its total area of occupancy (AOO) is almost certainly less than 500 km², but it is not exploited, nor are the forest patches in which it occurs threatened by deforestation. This species is therefore considered to be outside any category of threat of extinction in the wild.
IUCN: LC

Uses

No uses have been recorded of this species and it is not known to be in cultivation.

Podocarpus subtropicalis de Laub., Blumea 30 (2): 277. 1985. Type: China: Sichuan, Emei Shan, ["Mt. Omei"], *E. H. Wilson 3007* (holotype A).

Podocarpus subtropicalis de Laub. var. *medogensis* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 40. 2000.

Etymology

The species epithet refers to the subtropical habitat or distribution of this species.

Vernacular names

No vernacular name is recorded for this species.

Description

Trees to 20 m tall, monopodial. Bark not described or observed. Foliage branches terete, grooved, terminating in buds of 4–5(–7?) × 2–3 mm, with lanceolate, keeled and spreading or recurved scales. Leaves linear-lanceolate, petiolate (petioles 3–7 mm long), on juvenile plants up to 18 cm long and 14 mm wide; on adult plants 5–12(–15) cm long, (5–)7–13 mm wide, coriaceous, stiff, straight or more or less falcate, gradually tapering at both ends, acute or acuminate. Midrib prominent on both sides, acutely raised adaxially, wider and centrally grooved abaxially. Leaf colour bright green above (adaxially), pale green below; new leaves flushing yellowish green. Stomata on abaxial (under) side, very small, in numerous irregular lines on either side of midrib. Pollen cones axillary, sessile, in clusters of (1–)2–5, subtended by scarious, rostrate, keeled scales 3–5 mm long, cylindrical; cones elongating to 20–40(–60?) mm × 2.5–3.5 mm at anthesis; microsporophylls spirally arranged, with a triangular, spreading, 0.3 mm long apex and with two pollen sacs. Seed cones solitary and axillary on 5–15 mm long, slender peduncles; receptacles 7–12 mm long, with two 1–2 mm long bracts ('foliola') at their base, swelling when ripe to a succulent, red pseudo-fruit ca. 10 mm thick. Seeds single (sometimes 2) at truncate distal end of receptacle, obliquely globose, 10–12 × 8–10 mm including the green epimatium, minutely crested distally, ripening to blackish purple. Seed proper ca. 8 × 7 mm, slightly flattened, brown.

Taxonomic notes

Podocarpus subtropicalis has been identified with *P. neriifolius* by Chinese botanists (see Flora of China 4: 82, 1999), although it is usually not explicitly synonymized with that species in the recent floristic literature. Its taxonomic status remains somewhat uncertain and is not helped by the circumstance that it seems to have been widely spread in cultivation. Its morphology is also close to *P. fasciculus*, a species from Taiwan described by De Laubenfels (1985) in the same paper on the same page, both with short Latin descriptions and type designations, but without comparative discussion. I have retained these species here as distinct, but more critical taxonomic comparison based on further sampling from trees occurring in the wild is needed.

Distribution

China: Sichuan (Emei Shan [Mt. Omei]), Yunnan.
TDWG codes: 36 CHC-SC CHC-YN

Ecology

This species was described and named in 1985 by David J. de Laubenfels, based on a collection from the

famous mountain with Buddhist shrines and stairway paths Emei Shan [Mt. Omei] in Sichuan, China. Little is known of the ecological circumstances and many trees have been introduced there over the centuries. It was subsequently reported from Yunnan, but it remains a poorly known taxon. It is also widely planted elsewhere in China and, according to David de Laubenfels, in many other parts of the world with a warm-temperate to subtropical climate.

Conservation

IUCN: DD

Uses

This species, occurring on Emei Shan [Mt. Omei], has been taken from there and seeded and/or planted widely in other parts of China and beyond. It is often identified as *P. neriifolius*.

Podocarpus sylvestris J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 285. 1949. Type: New Caledonia: Grande Terre, Province Sud, Forêt du Mois de Mai, *J. T. Buchholz 1696* (holotype ILL).

Podocarpus novae-caledoniae Vieill. var. *colliculatus* N. E. Gray, J. Arnold Arbor. 39: 432. 1958; *Podocarpus colliculatus* (N. E. Gray) de Laub., Adansonia, ser. 3, 27 (2): 152. 2005.

Etymology

The species epithet *sylvestris* means 'from the forest' and refers to its habitat.

Vernacular names

No common names have been recorded of this species.

Description

Small to medium size trees to 20 m, rarely to 30 m tall and 80 cm d.b.h., or at high altitude shrubby trees 1.5–3 m tall. Bark on large trees thick and fibrous, fissured longitudinally, or on small trees thin and more or less tesselated, brown. Branches on trees spreading to form a broad crown, densely set on shrubby trees, spreading out wide. Foliage branchlets terete, finely grooved, terminating in small, globose or ovoid buds with 1–2 mm long, imbricate, appressed and obtuse scales. Leaves on juvenile plants larger than on mature plants, to 16 cm long and 18 mm wide. Leaves on mature trees and shrubs variable, (3–)5–10(–13) cm long, (5–)7–11(–13) mm wide, oval-linear (widest at midpoint) to linear, tapering gradually down to a more or less petiolate base and to an obtuse apex, coriaceous, straight or only slightly curved. Midrib prominent but obtusely raised on adaxial (upper) side, 1–1.2 mm wide, flat or forming a groove in dried leaves on abaxial side. Leaf colour bright lustrous green above, dull light green below. Stomata very small, in two bands forming numerous intermittent lines on abaxial side. Pollen cones from clustered buds in axils of leaves or below these, sessile, solitary or 2–3 together, subtended by small, rounded, imbricate bud scales, cylindrical, 10–20 mm long, 3 mm wide, yellow turning brown; microsporophylls imbricate, peltate, with erose-denticulate margin and minutely apiculate, bearing two basal, globose pollen sacs. Seed cones axillary and solitary on slender, 7–15 mm long peduncles; receptacle subtended by two small bracts ('foliola'), growing to 6–10 mm long, swelling to 5–6 mm thick, maturing to red or red-brown. Seeds including the epimatium relatively large, 10–15 × 7–9 mm, obliquely ovoid with a faint crest, smooth, olive green turning brown. Seed proper ovoid, smooth, ca. 9 × 6 mm.

Taxonomic notes

De Laubenfels (*op. cit.*) elevated var. *colliculatus* of N. E. Gray (*op. cit.*), which she had placed with *Podocarpus novae-caledoniae* and described from the Île des Pins in New Caledonia, to a species. Gray should have placed this taxon (as a variety) with *P. sylvestris*, from which it differs only slightly in having somewhat larger receptacles and longer peduncles. Both *P. novae-caledoniae* and *P. sylvestris* occur on the Île des Pins and are well distinguished morphologically, but the differences between *P. colliculatus* and *P. sylvestris* are minor and not constant in the specimens I have seen.

Distribution

New Caledonia (mountainous parts of Grande Terre, Île des Pins).
TDWG codes: 60 NWC

Ecology

Podocarpus sylvestris grows as a scattered tree in the tropical evergreen rainforests that cover parts of the mountains of New Caledonia; it is also found in wooded ravines and at high altitude in vegetation bordering on 'maquis minier', the shrubby vegetation on serpentine. It is not restricted to these ultramafic soils, as it also occurs on micaschist in the far NE of the main island Grande Terre. The altitudinal range is 150 m to 1200 m a.s.l. At high altitude or on ultramafic rocks it becomes a shrub or shrubby tree of low stature; in well developed rain forest it can reach 20–30 m tall. Besides numerous angiosperms, its associated species are sometimes conifers, mainly *Araucaria* spp. and *Agathis* spp. It is most often found as a small understory tree with these conifers, but is fertile in these circumstances just as in more open maquis-like vegetation or as a canopy tree.

Conservation

This species has been the target of logging, an activity which has undoubtedly led to a reduction in its abundance, but is difficult to quantify. Such operations have now virtually ceased. This species is widely distributed and still locally common and if forests are allowed to regenerate it will again spread from these localities.
IUCN: LC

Uses

This species has been subject to logging in the past; its wood provides good material for construction and indoor carpentry, floor boards, and furniture and has been known as 'false kauri' in the timber trade. Exploitation has virtually ceased as the more accessible forests have been logged and forest conservation of the remainder is now the prevailing management practice. This species has been planted in some parks and gardens in New Caledonia.

Podocarpus tepuiensis J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 134. 1948. Type: Venezuela: Bolivar, La Gran Sabana, Ptari-tepui, *J. A. Steyermark 59716* (holotype F).

Etymology

The species epithet refers to the (region of the) tepuis or table mountains of Venezuela.

Vernacular names

No common names have been recorded for this species.

Description

Shrubs or small trees 1–6 m, rarely to 15 m tall; trunks on the largest trees to 30 cm d.b.h. Bark thin, fibrous, reddish brown. Branches ascending, forming a (narrowly) pyramidal, dense crown in small trees, spreading more horizontally in shaded trees and with more or less erect foliage in shrubs. Foliage branchlets slender, terete, with fine grooves between leaf bases, terminating in small, globose buds 2–3 mm long and wide, with inbricate, broadly triangular, carinate scales with narrow scarious margins. Leaves densely set, spreading at wide angles to shoot; on juvenile plants up to 6 cm long and 8 mm wide; on mature plants (1–)1.5–2.5(–3.5) cm long, oblanceolate or elliptic, 3.5–5 mm wide, often slightly or markedly curved down, gradually narrowing to a short petiolate base; margins slightly revolute; apex obtuse or more or less acute; leaf texture coriaceous; leaf colour deep lustrous green above, pale green below; young leaves flushing pinkish white. Midrib on adaxial (upper) side of leaf a continuous groove, inconspicuous and nearly flat on abaxial side. Stomata very small, in numerous intermittent lines on abaxial face of leaf. Pollen cones axillary, solitary, sessile with rounded perular scales at base, cylindrical, 10–15 mm long, 1.5 mm wide, cream coloured when mature; microsporophylls triangular, with scarious margins, bearing two globose pollen sacs at base. Seed cones axillary, solitary on a short (2–3 mm long) peduncle; receptacles constituting of an axis with two unequal, divergent but mostly fused, slightly swollen, fleshy bracts, the largest fertile, ca. 5 mm long, green pruinose ripening to red

or purple. Seeds including the epimatium 6–7 mm long, 4 mm wide, obliquely ovoid, with a distal crest forming a papillate protrusion.

Distribution

Ecuador: Cordillera del Condor, Cordillera Sacha Llanganates; Venezuela: Bolivar, Amazonas; Guyana: Cuyuni-Mazaruni Region.
TDWG codes: 82 GUY VEN 83 ECU

Ecology

Podocarpus tepuiensis occurs in the mountains (tepuis = table mountains and other mountains) as well as in the lowlands. The altitudinal range in the mountains is from 700 m to 2450 m a.s.l.; the two herbarium collections in the southern Venezuelan lowlands are from 100–110 m a.s.l. In the latter locality it occurs on the edge of forest near savanna, on white sand with seasonal flooding (black water), and with occasional fires on the savanna; associated species are e.g. *Henriquezia nitida, Leopoldina piassaba, Emmotum* sp., and *Aldina* sp. On the Venezuelan tepuis it occurs on slopes and summits, usually along streams in gallery forest or at higher altitudes in dwarf forest patches. It may sometimes be associated with *P. roraimae* and *P. steyermarkii*, but these two podocarps do not occur at lower altitudes than 1800 m a.s.l. and in most localities only one of these species has been found. The disjunct localities in Ecuador, where this species has been found since 1993 are at altitudes between 1600 m and 2740 m. It occurs on quarzite outcrops in a sandstone formation similar to the Guyana Shield mesa sandstones and on granite.

Conservation

Podocarpus tepuiensis is the most common and widespread of the 'tepuis podocarps' and actually occurs elsewhere, too. It is a shrub or small tree of little interest for timber and most of the populations are remote from roads and towns. The disjunct occurrence in Ecuador makes it likely that its total range is incompletely known at present.
IUCN: LC

Uses

No uses have been recorded of this species and it is unknown in cultivation.

Podocarpus teysmannii Miq., Fl. Ned. Ind. [Fl. Ind. Batavae] 2 (7): 1072. 1859. *Podocarpus neriifolius* D. Don var. *teysmannii* (Miq.) Wasscher, Blumea 4 (3): 453. 1941. Type: Indonesia: Sumatera, Utara, on the coast near Sibolga, *J. E. Teijsmann s.n.* (holotype L).

Etymology

This species epithet commemorates the Dutch botanist Johannes Elias Teijsmann (1809–1882).

Vernacular names

On the west coast of Sumatera this species is known as kalek rotan; Pilger (1903) cited the name Sikuju laut, presumably also from Sumatera.

Description

Trees to 36 m tall, commonly to 20 m, d.b.h. to 50 cm; trunk erect, straight, terete; large trees with slightly fluted base. Bark smooth, eventually with small, powdery scales, brown; inner bark soft and fibrous, orange-brown. Branches spreading, forming a rounded crown. Foliage branchlets terete, slightly grooved or ridged, terminating in globose compact buds of 3–6 mm diam. with imbricate, rounded scales with erose margins. Leaves on juvenile plants lanceolate, to 20 cm long and 22 mm wide, straight or falcate, thin, gradually tapering to an acute apex. Leaves on mature plants lanceolate to linear-lanceolate, 7–14 cm long, (10–)12–17(–20) mm wide, straight or slightle curved, thinly coriaceous, gradually tapering to a petiolate base; apex acute or acuminate. Midrib on adaxial side narrow, acutely raised from base to apex, on abaxial side wider, to 1.5 mm, obtusely raised. Stomata very small, in numerous irregular lines on abaxial (under) side. Pollen cones axillary, solitary or in clusters of 2–3, sessile, subtended by rounded bracts (bud scales), narrowly cylindrical, 25–40 mm long, ca. 3 mm

wide; microsporophylls spirally arranged, spreading, with triangular apex and two basal pollen sacs. Seed cones axillary, solitary on a 3–10 mm long, slender peduncle; receptacles subtended by 2 minute, early deciduous bracts ('foliola'), slender, ca. 10 mm long, consisting of two lobes (axes?) each with a distal bract, one of these being fertile; lobes swelling mostly distally, ripening to purplish pruinose. Seeds single, obliquely attached, including the epimatium 7–9 × 5–7 mm, subglobose with a small crest, dark green turning blackish brown.

Distribution

Malesia: Peninsular Malaysia, Sumatera (including Bangka & Lingga Islands), Borneo (Brunei, Sabah).
TDWG codes: 42 BOR-BR BOR-SB MLY-PM SUM

Ecology

In Flora Malesiana, ser. 1, 10 (3): 407 (1988) *Podocarpus teysmannii* was described as an understorey tree to 12 m tall, but in fact sometimes trees are found reaching the canopy with a height of 36 m (*T. C. Whitmore FRI 8835* collected on Gunung Blumut in Peninsular Malaysia at 510 m on a ridge). This species occurs in both primary and secondary rain forest from near sea level to occasionally 1350 m a.s.l., but mostly up to 800 m. It is often restricted to sites with poor, sandy, or rocky soils and therefore will not attain large size under these conditions. On the coast of Sabah it often occurs on sandy ridges or hills with the broadleaved tree *Dryobalanops rappa* (*Dipterocarpaceae*); in the Mt. Kinabalu area (Mesilau River) it was collected in 'kerangas' forest dominated by *Agathis* sp.

Conservation

IUCN: NT

Uses

Larger trees of this species are undoubtedly logged for their timber; the use of which will be similar to that of other 'podocarps' of the region. Podocarp wood is suitable for light construction, carpentry and joinery, furniture making, etc.

Podocarpus totara G. Benn. *ex* D. Don, in Lambert, Descr. *Pinus*, ed. 2: 184. 1828. [& in ed. 8°, 2: [189]. 1832]. Type: New Zealand: North Island, Bay of Islands, *[?] Bennett s.n.* (lectotype BM, [specimen a] designated here). Fig. 293, 294, 295

Podocarpus totara G. Benn. *ex* D. Don var. *waihoensis* Wardle, New Zealand J. Bot. 10 (1): 201. 1972.

Etymology

The species epithet uses the Maori name for this tree.

Vernacular names

totara (Maori)

Description

Trees to 30(–40) m tall, with a straight, sometimes massive trunk to 3.6 m d.b.h. Bark thick, fibrous, stringy, with longitudinal furrows, exfoliating in small, fragmentary strips, light grey-brown. Branches spreading, forming a rounded crown, in veteran trees irregular through much reiteration. Foliage branchlets terete, glabrous, finely grooved; branching irregularly, sometimes dense, but shaded branchlets more or less pectinate. Terminal buds 2–3 mm long, subglobose, the inner scales imbricate and obtuse, the outer scales acute with free tips. Leaves sessile, short decurrent, spreading at wide angles, lanceolate-linear, (0.5)1–2.5(–3) cm long, (1.5–)2–3.5(–4.5) mm wide (narrowest leaves on saplings and young trees, widest leaves on fertile branches of large trees), straight or slightly curved, tapering to a slightly twisted base and an acute-pungent or sometimes obtuse-mucronate apex, coriaceous, stiff; a faint groove through the middle adaxially (upperside) and an obtuse midrib abaxially; leaf colour dark green, more or less lustrous above, dull and lighter green below. Stomata in two irregular bands of intermittent lines on abaxial side. Pollen cones axillary, solitary or sometimes in pairs on short peduncles, subtended by small, triangular scales, cylindrical, 12–15(–20) mm long, 3–4 mm wide at anthesis, straight or curved after shedding pollen, yellowish green turning brown; microsporophylls imbricate, peltate-triangular, upper margin

denticulate, with two sublateral, globose, yellow pollen sacs. Seed cones axillary, solitary on a short peduncle; receptacles when growing narrowly oblong, with two distal bracts subtending 1–2 ovules, swelling to nearly globose, 4.5–5.5 mm long, yellow ripening to scarlet, soft and succulent. Seeds including the epimatium ovoid-oblong, with a constricted distal part, 3–3.5 × 2–2.5 mm, lustrous green or glaucous green. Seed proper ca. 2.5 mm long, narrowly ovoid; seed coat smooth and hard.

Taxonomic notes

A herbarium sheet of this species at BM contains a mixture of specimens collected by different people at different localities and times. The largest branchlet marked a) was collected by Bennet in July 1829 at the Bay of Islands. Brian Molloy annotated this as the lectotype of *Podocarpus totara* in October 1991, but since he never published this, that lectotypification is effected here.

Distribution

New Zealand: North Island, South Island.
TDWG codes: 51 NZN NZS

Ecology

Podocarpus totara was the largest conifer dominating the lowland forests that covered much of the two large islands of New Zealand before humans, and especially Europeans, intervened. It now occurs only in forest fragments, often in secondary vegetation. It is a slow growing, emergent tree dependent in that ecosystem upon episodal events of disturbance enabling massive regeneration. Past forest clearance, if it took place in what are now forest rerserves, can provide these conditions. Maximum age is ca. 800–1000 years and one tree is estimated to exceed 1800 years. In primary forest this species is often associated with other conifers, e.g. *Dacrycarpus dacrydioides, Dacrydium cupressinum, Prumnopitys ferruginea, Phyllocladus trichomanoides*, and in Northland *Agathis australis*. Angiosperm trees can also be common and are often varied. Usually *Podocarpus totara* grows well below the altitude where *Nothofagus* begins to dominate, but occasionally it penetrates into this zone at around 500 m a.s.l. Above this altitude it is replaced by the similar species *P. cunninghamii*.

Conservation

Under the A criterion of IUCN's Red List of Threatened Species™, this species would have to be listed in a threatened category due to relatively recent major decline, caused by logging and forest clearance in the past 150 years. In New Zealand, this criterion, if applied to native trees, is not accepted by conservationists, due to more recent legislation that gives protection to most of the remaining forests and trees, both within reserves and through legal bans on cutting and other means of clearance of native forest. This policy has in fact already led to an increase in abundance (from an all-time low just before forest clearance was prohibited), due to regeneration and spread from seed trees into secondary vegetation and pioneer phases of native forest. As demand for further conversion of forested land for agriculture (diary, sheep farming) is presently waning, for the foreseeable future *Podocarpus totara* and other lowland conifers are indeed out of danger. However, this situation is policy dependent and there is no absolute guarantee that this policy will never change in the other direction in the future. The current situation indeed does not warrant listing of this species in a threatened category.
IUCN: LC

Uses

The Maori have used 'totara' (not exclusively *P. totara*) for many purposes, but especially construction of houses. Europeans began large scale logging and forest clearing in the 19th century and much of the wood of totara went into fence posts on the establishing farms and later in that century for railway sleepers. Only the 'best' trees were sawn in the numerous sawmills that had sprung up everywhere, the remainder were wasted (Ogden & Stewart in Enright & Hill, 1995). Timber export between 1850–1900 included totara, but its main source was kauri (*Agathis australis*) until that resource was almost exhausted. The wood is reddish, but variable in hue, dense and straight-grained, and was

used for general construction, joinery, furniture and cabinet making, as well as the coarser applications like railway sleepers, posts for communication lines, and fencing. At present, native trees are virtually universally protected in New Zealand and the exploitation of the wood of totara is much restricted, essentially to dead trees outside reserves, and put to specialist wood work only. In horticulture it remains uncommon, mostly restricted to arboreta and botanic gardens. Although eventually growing to a large tree if left alone, it can be planted and trimmed for hedges.

Podocarpus transiens (Pilg.) de Laub. *ex* Silba, Phytologia Mem. 7: 68 (1984). *Podocarpus lambertii* Klotzsch *ex* Endl. var. *transiens* Pilg., in Engler, Pflanzenr. IV.5 [18]: 86. 1903. Types: S Brazil, *F. Sello s.n.; A. F. M. Glaziou 16335* (syntypes, not located).

Podocarpus transiens (Pilg.) de Laub. *ex* Silba var. *harleyi* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 39. 2000.

Etymology

The species epithet *transiens* is Latin for 'passing over into' and presumably refers to similarities with *P. lambertii*.

Vernacular names

No common names have been recorded for this species other than the generic 'pinheirinho', which means little more than 'conifer'.

Description

Small trees to 8–12 m tall, d.b.h. to 30 cm. Branches spreading, forming a rounded or irregular crown. Foliage branchlets slender, terete, longitudinally grooved between leaf bases, terminating in small, subglobose buds with imbricate, broadly triangular, carinate, short apiculate scales. Leaves on saplings similar but slightly larger than on mature trees. Leaves on mature trees crowded, spreading at wide angles or more or less directed forward, (1.5–)2.5–5(–6.5) cm long, (3.5–)4–7(–9) mm wide, narrowly lanceolate to oblanceolate, straight, gradually narrowing to a short petiolate base, gradually or more abruptly tapering to an acute or obtuse apex; margins not parallel for most of leaf length, straight or slightly revolute; leaf texture coriaceous or thin coriaceous; leaf colour green or grey-green above, whitish green below. Midrib 0.5–0.7 mm wide, continuous or sometimes fading towards apex, mostly forming a groove on adaxial (upper) side, more or less raised from a flat leaf surface and continuous to apex on abaxial side. Stomata small, in numerous intermittent lines forming two bands on abaxial side. Pollen cones axillary, on short shoots or slender peduncles up to 15 mm long in 1-several clusters of 2–6 or more, subtended by apiculate perular scales, cylindrical, 6–12 mm long, 1.5–2 mm wide; microsporophylls ovate-triangular, with minutely denticulate margins, bearing two globose pollen sacs. Seed cones axillary, solitary on slender, 5–10 mm long peduncles; receptacles small, swelling to 6–7 mm long, 4–5 mm wide, succulent, purple, eventually chestnut brown. Seeds solitary, globose, including the epimatium 4–5 × 4–5 mm, glossy without a crest. Seed proper globose with a smooth surface.

Taxonomic notes

This taxon was originally described by Pilger (*op. cit.*) as a variety of *Podocarpus lambertii*, but it was noted by David de Laubenfels to be sufficiently and consistently different to be recognized as a species, whereupon Silba (*op. cit.*) published the new combination and status. The main or obvious differences are in the leaf shape and size, but another difference are the persistent, apiculate bud (perular) scales at the base of the pollen cones. It occurs further north than *P. lambertii*, but there is one herbarium record in K from Santa Catarina in the south, where *P. lambertii* is most common.

Distribution

Brazil (Bahia, Goiás, Minas Gerais, Paraná, Santa Catarina).

TDWG codes: 84 BZC-GO BZE-BA BZL-MG BZS-PR BZS-SC

Ecology

This species is an uncommon component of montane forest remnants surrounded by 'campo rupestre' (rocky grassland), a dryland vegetation in the interior. Nearer the Atlantic coast and in the south of its range it has been found in remnants of Atlantic Rain Forest. The altitudinal range of this species, based on data on herbarium specimen labels, is 1000–1780 m a.s.l. It may be associated with *Podocarpus lambertii*, especially in the southern parts of its range, but unequivocal evidence of this has not been recorded on herbarium labels or in the literature, probably due to identification problems, as most specimens were identified as *P. lambertii*.

Conservation

Due to very small numbers of trees in some of its locations, the area of occupancy (AOO) must be much smaller than 500 km², while populations appear always to be small in the ca. 10 locations recorded in the region, of which the most commonly visited is the Morro do Chapeu in Bahia. In several locations degradation of habitat and tree cutting for firewood are causing decline of this species. Deforestation caused by cutting, fire and grazing of domestic animals is the main threat. The tree cutting is mostly for firewood, much less for timber.
IUCN: EN [B2ab (ii, iii, v)]

Uses

No commercial uses have been recorded for this small tree, of which the timber has not much value. It is used locally for fence posts and more extensively for firewood. It is not known to be in cultivation.

Podocarpus trinitensis J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 135. 1948. Type: Trinidad and Tobago: Trinidad, Saint Andrew Co., Valencia, ["Valencia road"], *W. E. Broadway 7151* (holotype MO).

Etymology

The species epithet refers to the island of Trinidad.

Vernacular names

No common names have been recorded for this species.

Description

Trees to 15–20 m tall; trunk with d.b.h. to 60–80 cm, often fluted at base. Bark smooth, on large trunks exfoliating in small strips, dark brown weathering grey. Branches spreading, forming a wide crown in old trees. Foliage branches terete, finely grooved between leaf bases, terminating in small subglobose buds with free, triangular, apiculate outer scales and imbricate inner scales. Leaves on shaded branches and juvenile trees larger than on sun-exposed branches of mature trees, 6–10 cm long, 10–15 mm wide, straight or sometimes slightly falcate. Leaves on sun-exposed branchlets (2.5–)4–6(–7) cm long, 6–12 mm wide, spreading or directed forward on ends of shoots, coriaceous, dark green above, pale green below, straight, elliptic to oblanceolate or oblong, gradually narrowing to a short petiolate base and more abruptly to an acute to weakly apiculate or rarely obtuse apex. Midrib on adaxial (upper) side prominently raised but sometimes fading towards apex, less than 0.5 mm wide and lying in a shallow depression, on abaxial side flat or forming a shallow groove (*in sicco*). Stomata small, in numerous intermittent, irregular lines on abaxial side. Pollen cones axillary, solitary, sessile, subtended by thin, scarious bud scales, cylindrical, maximum elongation not observed; microsporophylls triangular, minutely apiculate, bearing two relatively large, ovoid-oblong pollen sacs. Seed cones axillary on short peduncles; basal bracts ('foliola') deciduous; receptacles formed of an axis with two unequal, fused bracts, swelling to a 7–8 × 6 mm large, succulent, red body. Seeds solitary, including the epimatium ovoid, 7–8 × 5–6 mm, with or without a distal, curved, thin crest. Seed proper ovoid, smooth with a thin, light brown seed coat.

Taxonomic notes

There is some doubt about the taxonomic status of this species. The leaves are generally smaller than those of *P. coriaceus*, but the dimensions appear to

overlap, especially in younger trees or on branches of shaded growth. The apex of leaves of *P. trinitensis* narrows more abruptly and is often weakly apiculate. Whether the pollen cones can reach the length found in *P. coriaceus* is not known, because only immature cones, not much beyond the bud stage, have so far been observed in collected specimens. *Podocarpus trinitensis* may turn out to be only a short-leaved variety of *P. coriaceus*; both taxa are present on the island of Trinidad, but *P. coriaceus* extends along the Lesser Antilles as far as Puerto Rico.

Distribution

West Indies: Trinidad.
TDWG codes: 81 TRT

Ecology

Podocarpus trinitensis occurs in montane, evergreen tropical forest.

Conservation

This species has an area of occupancy (AOO) of little more than 20 km². It does not appear to be in decline, even though it does not occur within a protected area, but its small AOO would place it in a category of threat if its habitat were to be affected by destructive events.
IUCN: NT

Uses

No uses have recently been recorded of this species. In the past, larger trees were probably used for construction and general carpentry.

Podocarpus urbanii Pilg., in Engler, Pflanzenr. IV.5 [18]: 89. 1903. Type: Jamaica: Saint Thomas, Blue Mountains, ["near the summit of the Blue Mountains"], *J. MacFadyen 27* (holotype K). Pl. 40

Etymology

This species was named after the German botanist Ignatz Urban (1848–1931), who published the first synthetic account of Caribbean or West Indies plants.

Vernacular names

Yacca

Description

Small trees to 16 m tall, often only 5–10 m. Bark smooth, dark reddish brown. Branches spreading, forming a wide crown in old trees. Foliage branches becoming densely leaved in mature trees with sun-exposed crowns, terete, finely grooved between more remote leaf bases, terminating in small, globose buds with imbricate, keeled, obtuse or (outer scales) minutely apiculate scales. Leaves on shaded branches and juvenile trees larger than on sun-exposed branches of mature trees, 3–6 cm long, 5–9 mm wide, straight or slightly falcate. Leaves on sun-exposed branchlets (1–)2–3(–3.5) cm long, 3–5 mm wide, densely crowded and directed forward at an angle of 30–45° so as to obscure shoots, coriaceous, rigid, dark green above, straight, narrowly lanceolate; margins nowhere parallel, gradually converging to a sessile base and an apiculate-pungent or acute or rarely obtuse apex. Midrib on adaxial (upper) side raised from leaf base to beyond the middle but fading towards apex, less than 0.5 mm wide, on abaxial side obscurely raised or flat or forming a shallow groove (*in sicco*). Stomata in two whitish bands of numerous irregular, wavy lines on abaxial side. Pollen cones axillary, solitary, sessile, subtended by thin, scarious bud scales, cylindrical, 12–15 mm long, ca. 4 mm wide; microsporophylls more or less oval, obtuse with erose-scarious margins, bearing two relatively large, ovoid-oblong pollen sacs. Seed cones axillary on short peduncles; basal bracts ('foliola') deciduous; receptacles formed of an axis with two fused, slightly diverging bracts, swelling to a 7–8 × 6 mm succulent, red 'pseudo-fruit'. Seeds solitary, including the epimatium obliquely ovoid, 6–7 × 4 mm with a distal conical crest, dark green turning blackish. Seed proper not observed.

Distribution

West Indies: Jamaica (Blue Mountains).
TDWG codes: 81 JAM

PLATE 40. *Podocarpus urbanii*. **1, 2.** Branches with leaves and seed cones. **3.** Branchlet with leaves and pollen cones. **4.** Leaves. **5.** Seed cone.

Ecology

Podocarpus urbanii occurs in montane to high montane forests at altitudes between 1160 m and 2256 m a.s.l. in the Blue Mountains of E Jamaica.

Conservation

In the Global Red List of Conifers (Farjon & Page, 1999) this species was listed as Near Threatened (LRnt following 1994 criteria) and this was still its status in the IUCN Red List 2008. It has a limited distribution confined to a single mountain range, where it is locally common. A recent re-assessment in 2011 has found that it is Critically Endangered due to its limited occurrence and continuing decline.
IUCN: CR [B1ab (i–iii, v)]

Uses

No economic uses have been recorded of this species.

Prumnopitys Phil., Linnaea 30: 731. 1861. Type: *Prumnopitys andina* (Poepp. *ex* Endl.) de Laub. (*Podocarpus andinus* Poepp. *ex* Endl.) [*Prumnopitys elegans* Phil.] (*Podocarpaceae*).

Stachycarpus Tiegh., Bull. Soc. Bot. France 38: 163. 1891. Type: *Stachycarpus andinus* (Poepp. *ex* Endl.) Tiegh. [*Prumnopitys andina* (Poepp. *ex* Endl.) de Laub. (*Podocarpus andinus* Poepp. *ex* Endl.)]

Greek: *prumme, prumne* = stern; *pitys* = pine or fir tree.

Description

Trees or multistemmed shrubs, evergreen, dioecious, with smooth or scaly bark. Resin canals in leaves (1) and resin in bark. Foliage branches alternate, spreading in a more or less horizontal plane. Leaves small, spirally inserted, in vegetative lateral shoots usually pectinately arranged, flattened, more or less falcate-linear, epistomatic with stomata in two bands separated by a thin midrib. Pollen cones aggregate on relatively long, leafless branchlets, cylindrical, slender; pollen sacs relatively large, yellow, two on each microsporophyll, transversely dehiscent, containing bisaccate pollen. Seed cones on small axillary branchlets with a few reduced leaves, consisting of one to a few spirally arranged bracts developing a single erect ovule (seed) in the axil of a small (terminal) bract, lacking any fleshy receptacle at maturity. Seeds ovoid, with a drupe-like, thick, fleshy and globose or ovoid-elliptic epimatium (outer layer) covering the seed entirely and becoming yellow, red or black.

9 species

Distribution

Australia: Queensland. SW Pacific: New Caledonia; New Zealand. America: Costa Rica (Central America); in South America along the Andes from W Venezuela to Bolivia; disjunct in S Chile.

Key to the species of *Prumnopitys*

The vegetative characters are often very similar among the species of *Prumnopitys* and the few different character states in the leaves that are easily observable in the field are insufficient to differentiate between them. Therefore pollen cones and ripe seeds are necessary to arrive at a correct identification if one has to make a choice from among all nine species.

1a. Adult leaves spreading to all sides (but more or less pectinate on shaded shoots), slightly curved backward or assurgent, slender, (1–)1.5–2 mm wide ***P. taxifolia***

1b. Adult leaves pectinately arranged, nearly straight or slightly curved sideways, sometimes falcate, (1.8–)2–3.8 mm wide **2**

2a. Small trees to 15 m tall, with a short bole or multi-stemmed. Adult leaves 1.8–2.5 mm wide. Seeds including the fleshy epimatium 18–25 × 18–20 mm, bluish green ripening to yellow ***P. andina***

2b. Trees usually with a single bole and potentially taller than 15 m. Adult leaves 2–3.8 mm wide. Seeds including the fleshy epimatium 10–20 × 7–15 mm, variably coloured (if larger than 20 × 15 mm, dark blue to blue-black) **3**

3a. Adaxial (upper) midrib (midvein) of leaves distinctly grooved. Pollen cones arranged in axillary spikes of 15–25 **4**

3b. Adaxial midrib of leaves indistinctly raised (not a groove). Pollen cones solitary, nearly sessile **7**

4a. Leaf apex obtuse, sometimes acute or acuminate. Seeds including the fleshy epimatium crested, pruinose when ripe **5**

4b. Leaf apex acute or acuminate, sometimes mucronate or obtuse. Seeds including the fleshy epimatium rounded or with an apical knob, yellow or bluish, but not pruinose when ripe **6**

5a. Seeds (cones) on 0.5–1.5 cm long branchlets with deciduous scale leaves. Microsporophylls of pollen cones with an acute apex, 0.5 mm wide ***P. exigua***

5b. Seeds (cones) on 1.5–2.5 cm long branchlets with persistent scale leaves at base and deciduous reduced leaves. Microsporophylls of

pollen cones with broadly triangular apex, 0.7 mm wide ***P. harmsiana***

6a. Seeds (cones) on 0.5–1.5 cm long branchlets with a few reduced leaves, solitary. Seeds including the fleshy epimatium 10 × 7–8 mm, without an apical crest or knob ***P. standleyi***

6b. Seeds (cones) on 2–3 cm long branchlets with (near) normal leaves, solitary or in pairs. Seeds including the fleshy epimatium 14–16 × 10–12 mm, with a distinct apical knob ***P. montana***

7a. Pollen cones very small, 3–4 × 1.3–1.6 mm. Seeds including the fleshy epimatium 10–14 × 7–10 mm, with a ridge and apical knob ***P. ferruginoides***

7b. Pollen cones larger, 7–20 × 2–3 mm. Seeds including the fleshy epimatium 15–30 × 9–25 mm, only with an apical knob **8**

8a. Adult leaves 2–3 mm wide, curved downward. Pollen cones 8–20 mm long. Seeds including the fleshy epimatium 15–18 × 9–13 mm, yellow becoming bright red ***P. ferruginea***

8b. Adult leaves 2.5–3.5 mm wide, (nearly) straight. Pollen cones 7–9 mm long. Seeds including the fleshy epimatium 22–30 × 18–25 mm, dark blue to blue-black ***P. ladei***

Prumnopitys andina (Poepp. *ex* Endl.) de Laub., Blumea 24 (1): 189. 1978. *Podocarpus andinus* Poepp. *ex* Endl., Syn. Conif.: 219. 1847. Type: ["Habitat in Chile australis alpinis frigidis, locis umbrosis convallis Quillai-Leuvu versus Antuco. Pöppig msc."] (HAL?, W destroyed). Fig. 296, 297

Podocarpus spicatus Poepp., in Poeppig, Nov. Gen. Sp. Pl. 3: 18. 1845, *non* R. Br. (1838); *Prumnopitys spicata* (Poepp.) Molloy & Muñoz-Schick, New Zeal. J. Bot. 37: 190. 1999 (*nom. illeg.*, Art. 53.3).
Prumnopitys elegans Phil., Linnaea 30: 732. 1860.
Prumnopitys andina (Poepp. *ex* Endl.) de Laub. subsp. *blijdensteinii* Silba, J. Int. Conifer Preserv. Soc. 9 (1): 33. 2002.

Etymology

The species epithet refers to its occurrence in the Andes.

Vernacular names

Plumyew; Lleuque, Lleuqui, Uva de Cordillera (Chile)

Description

Trees to 15 m tall; trunk to 1 m d.b.h., with a short bole or multi-stemmed. First order branches spreading or ascending forming a broadly pyramidal or rounded crown. Bark smooth on younger trees, becoming scaly and exfoliating in irregular small strips; bark colour purplish grey, weathering grey. New foliage glaucous green, turning greyish green. Seedlings and young plants with slender leaves 8–15(–20) mm long and 1.2–2 mm wide; apex acuminate. Leaves on mature trees alternate, twisted at a petiolate base, mostly pectinately arranged in two rows and one plane, linear, (8–)12–20(–25) mm long, 1.8–2.5 mm wide, slightly curved sideways above base or more or less falcate, with parallel sides, with a indistinct proximal midrib adaxially (upperside) and a low midrib abaxially (underside); margins entire; apex acuminate or sometimes obtuse; leaf colour dull greyish green above, whitish green below. Stomata in two indistinct bands of numerous lines, more or less separated by midrib on abaxial (under) side of leaves. Pollen cones on lateral and axillary spikes towards ends of foliage branches; up to 25 spreading cones per spike, 4–7 mm long and 2 mm wide, each subtented by a leaf-like bract 3 mm long. Microsporophylls subpeltate with acute apex, 0.5 mm wide, incurved at anthesis, light green, each with two yellow pollen sacs. Seed cones 1–3 on 2–3 cm long branchlets with persistent scale leaves at base and deciduous, acute scale leaves, axillary to a scale leaf (bract), consisting of an epimatium enclosing a subglobose, slightly flattened, smooth seed, growing into a globose to broadly elliptical, bluish green ripening to yellow 'pseudo-fruit' 18–25 × 18–20 mm diam. with an apical small knob.

Distribution

S Argentina: Neuquén; S Chile: Biobio, La Araucana, Maule.

TDWG codes: 85 AGS-NE CLC-BI CLC-LA CLC-MA

Ecology

Prumnopitys andina occurs in valleys close to rivers, in mixed forests with *Austrocedrus chilensis, Cryptocarya alba, Quillaja saponaria* and other sclerophyllous shrubs and trees. In the Andes and Coastal Cordillera it grows with *Nothofagus dombeyi, N. nervosa* and *N. obliqua* in non-sclerophyllous montane rain forests. Its altitudinal range is from 200 m to 1400 m a.s.l.

Conservation

There are probably fewer than 12 subpopulations and only two of these have more than 1000 mature individual trees, while many have fewer than 100. Several subpopulations have been reduced recently, e.g. by conversion of the natural forest to plantations of exotic trees for commercial forestry. Other threats are clearing of woodland to make space for agriculture, flooding in relation to hydroelectric projects, and increased wildfires. Regeneration is high in some subpopulations but very low in others, possibly due to domestic animals eating the fleshy seeds. There are three protected areas in Chile which contain this species: Reserva Nacional Nuble, Parque Nacional Conguillio and Parque Nacional Tolhuaca. Germination experiments conducted in Chile and the UK have resulted in increased germination rates that could help restocking lost or diminished natural populations.
IUCN: VU [B2a, b (ii–v)]

Uses

In the past the wood was much used to make furniture; at present trees are not felled at a commercial scale but its wood can become available when forest patches that contain it are cleared for other land uses. The succulent tissue surrounding the seeds is sweet and these are harvested for consumption by local people, as most female trees bear large quantities of 'fruit' each year. There are also potential medicinal properties, e.g. chemicals that actively deter fungal infections detected in the bark of this tree. *Prumnopitys andina* is in cultivation in arboreta, botanic gardens and private tree collections in many countries, mostly based on cuttings taken from earlier introductions. Growing anew from seed would increase genetic diversity, thought to be crucial to counter potential pathogens.

Prumnopitys exigua de Laub. ex Silba, Phytologia Mem. 7: 68. 1984. Type: Bolivia: Cochabamba, road from Sihuenca to Totora, *M. Cardenas 4879* (holotype US).

Etymology

The species epithet is from Latin: *exiguus* = short, insignificant; this species was at first believed to be a stunted form, but larger trees were found later.

Vernacular names

pino colorado, pino negro (Spanish)

Description

Trees to 20 m tall; trunk to 1 m d.b.h., with a short, stout bole. First order branches spreading in large trees forming a rounded crown. Bark smooth on younger trees, eventually exfoliating in irregular small papery strips; bark colour reddish brown, weathering blackish brown. New foliage yellowish green, turning dark green. Seedlings and young plants with slender leaves 12–20 mm long and 1.8–2.3 mm wide; apex acute. Leaves on mature trees alternate, twisted at a petiolate base, mostly pectinately arranged in two rows and one plane, linear, 10–20 mm long, 2.2–3.1 mm wide, slightly curved sideways above base, widest above the middle, with a distinct grooved midrib adaxially (upperside) and a midrib abaxially (underside); margins entire; apex obtuse or sometimes acute; leaf colour lustrous dark green above, dull light green below. Stomata in two bands of numerous lines separated by midrib on abaxial (under) side of leaves. Pollen cones on lateral and axillary spikes towards ends of foliage branches; up to 20 spreading cones per spike, each cone axillary to a small leaf, 7–10 mm long and 2 mm wide. Microsporophylls sub-peltate with acute apex, 0.5 mm wide, incurved at anthesis, light green, each with two yellow pollen sacs. Seed cones solitary on 5–15 mm long branchlets with deciduous scale

leaves, axillary to a scale leaf (bract), consisting of an epimatium enclosing a globose, slightly flattened seed, growing into a globose, pruinose 'pseudo-fruit' 10–12 mm diam. with an apical crest.

Distribution

Bolivia: Cochabamba, W Santa Cruz.
TDWG codes: 83 BOL

Ecology

This species occurs in upper montane evergreen rainforest. The altitudinal range (from information on herbarium labels) is 1850 m to 3000 m a.s.l. At the upper limit this forest becomes stunted (low cloud forest) and both vegetation formations are rich in epiphytes. It appears to occupy rather similar high altitude habitats as *P. montana*, but is disjunct from that species by ca. 1000 km.

Conservation

Restricted to upper montane forest in two departments in Bolivia. The extent of occurrence (EOO) is less than 10,000 km² and there are 5–6 subpopulations in about 15–20 locations. A reduction in the extent of habitat is caused by deforestation in the region, which affects this species. The area of occupancy (AOO) for this species has been estimated as ca. 525 km² but the number of known locations exceeds the threshold for a threatened category.
IUCN: NT

Uses

This species is probably logged with other podocarps if of sufficient size. The wood of this tree is valued for construction and carpentry, but probably only of local significance. Many trees at higher altitudes are too stunted to be of any use for their timber, even though at least one old tree is known to have a trunk in excess of 1 m diam.; several herbarium collectors have taken their samples of it. It is not recorded to be in cultivation.

Prumnopitys ferruginea (G. Benn. *ex* D. Don) de Laub., Blumea 24 (1): 190. 1978. *Podocarpus ferrugineus* G. Benn. *ex* D. Don, in Lambert, Descr. *Pinus*, ed. 8°, 2: [189]. Type: "Habitat in Nova Zelandia. Phillip, Bennett." (LINN?, not designated).

Etymology

The species epithet means 'with the colour of rusted iron' (Latin *ferrum* = iron) and refers to the leaves of young plants.

Vernacular names

Brown pine; miro (Maori)

Description

Trees to 25 m tall; trunk to 1 m d.b.h. First order branches ascending and eventually spreading, in old trees forming a domed or rounded crown. Bark more or less smooth on younger trees, covered in tiny pustules, becoming scaly and exfoliating in thick flakes from the bole of large trees; bark colour dark brown, weathering blackish grey. Seedlings and very young plants with pectinately spreading leaves 7–15(–20) mm long and 1.4–2 mm wide. Leaves on young trees alternate, twisted at a petiolate base, mostly pectinate, falcate, 15–30 mm long, 1.8–2.7 mm wide, with a distinct, raised midrib on both sides; margins entire, tapering to an acute apex; leaf colour light green to brownish red. Leaves on adult trees shorter, mostly pectinate and curved downward, falcate-linear, 10–20 mm long and 2–3 mm wide, with an indistinct midrib adaxially (above) and a distinct green midrib on the stomatal side; apex obtuse or faintly apiculate; leaf colour lustrous green above, whitish green below. Stomata in two broad bands separated by a green midrib on abaxial (under) side of leaves. Pollen cones axillary, solitary, nearly sessile, cylindrical, 8–20 mm long and 2.5–3 mm wide. Microsporophylls sub-peltate with apiculate apex, 1 mm wide, light green, each with two yellow pollen sacs. Seed cones solitary on short axillary branchlets with deciduous scale leaves, subterminal with 7–9 bracts but developing a single ovule (seed). Epimatium enclosing a broadly ovoid, slightly flattened, smooth and ridged seed, growing

into an ellipsoid, green or blue-green, then yellow and finally bright red 'pseudo-fruit' 15–18 mm long and 9–13 mm wide, with a distinct apical knob.

Distribution

New Zealand: North Island, South Island, Stewart Island.
TDWG codes: 51 NZN NZS

Ecology

Prumnopitys ferruginea is a constituent of podocarp forest occurring in lowland areas from near sea level to as high as about 1000 m. Most of this forest has now gone and remnants are often disturbed or at any rate altered. Those forest reserves that still contain primary forest show a mixed podocarp-broad-leaved forest with *Dacrycarpus dacrydioides, Dacrydium cupressinum, Podocarpus totara, Manoao colensoi, Prumnopitys taxifolia*, and *P. ferruginea* as dominant conifers (all *Podocarpaceae*) and a mixture of angiosperm trees and tree ferns in a second layer. In Northland it also occurs with *Agathis australis* (*Araucariaceae*). All of these are slow growing (except for an initial stage of establishment) and long-lived conifers with 'K' ecological strategies. On the cooler west coast of the mountainous South Island, these conifers form a narrower belt below *Nothofagus* forest and are mixed with the southern beeches in a transition zone. On Stuart Island monospecific stands of *P. ferruginea* occur with *Pseudopanax crassifolius* in the understorey.

Conservation

IUCN: LC

Uses

The wood of miro has similar properties as that of matai (*P. taxifolia*) and is used in construction for floors and weatherboards. It sometimes is beautifully figured, especially in radial cuts, which makes it desirable for furniture, e.g. table tops and cabinet making. Salmon (1996, repr. 2001) states that it is "exploited increasingly as a substitute for matai", but that observation may be dated as the native timber producing conifer trees in New Zealand are now protected from logging. Perhaps this tree is used here and there under licence on a small scale, as it is certainly more common and widespread than its congener. It is rare in cultivation, restricted to some botanical collections in warm temperate regions, e.g. California and Ireland.

Prumnopitys ferruginoides (R. H. Compton) de Laub., Fl. Nouv. Calédonie Dépend. 4: 56. 1972. *Podocarpus ferruginoides* R. H. Compton, J. Linn. Soc., Bot. 45: 424. 1922. Type: New Caledonia: Grande Terre, Province Sud, Mt. Nékando, *R. H. Compton 1073* (holotype BM). Fig. 298

Podocarpus distichus J. T. Buchholz, J. Arnold Arbor. 32: 89. 1951.
Podocarpus distichus J. T. Buchholz var. *maialis* J. T. Buchholz, J. Arnold Arbor. 32: 89. 1951.

Etymology

The species epithet *ferruginoides* compares this species with *P. ferruginea* from New Zealand.

Vernacular names

No vernacular names have been recorded for this species.

Description

Trees to 20 m tall; trunk to 0.5 m d.b.h., but often remaining smaller, densely branched forming a rounded crown. Bark more or less smooth on younger trees, becoming scaly and breaking up into small quadrangular flakes on the bole of large trees; inner bark fibrous; bark colour yellowish or reddish brown, weathering grey. Leaves on young trees alternate, twisted at a short decurrent and more or less petiolate base, mostly pectinate, (nearly) straight, (10–)15–30 mm long, 3.5–4.5 mm wide, with a distinct, raised midrib on both sides; margins entire, parallel to shortly below the obtuse or minutely mucronate apex; leaf colour light green to brownish red. Leaves on adult trees much shorter, mostly pectinate, linear or more or less oval in shortest leaves, (5–)8–12(–18) mm long and 2–3.8 mm wide, with a faint midrib on both sides; margins slightly

incurved; apex obtuse or mucronate; leaf colour lustrous green above, whitish green below. Stomata densely scattered on both sides of leaves, not separated by midrib. Pollen cones axillary, solitary, on a 1 mm long peduncle, ovoid-oblong, 3–4 mm long and 1.3–1.6 mm wide. Microsporophylls sub-peltate with faintly apiculate apex, 0.5 mm wide, light green, each with two yellow pollen sacs. Seed cones solitary on short axillary branchlets covered by persistent scale leaves, terminal with 6–8 spreading, 3–4 mm long bracts, but developing a single ovule (seed) subtended by the distal, largest bract. Epimatium enclosing a broadly ovoid, slightly flattened seed, growing into an ellipsoid, slightly flattened, green or blue-green and finally dark blue 'pseudo-fruit' 10–14 mm long and 7–10 mm wide, with a distinct polar ridge and apical knob.

Distribution

SW Pacific: New Caledonia.
TDWG codes: 60 NWC

Ecology

Prumnopitys ferruginoides is a tree of montane rainforest distributed mainly on ultramafic soils derived from serpentine; in the extreme north of the island (Mont Panié) it occurs on micaschist. Its altitudinal range is approximately from 150 m to 1400 m a.s.l. This species is scattered in these forests as mostly solitary trees dispersed by birds, which eat the 'pseudo-fruits', and therefore this species can occur randomly with many other trees, both conifers and angiosperms. Apparently this species is shade tolerant, juveniles up to 5–6 m tall growing up under canopy have markedly larger leaves than mature trees of which the crowns have reached abundant sunlight.

Conservation

IUCN: LC

Uses

There are no uses recorded of this species. If it is or was logged it would have been treated as podocarp timber not distinct from other tree forming species, but its scarcity in the forest means it has no economic importance. As a rare tropical species it is not likely to be in cultivation outside a few botanic gardens.

Prumnopitys harmsiana (Pilg.) de Laub., Blumea 24 (1): 190. 1978. *Podocarpus harmsianus* Pilg., in Engler, Pflanzenreich IV. 5 [18]: 68. 1903. Type: Venezuela: Merida, Cordillera do Merida, Tovar, *A. Fendler 1289* (lectotype K, designated here).

Podocarpus utilior Pilg., Fedde's Repert. Sp. Nov. Regni Veg. 1 (12): 189. 1905.

Etymology

This species was named after the German botanist H. A. T. Harms (1870–1942).

Vernacular names

romerillo hembra, granadillo (Spanish); uncumanu (Peru)

Description

Trees to 35 m tall; trunk to 1.8 m d.b.h., with an erect bole. First order branches ascending or spreading in large trees forming a rounded crown. Bark smooth on younger trees, becoming scaly and exfoliating in irregular small strips; bark colour purplish brown, weathering grey. Seedlings and young plants with slender, nearly straight to more or less falcate leaves 20–30 mm long and 2–4 mm wide; apex acute. Leaves on mature trees alternate, twisted at a petiolate base, mostly pectinately arranged in two rows and one plane, linear, (8–)15–20 mm long, 2–3.5 mm wide, slightly curved sideways above base, mostly parallel-sided, with a distinct grooved midrib adaxially (upperside) and a thin midrib abaxially (underside); margins entire; apex mostly obtuse or slightly acuminate; leaf colour green above, glaucous below. Stomata in numerous lines not separated by midrib on abaxial (under) side of leaves. Pollen cones on lateral and axillary, 3–4 cm long spikes towards ends of foliage branches; 15–20 cones axillary to 2 mm long bracts, 8–10 mm long and 2 mm wide. Microsporophylls sub-peltate with broadly triangular apex, 0.7 mm wide, imbricate, light green, each with two yellow pollen sacs. Seed cones solitary on 1.5–2.5 cm long axillary branchlets with persistent

scale leaves at base and deciduous reduced leaves, subtended by a longer scale leaf (bract); consisting of an epimatium enclosing an ovoid, slightly flattened, rugose seed, growing into a subglobose, pruinose 'pseudo-fruit' 10 mm long and 8 mm wide with a small apical crest.

Taxonomic notes

Pilger (*op. cit.*) mentioned collections by Karsten (unspecified) and A. Fendler (*No. 1289*) when describing *Podocarpus harmsianus* as a new species from Venezuela. When De Laubenfels (*op. cit.*) transferred this species to the genus *Prumnopitys*, he did not designate its type; that opportunity is here fulfilled with a duplicate of *Fendler 1289* at K designated as the lectotype. It consists of a foliage branch of a probably juvenile (sterile?) treelet. Pilger saw the spiked pollen cones, apparently on other material which was likely destroyed at Berlin-Dahlem (B) during World War II, and stated not to know the seed cones. In describing *Podocarpus utilior* from Peru two years later, Pilger (*op. cit.*) had seed cones but no pollen cones. His suspicion that the two might be one species has been confirmed to be the case and the two descriptions can be united.

Distribution

The Andean regions of Bolivia, Colombia, Equador, Peru, and Venezuela.
TDWG codes: 82 VEN 83 BOL CLM ECU PER

Ecology

Prumnopitys harmsiana is widespread but relatively uncommon in the Andean lower montane to montane forest belt at altitudes between 1000 m and 2200 m a.s.l.

Conservation

This species has a wide distribution in a forest type that is under pressure throughout its range as a result of deforestation. Most herbarium collections are from Bolivia and Peru. The extent of occurrence (EOO) has not been calculated due to a lack of specimen locality data in the other countries, where it is believed to occur more frequently than the available data suggest (data largely from the Tropicos database, which does not include all relevant major herbaria). The Conifer Specialist Group believes it is prudent to flag this species as NT as deforestation may well push it into a threatened category in future. This species has been recorded from the Machu Pichu National Park in Peru.
IUCN: NT

Uses

The timber of *Prumnopitys harmsiana* is valued for the construction of houses and large trees are often selectively logged for that purpose. It is probably the tallest of the Andean species in the genus and, depending on its forest setting, may grow a sizable straight bole. This species is not in cultivation outside a few arboreta and botanic gardens in (sub) tropical countries.

Prumnopitys ladei (F. M. Bailey) de Laub., Blumea 24 (1): 190. 1978. *Podocarpus ladei* F. M. Bailey, Queensland Agric. J. 15 (8): 899, t. 22. 1905. Type: Australia: Queensland, ["Mount Spurgeon, Mitchell River, Port Douglas, *F. W. H. Lade*, leaf specimens, December 1902; immature fruiting specimens, May 1905."] (syntypes, BRI). Fig. 299, 300

Etymology

The species epithet commemorates F. W. H. Lade, who collected the type specimens in 1902 and 1905.

Vernacular names

Mount Spurgeon Black Kauri Pine

Description

Trees to 33 m tall; trunk to 1 m d.b.h., may be buttressed; upper part of tree densely branched forming a rounded crown. Bark more or less smooth on younger trees, becoming scaly and breaking up into thin flakes on the bole of large trees; inner bark fibrous; bark colour reddish brown, weathering grey. Leaves on young trees alternate, twisted at a short decurrent and more or less petiolate base, mostly pectinate, (nearly) straight, 15–25 mm long, 3–4 mm wide, with a distinct, raised midrib on both sides; margins entire, parallel to shortly below the obtuse

and minutely hyaline apex; leaf colour green to brownish red. Leaves on adult trees shorter, mostly pectinate, linear or more or less oval in the shortest leaves, (5–)8–12(–16) mm long and 2.5–3.5 mm wide, with a faint midrib on both sides; margins slightly incurved; apex obtuse or faintly apiculate; leaf colour green above, whitish green below. Stomata densely scattered on both sides of leaves, not separated by midrib. Pollen cones axillary, solitary, sessile or on a short peduncle, oblong, 7–9 mm long and 2–3 mm wide. Microsporophylls sub-peltate with obtuse apex, 1 mm wide, light green, each with two yellow pollen sacs. Seed cones solitary on short axillary branchlets with deciduous small leaves, terminal with 1–2 bracts, the upper bract subtending a single ovule (seed). Epimatium enclosing a broadly ovoid, slightly flattened brown seed, growing into an ellipsoid to globose, green or blue-green and finally dark blue to blue- black 'pseudo-fruit' 22–30 mm long and 18–25 mm wide, with a distinct apical protrusion.

Distribution

Australia: NE Queensland, (Mt. Lewis, Mt. Spurgeon and a few other localities).
TDWG codes: 50 QLD-QU

Ecology

This rare species is restricted to (remnants of) rainforest habitat mainly on two mountains in NE Queensland. These mountains are granitic outcrops in the Atherton Tableland. The altitudinal range of the species is between 930 m and 1400 m a.s.l. The rainforest on these mountains is dominated by angiosperms with scattered podocarps: *Podocarpus smithii, Prumnopitys ladei* and *Sundacarpus amarus. Prumnopitys ladei* is the rarer of these species. The seeds are eaten by native rats.

Conservation

The surviving rainforests on both mountains are now partly within protected areas. Logging has almost certainly reduced the area of occupancy (AOO) of *Prumnopitys ladei* on Mt. Lewis, presently the smaller of the two populations. In 1974 a herbarium collection was made within the "North Mary Logging Area" of State Forest Reserve 143 (*B. P. M. Hyland 7882*); this implies that logging of primary forest was then still undertaken and it would not have spared this species. Several of these logging areas existed there between 1960–1980 according to data on herbarium labels. On the other hand, recent surveys have extended the occurrence of *P. ladei* to a few localities in between both mountains.
IUCN: VU (D1, D2)

Uses

The wood of this species is used for construction and carpentry, but it is too rare to be of much economic importance. It is said to have potential as an ornamental tree but is rarely used in that capacity and may not be present outside botanical collections.

Prumnopitys montana (Humb. & Bonpl. *ex* Willd.) de Laub., Blumea 24 (1): 189. 1978. *Taxus montana* Humb. & Bonpl. *ex* Willd., Sp. Pl. 4 (2): 857. 1806; *Podocarpus montanus* (Humb. & Bonpl. *ex* Willd.) Lodd. *ex* Britton, Bull. Torrey Bot. Club 16: 13. 1889. Type: ["Habitat in montibus Peruvianis."] (*Humboldt & Bonpland* in P-Bonpl.?, n.v.).

Podocarpus montanus (Willd.) Lodd. var. *diversifolius* Dallim. & A. B. Jacks., Handb. Conif.: 51. 1923.
Podocarpus montanus (Willd.) Lodd. var. *densifolius* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 70. 1948.
Podocarpus montanus (Willd.) Lodd. var. *meridensis* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 71. 1948.

Etymology

The species epithet refers to its habitat in mountains.

Vernacular names

diablo fuerte, pino criollo, pino de montaña, romerillo hembra (Spanish)

Description

Trees to 30 m tall; trunk to 1.5 m d.b.h., with an erect and straight bole, commonly buttressed at base. First order branches spreading or ascending in large trees

forming a broadly domed or rounded crown. Bark smooth on younger trees, becoming scaly and exfoliating in irregular small strips; bark colour purplish brown, weathering grey. New foliage yellowish or glaucous green, turning dark green. Seedlings and young plants with slender leaves 12–20 mm long and 1.8–2.3 mm wide; apex acute. Leaves on mature trees alternate, twisted at a petiolate base, mostly pectinately arranged in two rows and one plane, linear, (8–)12–20 mm long, 2–3.5 mm wide, slightly curved sideways above base, widest above the middle, with a distinct grooved midrib adaxially (upperside) and a midrib abaxially (underside); margins entire; apex acuminate or sometimes obtuse; leaf colour lustrous green above, glaucous below. Stomata in numerous lines not separated by midrib on abaxial (under) side of leaves. Pollen cones on leafless or nearly leafless, lateral and axillary spikes towards ends of foliage branches; up to 25 spreading cones per spike, 5–10 mm long and 2 mm wide. Microsporophylls sub-peltate with acute apex, 0.5 mm wide, spreading at anthesis, light green, each with two yellow pollen sacs. Seed cones one or two on 2–3 cm long branchlets with leaves, axillary to a scale leaf (bract); consisting of an epimatium enclosing an ovoid, slightly flattened, rugose seed, growing into an ovoid, olive-green ripening to yellow 'pseudo-fruit' 14–16 mm long and 10–12 mm wide with an apical knob.

Distribution

The Andean regions of Colombia, Equador, Peru and Venezuela.
TDWG codes: 82 VEN 83 CLM ECU PER

Ecology

Prumnopitys montana is a species of high montane forest and timberline scrubland, ranging from 1500 to 3600 m a.s.l. In the tropical high montane rainforest (cloud forest) it is a constituent in a forest type dominated by angiosperms such as *Clusia* (*Guttiferae*), *Weinmannia* (*Cunoniaceae*), *Ocotea*, and various other genera in *Lauraceae*. At the highest altitudes this forest is replaced by scrub, often dominated by *Ericaceae* and *Podocarpaceae*, where *P. montana* is an emergent but low tree or a dwarfed tree. Both vegetation formations are rich in epiphytes. In places with high water table near the tree line *Sphagnum* bogs prevail, with the scrub vegetation retreating to drier spots.

Conservation

Logging has caused a reduction of population size of at least 30% and the decline continues.
IUCN: VU (A2a, c, d)

Uses

This podocarp is a very valuable timber tree; the wood is of medium density, straight grained, workable and durable. It is used for construction, general carpentry, indoor floors, cabinet making, and tool handles. It is also very good for wood turning with light yellow sapwood and reddish heartwood. Where the forest has been cleared to make way for pasture, individual trees or small groups are often left standing to provide shade for cattle. It is rare in cultivation, mainly restricted to some botanic gardens.

Prumnopitys standleyi (J. T. Buchholz & N. E. Gray) de Laub., Blumea 24 (1): 190. 1978. *Podocarpus standleyi* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 72. 1948. Type: Costa Rica: Alajuela, Poas Mts., Volcan Poas, *A. Tonduz 10333* (holotype US).

Etymology

This species was named after the botanist Paul C. Standley (1884–1963), who studied the flora of Costa Rica.

Vernacular names

Ciprecillo (Spanish).

Description

Trees to 25(–30) m; trunk monopodial, to 1.5(–2) m d.b.h. Bark smooth in young trees, becoming scaly on large trunks, exfoliating in flakes, brown weathering grey. Branches spreading, forming a rounded crown, foliage branches alternate, forming flat sprays. Foliage twigs slender, glabrous, initially covered in narrow decurrent leaf bases, later

with thin, exfoliating bark. Leaves alternate, usually pectinately arranged in two rows and one plane, linear, twisted and slightly curved above the decurrent base and sometimes near apex, or more or less falcate, (12)15–20(–25) mm long, 2–3.5 mm wide, narrowed towards the petiolate base; apex acute to mucronate. Adaxial leaf surface (upperside) with a conspicuous longitudinal groove through the middle, dark green; abaxial surface (underside) with a narrow longitudinal midrib, with very small stomata in numerous lines covered with a greyish white wax. Pollen cones numerous on slender, leafless, axillary spikes towards ends of foliage sprays, close together, each cone on a 2–3 mm long 'stalk' (bare base of the rachis), cylindrical, 10–15 mm long, 2–2.5 mm wide at anthesis. Microsporophylls numerous, helically arranged, sub-peltate, curved upwards with a scarious-denticulate, acute apex, each bearing near base two relatively large pollen sacs. Seed cones terminal on small 0.5–1.5 cm long branchlets with a few reduced leaves; producing a single subapical, broadly oval 'pseudo-fruit' ca. 10 mm long, 7–8 mm wide, consisting of a fleshy epimatium enclosing a broadly ovoid, slightly flattened seed, initially green, bluish when mature.

Distribution

Costa Rica (Alajuela, Cartago, Heredia, San José).
TDWG codes: 80 COS

Ecology

Prumnopitys standleyi is a climax forest species in montane tropical rain forest. Its altitudinal range (GIS data) is 1349 m to 2603 m a.s.l.; based on herbarium specimen data it is 1800–2960 m, while some reports mention altitudes above 3000 m. Annual rainfall is high, from 2000 mm to 4000 mm. The species is reported to be slow-growing.

Conservation

This species is restricted to four to five locations. The extent of occurrence (EOO) based on specimen distribution data is calculated to be 611 km² and the area of occupancy (AOO) 130 km². Regeneration is reported to be poor and trees are scarce in the forest, with 0.1–1 per ha according to one study. The tree is selectively logged, while only a few localities are within protected areas. Some collections were made within the following protected areas: Volcan Poas Reserve and Rio Macho Reserve.
IUCN: EN [B1a, b (i–iii, v)]

Uses

The timber of *Prumnopitys standleyi* is valued for the construction of houses and large trees are often selectively logged for that purpose. The wood is suitable for construction, flooring, veneer, furniture and also used as fenceposts and for firewood. This species is not in cultivation outside perhaps a few botanic gardens.

Prumnopitys taxifolia (Banks & Sol. *ex* D. Don) de Laub., Blumea 24 (1): 190. 1978. *Dacrydium taxifolium* Banks & Sol. *ex* D. Don, in Lambert, Descr. *Pinus*, ed. 1, 2: 25. 1824. Type: New Zealand: [locality not stated], *J. Banks & D. Solander s.n.* (holotype BM.

Etymology

The species epithet refers to the yew-like leaves (yew = *Taxus*).

Vernacular names

Black pine; matai (Maori)

Description

Trees to 25 m tall; trunk to 1.3 m d.b.h., crown wide, domed or rounded. First order branches ascending and eventually spreading in old trees opening up the wide spreading crown. Bark smooth on younger trees, becoming scaly and exfoliating in irregular flakes leaving multi-coloured patterns on the bole. Flakes on younger trees large, becoming much smaller on large boles of older trees, when longitudinal grooves appear; bark colour pattern varying from greenish grey or nearly white to reddish or purplish brown. New foliage bright green, turning dark green. Seedlings and young plants with long,

whip-like shoots and brownish leaves 5–10 mm long and 1–2 mm wide. Leaves on mature trees alternate, twisted at a petiolate base, mostly spreading to all sides but on some shaded branchlets more pectinate, linear, (6–)10–20 mm long, (1–)1.5–2 mm wide, slightly curved backward or assurgent, or nearly straight, with a distinct, slightly raised midrib on both sides; margins entire; apex acuminate or sometimes obtuse; leaf colour lustrous green above, whitish green below. Stomata in two broad bands separated by a green midrib on abaxial (under) side of leaves. Pollen cones on leafless or nearly leafless, lateral and axillary spikes towards the ends of foliage branches; up to 25 spreading cones per spike, 5–12 mm long and 2 mm wide. Microsporophylls sub-peltate with rounded apex, 0.5 mm wide, light green, each with two bright yellow pollen sacs, giving the cones a yellow colour when mature. Seed cones several on stout branchlets with deciduous scale leaves, axillary to a scale leaf (bract) and consisting of an epimatium enclosing an ovoid, slightly flattened, rugose seed, growing into a globose or nearly spherical, purplish black 'pseudo-fruit' 8–10 mm diam. after most of the undeveloped, green seeds have fallen.

Taxonomic notes

The occurrence of pollen cones in spikes, i.e. situated on what appear to be specialized axillary shoots without functional leaves and arranged in rows, is rare in conifers. It occurs in *Metasequoia, Taxodium* (both *Cupressaceae*) and in five species of *Prumnopitys: P. andina, P. exigua, P. montana, P. standleyi*, and *P. taxifolia* (*Podocarpaceae*). It is recorded from the fossil record in *Cordaitales*, an extinct order of gymnosperms that was perhaps ancestral to conifers, and its limited occurrence in two not closely related extant conifer families indicates that this character has evolved more than once. There may be some adaptive advantage, because these elongated shoots bearing pollen cones without leaves help to expose the former unimpeded to the air, so that the slightest breeze could disperse the pollen.

Distribution

New Zealand: North Island, South Island.
TDWG codes: 51 NZN NZS

Ecology

Prumnopitys taxifolia is a constituent species of lowland to montane (20–800 m or even 1000 m a.s.l.) podocarp (conifer) forest, dominated by *Podocarpus totara, Dacrycarpus dacrydioides, or Dacrydium cupressinum*, and with *Prumnopitys* spp., *Manoao colensoi*, *Halocarpus kirkii*, and *Phyllocladus trichomanoides* as frequent associated conifers. In lowland areas few undisturbed forest remains and here numerous angiosperms are often mixed in, while at higher altitude especially in South Island's Westland District the genus *Nothofagus* is often codominant. As a slow growing conifer, reaching a maximum age in excess of 1000 years (Enright & Hill, 1995) *Prumnopitys taxifolia* is a species that typically regenerates only after episodal distrurbances such as fires caused by volcanic eruptions. It then competes with other invading podocarps as well as angiosperms for light and space, resulting in the long term survival of only a few individuals of this species in the forest.

Conservation

IUCN: LC

Uses

Matai is a slow growing tree and produces dense, hard and heavy brown wood with exceptional strength and durability. It was extensively logged and used for railway sleepers, bridges, house building, especially floors and weatherboards, and to a lesser extent for furniture. The logging of this and other native conifers is now outlawed and consequently the use of its wood has greatly diminished. It is rare in cultivation and only suitable for regions with mild winters that rarely experience light frosts and have plentiful and evenly distributed rainfall.

Pseudolarix Gordon, Pinetum: 292. 1858 (*nom. cons.*). Type: *Pseudolarix amabilis* (J. Nelson) Rehd. [*Larix amabilis* J. Nelson] (*Pinaceae*).

Laricopsis Kent, in Veitch, Man. Conif., ed. Kent: 403. 1900 (*nom. illeg.*). Type: *Laricopsis kaempferi* (Lindl.) Kent [*Abies kaempferi* Lindl.]. *Chrysolarix* H. E. Moore, Baileya 13: 133. 1965. Type: *Chrysolarix amabilis* (J. Nelson) H. E. Moore [*Larix amabilis* J. Nelson].

Greek: *pseudo* = false; i.e. resembling but not equalling the genus *Larix*.

Description

See the species description.

Taxonomic notes

The genus *Pseudolarix* is known from the fossil record (Early Cretaceous to Pleistocene) in numerous localities in North America and Eurasia. It occurred in Europe at least until the end of the Pliocene and in the Early Tertiary extended far north into the Arctic. At least two species were present during the Tertiary. It is a classic example of a relict conifer which once was very common and widespread, but has been reduced to a few localities in China. This conifer was 'traditionally' classified with *Cedrus* and *Larix* based on vegetative characters but more detailed phylogenetic analyses using both morphology and DNA have refuted this. Its affinities are with *Keeteleria*, *Nothotsuga* and *Tsuga* in an 'abietoid' clade (Farjon, 1990; Wang *et al.*, 2000) separate from a 'pinoid' clade which includes among others *Cedrus* and *Larix*. The short shoots and deciduous leaves are parallelisms which evolved at least twice within the *Pinaceae*.

Distribution

As for the species.

Pseudolarix amabilis (J. Nelson) Rehd., J. Arnold Arbor. 1: 53. 1919. *Larix amabilis* J. Nelson, Pinaceae: 84. 1866; *Chrysolarix amabilis* (J. Nelson) H. E. Moore, Baileya 13: 133. 1965. Type: United Kingdom: England, cultivated, *G. Gordon s.n.* (holotype K). Fig. 301, 302

Abies kaempferi Lindl., Penny Cyclop. 1: 34. 1833, (*quoad descr.*, *non basion.*); *Pseudolarix kaempferi* (Lindl.) Gordon, Pinetum: 292. 1858.
Pseudolarix pourtetii Ferré, Trav. Lab. Forest. Toulouse T. 1 (4, 4): 1, f. 1–13. 1944.

Etymology

The species epithet (Latin *amabilis* = 'lovely' or 'lovable') refers to its golden yellow autumn foliage.

Vernacular names

Chinese golden larch; jin qian song (Chinese)

Description

Monoecious, deciduous trees to 30–40(–68) m tall, d.b.h. to 1.5 m; trunk monopodial, straight or curved; crown irregular, broadly domed and open in old trees. Bark rough and scaly, breaking into thick, square scales, brown-grey. Branches spreading horizontally or slightly ascending, drooping at ends. Branchlets slender, flexible, in second year thicker and firm, pale yellowish, darkening to pinkish or purplish brown, later grey, ridged and grooved, glabrous, young shoots slightly pruinose. Short shoots cylindrical-oblong, marked with annual rings of perular scale bases, length increasing with age, 0.5–3.5 cm. Vegetative buds of long shoots ovoid, pale brown, (axillary) lateral buds of short shoots globular, yellowish green, 2–3 mm, not resinous. Leaves spirally arranged, remote on long shoots, dense on short shoots, in false terminal whorls of 10–30, assurgent, (2–)3–6(–7.5) cm long, (1.5–)2–3(–4) mm wide, linear, flaccid, flattened, shallowly grooved above, keeled below, obtuse or acutish at apex; hypostomatic, stomata in 2 broad bands separated

by a midrib; leaf colour light green, pale green below, turning bright yellow, finally orange-brown in autumn. Pollen cones terminal on short shoots, clustered with 10–25 in umbels, ovoid at first, cylindrical and pendulous when ripe, becoming yellow. Seed cones terminal on short shoots, solitary, erect, with short-leaved, 0.5–1.5 cm long peduncles, ovoid-globose, open, resembling artichokes, (4–)5–7(–8) cm long, 4–5.5 cm wide with opened scales, colour light green or purplish green, ripening to light yellowish brown, disintegrating; cone rachis weak, narrowly conical. Seed scales narrowly deltoid-triangular, auriculate-pedicellate at base, slightly recurved or straight at apex, 2.8–3.5 × 1.3–1.8 cm at mid-cone, coriaceous, striated or rugose at maturity, sometimes with orange-yellow resin, nearly glabrous; margins entire, erose in old scales. Bracts lanceolate, 6–8 mm long, entirely included. Seeds ovoid-cuneate, partly enveloped by wing membrane, 5–7 mm long, pale brown or rose-brown; seed wings obliquely pointed, extending beyond the seed scales, 23–30 × 8–13 mm, yellow or pale brown.

Distribution

China: lower Chang Jiang (Yangtse) valley (Anhui, Hunan, Jiangxi, Jiangsu, Zhejiang). The true geographic range of this species is difficult to ascertain. In Atlas of the Gymnosperms of China (Ying *et al.*, 2004), a map with dots (based on herbarium specimen data from Chinese herbaria) is produced which gives a much wider range than here presented. A map given in China Plant Red Data Book 1 (Fu & Jin, 1992) is similarly optimistic. A check by Dr Xiang Qiao-ping in the Beijing Herbarium (PE) revealed that most of these specimens were collected from planted trees or trees in villages and towns (e.g. near temples) that did not occur in the wild. This problem is acknowledged in Flora of China 4 (1999). Wang (1961) has given an indication where we may expect this attractive tree to occur in its natural habitat: his examples are all in northern Zhejiang.
TDWG codes: 36 CHS-AH CHS-HN CHS-JS CHS-JX CHS-ZJ

Ecology

Pseudolarix amabilis is a component of the mixed mesophytic, partly evergreen forest, very rich in tree species (Wang, 1961). Its altitudinal range is from 180 m to 1000 m a.s.l., so it is a component of lowland forest in a warm temperate, humid climate which can experience occasional cold winter frost at the higher altitude. This species grows on a variety of soils derived from acidic rock; it does not occur on limestone. Several localities where *P. amabilis* still occurs in the wild are likely to have been altered by man and will support secondary forest, indicated by the presence of *Cunninghamia lanceolata* and *Pinus* spp.; some of these trees may have been planted in reforestation projects nearby. On the other hand, *P. amabilis* is a light demanding tree and perhaps not a constituent of a late phase in the succession, which tends to angiosperm (broad-leaved) dominance. Undisturbed primary forest that contains *P. amabilis* is now extremely rare and, if it still exists, should be subjected to detailed ecological study.

Conservation

The natural distribution of this species is based upon the populations in and around Zhejiang and two localities in southern Anhui and northern Jiangxi and (tentatively) one in Hunan; all other herbarium based localities are believed to be planted or introduced and here and there perhaps naturalized; they are excluded from the assessment. This species is very rare in the wild and occurs in a few remnants of primary forest on isolated mountains. Most locations are not within protected areas and loss of habitat is still continuing in this densely populated part of China. A detailed survey of existing truly natural populations occurring in primary mixed forest to determine more exactly the number of remaining mature trees, as well as the number of populations and their localities, is a first and necessary step to conservation action. This should next lead to the establishment of protected areas including the major sites and populations.
IUCN: VU [B2a, b (iii, v)]

Uses

This species has been planted in arboreta and parks in many countries, providing ample material for study. Herbarium specimens from (wild) locations in China are very rare, therefore the majority of material studied has come from European arboreta.

Due to its rarity and slow growth the value as a timber tree of this conifer is limited to local use, primarily for boat building, wooden foot bridges, and furniture. The Chinese golden larch has been in cultivation in Europe since the early 1860's when it was first described as a species of larch in England, based on small plants grown from seed and from seedlings transported by Robert Fortune from China to England in a Wardian case. It is a desirable and successful tree in cultivation, which has been responsible for its wide 'distribution' in China probably centuries before it came to Europe. It is now present in most collections of planted conifers in the temperate climate regions of the world, especially in the northern hemisphere, but it remains relatively uncommon in the trade, perhaps because it is difficult to propagate and slow growing. It is mostly used as a specimen tree in large gardens and parks in W Europe and the eastern USA. A few dwarfed forms have been selected and are grown as cultivars in Chinese and Japanese style gardens.

Pseudotaxus W. C. Cheng, Notes Forest. Inst. Nat. Centr. Univ. Nanking, Dendrol. Ser., 1: 1. 1947. Type: *Pseudotaxus chienii* (W. C. Cheng) W. C. Cheng [*Taxus chienii* W. C. Cheng] (*Taxaceae*).

Nothotaxus Florin, Acta Horti Berg. 14 (9): 394. 1948 (*nom. illeg.*). Type: *Nothotaxus chienii* (W. C. Cheng) Florin [*Taxus chienii* W. C. Cheng].

Greek: *pseudo-* = false, i.e. resembling but not equalling; *Taxus* is the classical Latin name for yews.

Description

See the species description.

Distribution

As for the species.

Pseudotaxus chienii (W. C. Cheng) W. C. Cheng, Notes Forest. Inst. Nat. Centr. Univ. Nanking, Dendrol. Ser., 1: 1. 1947. *Taxus chienii* W. C. Cheng, Contr. Biol. Lab. Sci. Soc. China, Sect. Bot. 9: 240. 1934; *Nothotaxus chienii* (W. C. Cheng) Florin, Acta Horti Berg. 14 (9): 394. 1948. Type: China: Zhejiang, Longquan Xian, Maoshan, *S. Chen 1384* (lectotype PE). Fig. 303

Pseudotaxus liana Silba, Phytologia 81 (4): 327. 1996 ["*liiana*"]; *Pseudotaxus chienii* (W. C. Cheng) W. C. Cheng subsp. *liana* (Silba) Silba, J. Int. Conifer Preserv. Soc. 14 (1): 19. 2007.

Etymology

The species epithet commemorates S. S. Chien, a Chinese botanist who was Head of the Botanical Division of the Biological Laboratory of the Science Society of China.

Vernacular names

Whiteberry yew; bai dou shan (Chinese)

Description

Dioecious, evergreen shrubs to 4 m tall. Bark grey-brown, exfoliating in strips. Branches usually whorled, spreading or ascending, forming a bushy crown. Foliage branchlets subwhorled or suboppositе, slender, terete, smooth, green turning dark green in the second year, terminating in small, ovoid-conical buds with persistent bud scales. Leaves helically arranged, distichous, spreading at 40–90° to shoot axis, well spaced but some overlapping at various angles, 1.2–2.8 cm long, linear, straight or slightly falcate in some leaves only, (1.5–)2–4(–4.5) mm wide, short petiolate or sessile, obtusely rounded at base; margins parallel and revolute, abruptly converging and terminating in a mucronate apex; mucro hooked, pale whitish green; leaf texture slightly coriaceous, smooth or slightly rugose; leaf colour green above, abruptly turning dark green in second year, green with two white bands below. Midrib raised on both sides, ca. 0.4 mm wide, continuous. Stomata in two bands 0.5–1 mm wide on abaxial (lower) side, slightly wider than midrib and green margins, forming 10–20 intermittent white lines in each band. Pollen cones usually concentrated towards ends of lateral branchlets, axillary, solitary, sessile, globose, 2–3.5 mm long, 3 mm wide, with 4 pairs of decussate basal bracts; microsporophylls 6–12, decussate, peltate, with 4–6 radially placed pollen sacs. Seed-bearing structures axillary, solitary, sessile, with 7 pairs of decussate basal bracts. Seed arils cupular, only partly enclosing the seed, succulent and white when ripe, 5–7 mm long. Seeds ovoid, 5–8 mm long, 4–5 mm wide, slightly flattened distally, with two obscure ridges below mucronate apex.

Taxonomic notes

This is a monotypic genus endemic to SE China. *Pseudotaxus liana* was described by Silba (*op. cit.*) from a specimen collected in Guangxi and said to have slightly broader leaves which are "leathery", but the leaf measurements at least appear to overlap considerably with *P. chienii* as described in Flora of China 4 (1999). In a recent morphometric study of herbarium specimens in Chinese institutions (very little material of this taxon is available in Western herbaria), Wang & Yang (2007), although finding statistically significant differences in mean leaf

width between specimens from Zhejiang (*P. chienii*) and from outside that province, also found that these different measurements among the specimens are continuous. They therefore reduced *P. liana* to synonymy of *P. chienii*, a conclusion which is here accepted.

Distribution

China: N Fujian, N Guangdong (Nan Ling Shan, Ruyian), Guangxi, N and SW Hunan, SW and NE Jiangxi, SW Zhejiang.
TDWG codes: 36 CHS-FJ CHS-GD CHS-GX CHS-HN CHS-JX CHS-ZJ

Ecology

Pseudotaxus chienii occurs scattered in evergreen and deciduous broad-leaved forests of middle altitude mountains (ca. 700–1500 m a.s.l.) in warm temperate regions. The climate on these mountains is temperate, cool and humid, with annual precipitation around 1800–2000 mm and frequent cloud cover or fog. It grows in shallow yellow earth (pH 4.2–4.5), or in crevices on acidic rock, often on precipices above streams. In Zhejiang it is associated with *Schima superba, Acer elegatulum* and *Rhododendron simianum*. In Guangxi it is found with *Schima argentea* and *Castanopsis eyrei*, always in the shade of these trees. In N Guangdong and SW Hunan I have seen *Pseudotaxus chienii* growing over rock precipices above streams or roads. With exposure to sun its growth becomes retarded and the habit changes to a low shrub. Seed production is infrequent, with seed maturation from late September to October and seeds remain dormant for a year or more.

Conservation

This species, although distributed widely, is rare and threatened due to deforestation. Fragmentation of populations into individual shrubs affects pollination success, which is already naturally difficult for an understorey species in evergreen forests. According to Fu & Jin (1992) this taxon has suffered rapid decline in recent times due to destruction of habitat. Some localities are within nature or forest reserves, e.g. in the Fenyang Shan and Jiulong Shan (Zhejiang), the Jinggang Shan (Jiangxi), the Nan Ling Shan (Guangdong), and the Zhangjiajie Shan (Hunan). Further protection is needed, both *in situ* and *ex situ*; some efforts are being made in China to cultivate the species.
IUCN: VU (A2cd)

Uses

The wood is used as a carving material and for making utensils. The species has been planted in the botanic garden of Nanjing, Fujian, and is in cultivation as an ornamental on a limited scale in Zhejiang. Outside China this interesting species is extremely rare in cultivation, although W. C. Cheng introduced it in the 1930s to the Arnold Arboretum in Massachussetts, where plants grew for some time before they died.

Pseudotsuga Carrière, Traité Gén. Conif., ed. 2, 1: 256. 1867. Type: *Pseudotsuga menziesii* (Mirb.) Franco [*Abies menziesii* Mirb.] (*Pinaceae*).

Abietia A. H. Kent, in Veitch, Man. Conif., ed. Kent: 474. 1900. Type: *Abietia douglasii* (Sabine *ex* D. Don) A. H. Kent [*Pinus douglasii* Sabine *ex* D. Don].

Greek: *pseudo* = false, i.e. resembling but not equalling the genus *Tsuga*.

Description

Monoecious, sometimes very tall (–100 m), evergreen trees, monopodial with a columnar trunk and a conical or spreading crown and pseudo-whorled, plagiotropic branching (Massart's model). Resin canals in wood, bark, leaves and seed cones. Bark thick, with deep, longitudinal fissures in large trees. (Sub-)terminal buds ovoid conical, not resinous, with triangular scales persisting 1–2 years. Leaves spirally arranged, spreading more or less radially or pectinate, placed on small depressions, linear, flattened, with two bands of stomata only on the abaxial side. Pollen cones axillary, solitary, catkin-like, 1–2 cm long, subtended by conspicuous perular scales; microsporophylls spirally arranged, peltate, with two pollen sacs containing globular pollen with 3 converging ridges on a smooth surface. Seed cones axillary, solitary, more or less erect at pollination but soon pendulous on curved peduncles, deciduous some time after seed dispersal or semi-persistent. Bract scales exserted, as long as or longer than the seed scales, trilobate, with the cusp longer than the lateral lobes, straight or reflexed. Seed scales with a rounded upper margin and a broad base, opening more or less wide. Seeds held in a shallow membranous cup covering one side of the seed and which is continued in an adnate, short, obliquely ovate wing. Seedlings with (5–)7–10(–14) cotyledons.

4 species.

Distribution

North America: from SE Alaska (coast) and British Columbia to Pueblo, Mexico in coastal mountains and the North American Cordillera, southward increasingly scattered. Asia: in the eastern Himalaya, Central and SE China, N Viet Nam, Taiwan, Japan.

Key to the species and some varieties of *Pseudotsuga*

1a. Seed scales not wider than long, thin; bracts much longer than the seed scales, usually not reflexed. Leaves 1–1.5 mm wide, parted above the shoot but not pectinate. Bark on the lower trunk of large trees very thick and deeply fissured ***P. menziesii***

1b. Seed scales wider than long, relatively thick; bracts as long as or slightly longer than the seed scales, often reflexed. Leaves 1.5–2 mm wide, mostly pectinate. Bark on the lower trunk relatively thin **2**

2a. Seed cones ovoid-cylindrical, very large (9–18 cm long); bracts slightly longer than the seed scales, usually not reflexed. Leaf apex acute ***P. macrocarpa***

2b. Seed cones ovoid, smaller than 8 cm; bracts equally long as the seed scales, reflexed. Leaf apex usually emarginate **3**

3a. Seed cones broad, ovoid, usually 4.5–7.5 × 4–5.5 cm. Leaves variable in length, up to 5 cm long (leaves 0.7–2 cm long and 2–3 mm wide = *P. sinensis* var. *brevifolia*) ***P. sinensis var. sinensis***

3b. Seed cones smaller (not longer than 5 cm). Leaves up to 3 cm long **4**

4a. Seed cones ovoid-conical; seed scales variable, slightly wider than long, with rounded upper margin ***P. japonica***

4b. Seed cones ovoid-oblong; seed scales reniform to broad flabellate, much wider than long, with truncate upper margin ***P. sinensis var. gaussenii***

Pseudotsuga japonica (Shiras.) Beissn., Mitt. Deutsch. Dendrol. Ges. 1896 (5): 62. 1896.
Tsuga japonica Shiras., Bot. Mag. (Tokyo) 9: 84, t. 3. 1895. Type: Illustration in Bot. Mag. (Tokyo) 9, t. 3 opp. p. 41. 1895. (lectotype designated here).
Fig. 304, 305

Etymology

The species epithet refers to Japan, its country of origin.

Vernacular names

Japanese Douglas-fir; toga-suwara, goyo-toga (Japanese)

Description

Trees to 25–30 m tall, d.b.h. to 1–1.5 m; trunk usually monopodial, more or less straight. Bark breaking into vertical, flaking plates, in old trees longitudinally fissured, grey. Branches spreading out in all directions, crooked; branches of second order slender, spreading horizontally or ascending; crown broad, open, usually domed or flat topped. Branchlets slender, firm, yellowish grey, becoming light greyish brown or grey, glabrous, with small, angular leaf scars. Vegetative buds ovoid to fusiform-conical, acute, 4–6 × 2–3 mm, not resinous; bud scales triangular, older scales with erose margins, shining reddish brown, persisting 1–2 years. Leaves spreading irregularly on both sides of the shoot, or pectinate, especially on shaded vegetative shoots, (1.5–)2–3 cm long, 1.5–2 mm wide, slightly twisted or curved at base, linear, straight, longitudinally grooved above, flattened, (slightly) emarginate at apex; stomata in two bands separated by a midrib below (abaxial side); leaf colour (light) green above, two whitish stomatal bands below. Pollen cones 1–1.5 cm long, yellowish brown. Seed cones on 1–2 cm long, curved peduncles, ovoid or ovoid-conical, tapering towards apex when closed, 3.5–5.5(–6) cm long, 2–3.5(–4) cm wide with opened scales, pale purplish or purplish brown, ripening to dark, dull brown or blackish brown; old cones deciduous after shedding seeds, but often persisting 2–4 years thereafter. Seed scales flabellate to semi-orbicular or sub-reniform, convex, 1.5–2.2 × 2.5–3 cm at mid-cone; upper margin entire, incurved; base shortly narrowed. Bracts oblong-spathulate, with 3-lobed apex, central cusp longer and narrower than lateral lobes, 1.5–2 cm long, widest (–8 mm) near apex, exserted, recurved or reflexed. Seeds ovoid to more or less triangular, 4 × 7 mm, pale brown, with dark spots; wings ovate, 4–10 mm long, light or dark brown.

Distribution

Japan: W Honshu (Chugoku District), Shikoku. [Wilson's reporting it from Kyushu has not been confirmed.]
TDWG codes: 38 JAP-HN JAP-SH

Ecology

Pseudotsuga japonica occurs at elevations between 500 m and 650 m a.s.l. on Shikoku; Wilson (1916) reports it from about 1000 m on the same island. It is rare and scattered in sheltered valleys and steep ravines, growing on old volcanic rock. The climate is warm temperate, moist, with annual precipitation between 1000 and 2000 mm. It is locally a (major) constituent of mixed conifer-broad-leaved forests, with *Tsuga sieboldii* usually as the dominant species. Other conifers are *Abies firma, Chamaecyparis obtusa, Torreya nucifera* and *Cryptomeria japonica*, broad-leaved trees are e.g. *Quercus salicina, Q. sessilifolia, Cleyera japonica*, and *Illicium religiosum* (small tree), common shrubs are *Eurya japonica, Pieris japonica, Rhododendron serpyllifolium*, and *Thea japonica*. As in China, in Japan the genus, represented by a single species, is a minor constituent of mixed forests.

Conservation

The total population of this species in Japan is estimated to be ca. 2000 mature trees and is considered to be continuously declining.
IUCN: EN [C2a (i)]

Uses

Japanese Douglas fir is of minor importance as a timber tree due to its rarity and modest size, although veteran trees can attain substantial trunk diameters. The wood is used for construction of traditional

buildings and gateways and for furniture. In Japan, it may be seen planted in some parks and traditional gardens, outside its country of origin it is a rare tree only present in some arboreta. This species was collected by Ernest H. Wilson in 1914 and introduced via the Arnold Arboretum of Harvard University to the USA. In Europe it seems to have arrived a few years earlier, perhaps a little after 1900 in Germany. It grows slowly in cultivation and seems to remain a small tree with a rather limited life span.

Pseudotsuga macrocarpa (Vasey) Mayr, Wald. Nordamer.: 278, t. 6, 8, 9. 1889. *Abies macrocarpa* Vasey, Gard. Monthly & Hort. 18: 21. 1876; *Pseudotsuga menziesii* (Mirb.) Franco subsp. *macrocarpa* (Vasey) E. Murray, Kalmia 12: 24. 1982. Type not designated.

Etymology

The species epithet means 'with large fruit' and refers to the seed cones.

Vernacular names

Bigcone Douglas-fir

Description

Trees to 20–25 m tall, d.b.h. to 1–1.3 m; trunk monopodial, straight. Bark on trunk dark, blackish grey, scaly, longitudinally fissured, exposing reddish brown inner bark. Branches spreading horizontally, the lowest may be bent down; crown broad pyramidal, very open in old trees. Branchlets firm when short, slender, flexible and pendulous when longer, reddish brown or pale brown, in second year grey-brown, faintly ridged, minutely pubescent when young, soon glabrous; leaf scars small, circular. Vegetative buds ovoid-conical to fusiform-conical, acute, 7–8 × 4–5 mm, not resinous; bud scales triangular, with serrulate-erose margins, reddish brown, persisting 1–2 years. Leaves directed forward and sideways, several raised above shoot, on shaded shoots more pectinate, 2.5–3.5(–4) cm long, ca. 2 mm wide, more or less petiolate and strongly twisted at base, linear, straight, longitudinally grooved above, flattened; apex acute; stomata in two grey-white bands separated by a midrib below; leaf colour lustrous dark green or glaucous green above. Pollen cones 2 cm long, pale yellow, with red brown perular scales at base. Seed cones becoming pendulous on 1–2 cm long peduncles and deciduous, ovoid-cylindrical, more or less pointed at apex, 9–13(–18) cm long, 4–6 cm wide with opened scales, greenish yellow, with light green bracts, maturing to light brown, ripening to dull brown, with light brown bracts. Seed scales broadly cuneate-flabellate, thick, transversely convex, 2–2.5 × 3–3.5 cm at mid-cone, puberulent when young, soon glabrous, often resinous; upper margin rounded, entire; base cuneate-pedicellate. Bracts ligulate, with trilobate apex and a central cusp longer than lateral lobes, 3–3.5 cm long, exserted, not reflexed. Seeds ovoid-conical, 10–12 × 6 mm, brown; wings obovate, 10–14 × 6–8 mm, light brown.

Distribution

USA: S California (San Rafael Mts., San Gabriel Mts., San Bernardino Mts., San Jacinto Mts., and Santa Ana Mts.).
TDWG codes: 76 CAL

Ecology

Pseudotsuga macrocarpa grows on the seaward slopes of coastal mountains at elevations between 275 m and 2450 m a.s.l., on mountain soils of various origin, usually rocky and well drained, dry in summer. The climate is warm temperate, with cool, moist winters and warm, dry summers (annual precipitation 500 mm to 1500 mm), snow occurs only at the higher elevations. Above 800 m (Transition Zone) this species is mainly mixed with *Pinus jeffreyi, P. ponderosa, P. coulteri*, and *Abies concolor* at the highest elevations. Common evergreen shrubs in these open pine forests are *Ceanothus cordulatus* and *Arctostaphylos patula*. At the lower elevations it occurs in the drier Canyon Live Oak forest type, with sclerophyllous oaks, e.g. *Quercus kelloggii, Q. chrysolepis* and *Q. agrifolia*.

Conservation

The range of this species is relatively small and confined to the Transverse and Peninsular Ranges of

the State of California, USA. The long, hot summers make it susceptible to forest fires, which are by far the main threat to this no longer exploited species. It has limited resistance to fire, but as fire frequency has increased due to human causes, protection from forest fires has become a major concern. As yet there seems to be no marked decrease of total known area of occupancy (AOO) since surveys on the geographic relationships between this conifer and wildfires were first reported in 1980, probably thanks to fire fighting and preventive measures.

IUCN: NT

Uses

The wood of this species is close grained, hard and heavy, but not durable. It would only be suitable for coarse lumber, but is not exploited due to scarcity of the resource and other, more ecological values. It is perfectly suitable for amenity planting and as a specimen tree in gardens and parks in milder climates, but rarely seen outside specialist collections in arboreta and botanic gardens. It grows to a well-shaped, medium sized tree with attractive, large, pendulous seed cones and is worth being introduced and planted more often; obviously in regions with a suitable climate, such as southern Europe, or perhaps New Zealand and parts of Australia.

Pseudotsuga menziesii (Mirb.) Franco, Conif. Duarum Nom.: 4. 1950 [& Bol. Soc. Brot., ser. 2, 24: 74. 1950].

Etymology

The species was named after Archibald Menzies, who sailed with George Vancouver along the west coast of North America in 1794.

Vernacular names

Douglas-fir, Oregon pine (wood)

Description

Trees to 90–100(–110?) m tall, d.b.h. to 4–5 m; trunk monopodial, straight, columnar. Bark on large trunks rough and scaly, with deep, longitudinal fissures, dark grey brown or blackish grey. Branches spreading horizontally, but lower ones curved downward; crown of young trees broad conical, sometimes with drooping leader, in old trees more columnar or irregular. Branchlets slender, flexible, at first yellowish green later grey, minutely pubescent in the first year, then glabrous, leaf scars small, circular. Vegetative buds ovoid-conical, acute, ca. 10 × 5 mm, not resinous; bud scales triangular, lustrous reddish brown, persisting 1–2 years. Leaves spreading more or less radially, on shaded shoots more pectinate, (1.5–)2.5–3.5(–4) cm long, 1.2–1.5(–1.7) mm wide, more or less petiolate and slightly twisted at base, linear, straight, flattened, obtuse or acute at apex; stomata in two whitish bands separated by a midrib on abaxial (= under) side, lustrous dark green above or more or less glaucous. Pollen cones 1.5–2 cm long, yellow, with red brown perular scales at base. Seed cones pendulous on 0.5–1 cm long peduncles, deciduous, ovoid-conical, obtuse or pointed at apex, 4–9(–10) cm long, 2–4 cm wide with opened scales, green, with yellowish green bracts, ripening to brown or dull grey brown, with light brown bracts. Seed scales obovate-cuneate, convex, 2–2.5 × 2–2.5 cm at mid-cone; base more or less cuneate. Bracts ligulate, trilobate at apex, with cusp longer than lateral lobes, 2.5–3.5 cm long, exserted, not reflexed, often curved towards cone apex. Seeds ovoid-cuneate, 6–8 × 4–5 mm, light brown, often with dark spots; wings ovate oblong, 9–14 × 5–8 mm, yellowish brown.

Distribution

W North America: from British Columbia to Central Mexico (Puebla).

TDWG codes: 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 76 ARI CAL NEV UTA 77 NWM TEX 79 MXC-PU MXE-CO MXE-CU MXE-DU MXE-HI MXE-NL MXE-SL MXE-ZA MXN-SO

Ecology

Pseudotsuga menziesii occurs in a huge area from north to south (55° N to 17° N) in W North America, consequently it occupies a variety of climatic zones, landscapes and habitats. Along the coast in British Columbia and the Pacific Northwest this species attains great size and is a codominant or dominant

tree in the temperate rainforests from near sea level to 1900 m a.s.l. depending on latitude. It profits from the high rainfall, yet occupies better drained sites commonly on slopes or high, no longer flooded river terraces, where it can compete successfully with other conifers, mainly *Abies, Picea, Tsuga*, and *Thuja*, especially after fire. Giant trees attain 100 m, and there is evidence of taller trees that were logged in the days that Americans of European descent could see only the timber in them. Somewhat further inland the species grows also in valley bottoms near streams, still attaining great sizes and living to 800–1000 years maximum. These coniferous forests are of similar composition as those on the coast. In the Rocky Mountains occurs var. *glauca*, a smaller, but still large tree; here it occupies a mixed conifer belt between open *Pinus contorta* and/or *P. ponderosa* woodland and a subalpine conifer forest dominated by *Abies lasiocarpa, Picea engelmannii* or, further south, *Pinus albicaulis* and *P. flexilis*. In the southern Rocky Mountains and into Mexico, *Pseudotsuga menziesii* var. *glauca* becomes more and more scattered and restricted to sites with permanent moisture, e.g. under N-facing canyon walls and at the highest forested altitudes, up to 2900–3350 m a.s.l. In canyons on the Colorado Plateau it can form small groves rising above Gambel oaks (*Quercus gambellii*), or it occurs as a constituent of mixed conifer forests with *Pinus* spp. and sometimes *Abies* or *Picea* as well as Aspen (*Populus tremuloides*) on high plateaus and on N-facing slopes and in moist ravines at high altitude. Winter snowfall, unlike on the Pacific coast, constitutes a high proportion of annual precipitation in these habitats.

Uses

Douglas fir is one of the world's most important timber trees. The huge size, especially of the coastal variety, as well as the excellent wood properties make it a choice tree providing knot-free sawn timber of great length. It is used for plywood and construction, both exterior and interior, and its reasonable good durability makes it useful for telephone wire poles and railway sleepers. However, the more continental variety *P. menziesii* var. *glauca* grows much slower and to a more moderate size and yields denser, heavier wood, excellent for cooperage for vats and tanks for breweries and distilleries. Douglas fir has been introduced to many countries in plantation forestry as well as an ornamental tree and a good number of cultivars are known and used in horticulture. Its first introduction was in England in 1827 by David Douglas; its best growth is attained in western Scotland, where one tree has made nearly 65 m in about 100 years. In the NW USA and W Canada it is also grown as a Christmas tree, needing regular shearing to obtain a pyramidal shape.

2 varieties are recognized:

Pseudotsuga menziesii (Mirb.) Franco var. ***menziesii***. *Abies menziesii* Mirb., Mém. Mus. Hist. Nat. 13: 63, 70. 1825. Type not designated. Fig. 306, 307, 308

Description

Potentially very tall trees to 100 m and more. Leaves (2–)2.5–3.5(–4) × 1.2–1.5 mm, dark green. Seed cones 4–9(–10) cm long.

Distribution

W North America: from British Columbia to California.
TDWG codes: 71 BRC 73 ORE WAS 76 CAL

Conservation

IUCN: LC

Pseudotsuga menziesii (Mirb.) Franco var. ***glauca*** (Beissn.) Franco, Conif. Duarum Nom.: 6. 1950 [& Bol. Soc. Brot., ser. 2, 24: 76. 1950]. *Tsuga douglasii* (Sabine *ex* D. Don) Lindl. var. *glauca* Beissn., in Jäger & Beissner, Ziergeh. Gärt. Park., ed. 2: 446. 1884; *Pseudotsuga menziesii* (Mirb.) Franco subsp. *glauca* (Beissn.) E. Murray, Kalmia 12: 24. 1982. Type not designated.

Pseudotsuga flahaultii Flous, Bull. Soc. Hist. Nat. Toulouse 66: 332. 1934; *Pseudotsuga menziesii* (Mirb.) Franco var. *flahaultii* (Flous) Silba, Phytologia 68: 70. 1990.
Pseudotsuga menziesii (Mirb.) Franco var. *oaxacana* Debreczy & Rácz, Phytologia 78 (3): 21. 1995.

Description

This variety remains a smaller tree than *P. menziesii* var. *menziesii* and has usually shorter, wider (1.5–2.5(–3.5) cm × 1.4–1.7 mm) and more glaucous green leaves. The female cones are usually smaller, but variable.

Distribution

W North America: Rocky Mountains from British Columbia to Central Mexico (Puebla).
TDWG codes: 71 ABT BRC 73 COL IDA MNT ORE WAS WYO 76 ARI NEV UTA 77 NWM TEX 79 MXC-PU MXE-CO MXE-CU MXE-DU MXE-HI MXE-NL MXE-SL MXE-ZA MXN-SO

Conservation

IUCN: LC

Pseudotsuga sinensis Dode, Bull. Soc. Dendrol. France 23–24: 58. 1912.

Etymology

The species epithet refers to China.

Vernacular names

Chinese Douglas-fir; huang shan (Chinese)

Description

Trees to 50 m tall, d.b.h. to 2 m; trunk more or less straight, columnar, or forked. Bark on trunk rough and very scaly, longitudinally fissured below, grey. Branches spreading wide, nearly erect near the top, forming a domed or flat topped crown. Branchlets slender, reddish brown in the first year, soon becoming grey, variably but usually minutely pubescent in the grooves, soon glabrous, with small, slightly elevated, circular or angular leaf scars. Vegetative buds ovoid or ovoid conical, 4–8 × 3–4.5 mm, not or only slightly resinous; bud scales triangular, acute, lustrous red-brown, deciduous in the second year. Leaves more or less remote, pectinate, (0.7–)2.5–4(–5) cm long, highly variable, (1–)1.5–2.1(–3) mm wide, slightly twisted or curved at base, linear, usually straight, longitudinally grooved above, flattened, emarginate or sometimes obtuse at apex; hypostomatic, stomata in two greenish white bands separated by a midrib on abaxial (= under) side; leaf colour dark green above. Pollen cones pendulous at maturity, 1–1.5 cm long, yellowish. Seed cones on 1–2.5 cm long peduncles, persisting some years but finally deciduous, ovoid to ovoid-oblong, (3.5–)4–6.5(–8) cm long, (2–)3.5–5(–5.5) cm wide with opened scales, purplish, maturing to purplish brown or brown. Seed scales rhombic-orbicular, suborbicular, or semi-orbicular to reniform, convex, usually apically slightly thickened and lignified, 2.5–3 × 3–3.5 cm at mid-cone, slightly puberulent at first, but soon glabrous; upper margin entire; base short pedicellate. Bracts ligulate-linear, with trilobate apex, cusp longer than lateral lobes, 3.5–4 cm long, exserted, recurved or reflexed. Seeds cuneate-ovoid, 8–12 × 5–8 mm, light brown with dark spots; seed wings ovate, 8–15 mm long, brown with dark spots.

Taxonomic notes

In Flora of China 4: 38 (1999) *P. brevifolia* and *P. forrestii* are treated as distinct species and *P. wilsoniana* is recognized as a variety of *P. sinensis*.

Distribution

China: S Anhui, Fujian, SW Guangxi, Guizhou, W Hubei, N Hunan, N Jiangxi, S Shaanxi, Sichuan, SE Xizang [Tibet], Yunnan, Zhejiang; Taiwan; N Viet Nam.
TDWG codes: 36 CHC-GZ CHC-HU CHC-SC CHC-YN CHN-SA CHS-AH CHS-FJ CHS-GX CHS-HN CHS-JX CHS-ZJ CHT 38 TAI 41 VIE

Ecology

Pseudotsuga sinensis is a species occurring in low to medium high mountains at various elevations. In SE China it occurs between 600 m and 1200 m, in Taiwan between 1000 and 2700 m, in Sichuan and Yunnan it may be found above 3000 m, the highest record is 3300 m a.s.l. The soils in the SE are red and yellow earth, in the western part of the range

described as mountain red earth (Wang, 1961). It requires a moist, temperate or warm temperate climate with annual precipitation between 1000 and 2000 mm. It is a constituent of the mixed mesophytic forest formation in SE China, mainly with broad-leaved trees, in Sichuan also of the evergreen oak and deciduous hardwood forest, where besides *Pseudotsuga* other conifers occur (e.g. *Tsuga chinensis, T. dumosa, Picea brachytyla* var. *complanata*). Unlike in North America, *Pseudotsuga* in Asia does not form extensive stands or occur in pure or nearly pure conifer forests. Its habit as a mature forest tree reflects this: trees are not columnar or pyramidal but develop spreading crowns much like the surrounding broad-leaved trees.

Uses

Chinese Douglas fir is a timber tree used for construction, bridge building, furniture and wood fiber. Very large trees are rare as they have been extensively logged in the past; hence the economic value of this species has diminished as it appears not very suitable for plantation forestry. Although introduced in Europe under its various synonyms by E. H. Wilson, George Forrest, Camillo Schneider, and others in the early 20th century, the species remains very rare in cultivation as an amenity tree and is virtually restricted to a few arboreta and botanic gardens.

3 varieties are recognized:

Pseudotsuga sinensis Dode var. ***sinensis***. Type: China: Yunnan, Dali Baizu Zizhizhou, Dengchuan, *E. E. Maire s.n.*, 1911 (holotype P). Fig. 309, 310

Pseudotsuga wilsoniana Hayata, Icon. Pl. Formos. 5: 204, t. 15. 1915; *Pseudotsuga sinensis* Dode var. *wilsoniana* (Hayata) L. K. Fu & Nan Li, Novon 7 (3): 263. 1997.
Pseudotsuga forrestii Craib, Notes Roy. Bot. Gard. Edinburgh 11: 189. 1919; *Pseudotsuga sinensis* Dode var. *forrestii* (Craib) Silba, Phytologia 68: 72. 1990.
Pseudotsuga xichangensis C. T. Kuan & L. J. Zhou, Fl. Sichuan. 2: 54. 1983.
Pseudotsuga shaanxiensis S. Z. Qu & K. Y. Wang, Acta Bot. Bor.-Occid. Sin. 8 (2): 129. 1988.

Description

Leaves 1.3–4 cm long, 1.5–2 cm wide. Buds ovoid-conical, more or less acute, 4–7 × 3–4 mm. Seed cones 4.5–8 cm long, 3–5 cm wide when opened. Seed scales suborbicular to rhombic-orbicular.

Distribution

China: S Anhui, Chongqing, Fujian, Guizhou, W Hubei, N Hunan, N Jiangxi, S Shaanxi, Sichuan, Yunnan, Zhejiang; Taiwan; N Viet Nam.
TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-SA CHS-AH CHS-FJ CHS-HN CHS-JX CHS-ZJ 38 TAI 41 VIE

Conservation

A continuing decline, especially of large mature trees due to logging, has led to a situation in which large trees have become scarce and most are restricted to inaccessible mountain ridges and summits. Even under the broader taxonomic circumscription here employed, it has become a rare, though still widespread tree. Only small subsets of the total population are within protected areas.
IUCN: VU (A2c, d)

Pseudotsuga sinensis Dode var. ***brevifolia*** (W. C. Cheng & L. K. Fu) Farjon & Silba, Phytologia 68: 71. 1990. *Pseudotsuga brevifolia* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975. Type: China: Guangxi, Nanning, near Longzhou, *Chinese collector No. 40103* (holotype PE).

Description

Leaves 0.7–1.5(–2) cm long, 2–3(–3.2) mm wide. Buds ovoid, obtuse, 4–5 × 3 mm. Seed cones 3.7–6.5 cm long, 3–4 cm wide when opened. Seed scales suborbicular to rhombic-orbicular.

Taxonomic notes

Pseudotsuga sinensis var. *brevifolia* has been reported from the limestone region in northern Viet Nam, but more recent assessments of the Vietnamese

trees (e.g. Nguyen Tien Hiep *et al.*, 2004) have concluded that the common species on the ridge tops and summits of the limestone mountains is *P. sinensis* with normally long leaves. I confirmed this on a visit to Bat Dai Son in 2002 at least for that area. The distribution of *P. sinensis* var. *brevifolia* in Atlas of the Gymnosperms of China (Ying *et al.*, 2004) on pp. 100–101 borders the distribution of *P. sinensis* in Viet Nam given on a map in Nguyen Tien Hiep *et al.* (2004). Is var. *brevifolia* restricted to China? It seems unlikely, but it may also be incorrect determination of specimens on either side of the border that has lead to this 'parapatric' distribution pattern. A critical evaluation of the material (and this taxon) seems needed.

Distribution

China: SW Guangxi, Guizhou (Anlong, Lipuo); N Viet Nam (?).
TDWG codes: 36 CHC-GZ CHS-GX

Ecology

Scattered on S-facing slopes and mountain tops, on calcareous and rocky soils at altitudes between 1000 and 1300 m a.s.l.

Conservation

This variety occurs in a limited area within the extensive eroded limestone massifs of SW China; its true extent and rarity remains unknown (see under Taxonomic notes). Trees are often inaccessible on mountain summits but those on easier sites have often already been logged.
IUCN: VU (A2c, d)

Pseudotsuga sinensis Dode var. ***gaussenii*** (Flous) Silba, Phytologia 68: 71. 1990. *Pseudotsuga gausseni* Flous, Bull. Soc. Hist. Nat. Toulouse 69: 417. 1936. Type: China: Zhejiang, between Ping-yung and Taiyuan, *R. C. Ching 2144* (holotype NY).

Description

Leaves 1.6–3 cm long, 1.7–2 mm wide. Buds ovoid-conical, more or less acute, 4–5 × 3 mm. Seed cones 3.5–5.5 cm long, 2–3.5 cm wide when opened; seed scales broad flabellate to reniform.

Distribution

China: SE Anhui, Fujian (?), N Guizhou, Jingxi (Dexing), N & NW Zhejiang.
TDWG codes: 36 CHC-GZ CHS-AH CHS-JX CHS-ZJ

Conservation

There are uncertainties about the distribution, abundance and rate of (past) decline of this variety. It has undoubtedly been reduced due to deforestation.
IUCN: DD

Retrophyllum C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 379. 1989. Type: *Retrophyllum vitiense* (Seem.) C. N. Page [*Podocarpus vitiensis* Seem.] (*Podocarpaceae*).

Decussocarpus de Laub., J. Arnold Arbor. 50: 340. 1969 (*nom. illeg.*, Art. 52.1). Type: *Decussocarpus nagi* (Thunb.) de Laub. [*Myrica nagi* Thunb.].

Latin: *retro-* = backwards, reversed; Greek: *phyllos* = leaf; referring to the peculiar phyllotaxis (see description).

Description

Dioecious, evergreen, dwarfed to large trees. Bark smooth, exfoliating in longitudinal flakes. Resin canals in leaves and seed cones. Leaves spirally inserted on shoots, lanceolate to narrowly ovate, obliquely directed into subopposite and decussate apparent pairs by at ca. 90° twisted petioles in opposite directions, forming regular pectinate rows on lateral shoots. Stomata on both faces of the leaves. Pollen cones axillary or sometimes terminally and single or in groups on short, naked peduncles; pollen bisaccate. Seed cones axillary, solitary or sometimes in pairs, at maturity consisting of a few small, fused basal bracts and a single large seed covered by a fleshy, drupe-like, elliptic to ovoid-pyriform epimatium colouring deep red, violet or purplish brown.

5 species.

Distribution

Malesia: Maluku [Moluccas], New Guinea, New Britain, New Ireland; SW Pacific: New Caledonia, Vanuatu, Fiji. South America: W Venezuela, Colombia, Equador, Peru, W Brazil.

Key to the species of *Retrophyllum*

1a. Shrubs or small, dwarfed trees; foliage branches ascending or spreading. Leaf apex always obtuse ***R. minus***

1b. Potentially tall trees; foliage branches spreading or more or less pendulous. Leaf apex acute, apiculate or some obtuse **2**

2a. Adult leaves (5–)8–11 mm long, 2–3.5 mm wide; midrib on both sides of leaves narrow and conspicuous ***R. piresii***

2b. Adult leaves (6–)10–25(–40) mm long, 2.5–5 (–7) mm wide; midrib on the adaxial (upper) side of leaves inconspicuous or wide and low **3**

3a. Midrib on both sides of leaves wide and low. Microsporophylls of pollen cones triangular, acute ***R. comptonii***

3b. Midrib inconspicuous on the adaxial (upper) side of leaves, narrow and conspicuous on the abaxial side. Microsporophylls of pollen cones triangular, acuminate **4**

4a. Adult leaves (6–)10–18(–25) mm long. Pollen cones 5–7 × 2–2.5 mm. Seeds including the epimatium 18–25(–30) × 13–18(–20) mm ***R. rospigliosii***

4b. Adult leaves (10–)15–25(–40) mm long. Pollen cones 10–25 × 2–2.5 mm. Seeds including the epimatium 14–20 × 10–13 mm ***R. vitiense***

Retrophyllum comptonii (J. T. Buchholz) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 380. 1989. *Podocarpus comptonii* J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 284. 1949; *Decussocarpus comptonii* (J. T. Buchholz) de Laub., J. Arnold Arbor. 50: 344. 1969; *Nageia comptonii* (J. T. Buchholz) de Laub., Blumea 32 (1): 211. 1987. Type: New Caledonia: Grande Terre, Province Sud, Mt. Mou, *J. T. Buchholz 1684* (holotype ILL). Fig. 311, 312

Etymology

This species was named after the botanist and plant collector R. H. Compton (1886–1979).

Vernacular names

No vernacular names are recorded for this species.

Description

Trees to 30 m tall, to 80 cm d.b.h., bole straight and erect, clear of branches for 10 m or more in large trees growing in forest. Bark smooth, eventually becoming rough and fissured, tan to dark brown, weathering grey, exfoliating in longitudinal flakes. Branches ascending or spreading, forming a pyramidal and eventually rounded crown. Foliage branches alternate or subopposite, spreading but becoming pendulous in shaded branches, with remotely dispersed, decurrent, spreading, small and thick scale leaves on leading shoots and at base of lateral shoots and more numerous and larger, photosynthetically dominant leaves only on lateral branchlets. Larger leaves on lateral branchlets spirally inserted, appearing opposite, pectinate on young plants and shaded shoots, more or less spreading in different directions on sun exposed branchlets, with a decurrent base and a 90° twist at the point where the leaf blade abruptly widens and is free from the shoot, twisting in opposite directions, orientating the blade alternatively with adaxial side uppermost and with adaxial side downwards. Leaf shape ovate-lanceolate or ovate-elliptic, longest in juvenile plants, much shorter in top of old trees, also shorter at the base of lateral branchlets, the free part (6–)13–24(–32) × 2.5–4(–6) mm, mostly widest below the middle, especially juvenile forms gradually tapering to an acute, or in short leaves obtuse apex; midrib wide but low on both sides. Stomata on both sides (leaves amphistomatic), numerous and scattered, not separated by the midribs. Pollen cones grouped at end of foliage branchlets, on lateral non-foliar branchlets, or solitary in the axil of a leaf, globose when immature, becoming short cylindrical, 5–10(–12) mm long and 2.5–3 mm diam. at anthesis; microsporophylls spirally arranged, triangular, with an acute apex, each bearing two pollen sacs. Seed cones on 10–15 mm long lateral or terminal branchlets with 2–3 pairs of decussate scale leaves, with a single (rarely two) fertilized ovule growing into an inverted seed covered by an epimatium. Seeds including the epimatium obovoid, with a curved beak at inverted apex and a short crest at distal end usually disappearing at maturity, 16–20 × 13–15 mm, green or glaucous becoming fleshy and deep red when ripe; seed proper subglobose, 13–17 × 10–12 mm, with shallow scallops and ridges.

Distribution

SW Pacific: New Caledonia.
TDWG codes: 60 NWC

Ecology

Retrophyllum comptonii is a tree forming species of montane rainforests, occurring commonly on steep forested slopes and ridges of the mountains throughout the main island (Grande Terre). It occurs on serpentine and other ultramafic rocks as well as on acidic micaschist (e.g. Mont Panié). It is shade tolerant and grows up well amongst other trees; it is not an emergent, but moves into the prevalent canopy, which can be up to 30 m tall in sheltered spots, but is often much lower, especially on mountain ridges and summits. Common associated conifers are *Araucaria* spp. and *Agathis* spp. (*Araucariaceae*), *Acmopyle pancheri, Falcatifolium taxoides*, and to a lesser extent *Podocarpus* spp. (*Podocarpaceae*); there are also numerous angiosperms in these forests. Its altitudinal range is between 600 m and 1450 m a.s.l. Dispersal by birds accounts for a scattered occurrence of mature trees from where seedlings can spread in the surrounding vegetation closer to the parent tree.

Conservation

IUCN: LC

Uses

This species grows into a large tree in favourable habitat and has been logged with other trees especially in lowland forest. The wood has good timber qualities and is used for light construction, flooring and furniture. Trees on upper slopes and mountain ridges are generally too small or short stemmed for timber harvesting. This species is not in cultivation except as some recently collected young specimens in a few botanic gardens.

Retrophyllum minus (Carrière) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 380. 1989 ["*minor*"]. *Nageia minor* Carrière, Traité Gén. Conif., ed. 2, 2: 641. 1867; *Podocarpus minus* (Carrière) Parl., in Candolle, Prodr. 16 (2): 509. 1868; *Decussocarpus minus* (Carrière) de Laub., J. Arnold Arbor. 50: 346. 1969. Type: New Caledonia: Grande Terre, Province Sud, Plaine des Lacs ["Baie du Sud"], *E. Vieillard 1275* (holotype P). Fig. 313, 314

Podocarpus palustris J. T. Buchholz, Bull. Mus. Hist. Nat. (Paris), sér. 2, 21: 284. 1949.

Etymology

The species epithet *minus* denotes the small stature of this tree, it being the smallest in the genus.

Vernacular names

bois bouchon (French)

Description

Small trees or shrubs to 3 m tall, with a short, thick trunk quickly tapering upwards to short, stout branches, or sometimes multi-stemmed. Bark very thick on trunk, fibrous, soft, exfoliating in thin strips, brown (often discoloured by iron oxide from the river in which it stands). Branches few, spreading, forming an open, irregular crown. Foliage branches alternate or subopposite, ascending or spreading, often grouped together towards ends of main branches, stout, subtended by a few spreading scale leaves. Leaves on lateral branchlets spirally inserted, appearing opposite, distichous on juvenile plants, more or less spreading in different directions on mature plants, with a decurrent base and a 90° twist at the point where the leaf blade abruptly widens and is free from the shoot, twisting in opposite directions, orientating blade alternatively with adaxial side uppermost and with adaxial side downwards. Leaf shape ovate-lanceolate or ovate-elliptic, longest in juvenile plants, shorter in mature plants, in the latter those set near base of lateral branchlets very small, free part (3–)10–20(–30) × 2–4(–6) mm, mostly widest in the middle, juvenile forms more or less linear-lanceolate, all leaves with an obtuse apex; midrib wide but low on both sides. Stomata on both sides (leaves amphistomatic), numerous and scattered, not separated by the midribs. Pollen cones 2–5 clustered at end of foliage branchlets, or solitary in axil of a leaf below these, globose when immature, becoming short cylindrical, 4–8 mm long and 2.5–3 mm diam. at anthesis; microsporophylls spirally arranged, triangular, with an apiculate apex, each bearing two pollen sacs. Seed cones terminal on foliage branches ending in short branchlets with 2–3 pairs of decussate scale leaves, with a single fertilized ovule growing into an inverted seed covered by an epimatium. Seeds including the epimatium obovoid to pyriform, with a curved beak at inverted apex and a short, usually persisting crest at distal end, 18–20 × 12–13 mm, green or glaucous becoming fleshy and deep red when ripe; seed proper subglobose, 15–17 × 10–11 mm, rough and porous (floating in water).

Taxonomic notes

Establishing the type specimen of *R. minus* poses some difficulty in that the geographical information for *Vieillard 1275*, the type collection, differs on various sheets distributed to different herbaria. Carrière (*op. cit.*) mentions "Lac Arnaud" in the protologue, this appears on the Paris (P) specimen, but other specimens (BM, K) have "Baie du Sud" as the locality. Neither of these toponyms are in current use and were at any rate written on the labels later by someone who was not the collector. There are also male and female shoots mounted on different sheets with *No. 1275*, which seems to be a number Vieillard added to his specimens after they were collected (sometimes by someone else; one sheet at K has "*Pancher No. 1275*" as the collection of a female shoot with separate seed). Since the species is dioecious, these different sexes were collected from different plants. Carrière only described vegetative characters and it is assumed that he only had the male specimen at P at his disposal, but did not notice the small pollen cones. Isotypes therefore are limited to male (or sterile) specimens and female specimens are not type material. The locality information on the labels seems to be of less significance than the appearance that the sterile/male shoots all seem to have been gathered from the same plant.

Distribution

SW Pacific: New Caledonia (Plaine des Lacs).
TDWG codes: 60 NWC

Ecology

This is the only true rheophyte among gymnosperms. It grows along the banks of small rivers and shores of small lakes in shallow water over skeletal soils derived from serpentine, ironstone and laterite with high contents of heavy metals. The maximum altitude is 240 m a.s.l. The buoyant seeds are easily transported by running water and germinate in mud temporarily falling dry with fluctuating water tables in lakes and streams. The fleshy epimatium is consumed by birds, and perhaps fish, but also often rots away, even on the plant. The thick, fibrous bark is perhaps an adaptation against damage from stones transported in flash floods that may occur after torrential downpours over the sparsely vegetated plain discharge into the rivers. There are few other plants that occupy this habitat; near the Chûtes de la Madeleine on the Rivière des Lacs *Dacrydium guillauminii* occurs at the water edge with *R. minus*, and there are some sedges (*Carex* sp.).

Conservation

Retrophyllum minus is a rare species with a limited distribution and a very narrowly defined habitat. In extremely dry periods it is vulnerable to dehydration and small subpopulations could be wiped out by brush fires. These fires have increased in frequency in recent decades due to increased human visits and activity, e.g. pine plantations and geological surveys involving road building, on the Plaine des Lacs. Much of this plain falls within a mining concession. Currently, this species is only protected in a single small botanical reserve at the Chûtes de la Madeleine, which covers only one small subpopulation. The total number of mature individual plants is unknown, but lies somewhere below 2500 and is inferred to be declining because of habitat disturbance, destruction and fragmentation.
IUCN: EN [B1ab(iii)+2ab(iii); C2a(i)]

Uses

There are no uses recorded for this species. It is in cultivation in a few botanic gardens as a pot-grown young plant.

Retrophyllum piresii (Silba) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 380. 1989. *Decussocarpus piresii* Silba, Phytologia 54: 461. 1983; *Nageia piresii* (Silba) de Laub., Blumea 32 (1): 211. 1987. Type: Brazil: Rondonia, Serra dos Pacahas Novos, [in the National Park], *N. A. Rosa & J. M. Pires 856* (holotype US).

Etymology

This species was named after one of the collectors, J. M. Pires, who gathered the type collection.

Vernacular names

None have been recorded.

Description

Trees to 30 m tall, to 80 cm d.b.h., bole straight and erect, clear of branches for 15 m or more in large trees growing in forest. Bark not described. Branches spreading, forming a rounded crown. Foliage branches alternate or subopposite, spreading but becoming somewhat pendulous in shaded branches, with a few dispersed, decurrent, spreading, small scale leaves on leading shoots and more numerous and larger, photosynthetically dominant leaves on lateral branchlets. Leaves on lateral branchlets spirally inserted but pectinately arranged, appearing opposite, with a decurrent base and a 90° twist at the point where the leaf blade abruptly widens and is free from the shoot, twisting in opposite directions on either side of shoot, orientating blade on one side of shoot with adaxial side uppermost and on other side with adaxial side downwards. Leaf shape in mature trees (ob)ovate to elliptic, free part (5–)8–11 × 2–3.5 mm, widest in or just above the middle, more or less abrubtly narrowing to an obtuse or weakly apiculate apex;

midrib narrow and conspicuous on both sides. Stomata on both sides (leaves amphistomatic), numerous but not in regualar lines. Pollen cones not known. Seed cones on lateral branchlets with small leaves, subterminal fertile bract scale-like, 1–3 × 2 mm, with a single fertilized ovule growing into an inverted seed covered by an epimatium. Seeds including the epimatium ellipsoid, with a prominent thin crest at distal end, 20–22 × 10–14 mm, green becoming fleshy and brownish red when ripe; seed proper 12–14 × 7–8 mm, with a small beak at micropylar end.

Taxonomic notes

This species was first described and named as *Decussocarpus piresii* from a single collection; its taxonomic base is therefore not very convincing. The type collection N. A. Rosa & J. M. Pires (*et al.* on duplicates in K and MO) *856* (not 586 as published in the protologue!) has duplicates at K, MO and US (holotype) and appears to differ from those I have seen of *R. rospigliosii* in its smaller, narrower leaves and its more oblong seeds. Other stated differences, such as leaf shapes, are more difficult to assess for lack of more material. On the other hand, this genus had not been known from Brazil previously (the only other South American species, *R. rospigliosii* (Pilg.) C. N. Page, occurs in Colombia, Ecuador, Peru, and Venezuela and has a strictly Andean distribution). More material is needed, but as yet lacking, to ascertain the taxonomic status of this species more securely. It should at present be provisionally accepted as distinct.

Distribution

Brazil: Rondônia (Serra dos Pacahas Novos).
TDWG codes: 84 BZN-RO

Ecology

No details are known about the habitat of this species other than that its type specimen has been collected at an altitude of 250 m. The area appears to be well forested viewed via Google Earth© satellite imagery (accessed 13 March 2009).

Conservation

Only known from Rondonia (Serra dos Pacahas Novos) and occurring within a national park; new localities recently reported have not been verified by examination of herbarium specimens and need confirmation.
IUCN: DD

Retrophyllum rospigliosii (Pilg.) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 380. 1989. *Podocarpus rospigliosii* Pilg., Notizbl. Bot. Gart. Berlin-Dahlem 8: 273. 1923; *Decussocarpus rospigliosii* (Pilg.) de Laub., J. Arnold Arbor. 50: 347. 1969; *Nageia rospigliosii* (Pilg.) de Laub., Blumea 32 (1): 211. 1987. Type: Peru: Pasco, Oxapampa, *N. Esposto 556* (holotype USM).

Etymology

This species was named after Dr C. J. Rospigliosi of the Natural History Museum in Lima, Peru.

Vernacular names

pino hayuelo, pino laso, pino de montaña, pino romerón, romerillo macho (Spanish)

Description

Trees to 45 m tall, to 1.8 m d.b.h.; bole straight and erect, clear of branches for 15 m or more in large trees growing in forest. Bark brown, weathering blackish grey, exfoliating in large flakes. Branches ascending or spreading, forming a pyramidal and eventually rounded crown. Foliage branches alternate or subopposite, spreading but becoming pendulous in shaded branches, with dispersed, decurrent, spreading, small scale leaves on leading shoots and more numerous and larger, photosynthetically dominant leaves on lateral branchlets. Leaves on lateral branchlets spirally inserted but pectinately arranged, appearing opposite, with a decurrent base and a 90° twist at the point where the leaf blade abruptly widens and is free from the shoot, twisting in opposite directions on either side of shoot, orientating blade

on one side of shoot with adaxial side uppermost and on other side with adaxial side downwards. Leaf shape ovate-lanceolate or ovate-elliptic, longest in juvenile plants, much shorter in top of old trees, also shorter at base and end of lateral branchlets, free part (6–)10–18(–25) × 3–5(–6) mm, mostly widest just below the middle, tapering to an acute or apiculate apex; midrib narrow and conspicuous on abaxial side, inconspicuous on adaxial side. Stomata on both sides (leaves amphistomatic), numerous but not in regualar lines. Pollen cones at or near ends of foliage branchlets, axillary to leaves or in groups of 3–5 together with one terminal, globose when immature, 5–7 mm long, 2–2.5 mm diam. at anthesis; microsporophylls in spirals, triangular, with an acuminate apex, each bearing two pollen sacs. Seed cones on lateral branchlets with small leaves; subterminal fertile bract leaf-like, 3 × 2 mm, with a single fertilized ovule growing into an inverted seed covered by an epimatium. Seeds including the epimatium subglobose to ovoid-pyriform, with a short crest at distal end, 18–25(–30) × 13–18(–20) mm, green or glaucous becoming fleshy and dark red when ripe, drying to a hard shell; seed proper 13–17 × 9–12 mm, with a narrow beak at micropylar end.

Distribution

Colombia, Ecuador, Central Peru, W Venezuela (Merida and Tachira).
TDWG codes: 82 VEN 83 CLM ECU PER

Ecology

Retrophyllum rospigliosii occurs in montane tropical rainforest, in which it can attain large size. Its altitudinal range is from 1500 m to 3300 m (–3750 m in Colombia and Peru) a.s.l., so it occurs in wet rainforest up to high altitude cloud forest or mossy forest. It can form more or less extensive pure stands on exposed sites, but is more often found scattered among angiosperms or sometimes with *Prumnopitys* spp.

Conservation

This timber species is under much pressure from logging and most of the formerly quite extensive stands have now disappeared or are reduced to a few trees. It is considered still in decline as logging and forest clearing have left several trees from which herbarium collections were taken by David de Laubenfels in Venezuela standing alone in pasture since 1980. This situation is undoubtedly also found in the other countries where this tree occurs and in Peru populations are becoming reduced in number of mature trees (see e.g. Reynel *et al.*, 2006).
IUCN: VU (A2a, c)

Uses

This species is a valuable timber tree and can yield large sizes of sawn timber. Its wood is of very good quality, straight grained, of medium density, durable and workable. It is much used for construction, carpentry, cabinet making, and wood turning. Mature trees are often left standing from forest transformed into pasture for cattle and serve to give shelter from sun and heat for the animals. In future they may be planted for the same purpose; to what extent this is already being done is not known.

Retrophyllum vitiense (Seem.) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 380. 1989. *Podocarpus vitiensis* Seem., Bonplandia 10: 366. 1862; *Nageia vitiensis* (Seem.) Kuntze, Revis. Gen. Pl. 2: 800. 1891; *Decussocarpus vitiensis* (Seem.) de Laub., J. Arnold Arbor. 50: 342. 1969. Type: Fiji: Western Division, Viti Levu, *B. C. Seemann 576* (lectotype K, sheet 2/2, here designated).

Podocarpus filicifolius N. E. Gray, J. Arnold Arbor. 43: 74. 1962.

Etymology

The species epithet refers to Viti Levu, the island in Fiji from where it was first described.

Vernacular names

dakua salusalu, kau solo (Viti Levu); mugo (New Guinea, Danau Paniai [Wissel] Lakes)

Description

Trees to 45(–60?) m tall, to 1.5(–2?) m d.b.h.; large trees with spur-butresses at base; bole straight and erect, terete, clear of branches for 20 m or more in large trees growing in forest. Bark smooth, eventually with faint vertical fissures, light to dark brown, weathering blackish grey, exfoliating in small disintegrating longitudinal flakes. Branches ascending or spreading, forming a pyramidal and eventually rounded crown. Foliage branches alternate or subopposite, spreading but becoming pendulous in shaded branches, with remotely dispersed, decurrent, appressed, small and thin scale leaves on leading shoots and more numerous and larger, photosynthetically dominant leaves on lateral branchlets. Leaves on lateral branchlets spirally inserted but pectinately arranged, appearing opposite, with a decurrent base and a 90° twist at the point where the leaf blade abruptly widens and is free from the shoot, twisting in opposite directions on either side of shoot, orientating blade on one side of shoot with adaxial side uppermost and on other side with adaxial side downwards. Leaf shape ovate-lanceolate or ovate-elliptic, longest in juvenile plants, much shorter in top of old trees, also shorter at base and end of lateral branchlets, free part (10–)15–25(–40) × 3–5(–7) mm, mostly widest below the middle, especially juvenile forms gradually tapering to an acute, or in short leaves obtuse apex; midrib narrow and conspicuous on abaxial side, inconspicuous on adaxial side. Stomata on both sides (leaves amphistomatic), numerous but not in regualar lines. Pollen cones on relatively short subterminal or lateral branchlets with scale leaves, in groups of 2–3 together with one terminal, ovate when immature, becoming long cylindrical, 10–25 mm long and 2–2.5 mm diam. at anthesis; microsporophylls in ranks of tight spirals, triangular, keeled, with an acuminate apex, each bearing two pollen sacs. Seed cones on 6–12 mm long lateral branchlets with scale leaves; subterminal fertile scale(s) slightly longer than sterile scale leaves, with a single fertilized ovule growing into an inverted seed covered by an epimatium. Seeds including the epimatium more or less pyriform, with a short crest at distal end, 14–20 × 10–13 mm, green or glaucous becoming fleshy and deep red when ripe; seed proper subglobose, 12–16 × 8–10 mm, with a narrow beak at micropylar end.

Taxonomic notes

Lectotype collection number designated by De Laubenfels in J. Arnold Arbor. 50: 342 (1969). At K there are two sheets of *Seemann 576*, one (sheet 1/2) is a seedling (complete) and one (sheet 2/2) a branch from a young tree corresponding with the plate in the protologue. They cannot be both the lectotype as they come from two separate plants. The latter sheet is to be designated as the lectotype.

Distribution

Malesia: Maluku [Moluccas]; Papuasia: New Britain, New Guinea, New Ireland; Southwest Pacific: Santa Cruz Islands, Fiji Islands.

TDWG codes: 42 MOL 43 BIS NWG-IJ NWG-PN 60 FIJ SCZ

Ecology

Retrophyllum vitiense is a tall tree of tropical lowland to montane rainforest, usually occurring as scattered individual emergents. In New Guinea it is sometimes frequent in forests dominated by *Agathis labillardierei* and *Lithocarpus* spp. In the Bismarck Archipelago (New Ireland) it was found growing in montane forest with *Serianthes* sp., *Syzygium* sp., *Dacrycarpus imbricatus, Podocarpus* sp., and scattered palms and frequent thickets of bamboo; here a tree was reported to be 60 m tall. Its altitudinal range is from near sea level to 1800 m a.s.l. In Fiji it is a common constituent of lowland to montane rainforest containing several other conifers: *Agathis macrophylla, Dacrycarpus imbricatus, Dacrydium nausoriense, D. nidulum*, and *Podocarpus neriifolius*, as well as various angiosperm trees including palms.

Conservation

Despite logging of this and other podocarp trees in many areas of its wide range, which undoubtedly has led to some reduction of its area of occupancy (AOO), since logged forest is often converted to

other land uses that do not bring back these trees, *Retrophyllum vitiense* is as yet not considered a threatened species.
IUCN: LC

Uses

This species is an important and valuable timber tree which can reach large size. The wood is traded within Fiji and used for heavy exterior construction timber, house building (e.g. floors), and furniture. Uses elsewhere within its natural range are similar. This tropical tree is in cultivation only in some botanic gardens.

Saxegothaea Lindl., J. Hort. Soc. London 6: 258. 1851. [& Paxton's Flower Gard. 2: 111. 1851] (*nom. cons.*). ["*Saxe-Gothaea*"]. Type: *Saxegothaea conspicua* Lindl. (*Podocarpaceae*).

Squamataxus J. Nelson, Pinaceae: 168. 1866 (*nom. illeg.*). Type: *Squamataxus albertiana* J. Nelson [*Saxegothaea conspicua* Lindl.].

Named after Prince Albert of Saxe-Coburg-Gotha (1819–1861), Prince Consort to Queen Victoria and a zealous supporter of science and the arts.

Description

See the species description.

Distribution

As for the species.

Saxegothaea conspicua Lindl., J. Hort. Soc. London 6: 258. 1851. *Squamataxus albertiana* J. Nelson, Pinaceae: 168. 1866 (*nom. illeg.*). Type: Chile: ["Patagonia"], *W. Lobb 81* (holotype not located, isotype K). Fig. 315, 316

Etymology

The species epithet means 'remarkable' or 'striking' (English conspicuous from Latin *conspicuus*).

Vernacular names

Prince Albert yew (England); manio, maniu, manio macho, manio hembra (Chile)

Description

Monoecious evergreen trees to 25(–30?) m tall; trunk 1–2 m diam., monopodial or with multiple stems. Bark smooth, exfoliating in rounded or irregular flakes, brown turning purplish, weathering blackish grey only where flakes persist. Branches long, ascending and spreading, eventually drooping or pendulous, forming a broad, rounded crown. Leaves spirally arranged, pectinate, short decurrent, spreading in two divergent planes on shaded branchlets, more irregularly in outer, sun-exposed foliage, linear or falcate, (10–)15–25(–30) × 2–3.5 mm; base petiolate, twisted; blade with a thin midrib on both sides, at upperside yellowish green or more often lustrous dark green; flushing leaves pinkish red or yellowish green; apex mucronate. Stomata in two centrally placed, whitish bands on abaxial (lower) side, arranged in continuous lines. Pollen cones axillary, situated on branchlets below seed cones or separately, solitary or sometimes in pairs, subtended by 2–3 bracts, cylindrical, 4–6 mm long, 1.5 mm wide at anthesis; microsporophylls spirally arranged, numerous, minute, with two pollen sacs. Seed cones terminal on short, axillary branchlets with deciduous scale leaves, globular with protruding scale tips at maturity, 9–12 mm diam., light glaucous green, purplish and fleshy when ripe. Cone scales 15–20, spirally arranged, at first imbricate; proximal part of (mostly) fertile scales swelling on both sides so that the tips stand out. Seeds 1 per scale (from 2 inverted ovules), enclosed, subglobose, ca. 3 mm diam., slightly flattened, lustrous tan or yellowish with a dull hilum.

Distribution

S Argentina: Chubut, Neuquén, Rio Negro; S Chile: Aisén, Biobio, La Araucania, Los Lagos, Maule.
TDWG codes: 85 AGS-CB AGS-NE AGS-RN CLC-BI CLC-LA CLC-MA CLS-AI CLS-LL

Ecology

Saxegothaea conspicua occurs in wet (Valdivian) rain forest, usually along streams in the Andean part of its range, but on slopes of mountains in very high rainfall areas in the coastal mountains. Its altitudinal range is from near sea-level (in the coastal ranges) to ca. 1000 m a.s.l. in the Andes. North of 38° S it becomes scarce due to the transition to a drier climate. It is an extremely shade tolerant tree that can grow under canopy of (evergreen) angiosperm forest, reminiscent of *Taxus* in the northern hemisphere. This species is often associated

with *Podocarpus nubigenus, Laureliopsis philippiana, Dasyphyllum diacnathoides, Embothrium coccineum, Nothofagus obliqua, N. nervosa, N. dombeyi, Weinmannia trichosperma*, and trees and shrubs of *Myrtaceae*. Most of these trees and shrubs are evergreen, as is *Saxegothaea conspicua*, with the exception of *Nothofagus* spp. Little is known about seed dispersal, it is assumed that birds will be involved.

Conservation

Despite its wide distribution logging still threatens this species. Increasing demands for firewood make much of this cutting indiscriminate, on the other hand selective logging aims at relatively young, straight trees. Conversion of natural forest to plantation forest with exotic tree species and to agriculture further reduce its extent of occurrence (EOO) and area of occupancy (AOO); if these trends continue it may reach a threatened status. On the other hand it occurs in many protected areas both in Argentina and Chile.

IUCN: NT

Uses

The wood of this species is used when straight for contstruction work and carpentry; more often trees occur that do not grow straight boles and these are put to firewood. In general, it is not considered an important timber tree. This species is well established in cultivation as an amenity tree in countries with relatively abundant rainfall and mild winters, where it makes a large, domed and usually multi-stemmed tree when planted free standing in parks and large gardens. Planted in woodland surrounded by other trees, its habit will be more upright with a narrow crown. Cultivars are not known from this species.

Sciadopitys Siebold & Zucc., Fl. Japon. 2 (1): 1. 1842. Type: *Sciadopitys verticillata* (Thunb.) Siebold & Zucc. [*Taxus verticillata* Thunb.] (*Sciadopityaceae*).

Greek: *skias* = canopy, umbel; *pitys* = pine or fir tree; referring to the verticillate, spreading cladodes, hence 'umbrella pine'.

Description

See the species description.

Distribution

As for the species.

Sciadopitys verticillata (Thunb.) Siebold & Zucc., Fl. Japon. 2 (1): 3, t. 101–102. 1842. *Taxus verticillata* Thunb., in Murray, Linn. Syst. Veg., ed. 14: 895. Mai-Jun 1784. Type: Japan: Honshu, [locality not stated], *C. P. Thunberg UPS 23787* (holotype UPS). Fig. 317, 318

Etymology

The species epithet refers to the whorled phyllotaxis of the leaf-like cladodes.

Vernacular names

Japanese umbrella pine; koya-maki (Japanese)

Description

Trees to 40–45 m tall, evergreen, monoecious; trunk monopodial, columnar, up to 3(–3.5?) m d.b.h. Bark thin and scaly, becoming fissured on trunk, exfoliating in long, thin strips and flakes; inner bark reddish brown; outer bark dull brown. Branches spreading horizontally or occasionally ascending, forming a pyramidal crown in young trees and a narrowly conical or cylindrical crown in mature trees. Foliage consisting of cladodes ('needles') in pseudowhorls on shortened terminal sections of long shoots, the density of this foliage dependent on shoot elongation. Long shoots glabrous, green, soon turning light brown, grooved longitudinally, dimorphic, with long sections alternating with much shortened, thicker sections, growing from terminal, conical, obtuse buds 3–5 × 2–4 mm with imbricate, thin chartaceous brown scales. Leaves much reduced, scale- or cataphyll-like, 3–5 × 2–4 mm, the distal, free portion scarious, yellowish green, soon brown, caducous. Cladodes (phylloid shoots) mostly on shortened sections of shoots, axillary to short, triangular scale leaves, arranged helically in pseudowhorls of (8–)10–25(–40), spreading, linear, mostly straight, (3–)8–10(–13) cm long, 2–3.5 mm wide, with a narrow longitudinal groove from base to apex adaxially and a wider, deeper groove from base to apex abaxially; margins thick, entire, distally converging to retuse or emarginate apex; surface smooth, lustrous light to dark green; abaxial groove lined with white papillae concealing the stomata, which are confined to this groove. Pollen cones in terminal or sublateral clusters of 8–20, helically arranged, effectively forming a cone ca. 2 × 1.5 cm, each individual cone subglobose or broadly ovoid, 4–6 × 3–5 mm, yellow turning brown. Microsporophylls helically arranged, imbricate, subpeltate, near abaxial base bearing two yellow pollen sacs. Seed cones terminal or sublateral, from a large, scaly bud, ovoid to cylindrical, truncate, often irregular, 3.5–11 × 2.5–5 cm, maturing in second year, closed at first, often exuding white resin, bract portion of bract-scale complex brown, ovuliferous scale portion green, entire cone turning brown with spreading scales. Bract-scale complexes helically arranged on a stout axis, more or less dolabriform, up to 3.5 × 3.5 cm; bracts and ovuliferous scales proximally fused, with ovuliferous scales exceeding the truncate bracts and these terminating in a thick ridge with a central, ligulate, 2–4 mm long, thin, caducous bract tip; outer surface of ovuliferous scale portion deeply grooved, glabrous; cones when falling often partially disintegrated. Seeds inverted, 8–13 × 6–8 mm (including 2 wings), compressed; base truncate; apex acute; surface smooth, brown with white hilum.

Taxonomic notes

For a detailed discussion, with references, of the segregation of the Japanese umbrella pine as the sole extant member of a distinct family *Sciadopityaceae* (and why it is not a yew [*Taxus*] nor a pine [*Pinus*]), I refer to A Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a).

Distribution

Japan: Honshu (Aichi, Fukushima, Hiroshima, Kyoto, Nagano, Nara, Okayama, Wakayama), Shikoku, Kyushu (Myazaki).
TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Ecology

Locally common in mixed conifer-angiosperm forests, with *Chamaecyparis obtusa, C. pisifera, Tsuga sieboldii, Abies firma, Pinus parviflora*, and angiosperms such as *Aesculus turbinata, Magnolia obovata, Acanthopanax* spp., *Cercidiphyllum japonicum*, and *Acer rufinerve*. In dense forest usually only ferns, mosses and liverworts grow under the trees, but in some localities shade tolerant shrubs and small trees such as *Ilex sugeroki* and *Skimmia japonica* can thrive. *Sciadopitys* occurs as solitary trees as well as in small 'groves' or more or less pure stands, reflecting events of recruitment and subsequent successional stages in the forest. This conifer is most commonly found in rocky, cool and moist ravines and valleys in mountainous areas, at altitudes between 200 m and 1700 m a.s.l.

Conservation

Being a component species in mixed conifer-angiosperm forests where *Chamaecyparis obtusa* is commonly the dominant species, past logging and subsequent conversion to managed or planted forest, or other land uses, has restricted the occurrence of *Sciadopitys* in many regions. Most of the remaining stands in Honshu are now only small remnant populations and larger stands in more or less undisturbed forest are confined to Shikoku and Kyushu. Past reduction has been inferred to have been ca. 20% and the decline has now slowed down or possibly ceased.
IUCN: NT

Uses

The durable wood of this species is used for construction purposes and to a limited extent for boat building and certain kinds of furniture. The fibrous bark was formerly used for caulking boats (oakum). Its most valuable commercial use is undoubtedly in the horticultural industry, as it is a popular planted tree in Japan and (more limited) in Europe and the USA. Apparently it was not introduced in China, as were a few other Japanese conifers such as *Cryptomeria japonica*. The Dutch, who were the only Europeans allowed to trade with Japan, brought it to Jawa early in the 19th century; it arrived successfully in England and the Netherlands in 1861. A small number of cultivars with dwarfed growth, variegated foliage and/or pendulous branches has been developed but these are rarely planted. Some of these seem to scarcely differ from the species.

Sequoia Endl., Syn. Conif.: 197. 1847 (*nom. cons.*). Conservation of this generic name was unnecessary (Straub *et al.* in Taxon 57 (2): 646 (2008). Type: *Sequoia sempervirens* (D. Don) Endl. [*Taxodium sempervirens* D. Don] (*Cupressaceae*).

Gigantabies J. Nelson, Pinaceae: 77. 1866. (*nom. illeg.*). According to Straub *et al.* in Taxon 57 (2): 646 (2008) this name was not validly published (Art. 32, Art. 33.9) but it has been listed as validly published in Index Nominum Genericorum (ING). Type: *Gigantabies taxifolia* J. Nelson [*Sequoia sempervirens* (D. Don) Endl.].

Named after Sequoya (ca. 1760–1843), a Cherokee chief who invented an alphabet for his people.

Description

See the species description.

Distribution

As for the species.

Sequoia sempervirens (D. Don) Endl., Syn. Conif.: 198. 1847. *Taxodium sempervirens* D. Don, in Lambert, Descr. *Pinus* 2: [24], t. 7, f. 1. 1824. Type: USA: California, Santa Cruz Co., Santa Cruz Mts., ["California: Santa Cruz Mr. Menzies" on back of sheet], *A. Menzies s.n.* (holotype BM). Fig. 319, 320

Etymology

The species name means 'evergreen' and was given to contrast this conifer with the deciduous *Taxodium distichum*, then thought to belong in the same genus.

Vernacular names

Redwood, Coast Redwood, California Redwood

Description

Trees to 100–110(–115) m tall, evergreen, monoecious; trunk monopodial, straight, erect, often strongly buttressed or with large burls at base, sprouting after damage, resulting in multi-stemmed trees, up to 6–7 m diam. above buttress. Bark 2–30 cm thick on trunk, deeply fissured, fibrous, exfoliating in long, thin strips, reddish brown to grey. Branches spreading, curved down except in top of tree, in old trees with many reiterations, with numerous spreading foliage branches forming a conical or pyramidal, in large trees more rounded crown. Foliage branches usually spreading horizontally and flattened, lateral (ultimate) branchlets 3–12 cm long, covered with decurrent leaf bases, green turning reddish brown, semi-deciduous. Leaves alternate, decurrent, on shaded shoots pectinate by a twist of lower free part, not twisted but curved on most fertile shoots, mostly linear, flattened, up to 25 × 3 mm (usually ca. 20 mm long but variable on the same shoot from base to middle to apex), straight or slightly curved; margins entire; apex acute or acuminate, primarily hypostomatic, with stomata adaxially in two broad bands separated by a narrow midrib; leaf colour lustrous green or dull grey-green to glaucous green, the stomatal bands whitish or glaucous. Pollen cones on the same branches as seed cones, subterminal or terminal from buds in leaf axils, solitary, ca. 5 × 4 mm; microsporophylls 10–15, helically arranged, peltate, with erose-denticulate margins, bearing 2–3 abaxial, globose pollen sacs. Seed cones terminal on short branchlets, 15–30 × 13–18 mm, maturing to purplish brown and finally (reddish) brown. Bract-scale complexes 18–25, helically arranged, parting when cone matures except distal 2–3, peltate; distal part irregularly diamond-shaped, 6–10 × 4–5 mm, rugose, with a central depression and transverse ridge in which the bract tip forms a 1.5–2.5 mm long process until it erodes; proximal part narrowing to a pedicellate base. Seeds 60–100 per cone, irregularly shaped, 5–6 × 3–4 mm, flattened, with angular margins, reddish brown, often with dark spots; wings 2, rudimentary, forming a 1 mm wide continuous margin. This species is the only known hexaploid (chromosome count 2n = 6x = 66) in conifers.

Distribution

W USA: Pacific Coast region from SW Oregon (Curry Co.) to California (Monterey Co.).

TDWG codes: 73 ORE 76 CAL

Ecology

The famous Redwood forests form a very distinctive lowland coastal vegetation type dominated by this tallest of all trees. The altitudinal range is (1–)30–750(–920) m a.s.l. Though pure stands of *Sequoia* are not uncommon especially at low altitudes on river flats near the coast, mixed stands with both conifers and angiosperms are more the rule. Most common among associated conifers are *Pseudotsuga menziesii*, *Tsuga heterophylla* and *Abies grandis*, most frequent angiosperm trees are *Acer macrophyllum* and *Lithocarpus densiflorus*. Especially in hilly terrain of upland sites many other tree species can be present and *Sequoia* often becomes a lesser component of the forest. The autecology of this species is remarkable for its capacity to resprout after damage at all levels up the tree, but especially from lignotubers forming massive, largely subterranean swellings. Evidence of fire in old growth Redwood forests attests to its adaptation to such disturbances mainly in this manner; many trees have formed several large stems around an old burnt stump. Longevity as evidenced from ring counts of boles exceeds 2000 years, but may on account of this survival strategy be substantially longer. The occurrence of frequent oceanic fog and the interception of this moisture through branchlet disposition, phyllotaxis and leaf shape in the crowns of especially old growth trees are apparently crucial to species survival in this otherwise summer dry region. Its distribution and inner limit of 61 km corresponds with the inner limit of the fog belt.

Conservation

The conservation issues involving *Sequoia sempervirens* pertain largely to the necessary preservation of the remaining 'old growth' Redwood forest for ecological reasons and involve much less questions about survival in the wild of the species. The "redwood belt" as given on published maps of distribution comprises forest with a (co)dominance of *Sequoia sempervirens*, forest with the species as a minor constituent, as well as 'potential' sites, i.e. where the species has grown historically but has been removed by logging and replaced by other tree species or a different type of land use from forest. 'Old growth' Redwood forest has been greatly reduced since Europeans arrived and covers currently ca. 80,000 ha, but almost all of this is now in protected areas. Its easy regeneration both from seeds and resprouting from stumps indicate the resilience of this tree against (man-made) disturbances. On the other hand, its late successional to climax dominance coupled with shade tolerance means it is easily replaced by more light demanding conifers such as *Pseudotsuga menziesii* (Douglas Fir). This can be made 'permanent' if forests are chosen to be so managed, as indeed they tend to be in commercial forestry operations. It is therefore considered that the long-term maintenance of the present abundance of this species is at least in part dependent on conservation action.

IUCN: EN (A2a, c, d)

Uses

The wood of this tree has been used extensively in the past for construction work wherever decay resistance was a requirement. Many of the older houses in California and Oregon were built with it, including the shingles on the roofs. Railroad sleepers and bridge timbers were other uses to which it was put. With the sharp decline in 'old growth' stands of this tree, which yielded the best quality saw timber for many of these purposes, uses have more recently shifted to specialities like turned wood products, cabinets and polished table tops from its burls or burrs, which produce knotty wood with beautiful patterns and colours. The thick, fibrous, and tough bark is used for insulation or mulched for application in gardens to suppress weeds in flower beds. The Coast Redwood is extensively cultivated as an ornamental tree in many countries and about 10 cultivars are in the trade. In favourable conditions growth is rapid and trees can reach impressive sizes within a century and, if their longivity in their natural range is even remotely approached, they could continue to grow for many more centuries.

Sequoiadendron J. T. Buchholz, Amer. J. Bot. 26: 536. 1939. Type: *Sequoiadendron giganteum* (Lindl.) J. T. Buchholz [*Wellingtonia gigantea* Lindl.] (*Cupressaceae*).

Steinhauera Presl, in Sternberg, Fl. Vorwelt 2: 202, t. 49, 57. 1838. Type: *Steinhauera gigantea* (Lindl.) Kuntze *ex* Voss [*Wellingtonia gigantea* Lindl. (*Sequoiadendron giganteum* (Lindl.) J. T. Buchholz)]; *Wellingtonia* Lindl., Gard. Chron. 1853: 819, 823. 1853, *non* Meisn. 1840. Type: *Wellingtonia gigantea* Lindl. [*Sequoiadendron giganteum* (Lindl.) J. T. Buchholz]; *Washingtonia* Winslow, Calif. Farmer 2: 58. 1854. (*nom. rej.*). Type: *Washingtonia californica* Winslow [*Sequoiadendron giganteum* (Lindl.) J. T. Buchholz]; *Americus* Hanford, Great Calif. Tree: 6. 1854 [*nom. rej. prop.* (1815) by Straub *et al.* in Taxon 57 (2): 645–647 (2008)]. Type: *Americus gigantea* (Lindl.) Hanford [*Wellingtonia gigantea* Lindl. (*Sequoiadendron giganteum* (Lindl.) J. T. Buchholz)].

Named after Sequoya (ca. 1760–1843); Greek: *dendron* = tree; the combination was made to denote relationship with yet separation from the genus *Sequoia*.

Description

See the species description.

Distribution

As for the species.

Sequoiadendron giganteum (Lindl.) J. T. Buchholz, Amer. J. Bot. 26: 536. 1939. *Wellingtonia gigantea* Lindl., Gard. Chron. 1853: 819, 823. 1853, *nom. illeg.*, Art. 53.1. Type: USA: California, Tulare Co., Stanislaus River, ["Headwaters of the Stanislaus and San Antonio Rivers"], *W. Lobb 436* (holotype not located, isotype K). Fig. 321, 322

Etymology

The species epithet refers to the great size of this tree.

Vernacular names

Giant Sequoia, Sequoia, Bigtree, Sierra Redwood; Wellingtonia (United Kingdom)

Description

Trees to 90–95 m tall, evergreen, monoecious; trunk monopodial, straight, erect, often strongly buttressed or with large root bases or burls at base, becoming very massive, up to 8–10 m diam. above buttress. Bark eventually 30–60 cm thick on lower part of trunk, deeply fissured, fibrous, soft, slowly exfoliating in small, thin strips, cinnamon to reddish brown. Branches heavy (to 2–2.5 m diam., in older trees often exceeding the leader), spreading and assurgent, with numerous spreading or drooping foliage branches forming a conical or pyramidal, in large trees more rounded crown. Foliage branches spreading or drooping, lax, branching alternately and irregularly, the last 3–4 orders covered with green scale leaves, persistent. Leaves helically arranged in 3 ranks, imbricate, decurrent, on mature trees variable with branch size, 1–8(–20) × 1–3.5(–5) mm, smallest on ultimate branchlets, straight or slightly curved, bluntly keeled; margins entire, acute to apiculate; amphistomatic, with scattered lines of stomata on abaxial face and two more conspicuous lines with more stomata on adaxial side; colour of adult leaves lustrous dark green. Pollen cones on the same branches as seed cones but well above them, terminal (rarely subterminal), solitary, subglobose, 4–6 × 3–5 mm; microsporophylls 15–20, helically arranged, peltate, bearing 2–3 abaxial, globose pollen sacs. Seed cones terminal on short branchlets, 30–70(–95) × 25–50(–65) mm, maturing in 2 seasons to green and eventually becoming dark brown. Bract-scale complexes helically arranged, parting when cone matures except distal 2–3, peltate; distal part diamond-shaped, 12–30 × 6–12 mm, rugose, thick and woody; proximal part narrowing to a pedicellate base. Seeds ca. 200 per cone, irregularly oval, 5–7 × 3–5 mm including wings, much flattened, greyish brown; wings 2, marginal, of unequal size, 1.5–2 mm wide, yellowish brown.

Taxonomic notes

The discovery of this tree by Europeans was an event well publicised in the popular press of the time, due

to its sensational size which at first caused disbelief among more cautious scientists. Although first seen by Albert Kellogg of San Francisco in 1852, specimens reached John Lindley of London late in 1853, and he first described it (hurriedly) as *Wellingtonia gigantea* in the popular Gardener's Chronicle (of which he was editor) on Christmas Eve of that year (Ornduff in Aune, 1994). Kellogg, however, had an American hero (Washington), not a British one, in mind for the biggest tree on earth. The furious and highly nationalistic pathos that ensued, not only in the popular press, but even in botany, is now amusing to read, especially when we realise that *Wellingtonia* was, as later homonym, illegitimate and that *Washingtonia* soon became the well-known name of a palm genus, causing its use for the Giant Sequoia to be officially rejected.

Distribution

USA: California, Sierra Nevada (Calaveras, Fresno, Madera, Mariposa, Placer, Tulare & Tuolumne Co.), in ca. 67 disjunct groves.
TDWG codes: 76 CAL

Ecology

This species is forming 'groves' of a few to over 20,000 individuals in the Mixed Conifer Forest belt on the western slopes of the Sierra Nevada. It is mixed with other conifers: *Abies concolor, A. magnifica, Calocedrus decurrens, Pinus lambertiana, P. ponderosa, P. jeffreyi, Pseudotsuga menziesii, Taxus brevifolia*, and with fewer broad-leaved trees: *Quercus kelloggii, Q. chrysolepis, Cornus nuttallii, Alnus rhombifolia, Salix scoulerana, Acer macrophyllum*, and shrubs: *Castanopsis sempervirens, Ceanothus cordulatus, C. parvifolius, C. integerrimus, Arctostaphylos patula*, etc. The relatively narrow altitudinal belt, (830–)1400–2150(–2700) m a.s.l., and the scattered concentration of groves, which tend to become smaller and further apart going north, indicate rather narrow climatic and soil conditions that are optimal in its natural habitat. Most groves are on granite-based residual and alluvial soils, some on glacial outwash, and mildly acidic; best growth is on deep, well-drained sandy loams with available ground water, the latter appears to be an important limiting factor. The climate is humid, with mostly autumn rain and winter snow, and dry summers, with mean annual precipitation between 900–1400 mm, but with high year-to-year variation. Temperature in winter is mild, with light frosts but occasional extremes, and warm, occasionally hot, in summer. *Sequoiadendron giganteum* is well adapted to low-intensity forest fires (extremely thick bark) and resists windfall exceptionally well; its wood is rot-resistant. As a result its longevity ranges from 2000–3000(–3200) years.

Conservation

Although nearly all groves are on public land, enjoying various levels of protection, the species is under IUCN criteria considered Endangered due to past decline caused by exploitation, but particularly because decline continues for other reasons caused by past mismanagement in protected areas. Present problems include fire risks, largely due to (past) management practices which tended to benefit its coniferous competitors (especially *Abies*) rather than the target species, and which have greatly accumulated the fuel load for future fires to burn more devastatingly. There is a considerable literature on the conservation aspects of this species; for a compilation see Aune (1994).
IUCN: EN [B2ab (ii, iii, v)]

Uses

Since its discovery by Europeans in the mid-19th century, exploitation during the latter half of that century and into the next was considerable. The trees, though of high lumber quality and rot-resistant, often shattered on impact of the giant boles. What wood could be used was put into mainly building applications, and many larger houses in San Francisco and the Bay Area were built of its timber. No commercial exploitation of wild groves occurs at present, and most of these were protected for their scenic and scientific values many years ago. The giant trees are a major international tourist attraction in California. The Giant Sequoia is also highly regarded as an ornamental tree in parks and gardens of large homes and, being easily propagated from seed, is sold by many tree nurseries. Several cultivars have been named and are in the trade. The species also has potential as a managed-forest tree for timber production, but has found few applications in commercial forestry thus far.

Sundacarpus (J. T. Buchholz & N. E. Gray) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 378. 1989. *Podocarpus* L'Hér. *ex* Pers. sect. *Sundacarpus* J. T. Buchholz & N. E. Gray, J. Arnold Arbor. 29: 57. 1948. Type: *Sundacarpus amarus* (Blume) C. N. Page [*Podocarpus amarus* Blume] (*Podocarpaceae*).

From 'Sunda', a name for the Indonesian archipelago (minus the Moluccas and New Guinea); Greek *karpos* = fruit.

Description

See the species description.

Distribution

As for the species.

Sundacarpus amarus (Blume) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 378. 1989. *Podocarpus amarus* Blume, Enum. Pl. Javae 1: 88. 1827; *Nageia amara* (Blume) F. Muell., Select Pl., ed. 2: 138. 1876; *Stachycarpus amarus* (Blume) Gaussen, Trav. Lab. Forest. Toulouse T. 2, 1 (2, 20): 105. 1974 (*nom. inval.*, Art. 33.2); *Prumnopitys amara* (Blume) de Laub., Blumea 24 (1): 190. 1978. Type: Indonesia: Jawa, [locality not stated], *leg. ign. s.n.* (holotype L). Fig. 323, 324, 325

Etymology

The species epithet '*amara*'given by Blume under *Podocarpus* (= *amarus*) means 'bitter' and refers to the taste of the 'fruit' i.e. the fleshy epimatium around the seed.

Vernacular names

Black pine; choopoola (Queensland); sitobu (Sumatera); ki merak, ki pait (Jawa); sempilau (Sabah); pasuig (Philippines) and numerous local vernacular names given in Flora Malesiana, ser. 1, 10 (3): 387 (1988).

Description

Dioecious evergreen trees to 60 m tall, with an erect trunk to 1.5 m diam., large trees with 3–5 m tall buttresses. Bark smooth, dark brown weathering blackish grey, in large trees breaking into numerous square plates; inner bark red-brown. Branches of trees in forest well above a clear bole, ascending or erect, then spreading; foliage branches more or less pendulous. Foliage buds small, globose, with imbricate, rounded scales. Leaves on seedlings and juvenile plants distinctly rostrate (abrubtly narrowed to an elongated apex), 3–6(–9) times as long as wide. Adult type leaves usually narrower, broadly linear, 5–15 cm long, 6–15 mm wide, petiolate and with a tapering base, with parallel or more or less undulating margins, spreading pectinately or assugent, straight or irregularly curved, with a central groove over the midvein adaxially and a raised midrib abaxially, usually acuminate at apex, dark green on the upper (grooved) side, light green below. Stomata restricted to abaxial side (leaves hypostomatic), in two broad bands of numerous densely set lines. Pollen cones on stalks axillary to foliage leaves or subtended by deciduous scale leaves, sometimes terminal and solitary, more often 3–7 on a stalk, short cylindrical when immature, elongating to 15–30 mm, 2.5–4 mm wide; microsporophylls triangular-trullate, usually keeled, with serrate or entire margins and two longitudinally dehiscing pollen sacs. Seed cones solitary or with 2–5 on leafless pedunculate shoots 1–4 cm long, borne subterminally on 3–5 mm long scaly dwarf shoots, with distal scales with abortive ovules spreading out or recurving and not enlarged or fused, with sterile scales falling off. Growing seeds covered by a green, then orange to red and finally glaucous purple, fleshy but firm epimatium, becoming nearly spherical with a small protruding apex, 22–30 mm diam. Seed proper globular, ca. 20 mm diam., smooth with an indistinct ridge. Cotyledons in 3 fused pairs.

Distribution

Malesia: from Sumatera and the Philippines to New Guinea, New Ireland and New Britain (not in Peninsular Malaysia and in Borneo only in Sabah); Australia: NE coastal Queensland.

TDWG codes: 42 BOR-SB JAW LSI-ET LSI-LS MOL PHI SUL SUM 43 BIS NWG-IJ NWG-PN 50 QLD-QU

Ecology

Sundacarpus amarus is a tree of tropical evergreen rainforests, holding out in primary forest as scattered tall and sometimes giant emergents and re-establishing in secondary forest. It is rare at sea level, but becomes common from 500 to 2200 m a.s.l. and has been found to 3000 m on Mt. Kinabalu in Sabah. At lower to middle elevations it is associated with conifers such as *Agathis* spp., *Dacrycarpus* spp., *Falcatifolium gruezoi*, and *Dacrydium* spp.; angiosperms are *Cryptocaria pomatia, Dysoxylum, Macaranga, Ficus* and many other tree species. It grows often in latosols derived from andesite, basalt, or granite, rarely in sandy soils or in marshes. In New Guinea it is very common in montane forests with *Castanopsis, Nothofagus, Calophyllum, Pasania, Syzygium*, and the conifer *Phyllocladus hypophyllus*. At the highest altitudes it occurs in mossy forest and becomes stunted. In Queensland *S. amarus* is a constituent of 'complex notophyll vineforest', a type of tropical rainforest with abundant lianas, where it occurs with *Podocarpus dispermus*.

Conservation

IUCN: LC

Uses

Sundacarpus amarus is a timber tree of sometimes very large dimensions and is logged often together with other podocarps. It is sometimes distinguished in the timber trade as black podocarp. Its wood is sawn and used for construction (e.g. government buildings in remote mountain areas of Papua New Guinea), carpentry and joinery, as well as furniture making. It is not well known in the trade as it is still being confused with other podocarpaceous species or treated with other species in the genus *Prumnopitys* (PROSEA, 1993). Outside some collections in botanic gardens it is not known in horticulture or as a planted forestry tree.

Taiwania Hayata, J. Linn. Soc., Bot. 37: 330. 1906. Type: *Taiwania cryptomerioides* Hayata (*Cupressaceae*).

Named after the island of Taiwan, from where it was first described.

Description

See the species description.

Distribution

As for the species.

Taiwania cryptomerioides Hayata, J. Linn. Soc., Bot. 37: 330. 1906. Type: Taiwan: Nantou Co., Chiayi-Nantou border, Wusungkengshan, ["ad pedem montis Morrison"], *N. Konishi s.n.* (lectotype TI). Fig. 326, 327, 328

Taiwania flousiana Gaussen, Trav. Lab. Forest. Toulouse T. 1 (3, 2): 6. 1939.
Taiwania yunnanensis Koidz., Acta Phytotax. Geobot. 11 (2): 138. 1942.

Etymology

The species epithet means 'resembling *Cryptomeria*' and refers to the type of leaves prevalent in young trees.

Vernacular names

Coffin tree, Taiwania, Taiwan cedar; tai wan shan (Chinese)

Description

Trees to 60–65(–70) m tall, evergreen, monoecious; trunk monopodial, straight, up to 3–4 m diam. above buttressed base. Bark on large trees relatively thin, exfoliating in thin strips and chips, becoming fissured, reddish brown or brown weathering grey. Branches spreading or assurgent, lower foliage branches pendulous, forming a conical or pyramidal crown in young trees, in old trees domed or flat-topped. Foliage branchlets (sub)pendulous, in young trees with long subulate leaves, in older trees covered with short, appressed scale leaves, persistent. Leaves alternate to helically arranged, short decurrent, dimorphic with tree age; juvenile leaves persistent for 30 years or longer (trees ca. 15 m tall), falcate-subulate, (5–)10–24 × 1.5–3.5 mm, widest near base, with free part spreading, bilaterally flattened, keeled on both faces, nearly straight or curved forward, acute-pungent, amphistomatic, glaucous-green; adult leaves short lanceolate-trullate, 3–6(–7) × 1.2–3 mm; margins entire; apex acute to obtuse, incurved, free or nearly appressed; leaves amphistomatic, lustrous (dark) green with whitish stomata. Pollen cones in terminal clusters of (2–)3–5(–7) on branchlets with scale leaves, ovoid-globose, 2–3 mm long; microsporophylls numerous, helically arranged, peltate, with (2–)3(–4) abaxial pollen sacs. Seed cones terminal, solitary, maturing in one season to ellipsoid to cylindrical brown cones (9–)12–20(–25) × 6–11 mm. Cone scales (=bracts) gradually transformed from scale leaves below, (12–)14–20(–25), broadly obdeltoid to obtrullate, 6–10 × 5–8 mm; proximal portion cuneate, yellowish brown or reddish brown; distal portion dull brown; apex mucronate. Seeds 14–30 per cone (1–2 per scale), ovate-oblong, flat, 4 × 2–3 mm (without wings), light brown or tan. Wings 2, partly overlapping, surrounding the seed, thin filamentous, hyaline, 1–2 mm wide.

Taxonomic notes

The very disjunct occurrence in Yunnan and Myanmar [Burma] in the west and Taiwan in the east (the *locus classicus*) seems to have been the primary reason why botanists have made taxonomic distinctions. A careful and critical comparison of types and many other specimens revealed no consistently different morphological characters (Farjon, 2005a). The recently discovered population in Viet Nam fits in well with material from the earlier known locations; here it was observed that reversal to juvenile

type leaves can occur in lower parts of the crown of mature trees. Transition from juvenile 'cryptomerioid' foliage leaves to adult 'sequoiadendroid' leaves occurs at an advanced age of trees, even in the wild.

Distribution

China: NW Yunnan, SE Xizang [Tibet]; NE Myanmar [Burma]; Taiwan: Nantou District; Viet Nam: Lao Cai, Van Ban District. [Other reported localities in China are here considered to be based on introduced trees].

TDWG codes: 36 CHC-YN CHT 38 TAI 41 MYA VIE

Ecology

Taiwania cryptomerioides is a conifer of montane forests at altitudes from 1750 m to 2900 m a.s.l. In Taiwan it grows in the cool temperate coniferous forest belt with *Chamaecyparis obtusa* var. *formosana* and *C. formosensis* as codominant species and more scattered occurrence of *Calocedrus formosana, Cunninghamia konishii, Picea morrisonicola, Pseudotsuga sinensis, Taxus wallichiana*, and *Tsuga chinensis*. Angiosperm trees are common but scattered, e.g. *Castanopsis, Quercus* and *Trochodendron aralioides*, while shrubs such as *Camellia brevistyla, Eurya, Rhododendron*, and *Vaccinium* are more abundant and the bamboo *Yushania niitakayamensis* can cover large areas. In Yunnan and accross the border in Myanmar [Burma] it occurs in the mixed coniferous forest with *Abies forrestii, Picea brachytyla, Larix potaninii, Pseudotsuga sinensis*, and *Tsuga dumosa*, and with *Cephalotaxus fortunei, Taxus wallichiana* and *Torreya grandis* var. *yunnanensis* in the understorey. All the trees are densely hung with the lichen *Usnea longissima* and mosses and leafy liverworts cover trunks and branches. Some angiosperm trees are mixed in and become more abundant at lower altitudes, e.g. *Acer, Castanopsis, Lithocarpus, Quercus, Magnolia, Schima*, and *Sorbus*, and in the understorey *Rhododendron* and many other shrubs are abundant. In Viet Nam it is scattered in remnants of montane evergreen forest dominated by *Fagaceae, Lauraceae* and some *Magnoliaceae*, with only one other large conifer, *Fokienia hodginsii*, common. In these forests *Taiwania* is an emergent, usually forming small groves in sheltered side valleys. It can attain an age of 1600+ (probably over 2000) years and belongs ecologically to those conifers which through longevity and canopy emergence survive all other forest trees, 'waiting' for episodal forest disturbance (most likely fire but possibly also landslides) to regenerate. The forest soils are yellow and red acidic derivatives of granitic or metamorphic rocks. The climate is strongly influenced by monsoons, with annual precipitation exceeding 4000 mm in China, but at about 3000 mm in Viet Nam. Reports of this species from other areas in China (Fu & Jin, 1992; Flora of China 4, 1999) do not refer to this type of extremely wet monsoon forest and it is very unlikely that *Taiwania* is indigenous there.

Conservation

In Yunnan many stands of old growth *Taiwania* are still liable to be exploited; the establishment of more reserves for this species is urgent. In Taiwan the establishment of Yushan National Park in 1984 protected several natural stands of trees, but many had been felled by that time. Plantation forestry using this species is limited in Taiwan and more extensive in Guizhou and Hunan in mainland China; it will take many years before these are trees suitable for harvest as the species is (beyond sapling and pole stages) slow growing. In Viet Nam, the small population is Critically Endangered (CR), because the forest remnants in which it still occurs are acutely threatened by deliberately set fires in the area; it is estimated that perhaps as much as 80% of its habitat has already been destroyed. The situation in Myanmar is unknown at present.

IUCN: VU (A2c, d)

Uses

The wood of *Taiwania* is very durable and valued for timber; notable is the (past?) use of it for coffin making. In Viet Nam it was observed that the local H'Mong mountain people use it together with that of *Fokienia hodginsii* for their houses, in particular for roof planks. Some of this wood is beautifully marked with red and pale yellow annual rings (late and early wood) and prized for furniture. This tree has been planted in China outside its natural habitat for much longer than the century that has passed

since its botanical description in 1906. It was introduced to Japan, Europe, North America, and New Zealand as an ornamental tree, where it grows well outside in temperate regions with none or only light frosts in winter and sufficient moisture. Despite its attractive form and foliage as a young tree, it has remained rare and is almost restricted to arboreta and botanic gardens.

Taxodium Rich., Ann. Mus. Natl. Hist. Nat. (Paris) 16: 298. 1810. Type: *Taxodium distichum* (L.) Rich. [*Cupressus disticha* L.] (*Cupressaceae*).

Schubertia Mirb., Nouv. Bull. Soc. Philom. 3: 123. 1812 (*nom. rej.*). Type: *Schubertia disticha* (L.) Mirb. [*Cupressus disticha* L.]; *Cuprespinnata* J. Nelson, Pinaceae: 61. 1866 (*nom. illeg.*). Type: *Cuprespinnata disticha* (L.) J. Nelson [*Cupressus disticha* L.]

The genus *Taxus* (yew) and Greek: *eidos* = 'resemblance'; referring to the leaves.

Description

Deciduous or semi-deciduous trees, monoecious; trunk monopodial, erect; base often swollen, fluted or buttressed, 'pneumatophores' or 'knees' present or absent. Resin canals in leaves. Bark fissured, exfoliating in more or less fibrous, long strips. Branches spreading or ascending, branching sympodially, forming a domed or flat-topped crown in large trees. Foliage branches dimorphic, with long and short shoots; long shoots indeterminate; short shoots determinate, alternate, distichously spreading from long shoots, or assurgent to nearly erect. Winter buds prominent, 3–5 mm, adventitious buds present. Leaves helically arranged, leaf bases short decurrent, the proximal part of the free blade twisted or not, if so spreading the leaves in two ranks, if not in 5–8 ranks, linear or (short) acicular, amphistomatic. Pollen cones arranged in spike-like to paniculate systems on clustered (sympodial) branchlets, solitary or in pairs; microsporophylls helically arranged, bearing abaxially in two rows near lower margin 2–10 pollen sacs. Seed cones terminal and often clustered, near end of last year's long shoots. Cones subglobose or more or less ovoid but irregular 12–40 mm long. Bract-scale complexes ca. 20–30, helically arranged, partly fused at base and/or apex of cone (infertile scales), others opening slightly, breaking away, thick woody, peltate, of unequal size and irregularly shaped; bracts entirely included or with a minute recurved tip emerging. Seeds 15–40 per cone, triangular or angular-ovate, oblique, more or less flattened, wings very small or vestigial. Cotyledons 3–9, usually 4–6, juvenile leaves at first 4-whorled, soon alternate, similar to adult leaves.

2 species.

Distribution

SE North America (USA), Mexico, Guatemala.

Key to the species of *Taxodium*

– Stomata on a leaf most abundant on the abaxial side, in broader bands than on the adaxial side. Seed cones mostly 20–35 mm long ***T. distichum***
– Stomata about equally abundant on both sides of the leaf. Seed cones mostly 14–25 mm long ***T. mucronatum***

Taxodium distichum (L.) Rich., Ann. Mus. Natl. Hist. Nat. (Paris) 16: 298. 1810.

Etymology

The species epithet describes the distichous or two-ranked position of the leaves on foliage shoots.

Vernacular names

Bald-cypress

Description

Trees deciduous, to 40(–46) m tall, to 2–3.5(–5) m d.b.h.; trunk monopodial, erect; base often swollen, fluted or buttressed; 'pneumatophores' or 'knees' common, numerous on root systems of trees growing in or near water, conical, 1(–4) m tall. Bark on trunk fissured, exfoliating in more or less fibrous, long strips, light brown, turning grey. Branches spreading or ascending, forming a conical or pyramidal crown in young trees (or in cultivation), old trees becoming increasingly flat-topped with long main branches in upper half of tree. Foliage short shoots distichously spreading from long shoots, or assurgent to nearly erect, mostly 8–10 cm long, deciduous. Winter buds prominent, 3–5 mm, globose, with 6–8 ovate, carinate, acute scales. Leaves on long shoots deciduous,

on short shoots mostly persistent, spreading in two ranks, or in 5–8 ranks, linear or (short) acicular, nearly straight or curved (subulate) or lanceolate; free part 3–15(–22) mm long, ca. 1 mm wide; margins entire; apex obtuse, mucronate, acute or pungent; stomata in two broad bands separated by a narrow ridge on abaxial (lower) side, in two narrower bands separated by a groove or ridge on adaxial side; leaf colour light green, or glaucous green, with glaucous green stomatal bands. Pollen cones solitary or in pairs, globose to ovoid-oblong, 3–5 × 2–3 mm, yellowish green turning purplish to brown; microsporophylls (5–)6–10(–15), ovate-peltate, keeled, bearing (2–)4–9(–10) globose pollen sacs. Seed cones often clustered, subglobose or more or less ovoid but irregular, (15–)20–35(–40) mm long. Bract-scale complexes distally rounded, more or less four-sided, smooth or more commonly rugose, with a transverse ridge, narrowing to a pedicellate base; external surface glaucous green, maturing to light ochraceous brown or grey-brown; internal surface yellowish brown, often with red resin. Seeds ca. 20–40 per cone, 4–7 mm long, lustrous brown, with a large, (sub)lateral, pale coloured hilum; wings very small or vestigial, forming up to 3 narrow ridges or parts thereof ca. 1 mm wide.

Distribution

SE USA: Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, S Texas and Virginia.

TDWG codes: 74 ILL MSO OKL 75 INI 77 TEX 78 ALA ARK DEL FLA GEO KTY LOU MRY MSI NCA SCA TEN VRG

Ecology

Taxodium distichum is a winter deciduous tall tree dominant in lowland river flood plains and swamps, mostly below 30 m but up to 530 m a.s.l., where it can form extensive forests of nearly pure stands on (seasonally) inundated fluvial sediment. The two varieties are largely sympatric, but var. *imbricaria* seems to avoid riparian habitat and to prefer stagnant pools and swamps. In permanently wet habitat with anaerobic soil conditions this species develops characteristic 'knees', which grow upwards from shallow roots, often at a considerable distance from the stem. The most commonly associated trees are *Nyssa aquatica* and *N. sylvatica* var. *biflora*, which form with *Taxodium distichum* a distinct vegetation type. Other common associated angiosperm trees are *Acer rubrum* in the northern part of the range of *T. distichum*, and *Magnolia grandiflora* in the southern States; *Pinus* spp., *Fraxinus* spp., *Quercus* spp., *Liquidambar styraciflua*, and shrubs e.g. *Ilex* spp., and *Viburnum* spp., are also often present. Especially in the southern States all trees are festooned with a trailing bromelioid epiphyte: *Tillandsia usneoides*. Flooding is frequent or sometimes nearly permanent with water levels up to 3 m deep; in riparian habitat silt is deposited annually. Away from rivers, clay, muck, or peat are common and in soils with a high organic content trees grow slower and stay smaller. Salinity above ca. 1% will cause trees to die, so the species avoids areas flooded by seawater. The climate varies greatly along the extensive range, with dry and cold winters in the interior along the middle section of the Mississippi River and a subtropical, warm and humid climate in S Florida.

Uses

The wood of *Taxodium distichum* is soft, straight-grained and extremely rot resistant and therefore widely used in construction and building of houses, boats, river pilings and sidings, as well as shingles, flooring, garden furniture, greenhouses, cooperage, fencing and other uses for which durability is desirable. Outside its natural range it is widely used as an ornamental tree and it has been introduced as early as 1640 in England. It is currently being planted on a large scale as an amenity tree in China. Only a limited number of cultivars has been selected; this species is almost uniformly planted with either of the two varieties here recognized. Planted on the shores of lakes and ponds, this tree often develops 1 m tall 'knees' from its root system along the water's edge, adding to the interest of this species. It grows well on higher ground away from water, where 'knees' will not develop. In its native riparian habitat it is increasingly recognized as a keystone species in swamp forest ecosystems providing both food and nesting opportunities for rare birds and other wildlife and as a natural regulator of floods.

2 varieties are recognized:

Taxodium distichum (L.) Rich. var. ***distichum***. *Cupressus disticha* L., Sp. Pl. 2: 1003. 1753. Type: USA: [locality not known; "*Cupressus* (*disticha*) *virginiana*"], *leg. ign.* [Herb. Clifford] *HSC 449.2* (lectotype BM). Fig. 329, 330

Cupressus disticha L. var. *nutans* Aiton, Hort. Kew. 3: 372. 1789; *Taxodium distichum* (L.) Rich. subsp. *nutans* (Aiton) E. Murray, Kalmia 12: 25. 1982.

Vernacular names

Bald-cypress, Cypress, Southern Cypress, Swamp Cypress, Red-cypress, Yellow-cypress, White-cypress, Gulf Cypress

Description

'Pneumatophores' or 'knees' common and numerous, conical, 1(–4) m tall. Short shoots spreading, but with occasionally assurgent or nearly erect branchlets with short subulate leaves on the same tree, or with intermediate forms. Linear, flattened leaves pectinately arranged, twisted near base, 10–15(–22) mm long, straight or slightly curved, obtuse or mucronate.

Distribution

As for the species.

Conservation

IUCN: LC

Taxodium distichum (L.) Rich. var. ***imbricarium*** (Nutt.) Sarg., Sylva North America 10: 152. 1896. *Cupressus disticha* L. var. *imbricaria* Nutt., Gen. N. Amer. Pl. 2: 224. 1818. Type: USA: ["Found from Florida to North Carolina, in swamps and ponds more remote from the sea."] "*C. disticha* * *imbricaria*", *T. Nuttall s.n. (spec. 1)* (holotype PH).

Taxodium ascendens Brongn., Ann. Sci. Nat. (Paris) 30: 182. 1833; *Taxodium distichum* (L.) Rich. var. *ascendens* (Brongn.) Mast., J. Hort. Soc. London 14: 248. 1892 ["adscendens"].

Vernacular names

Pond cypress, Cypress, Black-cypress

Description

'Pneumatophores' or 'knees' uncommon, if present more rounded (not conical). Short shoots assurgent or erect. Leaves 5–8 ranked, largely appressed but with free apices, not twisted at base, short acicular (subulate) to narrowly lanceolate, 3–10 mm long, keeled, acute or pungent.

Distribution

SE USA: Coastal Plain from Virginia to E Texas, generally not as far inland as *T. distichum* var. *distichum*. **TDWG codes:** 77 TEX 78 ALA FLA GEO LOU MSI NCA SCA VRG

Ecology

As for the species, but more often in swamps and near lakes more distant from rivers.

Conservation

IUCN: LC

Taxodium mucronatum Ten., Ann. Sci. Nat. Bot., sér. 3, 19: 355. 1854. *Taxodium distichum* (L.) Rich. var. *mucronatum* (Ten.) A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 1: 175. 1906. Type: Mexico: México, Valle de México, Netzahualcoyotl, *J. G. Hawkes & J. P Hjerting 1389* (neotype K). Fig. 331

Etymology

The species epithet refers to the apex of the leaves, which may terminate in a small, sharp point or mucron.

Vernacular names

Montezuma Bald Cypress, Mexican cypress; Ahuehuete, Ciprés, Sabino (Mexico)

Description

Trees (semi-) evergreen, to 30(–43) m tall, to 3–8 m d.b.h.; trunk monopodial or forked to multistemmed, often branching low above ground; 'pneumatophores' or 'knees' rare on root systems of trees growing in stream beds, rounded. Bark on trunk deeply fissured, forming anastomosing ridges, exfoliating in more or less fibrous, long strips, light brown to reddish brown, turning grey. Branches spreading or ascending, forming a conical or pyramidal crown in young trees, old trees often forked and with long main branches, forming a rounded or irregular crown. Foliage short shoots distichously spreading from long shoots, mostly 6–16 cm long, often drooping, usually deciduous shortly before new foliage emerges. Winter buds globose, with 6–8 ovate, carinate, acute scales. Leaves on long shoots deciduous, on short shoots mostly persistent, spreading in two ranks, linear, nearly straight or slightly curved, the free part 3–15(–20) mm long, ca. 1 mm wide; margins entire; apex obtuse, mucronate, or acute; stomata in two broad bands on both leaf faces; leaf colour light green, or glaucous green, with glaucous green stomatal bands. Pollen cones solitary or rarely in pairs, globose to ovoid-oblong, 2–4(–5) × 2–3 mm; microsporophylls 6–10(–15), peltate, keeled, bearing abaxially in two rows near the lower margin (2–)4–6(–9) globose pollen sacs. Seed cones subglobose or more or less ovoid but irregular, (12–)14–25(–30) mm long. Bract-scale complexes distally rounded, more or less four-sided, smooth or more commonly rugose, often pulverulent, with a transverse ridge, narrowing to a pedicellate base; external surface glaucous green, maturing to light ochraceous brown or nearly grey; internal surface yellowish brown, often with red resin. Seeds ca. 15–30 per cone, 4–6 mm long, lustrous brown, with a large, pale coloured hilum; wings very small or vestigial, forming up to 3 narrow ridges or parts thereof less than 1 mm wide.

Distribution

Guatemala; Mexico; USA: S Texas, scattered along the Rio Grande.

TDWG codes: 77 TEX 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-AG MXE-CO MXE-CU MXE-DU MXE-GU MXE-HI MXE-NL MXE-QU MXE-SL MXE-TA MXE-ZA MXG-VC MXN-SI MXN-SO MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 GUA

Ecology

This species differs ecologically from *T. distichum* in several ways. Its natural habitat is strictly riparian along upland rivers and lesser streams. It has, however, been introduced and planted in many localities away from these water sources since pre-Hispanic times throughout Mexico and Guatemala, but these grounds all have (or had) water tables reaching up to the relatively deep root system of the trees. Most of the largest trees are found among these planted specimens. Its altitudinal range is (20–)160–2700 m a.s.l. Germination requires wet soil conditions, either submerged or exposed to air. There is no formation of 'knees' but some trees have a wide, flat, mostly subterranean base suggesting a lignotuber (this needs investigation). As a result, *T. mucronatum* is a major constituent of gallery woodland or forest bordering rivers, arroyos and canyon bottoms with more or less perennial water at least near the surface. In many streambeds above-ground water occurs only episodically for a short time after heavy rains, carrying large amounts of sediment. Commonly associated tree genera are *Platanus, Populus* and *Salix*, at lower altitudes also *Ficus* and *Inga*, while many other taxa can occasionally occur, especially in the southern part of its range. In the northern, more arid part of its range *T. mucronatum* with its semi-evergreen foliage (only dropped under moisture stress) forms green ribbons along 'dry' stream beds in an often semi-arid landscape. This species is frost sensitive, unlike *T. distichum*, a species which can withstand extremely low temperatures.

Conservation

A recent assessment of the conservation status of this species in Mexico (Alanis Flores & Favela Lara, 2002) concluded that it is not threatened with extinction. In Texas, the species is listed as endangered for the State; in Guatemala its status is unknown.

IUCN: LC

Uses

This tree has undoubtedly been used as a source of timber from time immemorial, but perhaps its best known pre-Columbian use was as a 'rainmaking' tree which also had medicinal properties ascribed to it. The Aztecs planted it in avenues, gardens, and plazas of the Valle de México; some of these features still exist today (Chapultepec, El Contador). In Mexico, this tradition is now continued, with ancient trees being preserved and new ones planted. Martínez (1950) relates some traditional medicinal uses; in some parts of Mexico the foliage is used to decorate church altars during religious ceremonies. Its commercial value as a timber tree is limited due to the softness and weakness of the wood.

FIGURE 304. *Pseudotsuga japonica* foliage and young seed cone

FIGURE 306. *Pseudotsuga menziesii* tree in Mt. Rainier N. P., Washington, USA

FIGURE 307. *Pseudotsuga menziesii* giant trunk in Olympic N. P., Washington

FIGURE 305. *Pseudotsuga japonica* seed cones

FIGURE 308. *Pseudotsuga menziesii* var. *menziesii* seed cones

FIGURE 309. *Pseudotsuga sinensis* var. *sinensis* trees in Taroko N. P., Taiwan

FIGURE 310. *Pseudotsuga sinensis* var. *sinensis* fallen seed cones

FIGURE 313. *Retrophyllum minus* in Rivière des Lacs, New Caledonia

FIGURE 311. *Retrophyllum comptonii* young tree on Mt. Panié, New Caledonia

FIGURE 312. *Retrophyllum comptonii* foliage and seed (photo M. Gardner)

FIGURE 317. *Sciadopitys verticillata* foliage and pollen cone buds

FIGURE 314. *Retrophyllum minus* foliage and immature seeds

FIGURE 316. *Saxegothaea conspicua* foliage with pollen cones and seed cones

FIGURE 315. *Saxegothaea conspicua* tree (photo C. N . Page)

FIGURE 318. *Sciadopitys verticillata* seed cone (photo C. N . Page)

FIGURE 319. *Sequoia sempervirens* at Bull Creek, California (photo R. Van Pelt)

FIGURE 320. *Sequoia sempervirens* seed cones

FIGURE 324. *Sundacarpus amarus* foliage

FIGURE 325. *Sundacarpus amarus* pollen cones

FIGURE 322. *Sequoiadendron giganteum* pollen cones and seed cones

FIGURE 323. *Sundacarpus amarus* trunk and bark, Lake Barrine, Queensland

FIGURE 321. *Sequoiadendron giganteum* in California, USA (photo E. Parker)

FIGURE 326. *Taiwania cryptomerioides* in Yunnan, China (photo D. Long)

FIGURE 329. *Taxodium distichum* swamp forest in North Carolina, USA

FIGURE 327. *Taiwania cryptomerioides* tree (photo P. Thomas)

FIGURE 330. *Taxodium distichum* var. *distichum* foliage and seed cones

FIGURE 328. *Taiwania cryptomerioides* trunk in Taiwan

FIGURE 333. *Taxus baccata* foliage and pollen cones

FIGURE 331. *Taxodium mucronatum* in Oaxaca, Mexico

FIGURE 332. *Taxus baccata* ancient tree on ruined wall of Waverley Abbey

FIGURE 334. *Taxus baccata* foliage and seeds

FIGURE 335. *Taxus brevifolia* in the Wenatchee Mts., Washington, USA

FIGURE 336. *Taxus brevifolia* foliage and seeds

FIGURE 337. *Taxus cuspidata* var. *cuspidata* in Korea (photo Y. S. Kim)

FIGURE 338. *Taxus cuspidata* var. *cuspidata* foliage and seeds

FIGURE 339. *Tetraclinis articulata* seed cones (photo M. Gardner)

FIGURE 340. *Thuja koraiensis* in Korea (photo Y. S. Kim)

FIGURE 341. *Thuja koraiensis* foliage branch (upperside)

FIGURE 342. *Thuja koraiensis* foliage branch (underside)

FIGURE 343. *Thuja plicata* foliage and seed cones

FIGURE 345. *Thujopsis dolabrata* var. *dolabrata* foliage (upperside)

FIGURE 344. *Thuja sutchuenensis* in Daba Shan, China (© Bedgebury Pinetum)

FIGURE 346. *Thujopsis dolabrata* var. *dolabrata* foliage (underside)

FIGURE 347. *Torreya californica* foliage with pollen cones

FIGURE 348. *Torreya californica* foliage with seeds

FIGURE 349. *Torreya nucifera* foliage with seeds

FIGURE 350. *Tsuga chinensis* var. *chinensis* in the mountains of Taiwan

FIGURE 352. *Tsuga forrestii* foliage and seed cones

FIGURE 351. *Tsuga chinensis* var. *chinensis* foliage and seed cones

FIGURE 353. *Tsuga heterophylla* on a 'nurse log' in Olympic N. P., Washington

FIGURE 354. *Tsuga mertensiana* var. *mertensiana* foliage and seed cones

FIGURE 355. *Widdringtonia cedarbergensis* seed cones

FIGURE 359. *Wollemia nobilis* bud and foliage

FIGURE 357. *Widdringtonia whytei* on Mt. Mulanje, Malawi (photo P. Cribb)

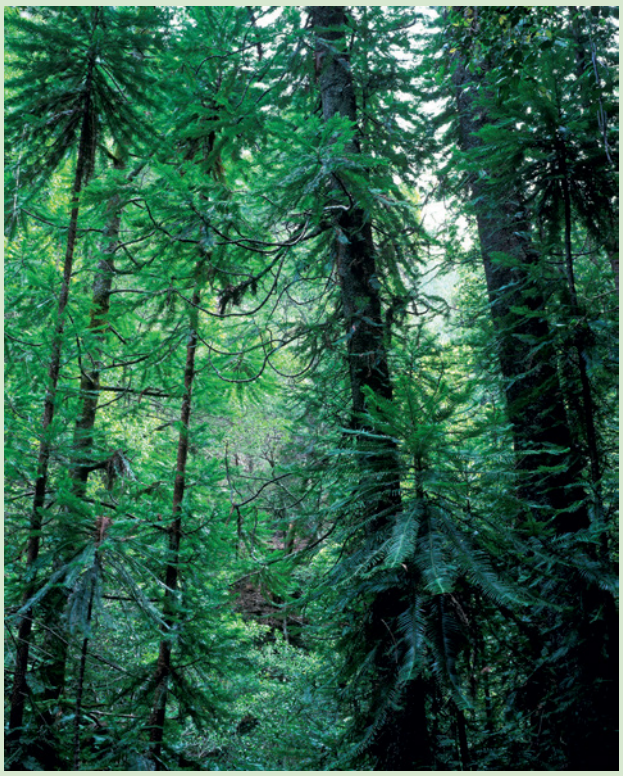

FIGURE 358. *Wollemia nobilis* trees in Wollemi N. P., Australia (photo J. Plaza)

FIGURE 356. *Widdringtonia nodiflora* seed cones

FIGURE 360. *Wollemia nobilis* foliage and pollen cones

FIGURE 362. *Xanthocyparis vietnamensis* foliage

FIGURE 361. *Xanthocyparis nootkatensis* trunk in Olympic N. P., Washington

Taxus L., Sp. Pl. 2: 1040. 1753. Type: *Taxus baccata* L. (*Taxaceae*).

Verataxus J. Nelson, Pinaceae: 168. 1866 (*nom. illeg.*). Type: *Taxus communis* J. Nelson (*nom. illeg.*) [*Taxus baccata* L.].

Taxus is the classical Latin name for yews.

Description

Dioecious (rarely monoecious) evergreen shrubs or trees. Resin in arils of seeds. Bark reddish or purplish brown, becoming scaly. Foliage branchlets irregularly alternate. Leaves helically inserted, twisted at the petiolate base so as to become pectinate or distichous, linear or falcate, flattened, soft coriaceous, flexible, with a prominent midrib and two pale greyish green or pale yellow stomatal bands on abaxial side, lacking resin canals. Pollen cones axillary, solitary, usually with each leaf on a fertile shoot, forming double rows, globose with densely clustered, peltate microsporophylls each with 4–9 radially inserted pollen sacs containing spherical pollen. Seed bearing structures axillary to foliage leaves, consisting of a short shoot with small scales and an axillary fertile dwarf shoot bearing a single, terminal, erect ovule. Seeds hard with a highly sclerified seed coat, partly surrounded by a cup-shaped, non-adnate, greenish, fleshy aril, swelling and becoming within a year glutinous and succulent, usually red or sometimes orange or yellow; the only non-toxic part of the plant. Seedlings with 2–3 cotyledons.

10 species.

Distribution

North America: E Canada and E USA south to Florida; W North America from Queen Charlotte Islands (BC) to California, E as far as W Montana. E & S Mexico into Central America to Honduras. Eurasia: W Europe (including Madeira) to S Scandinavia, NW Russia and Caucasus; Hindu Kush, Himalaya, NE India, Myanmar [Burma]; China, Korea, Japan, Taiwan, Russian Far East (Primorye); Indochina: Thailand, Lao PDR, Viet Nam. North Africa: Atlas Mountains. Malesia: Sumatera, Sulawesi, Philippines.

Taxonomic notes

The genus *Taxus* is considered notoriously difficult in terms of delimitation of species using morphological characters. Consequently, taxonomies have differed widely, from the recognition of a single species with subspecies and varieties (Pilger, 1903) to the recognition of 24 species with 55 varieties in the most recent treatment (Spjut, 2007). The more commonly accepted names amount to about 10 species and a few subspecies or varieties; a similar taxonomy is adopted here, with all of Spjut's new names synonymized with already established taxa. This genus is perhaps a good example of a group of species for which it could be illuminating to apply some more explicit methodology than intuitive taxonomy based on the careful observation of specimens, as has been done so far with the widely divergent results cited above. Morphometric analysis of leaf characters could test these in theory, but may not find many gaps between what are mostly quantitative characters. Another (and currently popular) approach is of course genetics (DNA), but here the comprehensive sampling of all the dispersed areas in which the genus is found to grow naturally becomes a major obstacle to obtain results that we can have any confidence in. Due to the wide use of yews in cultivation and their likely vulnerability to genetic introgression, genetically uncontaminated material is only guaranteed from natural populations isolated from any other named taxon, as well as from plants in cultivation. There appear to be no easy ways out of this dilemma (Stuessy, 2009). A 'consensus' taxonomy might be the only sensible solution, but that would require taxonomists to agree with each other.

Key to the species of *Taxus*

The morphological characters that distinguish between species of *Taxus* are notorious for their lack of variation, often resulting in similar or overlapping states. Species, as recognized here, can often only be determined using a combination of unrelated characters and observations of sufficient material to observe the range of character states that may occur in each. In cultivation, forms may be seen that differ

from those that occur in natural populations even without having been given a cultivar name.

1a. Leaves on lateral branchlets pectinate (spreading more or less in a plane); midrib raised only in proximal half on adaxial (upper) side and raised to apex on abaxial side **2**

1b. Leaves on lateral branchlets usually distichous (spreading sideways but not in a plane); midrib raised to apex on adaxial side and flat on abaxial side **5**

2a. Papillae present along midrib on abaxial (lower) side of leaves; leaves (1.5–)2–3 (–3.5) cm long ***T. globosa***

2b. Papillae absent; leaves (0.8–)1–2.5(–2.9) cm long **3**

3a. Leaves on lateral branchlets slightly S-curved or sometimes straight, (1–)1.5–2.5 (–2.9) cm long. Pollen cones few on a branchlet, forming scant rows ***T. floridana***

3b. Leaves on lateral branchlets straight or curved near base, (0.8–)1–2(–2.5) cm long. Pollen cones many on a branchlet, forming often dense rows **4**

4a. Leaves on lateral branchlets 1–2.3 mm wide. Ripe arils around the seeds 7–9 × 5–7 mm. Low shrubs ***T. canadensis***

4b. Leaves on lateral branchlets 1.5–3 mm wide. Ripe arils around the seeds 9–12 × 7–9 mm. Shrubs or trees ***T. brevifolia***

5a. Papillae present along midrib on abaxial (lower) side of leaves; leaves flat (in fresh leaves), (0.8–)1.5–2(–2.3) cm long ***T. chinensis***

5b. Papillae absent; leaves (slightly) revolute, rarely flat, (1–)1.5–4(–4.5) cm long **6**

6a. Leaves on lateral branchlets usually more or less directed upwards, arranged in a V-formation (rarely radially arranged), straight or only curved near base **7**

6b. Leaves on lateral branchlets distichous but not arranged in a V-formation, usually falcate (curved along most of their length), sometimes nearly straight **8**

7a. Leaves on lateral branchlets 1.5–2.5 mm wide, with a cuspidate apex. Pollen cones 6–8 mm diam. Foliage branchlets yellowish brown to grey ***T. contorta***

7b. Leaves on lateral branchlets 2.2–3.5 mm wide, with a mucronate or acute apex. Pollen cones 3.5–4.5 mm diam. Foliage branchlets pale orange-brown to reddish brown ***T. cuspidata***

8a. Leaves on lateral branchlets 2–2.5 mm wide. Pollen cones subglobose, 4–5 mm diam ***T. baccata***

8b. Leaves on lateral branchlets (1.5–)2–4(–5) mm wide. Pollen cones ovoid, 5–6 × 3–4 mm **9**

9a. Leaves on lateral branchlets linear, with revolute margins and a cuspidate or sometimes mucronate apex; papillae on abaxial (lower) midrib few, or absent ***T. mairei***

9b. Leaves on lateral branchlets linear to lanceolate, with flat or only slightly revolute margins and a mucronate apex; papillae absent ***T. wallichiana***

Taxus baccata L., Sp. Pl. 2: 1040. 1753. Type: [locality not stated ("Habitat in Europa, Canada")], *Herb. Clifford 464* (lectotype BM). Fig. 332, 333, 334

Etymology

The species epithet *baccata* (Latin *bacca* = berry) means 'berry-like'.

Vernacular names

Common yew, European yew; Eibe (German); If (French); Tis yagodnyi (Russian)

Description

Shrubs or trees to 20(–28) m tall; trunk of trees monopodial, short, or multi-stemmed, frequently fluted and asymmetrical, to 3.5 m d.b.h. but usually hollow in large specimens, with reiterated stems inside the old bole; tree bases often readily coppicing. Bark thin, exfoliating in large irregular flakes, reddish or purplish brown. Branches numerous, ascending to erect, then spreading or drooping, frequently reiterating, forming a spreading, rounded or pyramidal crown. Foliage branchlets irregularly alternate, slender, terete, with fine grooves alongside decurrent leaf bases, green turning light brown to grey. Terminal buds small, ovoid, with imbricate, closely appressed, rounded, dark brown scales persisting at base of new branchlets; lateral buds frequent, dormant, often causing burrs on stems from epicormic

new growth. Leaves on lateral shoots more or less distichous, sometimes slightly overlapping, linear, 1–3.5(–4) cm long, twisted at the short petiolate base, curved outward near base, falcate to nearly straight, 2–2.5 mm wide, coriaceous; margins slightly revolute, more or less gradually tapering to a cuspidate apex. Midrib on adaxial (upper) side raised, ca. 0.3 mm wide, nearly continuous to apex, on abaxial side flat, ca. 0.5 mm wide and continuous to apex; leaf colour lustrous dark green above, two pale green bands below. Stomata in two bands on abaxial side, densely and randomly distributed. Pollen cones axillary, solitary, forming rows on either side of fertile shoots, subglobose, 4–5 mm diam., short peduncu-late with dry, yellowish brown, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 6–15, peltate, each with 5–9 partly fused pollen sacs on the underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary or sometimes in pairs, distributed on underside of foliage branchlets, sessile, with tiny triangular scales covering a very small dwarf shoot and a single terminal ovule except the micropyle. Aril green at first, covering lower half of seed, swelling to succulent red (rarely yellow) and overtopping the seed, leaving its apex free, cup-like, 9–12 mm long, 7–9 mm wide. Seeds ovoid, slightly flattened, rarely 3–4-sided, with a small mucro, 6–7 × 4–5 mm, green turning brown or black.

Distribution

Europe; North Africa (Atlas Mts.); Macaronesia (Azores, Madeira); Caucasus; Western Asia: from Turkey to N Iran.

TDWG codes: 10 DEN FIN GRB IRE IRE-NI NOR SWE 11 AUT-AU AUT-LI BGM-BE BGM-LU CZE-CZ CZE-SL GER HUN NET POL SWI 12 BAL COR FRA-CI FRA-FR FRA-MO POR SAR SPA-AN SPA-SP 13 ALB BUL GRC ITA-IT ITA-SM KRI ROM SIC-SI TUE YUG-BH YUG-CR YUG-KO YUG-MA YUG-MN YUG-SE YUG-SL 14 BLR BLT-ES BLT-LA BLT-LI KRY RUC RUE RUN RUS RUW UKR-MO UKR-UK 20 ALG MOR-MO 21 AZO MDR 33 NCS TCS 34 IRN TUR

Ecology

Taxus baccata is capable of growing under (not entirely closed) canopy of beech (*Fagus* spp.) as well as other deciduous broad-leaved trees, but it will only develop to large trees in more open situations. In Switzerland, the richest area of Central Europe for yew, it forms a yew-beech wood on cool, steep marl slopes in the Jura and the foothills of the Alps up to 1400 m a.s.l. (Ellenberg, 1988). Under the evergreen yew, nothing else will grow. In England, *Taxus baccata* is best developed on chalk downs – again on steep slopes – and can form extensive stands outside the beech woods invading down grassland. In much of Europe where the climate is less oceanic it survives better in mixed forests, coniferous as well as mixed broad-leaved-conifer forests, again mostly on limestone substrates, and often occupying rocky cliffs and slopes. On acid soils yews perform less well under canopy and usually do not develop beyond a sapling stage in woods. Its northern limits in Scandinavia are determined by its sensitivity to severe frost. Its toxicity (all parts except the red arils around the seeds) prevent browsing by cattle and sheep, but not by rabbits and deer, as these animals have developed a level of immunity to the dangerous alkaloids. Apart from seed germination (dispersed by birds), *Taxus baccata* readily regenerates from stumps and roots (suckers); ancient hollow trees may rejuvenate constantly in this way. When planted, e.g. in church yards and cemeteries, soil pH seems unimportant; some of the largest and presumably oldest specimen trees in NW Europe, in particular Brittany (France) and the British Isles, are known from such locations and were planted probably since Celtic times.

Conservation

IUCN: LC

Uses

In the Middle Ages the wood of yew was very much in demand for long-bows and cross-bows and was exported from Switzerland to England. Yews were also planted near sacred wells, early Christian churches, monasteries, and castles for symbolic/religious reasons (Bevan-Jones, 2002) as well as practical (military) ones. It still is one of the obligatory cemetery trees in NW and Central Europe. The hard, slow growing wood is used for gates, furniture, parquet floors, panelling, and is excellent for carving and wood turning as its contorted growth and 'burls'

form intricate, vari-coloured patterns. For the same reasons yew does not provide timber suitable for construction. The toxicity to cattle and horses has led to extermination of *Taxus baccata* from many woodlands in past centuries, when almost all woodland served for grazing animals. Although of lower concentration than in some other species, its alkaloid taxanes, contained mostly in the leaves, yield a semi-synthesised anti-cancer drug similar to Taxol® and yew hedge clippings can still be sold to pharmaceutical companies. As an ornamental shrub or tree it reappeared in the formal gardens of the Baroque period, as it lends itself to clipped hedges and topiary of all shapes. This horticultural interest has in turn led to the development of numerous cultivars, some of which have bright yellow arils around the seeds.

Taxus brevifolia Nutt., N. Amer. Sylva 3: 86, t. 108. 1849. *Taxus baccata* L. subsp. *brevifolia* (Nutt.) Pilg., in Engler, Pflanzenr. IV.5 [18]: 113. 1903. Type: USA: Oregon, ["Columbia woods"], *T. Nuttall s.n.* (lectotype BM). Fig. 335, 336

Taxus brevifolia Nutt. var. *reptaneta* Spjut, J. Bot. Res. Inst. Texas 1 (1): 219. 2007.
Taxus brevifolia Nutt. var. *polychaeta* Spjut, J. Bot. Res. Inst. Texas 1 (1): 217. 2007.

Etymology

The epithet *brevifolia* means 'with short leaves'; the leaves are not much shorter than those of other species.

Vernacular names

Pacific yew

Description

Dioecious shrubs or trees to 15 m tall (rarely to 25 m) with monopodial stem but sometimes with low, ascending and layering stems (branches); trunk to 60(–130) cm d.b.h. Bark scaly; outer bark (exfoliating scales) purplish to brown; inner bark reddish to reddish purple. Branches often from low on trunk, spreading or strongly ascending to assurgent, sometimes drooping at ends, forming a wide, irregular crown or spreading bush from layered stems. Foliage branchlets slender, terete-angular with decurrent leaf bases, yellowish to reddish orange, turning reddish brown, with persistent bud scales at base of each season's growth. Leaves pectinately arranged, spreading at 60–90° from shoot axis, mostly parallel but some overlapping slightly, (0.8–)1–2(–2.5) cm long, linear, straight or curved near short petiolate base, 1.5–3 mm wide, more or less concave or with revolute margins; apex mucronate; texture coriaceous; leaf colour lustrous light or dark green adaxially, pale green abaxially; midrib raised especially in proximal half of leaf on adaxial (upper) side, continuously raised on abaxial side. Stomata in two bands on abaxial side; papillae present along the midrib. Pollen cones axillary, solitary, forming rows on either side of fertile shoots, ovoid to subglobose, 2–4 mm diam., short pedunculate with dry, yellow, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 5–10, peltate, each with 4–6 partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary, distributed on underside of foliage branchlets, with small triangular scales covering a small dwarf shoot 2–8 mm long and a single terminal ovule except the micropyle. Aril green at first, covering lower half of seed, swelling to succulent orange or red (rarely yellow) and when fully developed overtopping seed, leaving its apex free, cup-like, 9–12 mm long, 7–9 mm wide. Seeds ovoid, more or less 2–4-sided, with a small mucro, 5–8 × 4–5 mm, green turning brown or black.

Taxonomic notes

In Flora of North America 2: 425 (1993) *Taxus brevifolia* was described as being a shrub or tree, "usually upright, typically with a central stem;…" Apparently there are shrubs occurring within its geographical range which do not develop a single stem, but instead stems are more or less decumbent and through adventitious rooting of stems and branches that touch the ground (layering) form spreading thickets of ascending stems and branches. The habitat of these growth forms is often (but not exclusively) rocky places, avalanche shutes, talus slopes, and old stream beds in forests. This habit therefore seems to be an adaptation to environmental conditions. *Taxus canadensis*

is a shrub which often layers and *T. baccata* regularly forms clumps through its layering lower branches from a centrally growing parent tree; this is a trait present in the genus as a whole, even if rarely found in some species. *Taxus brevifolia* var. *reptaneta* Spjut, distinguished on the basis of a decumbent habit, is therefore better regarded as an ecotype, not a taxon.

Distribution

Pacific Coast Region of North America: S Alaska, British Columbia, Alberta; NW USA (California, Idaho, W Montana, Oregon, Washington).
TDWG codes: 70 ASK 71 BRC 73 IDA MNT ORE WAS 76 CAL

Ecology

Taxus brevifolia is a small understorey tree in the conifer forests of the cool and wet Pacific coast of North America roughly between 40° and 60° N and on the western slopes of the northern Rocky Mountains. The altitudinal range of this species is from near sea level to 2200 m a.s.l. In a few places in the southern parts of its range it becomes a dominant tree. In rocky, open places like avalanche chutes it may form layering thickets with decumbent to ascending stems. In localities with lower rainfall yews are confined to streamsides; in the densely forested inlets of the Queen Charlotte Islands they only grow on the borders between forest and sea. In most of the Pacific conifer forest yews are rare or occasional. In the Coast Range of southern Oregon and northern California, *T. brevifolia* is associated with *Quercus garryana* or *Fraxinus latifolia* and also grows along rivers with *Alnus rubra* or *Populus trichocarpa. Taxus brevifolia* is very shade tolerant and can hold its own under all but the densest canopies of the various evergreen conifers of the region. It is associated with most of the forest forming conifers of the Pacific Northwest, in particular with *Thuja plicata, Tsuga heterophylla, Pseudotsuga menziesii*, and *Sequoia sempervirens*, indicating its tolerance to shade.

Conservation

In the 1980's and early 1990's this species, formerly little valued in forestry and actually seen as a problem species in managed stands of timber trees, suddenly attained economic value because of its chemical taxane, a collective name for chemical compounds contained primarily in the bark of this species that turned out to have potent anti-cancer effects in humans. An uncontrolled rush by people eager to make unexpected money from these small trees by stripping them of their bark raised concerns from conservationists. It is unlikely, given its great range and presence in vast tracts of almost inaccessible forest, that this activity resulted in serious decline, but the species nevertheless made it onto the CITES Appendix II list. Pharmaceutical research and successes in synthesizing the active substances have substantially reduced the stripping of wild growing trees and the species is not considered to be in danger of extinction.
IUCN: NT

Uses

As with most yew wood, its application is only for special purposes such as wood carving and turning (mostly done in Japan), bows for archery, gun stocks, tool handles, small furniture and musical instruments. It is hard and rot resistant and can be used for fence posts. Native tribes of the Pacific Northwest used the wood for bows and also for wedges to split planks off large trees of Western red cedar (*Thuja plicata*). Some of the alcaloid chemicals of bark and leaves known as taxanes are refined and processed as an anticancer drug (paclitaxel or Taxol®). Especially the bark of this species contains high concentrations of pure paclitaxel (Hageneder, 2007). After initial failures the pharmaceutical industry has now succeeded in semi-synthesizing this drug from similar chemicals in the leaves of yews. The toxicity of all but the arils around the seeds can kill certain domesticated animals, but leaves other species unharmed. Pacific yews are not much used in horticulture and are only found planted in some arboreta and botanic gardens.

Taxus canadensis Marshall, Arbust. Amer.: 151. 1785. *Taxus baccata* L. subsp. *canadensis* (Marshall) Pilg. in Engler, Pflanzenr. IV.5 [18]: 113. 1903.
Type: USA: Vermont, *C. G. Pringle s.n.* 1877 (neotype US, orig. mat. unknown).

Taxus baccata L. var. *minor* Michx., Fl. Bor. Amer. 2: 245. 1803; *Taxus minor* (Michx.) Britton *ex* Small

& Vail, Mem. Torrey Bot. Club 4: 167. 1893. [Mem. Torrey Bot. Club 5: 19. 1893–94]; *Taxus canadensis* Marshall var. *minor* (Michx.) Spjut, J. Bot. Res. Inst. Texas 1 (1): 274. 2007.

Etymology

The species epithet means 'from Canada'.

Vernacular names

Canadian yew

Description

Usually monoecious shrubs to 2 m tall, often with low, ascending and layering stems. Bark thin, reddish to reddish purple. Branches spreading to assurgent, forming a spreading or prostrate bush. Foliage branchlets slender, terete-angular with decurrent leaf bases, yellowish to reddish orange, turning reddish brown, with persistent bud scales at base of each season's growth. Leaves pectinately arranged, spreading at 60–90° from shoot axis, mostly parallel but some overlapping slightly, (0.8–)1–2(–2.5) cm long, linear, straight or curved near short petiolate base, 1–2.3 mm wide, more or less concave or with revolute margins; apex mucronate; texture coriaceous; leaf colour lustrous light or dark green adaxially, pale green abaxially; midrib raised especially in proximal half of leaf on adaxial (upper) side, continuously raised on abaxial side. Stomata in two bands on abaxial side, papillae mostly absent. Pollen cones axillary, solitary, forming scant rows on either side of fertile shoots, ovoid to subglobose, 2–3 mm diam., short pedunculate with dry, yellow, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 5–8, peltate, each with 4–6 partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary, distributed on underside of foliage branchlets, with small triangular scales covering a small dwarf shoot 1–3 mm long and a single terminal ovule except the micropyle. Aril green at first (sometimes not developing, the seed then covered at base with scarious scales), covering lower half of seed, swelling to succulent orange or red (rarely yellow) and when fully developed overtopping seed, leaving its apex free, cup-like, 7–9 mm long, 5–7 mm wide. Seeds ovoid, slightly flattened, with a small mucro, 4–5 × 3–4 mm, green turning brown.

Distribution

NE North America: from Labrador and Newfoundland westwards to Manitoba and Minnesota, southwards to Tennessee.

TDWG codes: 71 MAN 72 LAB NBR NFL-NE NFL-SP NSC ONT PEI QUE 74 ILL IOW MIN WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 78 KTY TEN VRG

Ecology

Taxus canadensis occurs in forests, bogs, swamps, in wet and shady gorges and ravines, on rocky banks and slopes, at altitudes from near sea level to 1500 m a.s.l. In forests it is a scattered understorey shrub in deciduous broad-leaved forest, mixed forest, and coniferous forest. It occurs frequently under *Fagus grandifolia* and *Tsuga canadensis*, which demonstrates its tolerance to low light levels during the growing season. The shrubs will layer and form thickets under the right ecological circumstances, especially in permanently moist places.

Conservation

IUCN: LC

Uses

Due to its straggling, often prostrate habit Canadian yew is rarely used in horticulture and only a handful of cultivars has been selected. Its wood, although with properties not unsimilar to other species of *Taxus*, is of little use due to small sizes. Like other species in the genus, some of the alkaloids (taxanes) present in bark and leaves have properties useful in anti-cancer medicine.

Taxus chinensis (Pilg.) Rehd., J. Arnold Arbor. 1: 51. 1919. *Taxus baccata* L. subsp. *cuspidata* (Siebold & Zucc.) Pilg. var. *chinensis* Pilg., in Engler, Pflanzenr. IV.5 [18]: 112. 1903; *Taxus cuspidata* Siebold & Zucc. var. *chinensis* (Pilg.) C. K. Schneid., in Silva-Tarouca, Uns. Freil.-Nadelhölzer: 276. 1913; *Taxus wallichiana* Zucc. var. *chinensis* (Pilg.) Florin, Acta Horti Berg. 14 (8): 355. 1948. Type: China: Sichuan, Wushan Xian ["North Wushan"], *A. Henry 7155* (lectotype A).

Etymology

The species epithet refers to China.

Vernacular names

Chinese yew; hong dou shan (Chinese); Thông đỏ Bắc (Vietnamese)

Description

Shrubs or trees to 20 m tall; trunk of trees monopodial, to 1(–1.5) m d.b.h. Bark thin, exfoliating in strips or irregular flakes, variously coloured, reddish or purplish brown or grey. Branches numerous, ascending to erect, then spreading or drooping, forming a spreading, rounded or pyramidal crown. Foliage branchlets irregularly alternate, slender, terete, with fine grooves alongside decurrent leaf bases, green turning yellowish green to ochre or bronze coloured. Terminal buds small, ovoid, with imbricate, closely appressed, rounded, dark brown scales which are early deciduous; lateral buds frequent, dormant. Leaves on lateral shoots more or less distichous, sometimes slightly overlapping, short lanceolate to oblong, (0.8–)1.5–2(–2.3) cm long, twisted at short petiolate to nearly sessile base, straight or curved near base, 2–3.2 mm wide, thick and coriaceous, convex; margins flat in fresh leaves, more or less abruptly ending in a mucronate or sometimes obtuse apex. Midrib on adaxial (upper) side raised, 0.2 mm wide, continuous to apex, on abaxial side flat, densely papillate, 0.3–0.4 mm wide and continuous to apex; leaf colour lustrous dark green above, yellowish green with two pale yellowish bands below. Stomata in two bands on abaxial side, densely and randomly distributed. Pollen cones axillary, solitary, forming rows on either side of fertile shoots, ovoid, 5–6 mm long, 3–4 mm wide, short pedunculate with dry, yellowish green to pale brown, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 8–14, peltate, each with 4–6(–8) partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary or sometimes in pairs, distributed on underside in distal part of foliage branchlets, sessile, with tiny triangular scales covering a very small dwarf shoot and a single terminal ovule except the micropyle. Aril green at first, covering lower half of seed, swelling to succulent red or orange (often more or less translucent) and overtopping seed, leaving its apex free, cup-like, 10–13 mm long, 7–10 mm wide. Seeds ovoid or obovoid, slightly flattened, with two obtuse ridges and a small mucro, 5–8 × 3.5–5 mm, green turning brown or black.

Taxonomic notes

This species has been treated as a variety of *Taxus baccata*, *T. cuspidata*, or *T. wallichiana* (the latter in Flora of China 4: 90–91, 1999) or as a species, as I have accepted it here. Its most striking distinction are the short, thick, papillate leaves, quite different from the longer, thin, and flexible leaves of *T. wallichiana*. The classifications with *T. baccata* and *T. cuspidata* reflect much broader species concepts held in the past by some European botanists.

Distribution

China: Anhui, Chongqing, Fujian, S Gansu, N Guangxi, Guizhou, W Hubei, NE Hunan, S Shaanxi, Sichuan, E Yunnan, Zhejiang; N Viet Nam.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHS-AH CHS-FJ CHS-GX CHS-HN CHS-ZJ 41 VIE

Ecology

Taxus chinensis occurs in evergreen and deciduous broad-leaved forests, frequently along streams. Its altitudinal range in China is from 1100 m to 2700 m a.s.l. The undergrowth is often dominated by bamboo thickets. In Viet Nam, it occurs in the northern limestone karst formations on steep slopes and on ridges in subtropical to tropical evergreen forest at

altitudes between 900 m and 1500 m a.s.l. Here it is associated with the conifers *Pseudotsuga sinensis, Pinus fenzeliana* (syn. *P. kwangtungensis*), *Fokienia hodginsii, Tsuga chinensis, Podocarpus pilgeri, Nageia fleuryi*, and more locally *Xanthocyparis vietnamensis*. There are numerous small-leaved angiosperm trees and shrubs and an abundance of epiphytes due to high rainfall and frequent fog.

Conservation

Exploitation has reduced the population in many areas of China, but the species is still wide-spread. Logging in Viet Nam may have had a bigger impact as populations there are small; it may have reduced the species to some extent to the less accessible places. Exploitation of its bark and foliage for chemical/medical purposes has caused this species to be listed on CITES Appendix II. The species has poor regeneration, hence any exploitation would deplete the population. Harvesting can only be sustained from plantations, as indiscriminately stripping trees of bark and foliage may kill them. In China such plantations have been established in several places.
IUCN: EN (A2d)

Uses

The wood of this species is used in China in construction, cooperage, for the making of furniture, and for wood carving and turning. In Viet Nam it is also used for irrigation paddles in rice fields. Extracts of many parts of the plant (roots, wood, bark and leaves) are used in traditional Chinese medicine, while in modern times the pharmaceutical industry became much interested in the anti-tumor properties of some of its alkaloids (in particular taxanes, drug name: Taxol®), which appear to be present in all species in low but varying concentrations in bark and leaves. The seeds contain oils which are also extracted, but treatment is required to neutralize the poisonous alkaloids. In horticulture it has been used in bonsai and to a limited extent as a garden shrub. It is doubtful whether this species is in cultivation outside China and Viet Nam.

Taxus contorta Griff., Icon. Pl. Asiat.: t. 376. 1854 [It. Notes: 351, No. 116. 1848 (descr.); Not. Pl. Asiat. 4: 28. 1854 (nomen)]. Type: Afghanistan: Badakhshan, Kafiristan, *W. Griffith 5002* (lectotype K).

Taxus fuana Nan Li & R. R. Mill, Novon 7 (3): 263. 1997.

Etymology

The species epithet means 'contorted', but it is unclear what William Griffith had in mind when he chose this epithet.

Vernacular names

West Himalayan yew; mi ye hong dou shan (Chinese); postil (Kashmir); thuner (Hindi)

Description

Shrubs or trees to 15(–20) m tall; trunk of trees monopodial, short, or multi-stemmed, to 3 m d.b.h. but usually hollow in large specimens, with reiterated stems inside the old bole; tree bases often readily coppicing. Bark thin, exfoliating in large irregular flakes, reddish brown. Branches numerous, ascending to erect, then spreading, frequently reiterating, forming a rounded or pyramidal crown. Foliage branchlets irregularly alternate, slender, terete, with fine grooves alongside decurrent leaf bases, green turning yellowish brown to grey. Terminal buds small, ovoid, with imbricate, closely appressed, acute, brown scales persisting at base of new branchlets; lateral buds frequent, dormant. Leaves on lateral shoots more or less arranged in V-formation, spaced well apart, linear, 1.5–4(–4.5) cm long, only slightly twisted at short petiolate base, nearly straight or straight, 1.5–2.5 mm wide, with parallel, revolute margins and a cuspidate apex. Midrib on adaxial (upper) side raised, ca. 0.2 mm wide, nearly continuous to apex, on abaxial side flat, ca. 0.4 mm wide and continuous to apex; leaf colour lustrous dark green above, two pale yellowish green bands below. Stomata in two bands on abaxial side, densely and randomly distributed. Pollen cones axillary, solitary, forming rows on either side of fertile shoots, ovoid,

6–8 mm diam., short pedunculate with dry, yellowish green or brown, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 6–14, peltate, each with 4–9 partly fused pollen sacs on underside, pinkish turning brown. Seed-bearing structures axillary, solitary, sessile, with tiny triangular scales covering a very small dwarf shoot and a single terminal ovule except micropyle. Aril green at first, covering lower half of seed, swelling to succulent red and overtopping seed, leaving its apex free, cup-like, 9–12 mm long, 7–9 mm wide. Seeds oblong, slightly flattened, obtusely ridged on two sides distally, with a small mucro, 6–7 × 4–5 mm, green turning brown or black.

Taxonomic notes

Taxus fuana Nan Li & R. R. Mill was considered by its authors to be distinct from *T. wallichiana* and *T. yunnanensis*; the latter species is now commonly treated as synonymous with *T. wallichiana*. Recent morphometric analysis of the Himalayan yews confirmed this separation (Möller *et al.*, 2007). Spjut (2007) concluded that the long forgotten name *Taxus contorta* Griff. has to replace *T. fuana* because they are the same taxon. In Flora of China 4: 89–90 (1999), three species are keyed out with characters that in part have to be observed from living (or at least not herbarium pressed) foliage; two of these involve the Himalayan and Sino-Himalayan taxa *T. contorta* and *T. wallichiana*. Re-examination by me of the herbarium specimens held at the Herbarium at Kew (K) and the Natural History Museum, London (BM) under *T. wallichiana* confirmed the separation into two taxa. The (fuzzy) dividing line seems to lie in eastern Nepal, with all specimens collected west from there assignable to *T. contorta*.

Distribution

China: SW Xizang [Tibet] (Jilong Xian); Central & W Nepal; India (Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh); N Pakistan; Afghanistan.
TDWG codes: 34 AFG 36 CHT 40 NEP PAK WHM-HP WHM-JK WHM-UT

Ecology

In Nepal and Xizang [Tibet] this species occurs in pine forests or in mixed conifer-angiosperm forests, usually under canopy as a secondary layer shrub or tree to 12 m tall, at elevations between 1800 and 3100(–3400) m a.s.l.

Conservation

Exploited intensively in recent years by extraction of foliage and bark for its alkaloid chemical compounds (taxanes) which yield paclitaxel (drug name: Taxol®) and similar chemicals, from which a drug against ovarian and breast cancer in humans is produced, this species has come under threat of extinction. It was originally described from a limited area in the Tibetan Himalayas (Xizang, China) but is now understood to have a much wider distribution, encompassing all of the western range of the species commonly known as *T. wallichiana*. The latter species is listed on CITES Appendix II; this should now apply to both species.
IUCN: EN (A2a, c, d)

Uses

Recent discovery of anti-cancer effective compounds in the alkaloid taxanes of this and other species of *Taxus* has led to the exploitation of foliage and bark which effectively kills the shrub or tree. In India, Nepal, and Pakistan this species is commonly known as *T. wallichiana*; a more detailed account of uses is given under that species.

Taxus cuspidata Siebold & Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4 (3): 232. 1846.

Etymology

The species epithet refers to the leaves terminating in a small cusp.

Vernacular names

Japanese yew; dong bei hong dou shan (Chinese); ichi-i, araragi (Japanese); raramani (Ainu of Hokkaido)

Description

Shrubs or trees to 25 m tall; trunk to 1 m (–1.5 m) d.b.h., often branching low. Branches long and

spreading or ascending, forming a broadly rounded, usually compact crown. Bark thin, shallowly fissured, exfoliating in strips or flakes, reddish brown. Foliage branches numerous, horizontally spreading, erecto-patent or nearly erect, smooth with fine grooves along the decurrent leaf bases, green turning pale orange-brown or reddish brown. Terminal buds ovate, with imbricate but partly free, broadly elliptical or ovate, weakly keeled, green with hyaline margins, persistent at base of branchlets and turning brown. Leaves distichously spreading, directed more or less horizontally or often upwards (forming a V-shape) from lateral shoots, or sometimes more radially spreading, linear, (1.1–)1.5–3(–3.5) cm long, straight or curved near base, 2.2–3.5 mm wide; leaf base petiolate, twisted, decurrent; margins mostly parallel, revolute, abruptly narrowing to a mucronate or sometimes acute apex. Midrib on adaxial (upper) side slightly elevated, 0.2 mm wide and continuous to apex, nearly flat and 0.3–0.4 mm wide on abaxial side. Leaf colour lustrous dark green above, deep green with two pale yellowish green bands below. Stomata on abaxial side in two bands separated by a midrib and margins, numerous, arranged in irregular lines. Pollen cones axillary, arranged in rows on second year branchlets, sessile, globose, 3.5–4.5 mm diam., at base with imbricate, broadly ovate scales increasing in size, turning from pale yellow (on margins) to pale reddish brown. Microsporophylls 9–15 per cone, peltate, each bearing 5–8 obovate-cuneate, pale yellow pollen sacs. Seed bearing structures axillary, solitary, with numerous ovate or broadly ovate scales at base, partly enclosing a single terminal ovule. Arils with a few pairs of scales at base, obovate, 10–13 mm long, 9–11 mm wide, with a round opening showing the seed, succulent, deep scarlet or purplish red. Seeds broadly ovoid or trichonous-ovoid, 5–6 mm long, 4–4.5 mm wide, with 3(–4) obtuse ridges below acute or mucronate apex, lustrous chestnut brown when ripe.

Distribution

Russian Far East: Kuril Is., Sakhalin, Primorye; China: Heilongjiang, Jilin, Liaoning, Shaanxi; North Korea; South Korea; Japan.

TDWG codes: 31 KUR PRM SAK 36 CHM-HJ CHM-JL CHM-LN CHN-SA 38 JAP-HK JAP-HN JAP-KY JAP-SH KOR-NK KOR-SK

Ecology

Taxus cuspidata occurs sparsely in mixed conifer and conifer-deciduous broad-leaved forests in lowland to lower montane altitudes from 100 m to 1600 m a.s.l. In NE China it occurs in conifer forest with *Abies nephrolepis, Picea jezoensis, Pinus koraiensis*, and *Larix gmelinii* var. *olgensis*, in Sakhalin Island and northern Japan with *Abies sachalinensis, Picea glehnii, P. jezoensis, Larix kaempferi*, and various angiosperm trees e.g. *Acer* spp., *Betula* spp., *Populus maximowiczii, Juglans mandshurica, Sorbus aucuparia, Ulmus* spp., and *Kalopanax ricinifolium*. Further south in Japan it is common in the understory of woods with *Acer* spp., *Ulmus davidiana* var. *japonica, Tilia japonica, Juglans ailanthifolia, Quercus mongolica* var. *grossesserata*, and many other species of trees. It grows on a variety of soils derived from granitic, schistose or serpentine base rocks. The variety *nana* is mostly found growing on rocky sea coasts but may also occur on exposed rock outcrops in the interior.

Conservation

This species has been listed on CITES Appendix II in connection with the exploitation of its foliage for the extraction of chemicals active as an anti-cancer drug. This exploitation was localized and has not resulted in significant decline throughout the wide range of this species.

Uses

The wood of this yew is used in China in construction, cooperage, for the making of furniture and for wood carving and turning. In Japan it is prized for interior finish, household furniture, utensils, marquetry, wood turning and sculpture; on a more industrial scale it is used to make pencils. The Ainu people of Hokkaido and Sakhalin made their bows, as well as the scabbards of hunting knives, from its wood. The heartwood yields a brown or red dye. Extracts of many parts of the plant (roots, wood, bark and leaves) are used in traditional Chinese medicine (treating diabetes) while in modern times the pharmaceutical industry became much interested in the anti-cancer properties of its alka-

loids (taxanes, drug name: Taxol®), which appear to be present in all species in low but varying concentrations. The seeds contain oils which are also extracted, but treatment is required to neutralize the poisonous alkaloids. In horticulture it has been so popular for a long time that the species is now rare in the wild, but it is grown nearly everywhere in the urbanised areas of Japan. Numerous cultivars exist, and the species is used in bonsai culture. Japanese yew was introduced to Europe (England) in 1855 by Robert Fortune and more cultivars have been developed here as well as in the USA. A hybrid between *T. baccata* and *T. cuspidata* (*Taxus ×media* Rehd.) originated in the USA around 1900 and has given rise to further cultivars.

2 varieties are recognized:

Taxus cuspidata Siebold & Zucc. var. ***cuspidata***.
Taxus baccata L. subsp. *cuspidata* (Siebold & Zucc.) Pilg. in Engler, Pflanzenr. IV.5 [18]: 112. 1903.
Type: Japan: [locality not stated], *P. F. von Siebold s.n.* (lectotype not designated, syntype K).
Fig. 337, 338

Taxus baccata L. var. *microcarpa* Trautv., Mém. Acad. Imp. Sci. Saint-Pétersbourg (Sav. Etr.) 9: 259. 1859; *Taxus cuspidata* Siebold & Zucc. var. *microcarpa* (Trautv.) Kolesn., Vestn. Dal'nevost. Fil. Akad. Nauk SSSR 7: 43, f. 2. 1935; *Taxus umbraculifera* (Siebold *ex* Endl.) Lawson var. *microcarpa* (Trautv.) Spjut, J. Bot. Res. Inst. Texas 1 (1): 279. 2007.
Taxus baccata L. subsp. *cuspidata* (Siebold & Zucc.) Pilg. var. *latifolia* Pilg., in Engler, Pflanzenr. IV.5 [18]: 112. 1903; *Taxus cuspidata* Siebold & Zucc. var. *latifolia* (Pilg.) Nakai, Chôsen Sanrin Kaihô 158: 19. 1938; *Taxus caespitosa* Nakai var. *latifolia* (Pilg.) Spjut, J. Bot. Res. Inst. Texas 1 (1): 269. 2007.
Taxus caespitosa Nakai, Chôsen Sanrin Kaihô 158: 20. 1938; *Taxus cuspidata* Siebold & Zucc. var. *caespitosa* (Nakai) Q. L. Wang, Clavis Pl. Chinae Bor.-Or., ed. 2: 73. 1995.
Taxus biternata Spjut, J. Bot. Res. Inst. Texas 1 (1): 266. 2007.

Description

Large shrubs or trees. Leaves 1.5–3.5 cm long, more or less distichously arranged.

Distribution

As for the species.

Conservation

IUCN: LC

Taxus cuspidata Siebold & Zucc. var. ***nana*** hort. *ex* Rehd., in Bailey, Cycl. Amer. Hort. 4: 1773. 1902.
Taxus umbraculifera (Siebold ex Endl.) Lawson var. *nana* (Rehd.) Spjut, J. Bot. Res. Inst. Texas 1 (1): 281. 2007. Type: Japan: Honshu, Hyogo Pref., Mt. Hyonosen, *G. Murata 44671* (neotype A).

Taxus caespitosa Nakai var. *angustifolia* Spjut, J. Bot. Res. Inst. Texas 1 (1): 268. 2007.

Vernacular names

Dwarf yew

Description

Decumbent or low, densely branched shrubs to 2 m tall. Leaves 1.1–2 cm long, more or less radially spreading from branchlets.

Distribution

Japan: W Honshu; Russian Far East: Sakhalin, Primorskiy Krai (Bolshoy Pelis).
TDWG codes: 31 PRM SAK 38 JAP-HN

Conservation

IUCN: LC

Uses

The decumbent variety of this species has been in cultivation in Europe since 1866, when P. F. von Siebold introduced it to the Netherlands; it became known in horticulture as cv. 'Nana' when propagated from cuttings. The Japanese have undoubtedly had it in cultivation for much longer.

Taxus floridana Nutt. *ex* Chapm., Fl. S. United States: 436. 1860. *Taxus baccata* L. subsp. *floridana* (Nutt. *ex* Chapm.) Pilg., in Engler, Pflanzenr. IV.5 [18]: 113. 1903; *Taxus canadensis* Marshall var. *floridana* (Nutt. *ex* Chapm.) Silba, Phytologia Mem. 7: 72. 1984; *Taxus globosa* Schltdl. var. *floridana* (Nutt. *ex* Chapm.) Spjut, J. Bot. Res. Inst. Texas 1 (1): 224. 2007. Type: USA: Florida, ["near Aspalaga"], *H. B. Croom s.n.* (lectotype PH).

Etymology

The species epithet refers to its occurrence in Florida.

Vernacular names

Florida yew

Description

Dioecious shrubs or small trees to 6 m tall (rarely to 10 m); trunk to 40 cm d.b.h. Bark scaly; outer bark (exfoliating scales) purplish to brown; inner bark reddish to reddish purple. Branches often from low on trunk, spreading or ascending, forming a bushy crown, often layering. Foliage branchlets slender, terete-angular with decurrent leaf bases, yellowish to reddish orange, turning reddish brown, with persistent bud scales at base of each season's growth. Leaves pectinately arranged, spreading at (60–)80–90° from the shoot axis, mostly parallel and spaced well apart, (1–)1.5–2.5(–2.9) cm long, linear, mostly slightly S-curved but some straight, 1–2(–2.2) mm wide, more or less concave or with revolute margins; apex mucronate; texture coriaceous; leaf colour lustrous light or dark green adaxially, pale green abaxially; midrib raised especially in proximal half of leaf on adaxial (upper) side, continuously raised on abaxial side. Stomata in two bands on abaxial side, papillae present along midrib. Pollen cones axillary, solitary, forming scant rows on either side of fertile shoots, ovoid to subglobose, 2–3 mm diam., short pedunculate with dry, yellow, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 5–8, peltate, each with 4–6 partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary, distibuted on underside of foliage branchlets, with small triangular scales covering a small dwarf shoot 1–2 mm long and a single terminal ovule except the micropyle. Aril green at first, covering lower half of seed, swelling to succulent orange or red (rarely yellow) and when fully developed overtopping the seed, leaving its apex free, cup-like, 7–10 mm long, 6–8 mm wide. Seeds ovoid, slightly flattened, with a small mucro, 5–6 × 4 mm, green turning brown.

Taxonomic notes

Spjut (2007) has placed *Taxus floridana* as a variety under *Taxus globosa*, and considered it to occur also in northern Mexico (Nuevo Leon, Tamaulipas, and Veracruz). If this were accepted, the conservation status of *T. floridana* would change dramatically. Spjut seems to have based his taxonomic concepts in the genus on a few selected micromorphological characters in mainly the foliage leaves and sometimes bud scales or other characters, without due consideration of variation within populations and/or analysis of correlation between multiple characters. There are certainly similarities between the two taxa, such as the slender, slightly curved leaves, but there are also differences, and nothing short of a comprehensive morphometric analysis of all available characters would suffice to establish whether there were two 'clouds' of character states in the data or only one. These results would then ideally be tested with DNA markers. Pending such research, it is premature to unite these two species into one with two varieties.

Distribution

SE USA: Florida (along the Apalachicola River in Gadsden and Liberty Co.).
TDWG codes: 78 FLA

Ecology

Taxus floridana is restricted to shaded ravines and limestone bluffs along the Appalachicola River in Florida. These ravines where undisturbed develop a woodland/forest type dominated by *Fagus grandifolia, Magnolia grandiflora* and *Quercus laurifolia*; other frequent tree components are *Ilex* spp., *Quercus alba, Symplocos tinctoria*, and *Carya tomentosa*. Sometimes this species occurs in thickets dominanted by *Kalmia latifolia*; elsewhere it may be associated with the extremely rare and localized conifer *Torreya taxifolia*. These ravine forests are humid and if soils have developed they tend to be slightly acidic to neutral sandy loams.

Conservation

This species is considered seriously threatened due to habitat degradation. Artificial lowering of the water table due to practises in agriculture is believed to be responsible for significant water stress within the plant communities where *T. floridana* is most common. Although normally occuring in humid forests and thickets and therefore outside the danger of frequent fires that occur in Longleaf-Slash pine (*Pinus palustris-P. elliottii*) woods above the river ravines, the drying of the habitat has increased the risk of fire, to which *Taxus* is sensitive. Increased occurrence of fungal attacks may also be connected to these stress factors. The total area of occupancy (AOO) is estimated to be less than 10 km² ; population numbers are several thousand mature individuals in total. However, many are unhealthy and regeneration is poor, usually only observed immediately near parent trees.
IUCN: CR [B1ab (iii, v)]

Uses

The Florida yew is rare in cultivation and apparently only grown by a few local nurseries in Florida. Due to its suitability as a garden ornamental or hedge shrub and in view of its threatened status, its cultivation should be recommended.

Taxus globosa Schltdl., Linnaea 12: 496. 1838. Type: Mexico: Hidalgo, Real del Monte, ["zwischen el canino del paso und Huajalote"], *C. A. Ehrenberg s.n.* (lectotype K).

Etymology

The species epithet means 'like a ball', which refers to the shape of the (immature) seed.

Vernacular names

Mesoamerican yew, Mexican yew; Ciprecillo colorado, Pinabete colorado, Ciprés colorado (Spanish).

Description

Trees to 15 m tall; trunk to 80 cm d.b.h. Bark scaly; outer bark (exfoliating scales) purplish to brown; inner bark reddish to reddish purple. Branches spreading or ascending, forming a broadly rounded or irregular crown. Foliage branchlets slender, terete-angular with decurrent leaf bases, yellowish to orange, turning brown, with persistent bud scales at base of each season's growth. Leaves pectinately arranged, spreading at 50–80°(–90°) from shoot axis, mostly parallel and spaced well apart, (1.5–)2–3(–3.5) cm long, linear, mostly slightly falcate or S-curved but some straight, (1.6–)2–2.5(–2.8) mm wide, more or less concave or with revolute margins; apex mucronate to cuspidate; texture coriaceous; leaf colour lustrous (light) green adaxially, pale green abaxially; midrib raised especially in proximal half of leaf on adaxial (upper) side, continuously raised on abaxial side. Stomata in two bands on abaxial side, papillae present along midrib. Pollen cones axillary, solitary, forming scant rows on either side of fertile shoots, ovoid to subglobose, 3–4 mm diam., short pedunculate with dry, yellow, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 8–12, peltate, each with (3–)4–5 partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary, distributed on underside of foliage branchlets, with small triangular scales covering a small dwarf shoot 2–4 mm long and a single terminal ovule except the micropyle. Aril green at first, covering lower half of the seed, swelling to succulent orange or red

(rarely yellow) and when fully developed overtopping seed, leaving its apex free, globose, cup-like, 10–12 mm long, 9–11 mm wide. Seeds ovoid-globose, slightly flattened, with a small mucro, 6–7 × 5–6 mm, green turning brown.

Distribution

El Salvador; Honduras; Guatemala; Central, E and S Mexico.

TDWG codes: 79 MXC-DF MXC-ME MXC-MO MXC-PU MXC-TL MXE-HI MXE-NL MXE-TA MXG-VC MXS-CL MXS-GR MXS-JA MXS-MI MXS-NA MXS-OA MXT-CI 80 ELS HON GUA

Ecology

Taxus globosa is a species occurring in montane to high montane cloud forests in the subtropics to near tropics of Mexico and Central America. Its altitudinal range is generally between 2000 m and 3000 m a.s.l., but in Tamaulipas, Mexico, a collection was made at only 1380 m a.s.l. In El Salvador and Honduras the cloud forest community with conifers like *Abies guatemalensis, Cupressus lusitanica* and *Taxus globosa* is limited to the highest summits around 2500–3000 m. Further north in Mexico, in particular on the eastern declivity of the Sierra Madre Oriental and mountains in Tamaulipas, Oaxaca and Chiapas, the cloud forest has a more extensive altitudinal distribution, and there *Taxus globosa* can occur in forests dominated by broad-leaved trees, especially *Quercus* spp., *Liquidambar styraciflua*, *Magnolia* sp., *Platanus mexicana, Ulmus mexicana, Carpinus caroliniana, Fagus mexicana, Acer skutchii, Clethra* spp., and the conifers *Podocarpus matudae* and *Pinus strobus* var. *chiapensis*. In Nuevo León it is found in the understorey of *Abies-Picea* forest.

Conservation

This species has been assessed as having suffered a past decline exceeding 50% due to deforestation and general habitat loss.
IUCN: EN (A2c)

Uses

This species is uncommon in cultivation, virtually restricted to botanical gardens and arboreta in regions with mild winters. As with other species of *Taxus*, in the 1990's screening for taxanes (for the anti-cancer drug paclitaxel and similar chemicals) was undertaken for this species, and these substances when found present were cause of exploitation of this tree for a time.

Taxus mairei (Lemée & Lév.) S. Y. Hu *ex* T. S. Liu, Illustr. Native & Introd. Lign. Pl. Taiwan 1: 16. 1960. *Tsuga mairei* Lemée & Lév., Monde Pl. 2 (16): 20. 1914; *Taxus chinensis* (Pilg.) Rehd. var. *mairei* (Lemée & Lév.) W. C. Cheng & L. K. Fu, Fl. Hupehensis 1: 28. 1976; *Taxus wallichiana* Zucc. var. *mairei* (Lemée & Lév.) L. K. Fu & Nan Li, Novon 7 (3): 263. 1997. Type: China: NE Yunnan, Dongchuan Shi, *E. E. Maire s.n.* (holotype E).

Taxus speciosa Florin, Acta Horti Berg. 14 (8): 382, t. 6. 1948; *Taxus mairei* (Lemée & Lév.) S. Y. Hu *ex* T. S. Liu var. *speciosa* (Florin) Spjut, J. Bot. Res. Inst. Texas 1 (1): 246. 2007.
Taxus kingstonii Spjut, J. Bot. Res. Inst. Texas 1 (1): 240. 2007.

Etymology

This species was named after the plant collector E. E. Maire.

Vernacular names

Maire's yew; nan fang hong dou shan (Chinese)

Description

Shrubs or trees to 30 m tall; trunk of trees monopodial, to 1.5 m d.b.h. Bark thin, exfoliating in strips or irregular flakes, variously coloured, reddish or purplish brown or grey. Branches numerous, ascending to erect, then spreading or drooping, forming a spreading, rounded or pyramidal crown. Foliage branchlets irregularly alternate, slender, terete, with fine grooves alongside decurrent leaf bases, green turning orange-brown to purplish brown. Terminal

buds small, ovoid, with imbricate, closely appressed, rounded, dark brown scales mostly early deciduous at base of new branchlets; lateral buds frequent, dormant. Leaves on lateral shoots more or less distichous, spreading at nearly right angles, linear, 1.5–3.5 cm long, twisted at the short petiolate or nearly sessile base, usually falcate, 2–4 mm wide, thick and coriaceous; margins revolute, more or less gradually tapering to a cuspidate apex or more abruptly ending in a mucronate apex. Midrib on adaxial (upper) side raised in a shallow groove, 0.2–0.3 mm wide, nearly continuous to apex, on abaxial side flat, non-papillate or with few papillae, ca. 0.4 mm wide and continuous to apex; leaf colour lustrous dark green above, pale green with two pale yellowish bands below. Stomata in two bands on abaxial side, in short, irregular lines and/or randomly distributed. Pollen cones axillary, solitary, forming rows on either side of fertile shoots, ovoid, 5–6 mm long, 3–4 mm wide, short peduncule with dry, yellowish green to pale brown, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 8–14, peltate, each with 4–6(–8) partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary or sometimes in pairs, distributed on underside in distal part of foliage branchlets, sessile, with tiny triangular scales covering a very small dwarf shoot and a single terminal ovule except the micropyle. Aril green at first, covering lower half of seed, swelling to succulent red or orange (often more or less translucent) and overtopping seed, leaving its apex free, cup-like, 10–13 mm long, 7–10 mm wide. Seeds ovoid or obovoid, slightly flattened, with two obtuse ridges and a small mucro, 5–8 × 3.5–5 mm, green turning brown or black.

Taxonomic notes

Taxus mairei was treated as a variety of *T. chinensis* in Flora Reipublicae Popularis Sinicae 7: 443 (Cheng & Fu, 1978), but transferred to *T. wallichiana* later and so treated in Flora of China 4: 91 (1999). It has also been synonymized with *T. chinensis*, in which case *T. mairei* would have priority and the species should have that name, not *T. chinensis*. Here I treat them as distinct, although the distinctions are minor and confined to leaf morphology only. Spjut (2007), in a recent taxonomic treatment of the genus, has taken the splitting further and segregated *T. speciosa* Florin, commonly treated as a synonym, at varietal rank from *T. mairei* var. *mairei*. This appears to have been decided mostly on branching patterns, which in this case I do not consider to provide separable character states, as these are even more prone to environmental influences during development than leaf shapes and sizes.

Distribution

China: Anhui, Chongqing, Fujian, S Gansu, N Guangdong, N Guangxi, Guizhou, W Henan, W Hubei, Hunan, Jiangsu, Jiangxi, S Shaanxi, Shanxi, E Sichuan, Yunnan, Zhejiang; Taiwan.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHN-SX CHS-AH CHS-FJ CHS-GX CHS-HE CHS-HN CHS-JS CHS-JX CHS-ZJ 38 TAI

Ecology

Taxus mairei occurs in coniferous and mixed conifer-angiosperm forests and their more or less open, scrubby margins as a scattered, often understorey tree. It is more common on more or less open slopes with secondary vegetation after the removal of primary forest, on rocky slopes and escarpments, often on limestone. Its altitudinal range is substantial, from 100 m to 3500 m a.s.l. In the eastern provinces of China it occurs usually below 1200 m but as high as 2000 m a.s.l. In Sichuan, Yunnan and also in Taiwan it reaches to 3000 m and more. In forests *T. mairei* often occurs along streams, but in open terrain it can well grow at a distance from any surface water.

Conservation

Exploitation is considered to have caused a population reduction of ca. 30% which may not have ceased.

IUCN: VU (A2d)

Uses

The uses of this species are presumably similar to those stated in Flora of China 4: 90 (1999) under

Taxus wallichiana and are to provide building material, to make tools used in agriculture and gardens in the countryside, furniture, and stationery. It is in cultivation in China and, as with other species of *Taxus*, the leaves have been used to extract taxanes for use as an anti-cancer drug.

Taxus wallichiana Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 3: 803, t. 5. 1843. *Taxus baccata* L. subsp. *wallichiana* (Zucc.) Pilg., in Engler, Pflanzenr. IV.5 [18]: 112. 1903. Type: India: (eastern), *N. Wallich s.n.* [ex Herb. Zuccarini] (lectotype M).

Cephalotaxus celebica Warb., Monsunia 1: 194. 1900; *Taxus celebica* (Warb.) H. L. Li, Woody Fl. Taiwan: 34. 1963.

Taxus yunnanensis W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 86. 1975; *Taxus wallichiana* Zucc. var. *yunnanensis* (W. C. Cheng & L. K. Fu) C. T. Kuan, Fl. Sichuan. 2: 215. 1983; *Taxus chinensis* (Pilg.) Rehd. var. *yunnanensis* (W. C. Cheng & L. K. Fu) L. K. Fu, Vasc. Pl. Hengduan Mount. 1: 214. 1993.

Taxus sumatrana (Miq.) de Laub., Kalikasan 7 (2): 151. 1978; *Cephalotaxus sumatrana* Miq., Fl. Ned. Ind. [Fl. Ind. Batavae] 2 (7): 1076. 1859.

Taxus phytonii Spjut, J. Bot. Res. Inst. Texas 1 (1): 237. 2007.

Taxus contorta Griff. var. *mucronata* Spjut, J. Bot. Res. Inst. Texas 1 (1): 260. 2007.

Taxus florinii Spjut, J. Bot. Res. Inst. Texas 1 (1): 222. 2007.

Taxus suffnessii Spjut, J. Bot. Res. Inst. Texas 1 (1): 226. 2007.

Taxus obscura Spjut, J. Bot. Res. Inst. Texas 1 (1): 235. 2007.

Etymology

This species was named in honour of Nathaniel Wallich (1786–1854), a Danish botanist who amassed the famous Wallich Herbarium for the East India Company, now kept at Kew.

Vernacular names

East Himalayan yew; thuner (Hindi) & various other local names; xu mi hong dou shan (Chinese); tampinur batu (Karo).

Description

Shrubs or trees to 30 m tall; trunk of trees monopodial, to 1.5 m d.b.h. Bark thin, exfoliating in strips or irregular flakes, variously coloured, reddish or purplish brown or grey. Branches numerous, ascending to erect, then spreading or drooping, frequently reiterating, forming a spreading, rounded or pyramidal crown. Foliage branchlets irregularly alternate, slender, terete, with fine grooves alongside decurrent leaf bases, green turning orange-brown to purplish brown. Terminal buds small, ovoid, with imbricate, closely appressed, rounded, dark brown scales mostly early deciduous at base of new branchlets; lateral buds frequent, dormant. Leaves on lateral shoots more or less distichous, sometimes slightly overlapping, linear to lanceolate, (1–)1.5–3.5(–4.5) cm long, twisted at short petiolate or nearly sessile base, usually falcate, (1.5–)2–4(–5) mm wide, thin and soft; margins flat or slightly revolute, more or less gradually tapering to a cuspidate apex or more abruptly ending in a mucronate apex. Midrib on adaxial (upper) side raised, 0.2–0.3 mm wide, nearly continuous to apex, on abaxial side flat, ca. 0.5 mm wide and continuous to apex, usually without papillae; leaf colour lustrous dark green above, pale green with two pale yellowish bands below. Stomata in two bands on abaxial side, densely and randomly distributed. Pollen cones axillary, solitary, forming rows on either side of fertile shoots, ovoid, 5–6 mm long, 3–4 mm wide, short peduncular with dry, yellowish green to pale brown, increasingly larger bracts at base; axis slightly elongating at anthesis. Microsporophylls 8–14, peltate, each with 4–6(–8) partly fused pollen sacs on underside, creamy white or pale yellow. Seed-bearing structures axillary, solitary or sometimes in pairs, distributed on underside in distal part of foliage branchlets, sessile, with tiny triangular scales covering a very small dwarf shoot and a single terminal ovule except the micropyle. Aril green at first, covering lower half of seed, swelling to succulent red or orange (often more or less translucent) and overtopping seed, leaving its

apex free, cup-like, 10–13 mm long, 7–10 mm wide. Seeds ovoid or obovoid, slightly flattened, with two obtuse ridges and a small mucro, 5–8 × 3.5–5 mm, green turning brown or black.

Taxonomic notes

In most of the literature referring to *Taxus* in the Himalayas only one species, *T. wallichiana*, is recognized for the entire mountain chain [often referred to as *T. baccata* subsp. *wallichiana* (Zucc.) Pilg.]. More recently, all of the populations occurring from central Nepal westward to northern Pakistan and Afghanistan have been assigned to the relatively recently described species *T. fuana* Nan Li & R. R. Mill, which was first known from the Himalayas of SW Xizang [Tibet]. This species has turned out to be synonymous with *T. contorta* Griff., a much earlier name, which has therefore priority and must be used instead. It is quite distinct from both *T. wallichiana* and from *T. baccata*, which does not reach further east than N Iran. Two other species, *T. chinensis* and *T. mairei*, were included in *T. wallichiana* as varieties in Flora of China 4 (1999), but here it is preferred to treat these as (not very) distinct species. In Malesia, the species *Taxus celebica* and *T. sumatrana*, although considered distinct in recent treatments (Farjon, 1998 [2001], several Floras, Spjut 2007) do not differ consistently in their morphological characters from *T. wallichiana*; indeed, earlier botanists usually identified the specimens from the Philippines, Sumatera, and Sulawesi as that species. In some of these accounts, *T. celebica* and *T. sumatrana* are reported to extend from Malesia into Indochina and China, or even to Nepal, and there to occur alongside *T. wallichiana*. Here these two species are considered synonymous with *T. wallichiana*, which therefore extends from Nepal to Sulawesi. In this place, it is not possible to comment in detail on the recent work by Spjut (2007), other than to report that comparison of the type specimens of his new species from the region with specimens of *T. wallichiana* have caused me to conclude that they are synonyms of that species.

Distribution

China: SE Xizang [Tibet], NW Yunnan, S Sichuan; E Nepal; Bhutan; India: Arunachal Pradesh, Assam; Myanmar [Burma]; Viet Nam; Malesia: Philippines, Sulawesi, Sumatera.

TDWG codes: 36 CHC-SC CHC-YN CHT 40 ASS-ME ASS-NA EHM-AP EHM-BH EHM-DJ EHM-SI NEP 41 MYA VIE 42 PHI SUL SUM

Ecology

Taxus wallichiana is a small to large understorey or lower canopy tree in montane, temperate, warm temperate, and tropical submontane to high montane forest, both angiosperm and conifer dominated, deciduous or evergreen, or in mixed forests. In open situations on rocky slopes and cliffs it usually forms a large, broadly spreading shrub. Elevation ranges from 900 m to 3700 m a.s.l. and soils are mostly derived from silicate-bearing rocks, i.e. acidic to neutral. Like the European *T. baccata* it is easily dispersed by birds and can germinate quickly in large numbers on suitable sites. It has a very long life-span (theoretically indestructible) and sprouts from stumps as well as roots. *Taxus wallichiana* occurs in pure stands of limited extent or mixed in the understorey of *Quercus, Abies, Cedrus deodara*, and *Picea*, or in mixed conifer forest. In Viet Nam *T. wallichiana* has been found growing in submontane evergreen mixed forests associated with the conifers *Cephalotaxus mannii, Dacrycarpus imbricatus, Keteleeria evelyniana, Nageia wallichiana*, and *Podocarpus neriifolius*. It will form dense thickets on exposed rocky slopes with little tree growth. In the Philippines it occurs on high ridges and mountain summits in mossy forest, or sometimes in rocky grass and scrubland.

Conservation

In certain regions of India in particular, harvesting of leaves and bark for extraction of alkaloid taxanes, used to produce the anti-cancer drug paclitaxel or similar chemicals, has led to a decline perhaps as much as 90% in recent decades (Molur & Walker, 1998). Logging in Yunnan, China may have reduced the rare populations in that country. Even though its extent of occurrence (EEO) is very large and may include areas where this kind of exploitation has not occurred, its overall decline is inferred to have been in excess of 50%. *Taxus wallichiana* is listed under CITES Appendix II. It occurs in several protected

areas, e.g. the Sagarmatha National Park in Nepal. Cultivation on a large scale in the context of pharmacology could reduce the pressure on wild growing populations.
IUCN: EN (A2a, c, d)

Uses

The wood of Himalayan yew is durable and strong and is used for door frames, cabinet work and wood turning and wood inlaying, also for candlesticks, knife handles etc. Less refined products are gates and fences, poles, struts and 'wattle and daub' in walls of rural buildings. The wood is also burnt as incense in Nepal and parts of Tibet. The leaves are toxic but can be given as fodder to goats if no other foliage is available. The alkaloid compounds (taxanes) of the bark are a source for the anti-cancer drug paclitaxel (Taxol®) which has become a major reason for exploitation in recent years. The leaves yield similar chemicals in low concentrations. Traditional medicine has made use of young shoots and leaves and sometimes of inner bark for a long time in various potions, tinctures, and pastes. The only non-toxic part of yews, the fleshy aril around the seed, is consumed by local inhabitants as jams. The inner bark also produces a red dye, often used in religious ceremonies by Brahmins of Nepal (Singh, 2007). Since the exploitation of Himalayan yew for its foliage containing taxanes has proved to be unsustainable, cultivation efforts are being undertaken in the Himalayan foothills and elsewhere in India; this involves both species *T. contorta* and *T. wallichiana*. These species, because of their similarity with European yew (*T. baccata*), are rarely found in cultivation in Europe, but they are used as ornamentals elsewhere, as in Baguio, Philippines.

Tetraclinis Mast., J. Roy. Hort. Soc. London 14: 250. 1892. Type: *Tetraclinis articulata* (Vahl) Mast. [*Thuja articulata* Vahl] (*Cupressaceae*).

Greek: *tetra* = four; *kline* = bed, couch; referring to the leaves in whorls of 4.

Description

See the species description.

Distribution

As for the species.

Tetraclinis articulata (Vahl) Mast., J. Roy. Hort. Soc. London 14: 250. 1892. *Thuja articulata* Vahl, Symb. Bot. 2: 96. 1791. Type: Tunisia: Hammam-el-Lif, ["legi copiose in montibus ad Hamamelis"], *leg. ign. s.n. A* (holotype C). Pl. 41, Fig. 339

Etymology

The species epithet refers to the seemingly articulate ultimate branchlets.

Vernacular names

Sandarac; Thuya d'Algérie, Thuya de Barbarie, Bois de Citre; Arâr (Algeria, Morocco); Alerce (Spain)

Description

Shrubs or small trees to 6–8(–15) m tall, evergreen, monoecious; trunk monopodial or multistemmed, usually branching low or forked, up to 50 cm diam, coppicing from base. Bark on large stems becoming rough, fissured, breaking into small plates, turning from light brown to grey. Branches long and slender, more or less crooked angularly, forming a pyramidal crown only in young, undisturbed plants, otherwise irregular. Foliage branches articulate, branching alternately at various angles, ultimate branchlets 1–2 mm thick, seemingly costate, persistent. Leaves decussate, appearing in whorls of 4 on thinnest branchlets, obviously decussate on thicker branches, long decurrent, adnate to shoot except apex, 1.6–8 × 1–1.5 mm (still longer on older branches, smallest on ultimate branchlets), weakly dimorphic; facials linear, with broader, acute apex, partly covered proximally by the linear-spathulate, transversely convex laterals; apical margins denticulate; stomata in two lateral rows or bands on facials, more sparsely on laterals; glands subapical, small, most prominent on facials; abaxial leaf surface smooth, light green. Pollen cones terminal, solitary, ovoid-globose, ca. 4 × 2.5 mm, reddish, maturing to yellowish brown or brown; microsporophylls 8–12, decussate, peltate, obtuse, bearing 4 abaxial pollen sacs. Seed cones solitary or sometimes clustered, terminal on branchlets, maturing within one year to (sub)tetragonal cones 10–13 × 12–17 mm in size and becoming first glaucous, then purplish brown to light brown. Bract-scale complexes 4, decussate, nearly equal in size, thick woody, ovate-cordate, 10–12 × 8–12 mm; lower pair widest; upper pair with a truncate apex; all abaxially smooth or rugose, with a subapical, small, recurved process (bract tip), adaxially striate, with white seed scars near base, paler than exterior parts. Seeds 4–6 per cone, conical-triangular, 4–5 × 3 mm, brown, with dark spots; basal hilum whitish; wings 2, at oblique angle, large, ca. 10 × 6 mm, reniform, thin menbranous, hyaline.

Distribution

N Algeria, Malta, Morocco, S Spain, N Tunisia, NE Libya (?); in Malta and Spain only tiny relict populations remain.

TDWG codes: 12 SPA-SP 13 SIC-MA 20 ALG MOR-MO TUN

Ecology

Tetraclinis articulata occurs in the semi-arid to winter rain parts of the Atlas Mountains and some scattered localities in the coastal hills near sea level; there often on limestone, mixed with maquis. More commonly in subclimax vegetation with *Pistacia*

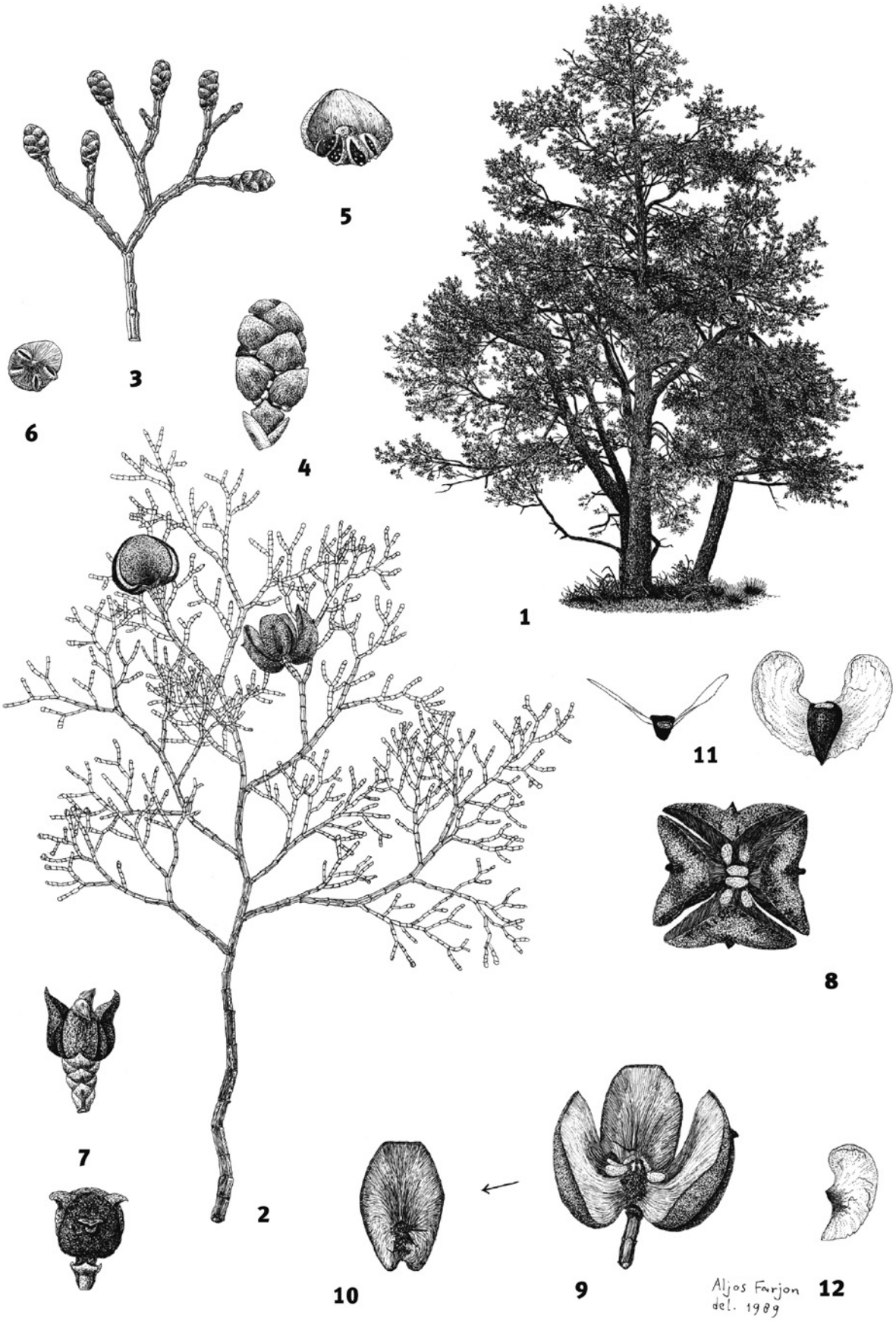

PLATE 41. *Tetraclinis articulata.* **1.** Habit of tree. **2.** Branch with foliage and seed cones. **3.** Branchlet with pollen cones. **4.** Pollen cone. **5, 6.** Microsporophylls with open pollen sacs and pollen. **7.** Immature seed cones. **8, 9.** Seed cones. **10.** Seed cone scale. **11, 12.** Seeds

lentiscus, *Quercus ilex*, and *Juniperus phoenicea*, locally into the zone with *Cedrus atlantica*, on S-facing, warm and dry slopes to 1800 m, on N-facing slopes to 1300 m a.s.l. Woodland with this species is often severely degraded; however, this species survives both fire and browsing by man's animals through its coppicing capacity, unless the pressure becomes too severe. Old coppice stools have very dense wood and may be very ancient, but dating is very difficult.

Conservation

The populations in Malta and southern Spain are highly threatened. In North Africa, however, the estimated area of occupancy is in excess of 1 million ha (Pardos & Pardos, 1997), with the largest populations in Algeria. Despite the capacity to coppice, there are indications that increased browsing pressure, especially by goats, prevent trees from regrowing in many areas (Gaussen, 1968, shows a photograph from Morocco to this effect).
IUCN: LC

Uses

From the time of Phoenician and Roman colonisation in North Africa to the present, the wood of *Tetraclinis*, and especially of the coppiced stools that formed burrs ('lupias'), was prized and used for furniture, cabinet making, and wood turning due to its intricate markings and figuring from adventitious growth. Today, only the larger trunks and stools with their contorted wood structure are valuable; most of the lighter wood is used for fuel locally, especially in regions deficient in trees and with a poor rural population. The resin ('sandarac') is used as incense in religious ceremonies and also forms a basis for varnishes and laquer work; Arabic tribes use(d) it for medicinal purposes. In cultivation it was formerly propagated by the French colonial powers (Service d'Eau et Forêts) in North Africa in attempts to extend its use as coppice wood in semi-arid areas. It is uncommon as an amenity tree or garden ornamental and outdoor planting is restricted to countries with a Mediterranean climate.

Thuja L., Sp. Pl. 2: 1002. 1753. Type: *Thuja occidentalis* L. (*Cupressaceae*).

Greek: *thyia* = resinous tree, also citrus tree.

Description

Shrubs or small to large trees to 75 m tall, evergreen, monoecious; trunk monopodial or multistemmed; bark fibrous, exfoliating in longitudinal flakes or strips. Branches spreading, curved down or assurgent to ascending, forming a conical to pyramidal crown; branching according to Massart's model. Foliage branches plagiotropic, branchlets alternate to subdistichous, ultimate branchlets often more numerous on the acroscopic side of lateral branchlets, lateral branchlets compressed, persistent. Leaves decussate (semi-whorled), on whip shoots long decurrent, on lateral branchlets dimorphic; facials obtrullate-rhombic, smaller than laterals; laterals broadly falcate, spreading from apex of facials, conduplicate; margins entire; most leaves amphistomatic, but upper facials often epistomatic; stomata most numerous on lower surface of laterals; glands inconspicuous or absent. Pollen cones terminal, solitary; microsporophylls 4–16, each with 2–4 abaxial pollen sacs. Seed cones terminal, solitary or rarely in pairs, maturing to ovoid-globose, narrowly ovoid or elliptical, partly opening cones. Bract-scale complexes 6–12(–14), decussate; lowest pair reduced; 2–3 following pairs enlarged and spreading; upper pairs gradually smaller and narrower and apical pair often connate. Seeds 4–10 per cone, flattened, with 2 wings. Seedlings with 2 cotyledons.

5 species.

Distribution

Asia: disjunct in China: Chongqing (Dabashan), Jilin (Changbai Shan); Korea; Japan. North America: (disjunct) E Canada & USA; W Canada & USA (coastal to N California).

Key to the species of *Thuja*

1a. Mature seed cones 5–8 mm long. Foliage sprays delicate, with very small eglandular leaves ***T. sutchuenensis***

1b. Mature seed cones (7–)8–16(–18) mm long. Foliage sprays coarse, with small and larger leaves; facial leaves usually glandular **2**

2a. Seed cones with 6–8(–10) scales. Pollen cones with 4–6 microsporophylls ***T. occidentalis***

2b. Seed cones with 8–12(–14) scales. Pollen cones with (6–) 8–16 microsporophylls **3**

3a. Seed cones with 8–12 scales, the two fertile pairs of equal size, more or less truncate. Shrubs or small trees ***T. koraiensis***

3b. Seed cones with 8–12(–14) scales, only one pair of equal size, obtuse or acute. Normally large trees **4**

4a. Seed cones 10–16(–18) mm long; largest scales narrow, l/w ratio > 1.5. Ultimate branchlets on foliage sprays more numerous on one (acroscopic) side of lateral branchlets, forming regular tapering units ***T. plicata***

4b. Seed cones 7–12(–14) cm long; largest scales broad, l/w ratio < 1.5. Ultimate branchlets on foliage sprays alternately arranged, forming irregular, more rounded units ***T. standishii***

Thuja koraiensis Nakai, Bot. Mag. (Tokyo) 33: 196. 1919. Type: North Korea: Hamkyongnam-do Prov., Samsu-gun, Paek-san, *V. L. Komarov 85* (lectotype LE). Fig. 340, 341, 342

Etymology

The species epithet refers to Korea, from where it was first known to science.

Vernacular names

Korean Arbor-vitae; chao xian ya bai (Chinese); nioi-nezuko (Japanese); nun chuk paek (Korean)

Description

Shrubs or small trees to 6–10 m in their native habitat; trunk often multistemmed, or monopodial, assurgent especially on slopes, to 30 cm d.b.h. Bark on stems thin, exfoliating in longitudinal flakes, reddish brown or purplish brown. Branches spreading

to assurgent or ascending, forming a low, layering shrub or a pyramidal crown. Foliage branches plagiotropic; branchlets alternate to subdistichous; third year shoots abruptly turning red-brown; lateral branchlets compressed, with underside more flattened than convex upperside, persistent. Leaves decussate, imbricate, on lateral branchlets dimorphic; facials obtrullate-rhombic; laterals broadly falcate, spreading from apex of facials, conduplicate; leaves variable in size from 1–10 mm long on a single branchlet system (facials smaller than laterals); margins entire; apex acute to obtuse, of laterals incurved, adnate; stomata most numerous on lower surface of laterals in a slightly sunken band; glands small, often visible on facials; leaf colour when newly emerged often glaucous, turning dark green; stomatal bands white. Pollen cones subglobose, 2–3 × 2–3 mm, purple maturing to purplish black; microsporophylls 6–10, peltate, each with 3–4 abaxial, yellow pollen sacs. Seed cones solitary or sometimes in pairs, maturing in one year (2 seasons) to ovoid-globose; opening cones 7–11 × 6–9 mm with brown scales. Bract-scale complexes 8–12, decussate; lowest pair reduced, recurved; two following pairs enlarged to 5–6 × 2–6 mm and spreading; upper pairs gradually smaller and narrower, to 1 mm wide, often connate; larger scales abaxially striate or with longitudinal grooves and a small, subapical bract tip, adaxially rugose, with two seed depressions. Seeds 8–10 per cone, ellipsoid, 4–5 × 1–3 mm, flattened, light brown; wings 2, marginal, 1–2 mm wide, meeting with a notch at both ends, thin menbranous, with minute puberulence near the distal part.

Distribution

NE China: Jilin (Changbai Shan); North Korea (Pyongannam-do, Pyonganpuk-do, Hamkyongnam-do, Kangwon-do); South Korea (Kyongsanpuk-do, Kangwon-do, Cholla-namdo).
TDWG codes: 36 CHM-JL 38 KOR-NK KOR-SK

Ecology

Thuja koraiensis occurs on middle and upper slopes of mountains, at altitudes between 750 m and 1950 m a.s.l. Where slopes are exposed, it forms dense, low thickets, but in sheltered ravines it can become a small upright tree. It is often associated with *Pinus pumila*, growing underneath its canopy; on lower slopes it occurs as a small tree in taller conifer forests with *Abies nephrolepis, Picea koraiensis, P. jezoensis, Pinus koraiensis*, or *P. sibirica*; less often it grows in clearings in mixed deciduous woodland in areas with thin, rocky soil. It appears to avoid rocks of volcanic origin and grows most abundantly on exposed, granitic slopes and crags with acidic skeletal soil. The climate is cool to cold temperate with high rainfall in the mountains and prolonged winter snow cover.

Conservation

The extent of occurrence (EOO) calculated for this species, based on distribution data of herbarium collections, is 48,091 km² and the area of occupancy (AOO) is unknown. This small, shrubby tree is not exploited for timber, but may be cut for its foliage used as incense. Most subpopulations are small, scattered and declining, and although detailed information for North Korea is not available, it is now thought that fewer than 1000 mature plants exist in the wild. The only sub-population in China occurs within a protected area; in South Korea it occurs in Sorak N. P.
IUCN: VU [B2ab (ii–v); C2a (i); D1]

Uses

Because most plants in the wild are shrubs, this species is not useful for its wood. It was introduced to the USA by Ernest Wilson in 1917, from where it came to Europe shortly after; however it remains relatively rare in cultivation and is mostly restricted to arboreta and botanic gardens. This is partly due to difficulties of access of new material, as most populations occur in North Korea. Remarkably, in cultivation in the UK, under conditions with ample moisture as in Hergest Croft Gardens, Herefordshire, some plants have grown into a tree much taller than any known in the wild in Korea; it shows no signs of being near its limits at ca. 15 m tall. This form is apparently based on E. H. Wilson's collection *No. 9244* made on 12 October 1917 on Kongo-san at 1500 m a.s.l. in South Korea. In the Netherlands, a very glaucous tree form is grown in the Gimborn Arboretum and University of Utrecht Botanic Garden. In NE China and Korea the shrubby form is used as an ornamental in gardens and some public parks on a limited scale.

Thuja occidentalis L., Sp. Pl. 2: 1002. 1753. Type: USA: [locality unknown], *P. Kalm LINN 1136.1* (lectotype LINN).

Etymology

The epithet means: 'from the west'; Linnaeus named another species *orientalis* ('from the east', i.e. China), but this is now accommodated in a different genus.

Vernacular names

Northern White-cedar, White-cedar, Eastern White-cedar, Arbor-vitae, Swamp Cedar, Thuier cèdre, Cèdre blanc

Description

Trees to 20–25(–30) m tall; trunk monopodial, erect, often curved at base, to 1–1.5(–1.8) m d.b.h. Bark on trunks relatively thin, fissured, often twisted in a long spiral around the trunk, exfoliating in very long, thin strips, grey-brown. Branches spreading; lower branches curved down, then upward, persistent; foliage branches drooping or subpendulous, forming a conical to pyramidal crown. Foliage branches plagiotropic; higher order branchlets flattened, covered with leaves, 5–20 × 2–3 mm, green, turning orange-brown with dying leaves, persistent. Leaves decussate, imbricate, appressed or laterals with free apices, dimorphic, all scale-like, on (sub) ultimate branchlets 1–4 × 1–2 mm; facials rhombic to obtrullate; apex obtuse, acute or short mucronate; laterals slightly larger, partially covering base of facials but spreading from their apex, bilaterally flattened, incurved; margins entire; apex connate, acute or obtuse; primary stomatal bands abaxial, on underside of laterals and on adjacent facials; glands conspicuous on facial leaves on both sides of branchlets near leaf apex; leaf colour green or grey-green, stomatal bands more or less whitish green, glands yellowish. Pollen cones globose, 1–1.5 mm diam., yellowish maturing brown; microsporophylls 4–6, decussate, peltate, bearing 3–4 abaxial, relatively large, yellow pollen sacs. Seed cones numerous, close together above pollen cones, terminal on upcurved, quadrangular branchlets with rhombic, gibbous scale leaves, narrowly ovoid when closed, 8–12 × 4–6 mm, erect at maturity. Bract-scale complexes (6–)8(–10), decussate; lowest pair much reduced; higher pairs narrowly oblong; upper pair connate or fused; two largest pairs spreading, ca. 8 × 4 mm, (ob)ovate-oblong, thin, obtuse or acute, with a subapical bract tip 0.2 mm, abaxially cinnamon or light brown, dull, adaxially light orange-brown, lustrous, without apparent seed marks. Seeds 4–8 per cone, usually only 4 (well) developed, 4 × 1–2 mm, flattened, light orange-brown; wings 2, marginal, of equal size and shape, surrounding seed but leaving a notch at one or both ends, 1–1.5 mm wide, thin membraneous, translucent.

Taxonomic notes

This species is morphologically similar throughout its range. Frequent vegetative reproduction through layering, especially in boggy environment, produces clonal trees characteristically with a curved basal part of the trunk and standing in (semi-)circles.

Distribution

NE North America: from Lake Winnipeg and the Great Lakes to the Canadian Maritime Provinces and the Appalachian Mountains.

TDWG codes: 71 MAN 72 NBR NSC ONT PEI QUE 74 ILL MIN WIS 75 CNT INI MAI MAS MIC NWH NWY OHI PEN RHO VER WVA 78 KTY NCA TEN VRG

Ecology

This species occupies a geographical range touching in the north on the subarctic taiga-tundra interface and in the south it extends well into the belt of deciduous angiosperm forests. It is therefore associated both with conifers, most common of which are *Abies balsamea, Larix laricina* in the boreal zone, *Picea mariana, L. laricina* and *Pinus banksiana* in swampy sites, and *Pinus strobus* and *Tsuga canadensis* in uplands, and with angiosperms, mainly *Populus balsamifera, P. tremuloides, Betula papyrifera, B. alleghaniensis, Acer rubrum, and Fraxinus nigra* in the tree layer and *Alnus rugosa, Acer spicatum, Cornus stolonifera*, and *Vaccinium* spp. in the shrub layer. The altitudinal range is (10–)150–600(–670) m a.s.l. It grows equally well in swamps and on

dry ground, but avoids extremes of both habitats; it is often growing abundantly on soils over limestone in upland areas and on alluvial soils with a high organic and mineral content in lowlands (rich fens supporting forest). This species also invades abandoned fields and pastures. The climate is cool to cold temperate and relatively moist, with a short growing season especially in the north of its range.

Conservation

IUCN: LC

Uses

The rot resistant properties of the wood of this species, known as 'northern white cedar' by lumbermen, make it an excellent timber for outdoor uses. These include rustic fencing, garden gates and sheds, and shingles. Canoes are still made from this wood because of its light weight, as are tubs and barrels. More industrial uses are found in kraft pulp and particleboard. The leaves were traditionally used in Native American medicine to prepare a decoction to suppress fevers and coughs and to cure rheumatism. White-cedar was introduced to Britain in 1596 and has been widely planted as a decorative tree. In horticulture there are many cultivars in common use, both tree forms and dwarfed forms. These emphasize shape of crown (while young plants) and colour of foliage, the latter with many shades of yellow in the new foliage. Some cultivars retain juvenile leaf shapes for many years looking like needles instead of the normal decussately arranged scales. This species can be used in hedges as it takes clipping well.

Thuja plicata Donn *ex* D. Don, in Lambert, Descr. *Pinus* 2: [19] 1824. Type: Canada: British Columbia, Vancouver Island, Nootka Sound, ["Longinquiter on the N. W. C. Am."], *A. Menzies s.n.* [*ex herb*. W. J. Hooker] (lectotype K). Fig. 343

Etymology

The species epithet *plicata* means 'folded' and refers to the shape of the lateral leaves.

Vernacular names

Western Red-cedar, Pacific Red-cedar, Giant Cedar, Giant Arbor-vitae, Canoe Cedar, Shinglewood

Description

Trees to 65–70(–75) m tall; trunk monopodial, erect, often fluted or buttressed at base, or multi-stemmed, readily layering, to 3–4(–6) m d.b.h. Bark on trunks relatively thin, fissured, fibrous, exfoliating in long, shredding strips, dark reddish brown, exposed bark grey-brown. Branches spreading, with lower branches curved down, then upward; foliage branches drooping or subpendulous, forming a conical to pyramidal crown. Foliage branches plagiotropic; higher order branchlets flattened, covered with leaves, 5–20 × 2–3 mm, green, turning reddish brown with dying leaves, persistent. Leaves decussate, imbricate, appressed or laterals with free apices, dimorphic, all scale-like, on (sub)ultimate branchlets 1–4 × 1–2 mm; facials rhombic to obtrullate, weakly ridged; apex obtuse, acute or short mucronate; laterals equally long or slightly larger, partially covering base of facials but spreading from their apex, bilaterally flattened, incurved; margins entire; apex connate or free, acute; primary stomatal bands abaxial, on underside of laterals and on adjacent facials; glands inconspicuous or absent on leaves of ultimate branchlets; colour of upper leaves lustrous green or dark green, of lower leaves and bases of leaves glaucous green, stomatal bands whitish green. Pollen cones ovoid-oblong, (2–)3–4 × 1.5–2 mm, purplish, maturing to blackish grey; microsporophylls 8–14, decussate, peltate, bearing 3–4 abaxial, reddish yellow pollen sacs. Seed cones numerous, close together above pollen cones, terminal on short, upcurved, quadrangular branchlets with rhombic, gibbous scale leaves, narrowly ovoid when closed, erect, 10–16(–18) × 6–8 mm. Bract-scale complexes 8–12(–14), decussate; lowest pair much reduced; upper pairs small, irregularly linear; 2–3 largest pairs spreading, (6–)7–8 × 3–5 mm, (ob)ovate-oblong, thin, obtuse or acute, with a subapical, straight or recurved, 1 mm long acute bract tip, abaxially dull brown, adaxially yellowish brown or reddish brown, lustrous. Seeds 4–10 per cone, usually only 4–6 (well) developed, 4–5 × 1.5–2 mm, flattened, light yellowish

brown; wings 2, marginal, surrounding seed but leaving a notch at one or both ends, 1–1.5 mm wide, thin membraneous, translucent.

Distribution

WNorth America: along the Pacific Coast Range and Cascade Range from S Alaska to N California and in the N Rocky Mountains from British Columbia to Idaho and W Montana.

TDWG codes: 70 ASK 71 ABT BRC 73 IDA MNT ORE WAS 76 CAL

Ecology

The two more or less disjunct areas in which this species occurs: Pacific coastal mountains and Rocky Mountains, experience a different climate and therefore sustain different forest types. The mostly much wetter (winter rainfall, up to 6600 mm p.a.) and milder coastal ranges support the tallest conifer forests in the world, with *Sequoia sempervirens* in the southern part exceeding 110 m and with *Abies grandis* to 80 m, *A. procera* 85 m, *Picea sitchensis* 87 m, *Pinus lambertiana* 75 m, *Pseudotsuga menziesii* 100 m, and *Tsuga heterophylla* to 80 m tall. Many of these trees also exceed any of their congeners elsewhere in overall size (Van Pelt, 2001). *Thuja plicata*, with max. 75 m, is one of the longest-lived in these forests, with veteran trees often in excess of 1000 years. Other conifers in these coastal forests are *Chamaecyparis lawsoniana* (extreme southern part of range), *Xanthocyparis nootkatensis, Calocedrus decurrens, Abies amabilis, Pinus monticola, Tsuga mertensiana*, and *Taxus brevifolia* in the understorey. Common angiosperm trees are *Acer macrophyllum*, *Alnus rubra* along rivers, and *Populus trichocarpa*; in the shrub layer are especially abundant *Vaccinium* spp., *Rubus spectabilis* and *Ribes bracteosum*. Deep layers of mosses and liverworts cover the forest floor and lower sections of tree trunks as well as fallen logs, on which latter most conifers find the only substrate to germinate. In the interior *Abies grandis, A. lasiocarpa, Larix occidentalis, Picea engelmannii, P. glauca, Pinus contorta, P. ponderosa, Pseudotsuga menziesii var. glauca*, and *Taxus brevifolia* are the most commonly associated conifers. Here annual precipitation does not exceed 1200 mm and winters are much colder than along the coast. The altitudinal range of this species is 1–2100(–2300) m a.s.l. It grows on a wide range of soil types over nearly all available geological formations.

Conservation

This species is common especially in the coastal sections of its extensive range and somewhat less so in the interior parts. (Selective) logging of mature trees and 'old growth' forest in which this species is a codominant continues in many areas where the forest is not on protected land. In situations where secondary forest growth is managed to favour other species (e.g. *Pseudotsuga menziesii*), this would lead to a decrease of occupancy of *Thuja plicata*. Plantation forestry focusing on this species should eventually reduce the level of exploitation of natural stands, in particular in 'old growth' forest with its high ecological value. At present this species is not considered to be in danger of extinction.

IUCN: LC

Uses

The wood of this species provided the main building material for the Amerindian tribes along the Pacific coast, who developed a technique to split large planks from the lower boles of big trees without destroying the trees themselves. Nowadays, its main use is for making shingles used in roofing residential buildings; as in most Cupressaceae, the wood is decay-resistant and easy to work. For large construction purposes it is less suitable as it tends to split, but it can be used for a variety of smaller utilities from garden sheds, glass houses, and furniture to tools. Western Red-cedar has been used in forestry plantations in some countries in NW Europe on a rather limited scale; it requires high rainfall and performs best in the wetter parts of the British Isles. *Thuja plicata* has been widely planted as an ornamental tree in parks and large gardens. It is also suitable for hedges as it grows back quickly from clipping. Fewer cultivars are known from this species than from *T. occidentalis*, but it is nevertheless of substantial importance in the horticultural trade.

Thuja standishii (Gordon) Carrière, Traité Gén. Conif., ed. 2, 1: 108. 1867. *Thujopsis standishii* Gordon, Pinetum Suppl.: 100. 1862. Type: Japan: Honshu, Kanagawa Pref., Yokohama, *leg. ign. s.n.* (holotype K).

Etymology

This species was named after John Standish, a nurseryman at whose tree nursery it was first grown in England.

Vernacular names

Japanese Arbor-vitae; kurobe, nezuko (Japanese)

Description

Trees to 20–25(–30) m tall; trunk monopodial, erect, or multistemmed, to 1 m d.b.h. Bark on trunks relatively thin, exfoliating in short, thin, curling flakes, reddish brown with grey-brown flakes. Branches spreading or ascending, foliage branches drooping or subpendulous, forming a pyramidal or broadly spreading crown. Foliage branches plagiotropic, higher order branchlets flattened, covered with leaves, forming more or less rounded sprays, green, abruptly turning reddish brown with dying leaves, persistent. Leaves decussate, imbricate, dimorphic, all scale-like, on (sub)ultimate branchlets 1.5–5 × 1–2.5 mm; facials rhombic to obtrullate; apex obtuse or acute to weakly apiculate; laterals slightly larger, partially covering base of facials but spreading from their apex, bilaterally flattened, incurved; margins entire; apex connate, acute-apiculate; primary stomatal bands abaxial, on underside of laterals and on adjacent facials; glands inconspicuous on (larger) facial leaves, small; leaf colour (yellowish) green to dark green, stomatal bands faintly whitish green. Pollen cones ovoid-oblong, 3–4(–5) mm long, purple maturing purplish black; microsporophylls 8–16, decussate, peltate, bearing 3–4 abaxial, yellow pollen sacs. Seed cones above pollen cones, terminal on short, straight, quadrangular branchlets with rhombic, gibbous scale leaves, broadly ovoid, 7–12(–14) × 6–7 mm, turning yellowish brown. Bract-scale complexes 8–10(–12), decussate; lowest pair much reduced; higher pairs irregular, partly spreading; two largest pairs ca. 5–7 × 4–5 mm, ovate-rhombic to obtrullate, thin, obtuse or acute, with a subapical triangular bract tip of ca. 0.5 mm. Seeds (6–)8–10 per cone, 4–5 × 2 mm, flattened, tapering towards base, light brown; wings 2, marginal, surrounding seed but leaving a notch at micropylar end, 1 mm wide, thin membraneous, apically puberulent, light brown.

Distribution

Japan: Honshu, Shikoku.
TDWG codes: 38 JAP-HN JAP-SH

Ecology

Thuja standishii occurs in mixed montane conifer or conifer-angiosperm forests, with *Abies homolepis, Chamaecyparis obtusa, C. pisifera, Thujopsis dolabrata, Tsuga diversifolia, Picea jezoensis, Pinus parviflora*, and *Larix kaempferi*. Common angiosperm trees are *Betula ermanii, B. corylifolia, Fagus sieboldii, Quercus mongolica* var. *grosseserrata*, and *Zelkova serrata. Thuja standishii* is a minor component in these forests, usually remaining a smaller tree than the dominants and not exceeding 15 m in height. Often it is confined to moist rocky precipices facing north, sites less suitable for larger trees. Its altitudinal range is (250–)500–2000(–2500) m a.s.l.

Conservation

IUCN: NT

Uses

The wood of this species is highly prized for special building purposes, e.g. ceilings and panelling, and is also used for furniture, fanlights and clogs (wooden shoes). It was in the past regarded as one of the 'five trees of Kiso' or 'Tome-ki' (preserved trees) which meant they were the property of the Emperors of the Tokugawa dynasty in the 17th and 18th centuries and not to be used by common people. This practice preserved several forests from overexploitation. In Japan it has been used as an ornamental tree for

many centuries. Robert Fortune first saw it in 1860 in gardens in Tokyo and introduced it to England via Standish's nursery at Ascot. It is still in cultivation in Europe and the USA but much less common there than some of the other species and mostly seen as specimen trees in dendrological collections.

Thuja sutchuenensis Franch., J. Bot. (Morot) 13 (8): 262. 1899. Type: China: Chongqing Municipality, Chengkou Xian, Daba Shan, ["Tchen-keou-tin" (vicinity of Chengkou)], *P. G. Farges 1158* (holotype P). Fig. 344

Etymology

The species epithet derives from Sichuan, China, in which the locality where the species was found at the time was located; this area has now been separated from that province.

Vernacular names

Sichuan Arbor-vitae, Sichuan thuja; ya bai, ya bai shu (Chinese)

Description

Trees to 20 m tall (sometimes a shrub); trunk monopodial, terete, to 30 cm d.b.h. Bark on trunks to 4–5 cm thick, fibrous and fissured lower down, exfoliating in short, thin, curling flakes, cinnamon-red or reddish brown to grey-brown. Branches spreading or ascending, forming a conical or pyramidal crown. Foliage branches plagiotropic; higher order branchlets flattened, covered with leaves, pinnately arranged up to ultimate branchlets, forming frondose sprays, green, abruptly turning orange-brown with dying leaves, persistent. Leaves decussate, imbricate, dimorphic, all scale-like, on (sub)ultimate branchlets 1.5–4 × 1–1.5 mm; facials rhombic to obtrullate, weakly keeled; apex obtuse; laterals slightly larger, broadly falcate, partially covering base of facials but spreading from their apex, bilaterally flattened, incurved; margins entire; apex obtuse; primary stomatal bands abaxial, on the underside of laterals and on the adjacent facials; leaves apparently eglandular, lustrous green, stomatal bands whitish green or glaucous. Pollen cones subglobose, 2–3 mm long, yellowish green maturing brown; microsporophylls 6–8, decussate, peltate, bearing (2–)3 abaxial, yellow pollen sacs. Seed cones terminal on short, straight branchlets with rhombic, gibbous scale leaves, (ob)ovoid or elliptical, 5–8 × 3–4.2 mm, with slightly spreading scales. Bract-scale complexes 8–10, decussate; lowest pair reduced; highest pair(s) small, connate; two largest pairs ca. 3–5 mm long, obovate, thick, obtuse, with a subapical ridge and triangular bract tip 0.5–1 mm, dull brown abaxially, lustrous yellowish brown or orange-brown adaxially. Seeds ca. 4 per cone, 3–4 × 1.5 mm, flattened, tapering towards both ends, lustrous light brown; wings 2, marginal, surrounding seed but leaving a notch at both ends, 0.5 mm wide, thin membraneous, yellowish brown.

Distribution

China: Chongqing (Chengkou Co., Kaixian Co.), Sichuan (Wangyuan Co.), Hubei (Baokang Co., now extinct?), on the southern slope of the Dabashan Mountains.
TDWG codes: 36 CHC-CQ CHC-SC

Ecology

This very restricted species occupies steep slopes and ridges of limestone mountain sides between 800 m and 2100 m a.s.l. in mixed angiosperm shrubland and forest. The soil is mountain yellow-brown earth developed from limestone, rich in organic matter (2.3–3%) and with a thick humus layer (ca. 20 cm) and a pH of 6.2–7. The climate is warm temperate and humid with mean annual precipitation ca. 1400 mm.

Conservation

Formerly this taxon was listed as the only conifer Extinct in the Wild (EW) by IUCN-SSC (Farjon & Page, 1999). In October 1999 it was rediscovered by a regional team of Chinese botanists, not far from (or perhaps even at) the locality where R. P. Farges had made his last collections almost 100 years previously (Xiang *et al.*, 2002). There is evidence of severe cutting at all localities going on between 1970 and 1990 or even later, and presumably the remaining individuals are only those left in inaccessible places and/

or of small stature. In order to achieve better protection, work involving local stakeholders is being carried out with help from the Bedgebury Pinetum (UK Forestry Commission) in Kent, England.
IUCN: EN (A1c, d)

Uses

The wood of this species is soft, light, easily worked and durable. It is used for applications requiring decay resistance by local people, e.g. home construction, production of shingles, application for funeral services etc. It is too rare to possess much commercial value. In China, it is grown in Wuhan Botanical Garden, but outside China this species is believed not to be in cultivation.

Thujopsis Siebold & Zucc. *ex* Endl., Gen. Pl. Suppl. 2: 24. 1842 (*nom. cons.*). Type: *Thujopsis dolabrata* (Thunb. *ex* L. f.) Siebold & Zucc. [*Thuja dolabrata* L. f.] (*Cupresaceae*).

Dolophyllum Salisb., Quart. J. Sci. Lit. Arts 2 (4): 313. 1817 (*nom. rej.*). Type: *Dolophyllum dolabrata* (L. f.) Salisb. [*Thuja dolabrata* L. f.].

Greek: *opsis* = 'aspect', 'appearance', i.e. appearing similar to the genus *Thuja*.

Description

See the species description.

Distribution

As for the species.

Thujopsis dolabrata (Thunb. *ex* L. f.) Siebold & Zucc., Fl. Japon. 2 (4): 34, tt. 119, 120. 1844.

Etymology

The species epithet, from Latin *dolabra* = hatchet or mattock, refers to the shape of the facial leaves.

Vernacular names

Hiba Arbor-vitae; asunaro, asuhi, hiba (Japanese)

Description

Trees to 15–20(–30) m tall, sometimes a large shrub, evergreen, monoecious; trunk monopodial or multistemmed, to 1 m d.b.h.; branches frequently layering. Bark on trunks with longitudinal plates, reddish brown with greyish strips of outer bark. Branches spreading or ascending to erect in (layering) shrubs, forming pyramidal to broadly conical or domed crowns. Foliage branches in flat but irregular sprays, branching alternately or divaricately; small branchlets variable in length, distinctly flattened, persistent. Leaves decussate, imbricate, dimorphic (on older, thickening branches becoming monomorphic, decurrent and gradually widening with the growing shoot), (1–)3–8 × 1–5 mm on flattened branchlets; facials dolabriform or spathulate, obtuse; laterals spreading from below their apex, bifacially flattened; margins entire; apex free, incurved, obtuse or acute; the broad primary stomatal bands all on underside of plagiotropic shoots, on both sides on erect shoots; leaf colour above lustrous dark green; stomatal bands conspicuous, white, bordered by light green margins. Pollen cones terminal, solitary, ovoid-globose, 3–4 mm long, reddish purple maturing to red-brown; microsporophylls 8–10, decussate, peltate, rounded, bearing 3–5 abaxial pollen sacs. Seed cones terminal on straight branchlets with small but unmodified scale leaves, subglobose, markedly umbonate, 8–16(–20) mm long. Bract-scale complexes 6–8(–10), decussate; lower and upper pairs reduced; 4 larger pairs cuneate or obdeltoid, apically thickened, subapically reflexed with a large 2–3 mm long, emerging and upturned bract tip, abaxially rugose, dull brown to grey, adaxially striated, with 2–5 seed scars at base, light brown. Seeds 15–25 per cone, narrowly ovate, irregularly compressed, 4–5 × 2 mm, greyish brown; wings 2, lateral, 1–1.5 mm wide, thin menbranous, yellowish.

Distribution

Japan: Hokkaido, Honshu, Kyushu, Shikoku.
TDWG codes: 38 JAP-HK JAP-HN JAP-KY JAP-SH

Ecology

This species is a constituent of conifer and conifer-angiosperm forests from lowland coastal areas to montane sites in regions with a cool, moist climate. Its altitudinal range is 400–1800(–2100) m a.s.l. The most commonly associated conifer is *Tsuga diversifolia*, but it can grow in natural forests with several others, e.g. *Chamaecyparis obtusa, C. pisifera, Cryptomeria japonica* (locally), *Thuja standishii*, *Sciadopitys verticillata* (locally), *Abies homolepis, A. mariesii, and Pinus parviflora*. Common angiosperm trees are *Betula ermanii, Fagus sieboldii, Quercus mongolica* var. *grosseserrata, Pterocarya rhoifolia, Aesculus turbinata*, and *Cercidiphyllum japonicum*.

Only occasionally does this species form more or less pure stands, this is mainly the case with the northern variety *T. dolabrata* var. *hondae*. Elsewhere, trees are mostly scattered and small and must be extremely shade tolerant, growing under canopy of *Tsuga* or *Fagus* and competing with e.g. *Ilex rugosa* (Wilson, 1916). The variable disposition of foliage branches and the development of stomatal zones on leaves indicate adaptability to changing light conditions; the capacity of layering is probably another strategy to maintain sufficient light interception under an expanding canopy, especially in earlier phases of growth.

Uses

Hiba Arbor-vitae is an important forest tree in Japan and is one of the 'five trees of Kiso' (all are conifers) originally preserved for imperial use. There are now managed state forests with this species as the dominant tree besides some imperial forests. Its light, soft, resinless and durable wood is used in construction, for bridges, buildings, furniture, the wooden basis of laquer work, wood carving, etc. Younger trees of this species are valued for their ornamental qualities due to a striking contrast between upper lustrous green and lower white banded leaf surfaces. Hiba Arbor-vitae is widely planted in Japan as well as in other countries with a temperate maritime climate. Several cultivars are known, most common are those with variegated leaves and some dwarf forms with compact growth and smaller leaves. The earliest of these were selected in Japan and introduced to Europe at the same time as the species, around the middle of the 19th century.

2 varieties are recognized:

Thujopsis dolabrata (Thunb. *ex* L. f.) Siebold & Zucc. var. ***dolabrata***. *Thuja dolabrata* Thunb. *ex* L. f., Suppl. Pl.: 420. 1782. Type: Japan: Honshu ["Habitat in Japonia"], *C. P. Thunberg UPS 22555* (holotype UPS). Fig. 345, 346

Description

Foliage relatively coarse with on average slightly larger leaves than in var. *hondae*. Seed cones 8–15 mm long, bract-scale complexes distinctly umbonate.

Distribution

Japan: S Honshu, Kyushu, Shikoku.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Conservation

IUCN: LC

Thujopsis dolabrata (Thunb. *ex* L. f.) Siebold & Zucc. var. ***hondae*** Makino, Bot. Mag. (Tokyo) 15: 104. 1901 ["*hondai*"]. Type: Japan: Honshu, Aomori Pref., Aomori, ["Prov. Mutsu, near Awomori"], *T. Makino s.n.(?)* (holotype TI).

Description

Foliage relatively slender, with on average slightly smaller leaves than in var. *dolabrata*. Seed cones 15–20 mm long, bract-scale complexes less umbonate.

Distribution

Japan: Hokkaido, N Honshu.
TDWG codes: 38 JAP-HK JAP-HN

Conservation

IUCN: LC

Torreya Arn., Ann. Mag. Nat. Hist., ser. 1, 1: 130. 1838 (*nom. cons.*). Type: *Torreya taxifolia* Arn. (*Taxaceae*).

Caryotaxus Henkel & W. Hochst., Syn. Nadelhölz.: 366. 1865. Type: *Caryotaxus nucifera* (L.) Henkel & W. Hochst. [*Taxus nucifera* L.]; *Foetataxus* J. Nelson, Pinaceae: 167. 1866. Type: *Foetataxus montana* J. Nelson (*nom. illeg.*) [*Torreya taxifolia* Arn.]; *Tumion* Raf. *ex* Greene, Pittonia 2: 193. 1891. Type: *Tumion taxifolium* (Arn.) Greene [*Torreya taxifolia* Arn.].

Named after John Torrey (1796–1873), American botanist.

Description

Dioecious or rarely monoecious evergreen trees or sometimes shrubs. Resin canals in leaves (1) and seed arils. Bark smooth or flaking, becoming fissured. Leaves alternate (helically inserted), pectinately arranged, flattened, linear-lanceolate, rigidly coriaceous, asperous, sharply acuminate or pungent, with a prominent midrib. Stomata in two separated bands on abaxial side. Pollen cones solitary in the axil of each leaf on fertile shoots, forming double rows on the underside of plagiotropic foliage branchlets, subglobose; microsporophylls decussately arranged, tightly clustered, peltate, with 3–6 pendulous pollen sacs forming a small umbel and containing subspherical, arillate pollen. Seed-bearing structures axillary to foliage leaves, consisting of a miniaturized branching shoot with a few spirally inserted bracts on the main and lateral axes and usually 2–3 subterminal, erect ovules of which only 1 develops into a large, hard seed with a strongly sclerified seed coat and completely surrounded (except at the distal tip) by a fleshy aril which ripens in the second year and becomes purplish green to bluish black. Seedlings with 4 short cotyledons.

6 species

Distribution

Asia: China, S Korea, Japan. North America: USA (disjunct): California, Florida.

Key to the species of *Torreya*

1a. Leaves (2–)3–6(–9) cm long. Branches spreading and drooping **2**

1b. Leaves 1.2–3.8(–4.5) cm long. Branches spreading and ascending **3**

2a. Leaves mostly drooping; stomatal bands 0.5–1 mm wide; margins on that side of leaves 0.5–0.7 mm wide. Ripe fleshy aril including seed 10–12 mm wide, pruinose to reddish yellow ***T. jackii***

2b. Leaves pectinately arranged; stomatal bands 0.3–0.4 mm wide; margins 0.7–1 mm wide. Ripe fleshy aril including seed to 25 mm wide, green with purplish streaks ***T. californica***

3a. Leaves straight or slightly down-curved, with a long cuspidate or spinose apex ***T. nucifera***

3b. Leaves straight or distally (slightly) falcate, with a short cuspidate apex **4**

4a. Leaves (0.7–)1–2.7(rarely to 4.5) cm long; stomatal bands 0.3–0.8 mm wide. Ripe fleshy aril including seed pale purplish brown or whitish pruinose ***T.grandis***

4b. Leaves 1.2–3.8(–4.5) cm long; stomatal bands 0.3–0.5 mm wide. Ripe fleshy aril including seed green streaked with purple, or slightly whitish pruinose **5**

5a. Midrib on the abaxial (lower) side of leaves 0.3–0.6 mm wide, leaf margins on that side 0.5–1.2 mm wide, total leaf width 2–4 mm. Ripe fleshy aril including seed pale green or slightly whitish pruinose ***T. fargesii***

5b. Midrib on the abaxial side of leaves 0.6–0.8 mm wide, leaf margins on that side 0.6–0.8 mm wide, total leaf width 2–3.2 mm. Ripe fleshy aril including seed dark green streaked with purple ***T. taxifolia***

Torreya californica Torr., New York J. Pharm. 3: 49. 1852. Type: not designated. Fig. 347, 348

Etymology

The species epithet alludes to its Californian native range.

Vernacular names

California nutmeg, Stinking cedar

Description

Trees (sometimes shrubs) to 25(–40) m tall; trunk to 1.2 m d.b.h. Bark irregularly vertically fissured, sometimes flaking, pale reddish brown or greyish brown, weathering to dark grey. Branches spreading or somewhat drooping, forming a broad conical to rounded crown. Foliage branchlets slender, usually with opposite branching, sometimes with more than 2 laterals from a node, spreading horizontally at 40–60° from the main axis in most cases, terete, with grooves along margins of decurrent leaf bases, green turning reddish brown after the first year. Buds at ends of branchlets very small; bud scales at lower node of previous year enlarged, triangular, keeled, lustrous brown, deciduous thereafter. Leaves pectinately arranged, spreading at 45–90° from shoot axis, linear to linear-lanceolate, (2–)3–6(–8) cm long, straight or slightly falcate, 2.4–4.5 mm wide, with 1–2 mm long, twisted petiole, abruptly widening at base, tapering to a long cuspidate apex, coriaceous, lustrous green on adaxial (upper) side, smooth, flat. Stomatal bands on abaxial side only, very narrow (0.3–0.4 mm), greenish white or glaucous, separated by a raised, 0.6–1.2 mm wide, green midrib and bordered by 0.7–1 mm wide, raised, flat margins; stomata small, randomly distributed. Pollen cones axillary, solitary, forming short rows on underside of lower leaves of lateral branchlets, with several pairs of basal bud scales in 4 rows, ca. 5–6 × 4.5–5 mm before anthesis, pale yellow or nearly white; microsporophylls numerous, peltate, each with 4–6 marginal, pendulous pollen sacs. Seed bearing structures axillary, solitary or in pairs, sessile, with rounded, keeled bract scales subtending seed. Ripe fleshy aril including seed smooth, light green or glaucous green, with darker green to purplish longitudinal streaks from base to below apex, obovoid or broadly elliptic, 25–35 mm long, to 25 mm wide, mucronate at apex. Seed proper smooth or with 2 opposite longitudinal ridges.

Distribution

SW USA: California (Coast Ranges, Sierra Nevada).
TDWG codes: 76 CAL

Ecology

Torreya californica is a scattered understorey tree usually growing in moist and shady places in hilly to mountainous terrain dominated by tall conifers, especially *Sequoia sempervirens, Picea sitchensis* and *Pseudotsuga menziesii*. In the western valleys of the Sierra Nevada it is associated with angiosperms, mainly *Acer* spp., *Cornus nuttallii*, *Platanus occidentalis*, and *Alnus rubra* and here it strictly adheres to stream banks in steep canyons at altitudes around 1200 m a.s.l. Its altitudinal range is from near sea level (but usually above 200 m) in the Coast Ranges to 2500 m a.s.l. in the Sierra Nevada. On serpentine rock it becomes a stunted tree or shrub and occurs on N-facing slopes in coastal chaparral.

Conservation

This species has suffered a past decline of 50% or more due to exploitation and habitat loss. This decline has now ceased or virtually ceased.
IUCN: VU (A1c, d)

Uses

Torreya californica is the most commonly cultivated species of its genus and can grow into an impressive, wide crowned tree with striking foliage and large, pendulous, plum-like green or glaucous seeds. It is almost exclusively used as an ornamental in large gardens or planted in arboreta. In the past, its wood was used for fencing and bridges, as it is rot resistant. California Indians used it for their bows. The name 'nutmeg' only refers to a superficial similarity with true nutmeg fruits (from *Myristica fragrans*, an angiosperm tree species). The native tribes roasted the seeds for food and some of them (e.g. the Pomo tribe) used the roots for basket weaving.

Torreya fargesii Franch., J. Bot. (Morot) 13 (8): 264. 1899.

Etymology

This species has been named after the French missionary and plant collector P. G. Farges.

Vernacular names

Farges nutmeg tree; ba shan fei shu (Chinese)

Description

Shrubs or trees to 20 m tall; trunk to 1 m d.b.h. Bark irregularly vertically fissured, sometimes flaking, pale brown or greyish brown, weathering to dark grey. Branches spreading and ascending, forming a broad crown. Foliage branchlets slender, usually with opposite branching, sometimes with more than 2 laterals from a node, spreading horizontally at 40–60° from main axis in most cases, terete, with grooves along margins of decurrent leaf bases, green turning yellowish brown after the first year. Buds at ends of branchlets very small; bud scales at lower node of previous year enlarged, broadly triangular, keeled, lustrous brown, deciduous thereafter. Leaves pectinately arranged, spreading at 55–90° from shoot axis, linear to linear-lanceolate, 1.2–3.5(–4.5) cm long, straight or distally falcate, 2–4 mm wide, with 0.5–1 mm long, twisted petiole, abruptly widening at base, tapering to a cuspidate apex, coriaceous, lustrous green on adaxial (upper) side, with two grooves on either side of an indistict midvein at least in lower half of blade. Stomatal bands on abaxial side only, 0.3–0.5 mm wide, light brown, separated by a 0.3–0.6 mm wide, green midrib and bordered by 0.5–1.2 mm wide, flat or very narrowly revolute green margins; stomata small, randomly distributed. Pollen cones axillary, solitary, forming short rows on underside of lower leaves of lateral branchlets, with several pairs of basal bud scales in 4 rows, ca. 5–6 × 4.5–5 mm before anthesis, pale yellow; microsporophylls numerous, peltate, each with (3–)4–5 marginal, pendulous pollen sacs. Seed bearing structures axillary, in pairs, sometimes grouped together on a branchlet, sessile, with rounded, keeled bract scales subtending seed. Ripe fleshy aril including seed smooth, pale green or slightly whitish pruinose, ovoid, globose or broadly ellipsoid, 15–25 mm diam., mucronate at apex. Seed proper smooth or with 2 opposite longitudinal ridges.

Taxonomic notes

This species, treated as a variety of *Torreya grandis* in the World Checklist and Bibliography of Conifers (Farjon, 1998, [2001]) and by most western botanists, is recognized as a distinct species in Flora of China 4: 95 (1999). In that Flora, *T. grandis* has two varieties, one (*var. grandis*) widespread in eastern China and one (var. *jiulongshanensis*) limited to S Zhejiang. *Torreya fargesii* partly overlaps that range, but extends further west and north. A consistent morphological difference is found in the relative width of stomatal bands and green margins and midrib on the leaf under (abaxial) sides, which appears to separate the two species. In *T. fargesii* the midrib is narrower than the margins; in *T. grandis* midrib and margins are of about equal width and as wide as the margins in *T. fargesii*. With roughly equal total leaf width in both species, this results in wider stomatal bands in *T. fargesii*. Two varieties are recognized also with this species: var. *fargesii* and var. *yunnanensis*; the latter has longer and wider leaves than both *T. fargesii* var. *fargesii* and *T. grandis*, but retains the relative widths mentioned above on the abaxial leaf faces. This character state is therefore accepted as sufficient to separate *T. fargesii* and *T. grandis* at species level.

Distribution

China: Chongqing, S Anhui, W Hubei, NW Hunan, Jiangxi, S Shaanxi, Sichuan (Emei Shan [Mt. Omei]), NW Yunnan.

TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHC-YN CHN-SA CHS-AH CHS-HN

Ecology

This species occurs in coniferous, mixed and broadleaved forests as an understorey shrub or a small to medium sized tree, in mountains from 700 m to 3400 m a.s.l.

Uses

This species yields high quality wood used in building houses, bridges (durability of the wood) and furniture; some of it is also used to make utensils and for wood turning. The seeds are edible and produce oil that is extracted; the essential 'torreya oil' is extracted from the aril. It is in cultivation in China, but not as widely as *T. grandis*; outside its native country it is only planted in a few botanic gardens and arboreta.

2 varieties are recognized:

Torreya fargesii Franch. var. ***fargesii***. *Torreya grandis* Fortune *ex* Lindl. var. *fargesii* (Franch.) Silba, Phytologia Mem. 7: 74. 1984. Types: China: Chongqing Municipality, Chengkou Xian, Daba Shan [near "Heou pin"], *P. G. Farges 100 & 945* (syntypes P).

Description

Leaves straight or rarely distally falcate, 1.2–2.5 cm long, 2–3.5 mm wide; grooves on adaxial surface prominent only below middle of blade, often fading towards shortly tapered apex.

Distribution

China: S Anhui, W Hubei, NW Hunan, Jiangxi, S Shaanxi, Sichuan.
TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHN-SA CHS-AH CHS-HN

Conservation

This taxon is considered threatened on account of deforestation in many areas where it occurs (or has occurred in the recent past according to herbarium collections made since the beginning of the 20th century).
IUCN: EN (A2c, d)

Torreya fargesii Franch. var. ***yunnanensis*** (W. C. Cheng & L. K. Fu) N. Kang, Bull. Bot. Res. Harbin 15 (3): 353. 1995. *Torreya yunnanensis* W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 87. 1975; *Torreya grandis* Fortune *ex* Lindl. var. *yunnanensis* (W. C. Cheng & L. K. Fu) Silba, Phytologia 68: 72. 1990. Type: China: NW Yunnan [cited in Chinese characters] *Chinese collector 20946* (holotype PE).

Description

Leaves straight or often distally falcate, (1.5–)2–4 cm long, 3–4.5 mm wide; grooves on adaxial surface extending to (near) apex.

Distribution

China: NW Yunnan (Gongshan, Lijian, Weixi, Zhongdian).
TDWG codes: 36 CHC-YN

Conservation

This taxon was not earlier evaluated under IUCN criteria; it was considered vulnerable in China Plant Red Data Book 1 (Fu & Jin, 1992) in which it was treated as a full species. The populations in Gongshan and Weixi are still of considerable size and should be conserved inside protected forest reserves. However, despite a recent governmental ban on logging, it was recently assessed as still under threat from exploitation for its highly desirable wood, resulting in overexploitation. Decline has been continuous and is likely to continue, while this variety occupies only a small area, probably less than 400 km².
IUCN: EN [B1ab (iii, v), B2ab (iii, v)]

Torreya grandis Fortune *ex* Lindl., Gard. Chron. 1857: 788. 1857.

Etymology

The species epithet means 'great' and may refer to the potentially large size of the arillous seed, especially in some cultivated forms.

Vernacular names

Chinese nutmeg tree; fei shu, yuan bian zhong (Chinese)

Description

Trees to 25 m tall; trunk to 1(–2) m d.b.h. Bark irregularly vertically fissured, sometimes flaking, yellowish grey or greyish brown, weathering to dark grey. Branches spreading and ascending, forming a broad crown. Foliage branchlets slender, usually with opposite branching, sometimes with more than 2 laterals from a node, spreading horizontally at 40–70° from main axis in most cases, terete, with grooves along margins of decurrent leaf bases, green turning yellowish green and then grey after first year. Buds at ends of branchlets very small; bud scales at lower node of previous year enlarged, broadly triangular, keeled, lustrous brown, deciduous thereafter. Leaves pectinately arranged, spreading at 65–90° from shoot axis, linear to linear-lanceolate, (0.7–)1–2.7(–4.5) cm long, straight or distally falcate, 2–3.5(–4) mm wide, with a twisted, 0.5–1 mm long petiole, abruptly widening at base, tapering to a cuspidate apex, coriaceous, lustrous green on the adaxial (upper) side, with (or without) an indistict midvein at least in lower half of blade. Stomatal bands on abaxial side only, 0.3–0.8 mm wide, light brown, separated by a 0.4–0.7 mm wide, green midrib and bordered by 0.5–0.8 mm wide, flat or very narrowly revolute green margins; stomata small, randomly distributed. Pollen cones axillary, solitary, forming short rows on underside of lower leaves of lateral branchlets, with several pairs of basal bud scales in 4 rows, ca. 5–8 × 4.5–5 mm before anthesis, pale yellow; microsporophylls numerous, peltate, each with 4–5 marginal, pendulous pollen sacs. Seed bearing structures axillary, solitary or in pairs, sometimes grouped together on a branchlet, sessile, with rounded, keeled bract scales subtending seed. Ripe fleshy aril including seed smooth, pale purplish brown or slightly whitish pruinose, obovoid-conical to ovoid, or ellipsoid to oblong-ellipsoid, 20–40 mm long, 12–25 mm wide, mucronate at apex. Seed proper smooth or with 2 opposite longitudinal ridges.

Taxonomic notes

Recently, a new species, *T. parvifolia*, was described from Sichuan in China, the type specimens of which are deposited in local Chinese herbaria. Its description, with an illustration, made comparison with *T. yunnanensis*, but not with *T. grandis* or any other species. Its reported characters fit well within those given here and elsewhere (e.g. Flora of China 4, 1999) for *T. grandis* var. *grandis* and it is therefore treated here as a synonym of that taxon. A fair number of varieties and forms have been described in this species; several of these are based on cultivated plants in China, which would probably be more appropriately be termed cultivars. They are often based on characters of the arrillous seeds and some of these forms attain large sizes and are of economic importance in Chinese traditional medicine. Only one recently described variety has been recognized in Flora of China 4: 95 (1999); its seeds are differently shaped and its leaves are longer than in other varieties. It is accepted here.

Distribution

China: Anhui, Fujian, Guizhou, Guangdong, Henan, Hubei, Hunan, Jiangxi, Sichuan, Zhejiang.

TDWG codes: 36 CHC-GZ CHC-HU CHC-SC CHS-AH CHS-GD CHS-FJ CHS-HE CHS-HN CHS-JX CHS-ZJ

Ecology

Torreya grandis is a constituent of the diverse mixed mesophytic forest (remnants) in Zhejiang, in which broad-leaved trees (angiosperms) dominate but several conifers can be present as associated trees. The altitudinal range of this species is between 200 m and 1400 m a.s.l. It is commonly found along streams and/or in shady spots in the forest, but large trees can reach the canopy and compete well with many other tree species. In secondary vegetation it may persist for some time, but eventually disappears due to excessive growth of bamboo and other weedy plants.

Uses

This species yields high quality wood used in building houses, bridges (durability of the wood), and furniture; some of it is also used to make utensils and for wood turning. The seeds are edible and produce oil that is extracted; the essential 'torreya oil' is extracted from the aril. The seeds proper (kernels) are sold in Chinese drug shops as a remedy against coughs and can be eaten as nuts. This species is common in cultivation in China (especially in Zhejiang), where some forms with various shapes and sizes (up to 5 cm long) of the arillous seeds are treated as cultivars and these are planted as fruit trees or shrubs in special plantations. The Chinese nutmeg tree was introduced to England by Robert Fortune in 1855, but remains uncommon in cultivation in Europe and elsewhere. Where it is grown it develops into a shrubby habit, not a monopodial tree.

2 varieties are recognized:

Torreya grandis Fortune *ex* Lindl. var. ***grandis***. *Torreya nucifera* (L.) Siebold & Zucc. var. *grandis* (Fortune *ex* Lindl.) Pilg., in Engler, Pflanzenr. IV.5 [18]: 107. 1903. Type: China: Zhejiang, ["mountains of Chekiang, China"], *R. Fortune s.n.* (holotype not located, isotype K).

Torreya parvifolia T. P. Yi, L. Yang & T. L. Long, Bull. Bot. Res. (China) 26 (5): 514. 2006.

Description

Leaves (0.7–)1–2.7 cm long. Ripe fleshy aril including seed obovoid to ovoid or ellipsoid.

Distribution

China: Anhui, Fujian, Guizhou, Guangdong, Henan, Hubei, Hunan, Jiangxi, Sichuan, Zhejiang.
TDWG codes: 36 CHC-GZ CHC-HU CHC-SC CHS-AH CHS-FJ CHS-GD CHS-HE CHS-HN CHS-JX CHS-ZJ

Conservation

IUCN: LC

Torreya grandis Fortune *ex* Lindl. var. ***jiulongshanensis*** Z. Y. Li, Z. C. Tang & N. Kang, Bull. Bot. Res. Harbin 15 (3): 356. 1995. Type: China: Zhejiang, Suichang, Jiulong Shan, *Z. Y. Li & Z. C. Tang 9009* (holotype PE).

Description

Leaves 2.5–4.5 cm long. Ripe fleshy aril including seed obovoid-conical.

Distribution

China: S Zhejiang (Suichang Xian).
TDWG codes: 36 CHS-ZJ

Conservation

IUCN: DD

Torreya jackii Chun, J. Arnold Arbor. 6: 144. 1925. Type: China: Zhejiang, Xianju, *R. C. Ching 1779* (lectotype PE).

Etymology

The species epithet commemorates the American botanist William Jack (1795–1822).

Vernacular names

Jack's nutmeg tree; chang ye fei shu (Chinese)

Description

Shrubs or small trees to 12 m tall; trunk to 20 cm d.b.h. Bark flaking, exposing pale brown new bark, weathering to grey or dark grey. Branches spreading and drooping, forming a thin, open crown. Foliage branchlets slender, long and flexible, usually with opposite branching, sometimes with more than 2 laterals from a node, spreading or drooping at 30–60° from the main axis in most cases, terete, with fine grooves along margins of decurrent leaf bases, green turning lustrous reddish brown after first year. Buds at ends of branchlets very small; bud scales at lower node of previous year enlarged, broadly triangular,

keeled, lustrous brown, deciduous thereafter. Leaves mostly drooping, linear to linear-lanceolate, (2.5–)3.5–7(–9) cm long, straight or slightly falcate, (2.5–)3–4 mm wide, with a 1–2 mm long, twisted petiole, abruptly widening at base, gradually tapering to a cuspidate apex, soft coriaceous, lustrous green on adaxial (upper) side, with an indistict midvein lying in a shallow depression at least in lower half of blade. Stomatal bands on abaxial side only, silvery grey to light brown, 0.5–1.4 mm wide, separated by a 1–1.2 mm wide, centrally sharply raised green midrib and bordered by 0.5–0.7 mm wide, flat or slightly downcurved green margins; stomata small, randomly distributed. Pollen cones axillary, solitary, with several pairs of basal bud scales in 4 rows, ca. 5–8 × 4.5–5 mm before anthesis, pale yellow; microsporophylls numerous, peltate, each with 4–5 marginal, pendulous pollen sacs. Seed bearing structures axillary, in pairs, sessile, with 2 pairs of rounded, keeled bract scales and a small lateral bract subtending seed. Ripe aril including seed smooth, whitish pruinose or glaucous, ripening to reddish yellow, obovoid, 20–30 mm long, 10–12 mm wide, mucronate at apex. Seed proper smooth or rugose.

Taxonomic notes

This species has a morphological similarity to *Cephalotaxus fortunei* when only sterile foliage is observed.

Distribution

China, N Fujian (Taining, Puchen), NE Jiangxi, S Zhejiang.
TDWG codes: 36 CHS-FJ CHS-JX CHS-ZJ

Ecology

Torreya jackii occurs in evergreen broad-leaved forest, along streams, on steep slopes in shade or in secondary vegetation usually near moisture. Its altitudinal range is between 120 m and 1320 m a.s.l. It is a species of warm temperate to subtropical regions affected by the SE monsoon with an annual precipitation of 1350 to 1600 mm and mean annual temperature 17–20° C, with absulute minimum of –10° C. It grows on acidic mountain yellow earth or rocky granitic or rhyolitic substrates with a low pH of 4.2–5 with good access to ground water or seepage. Associated species are e.g. *Quercus oxyphylla, Q. phillyrhaeoides, Photinia benthamiana, Loropetalum chinense, Cyclabalanopsis glauca, Castanopsis eyrei, Schima superba, and Rhododendron latoucheae*. In secondary vegetation shrubs like *Loropetalum chinense, Vaccinium bracteatum, Rhododendron ovatum, Symplocos caudata*, etc. are common. Roots have a fleshy cortex capable of water storage, enabling the species to withstand drought spells.

Conservation

Fu & Jin (1992) determined the conservation status of *T. jackii* as Vulnerable (VU) in China Plant Red Data Book 1, but the Conifer Specialist Group of IUCN-SSC (Farjon & Page, 1999) changed it to Endangered (EN); a later re-assessment confirmed this category of threat under slightly different criteria. This species occurs very locally and has been in steep decline, especially due to destruction of its forest habitat. Special reserves to protect this species in the wild are urgently needed. Natural regeneration is hampered by fragmentation of populations.
IUCN: EN (A2c, d)

Uses

The fragrant wood of this species is used to make agricultural implements, utensils and handicrafts; the wood is also used for firewood and chemicals are extracted from the leaves and bark for treating cancer. Outside China *T. jackii* is not in general cultivation and restricted to a few botanic gardens and/or private collections.

Torreya nucifera (L.) Siebold & Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4 (3): 234. 1846. *Taxus nucifera* L., Sp. Pl. 2: 1040. 1753. Type: Illustration: ["*Fi, vulgo Kaja, Taxus nucifera*"] in Kaempfer, Amoen. Exot. Fasc.: 814, 815. 1712. (lectotype). Fig. 349

Torreya ascendens Nakai *ex* Uyeki, [Not. Pl. Lign. Sikoku 11] Sci. Rep. Matsuyama Agric. Coll. 10: 3. 1953.

Etymology

The species epithet (Latin *nucis* = nut) means 'bearing nuts'.

Vernacular names

Japanese nutmeg tree; kaja, kaya (Japanese)

Description

Shrubs or trees to 25 m tall; trunk to 1(–2) m d.b.h. Bark irregularly vertically fissured, sometimes flaking in narrow strips, yellowish grey or greyish brown, weathering to dark grey. Branches spreading wide, forming a broad crown. Foliage branchlets slender, usually with opposite branching, sometimes with more than 2 laterals from a node, spreading horizontally at 40–80° from main axis in most cases, terete, with grooves along margins of decurrent leaf bases, yellowish green turning reddish to purplish brown after first year. Buds at ends of branchlets small; bud scales at lower node of previous year enlarged, broadly triangular, keeled, lustrous brown, deciduous thereafter. Leaves pectinately arranged, spreading at 75–90° from shoot axis, linear to linear-lanceolate, (1.5–)2–3.5 cm long, straight or slightly down-curved, 2.2–3.5(–4) mm wide, with 1–2 mm long, twisted petiole, abruptly widening at base, tapering to a long cuspidate or spinose apex, coriaceous, lustrous dark green on adaxial (upper) side, smooth or with two parallel grooves at least in lower half of blade. Stomatal bands on abaxial side only, 0.3–0.4 mm wide, yellowish, separated by a 0.5–0.8 mm wide, green midrib and bordered by 0.7–1 mm wide, flat and slightly raised green margins; stomata small, randomly distributed. Pollen cones axillary, solitary, forming short rows on underside of lower leaves of lateral branchlets, with several pairs of basal bud scales in 4 rows, ca. 5–7 × 4–5 mm before anthesis, pale yellow; microsporophylls numerous, peltate, each with 4–5 marginal, pendulous pollen sacs. Seed bearing structures axillary, solitary or in pairs, sometimes grouped together on a branchlet, sessile, with rounded, keeled bract scales subtending seed. Ripe aril including seed smooth, dark green ripening with purplish brown striation near apex, obovoid to ovoid, or ellipsoid, 20–30 mm long, 13–18 mm wide, mucronate at apex. Seed proper smooth or with 2 opposite longitudinal ridges.

Distribution

Japan: Honshu, Kyushu, Shikoku; South Korea: Cheju Island, Wando Island.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH KOR-SK

Ecology

Torreya nucifera is a woodland species occurring scattered in most types of mixed broad-leaved-conifer forest in the southern half of Japan. Wilson (1916) mentioned a locality SW of Tokyo, where it is more abundant, growing with *Abies firma* on steep slopes composed of shale on a hill ca. 500 m high. In other sites, including some islands in South Korea, it holds out in secondary vegetation where it becomes shrubby. Old-growth forest with ancient trees of *T. nucifera* in large numbers occurs in Korea's Bija-Rim Forest, Halla-san National Park, with trees estimated to be 500–800 years old. The altitudinal range is from near sea level to at least 1100 m a.s.l. Besides *Abies firma* and *Tsuga sieboldii*, the most common conifers among which *Torreya nucifera* is found, *Chamaecyparis obtusa, Podocarpus macrophyllus, Nageia nagi, Taxus cuspidata*, and *Sciadopitys verticillata* are often associated with this species. Locations dominated by conifers in the mixed mesophytic forests of warm temperate Japan are often on rocky S-facing slopes with poorly developed soils.

Conservation

IUCN: LC

Uses

The wood of this species is valued in Japan for its lustrous, pale brown leaf colour and its durability especially in contact with water. It is used for furniture and cabinet making, chests and boxes, Japanese chessmen, and formerly water buckets. The seeds are rich in edible oils and these as well as the arils are used in Japanese cuisine. This tree is widely planted near temples and in parks and gardens in Japan; all trees N of Tokyo are thought to be originally planted

(Wilson, 1916) and some of these are champion trees much larger than most trees in the forests. In Europe and North America it is an uncommon ornamental shrub or tree in arboreta, botanic gardens, and occasionally in private gardens.

Torreya taxifolia Arn., Ann. Mag. Nat. Hist., ser. 1, 1: 130. 1838. Type: USA: Florida, Appalachicola River, *J. Torrey s.n.* (holotype K).

Etymology

The species epithet compares the leaves with those of yew (*Taxus*).

Vernacular names

Florida nutmeg tree, Stinking cedar, Gopherwood

Description

Small trees to 13(–18) m tall; trunk to 80 cm d.b.h. Bark irregularly vertically fissured, sometimes flaking, pale brown or greyish brown, weathering to dark grey. Branches spreading and ascending, forming an open, broadly conical crown. Foliage branchlets slender, usually with opposite branching, sometimes with more than 2 laterals from a node, spreading horizontally at 40–60° from the main axis in most cases, terete, with grooves along margins of decurrent leaf bases, green turning yellowish brown after first year. Buds at ends of branchlets very small; bud scales at lower node of previous year enlarged, broadly triangular, keeled, lustrous brown, deciduous thereafter. Leaves pectinately arranged, spreading at 50–80° from shoot axis, linear to linear-lanceolate, 1.5–3.8 cm long, straight or very slightly falcate, 2–3.2 mm wide, with a 0.5–1 mm long, twisted petiole, abruptly widening at base, tapering to a cuspidate apex, coriaceous, lustrous green on adaxial (upper) side, slightly convex at least in lower half. Stomatal bands on abaxial side only, greyish white, 0.4 mm wide, separated by a 0.6–0.8 mm wide, green midrib and bordered by 0.6–0.8 mm wide, flat or very narrowly revolute green margins; stomata small, randomly distributed. Pollen cones axillary, solitary, forming short rows on underside of lower leaves of lateral branchlets, with several pairs of basal bud scales in 4 rows, ca. 5–6 × 4.5–5 mm before anthesis, pale yellow; microsporophylls numerous, peltate, each with 4–6 marginal, pendulous pollen sacs. Seed bearing structures axillary, in pairs, sometimes grouped together on a branchlet, sessile, with rounded, keeled bract scales subtending seed. Ripe aril including seed smooth, dark green streaked with purple, obovoid or broadly ellipsoid, 25–35 mm long, to 25 mm wide, mucronate at apex. Seed proper smooth or with 2 opposite longitudinal ridges.

Distribution

SE USA: NW Florida, SW Georgia, mainly along the Appalachicola River, with one population 11 km W of this river in Jackson Co., Florida.
TDWG codes: 78 FLA GEO

Ecology

Torreya taxifolia occurs along limestone bluffs on the Appalachicola River in a region with a warm and humid climate, occasionally influenced in winter by cold waves from the north that dip temperatures below the freezing point. It grows mostly in the shade of wooded ravines and steep, N-facing slopes under canopy of *Fagus grandifolia, Liriodendron tulipifera, Acer barbatum, Liquidambar styraciflua, Quercus alba*, and occasionally pines (*Pinus taeda, P. glabra*). Often these woods are hung with vines (e.g. *Smilax* spp., *Bignonia capreolata*). Another rare conifer, *Taxus floridana*, occasionally grows with *Torreya taxifolia*. A capacity to resprout from the stem base probably accounts now for most of the surviving individuals in the wild.

Conservation

This rarest of the species of *Torreya* is nearly extinct in the wild. It is almost restricted to a 64 km stretch of the Appalachicola River, where it occurs sporadically in a specific limestone bluff habitat. The number of individuals has been drastically reduced in recent decades, probably caused by a pathological fungal disease (*Ascomycota*) of the stem and leaves, first observed in 1962 and presumably alien to the region, having arrived in the late 1950's. Currently between 500 and 1000 individual plants

remain, many only as resprouts from stumps. At the moment *in situ* conservation is considered not a viable option; therefore, an extensive *ex situ* conservation programme has been established. This project is collaborative between the Botanic Garden of Smith College and Atlanta Botanical Gardens, USA. The programme has involved the collection of over 6,000 cuttings taken from plants throughout the natural range of the species. Rooted plants have now been shipped to gardens throughout the world in the hope that, if and when the natural environment has stabilised, material from these plants can assist the restoration of the species in its natural habitat. Recently, "assisted migration" to areas in the southern Appalachian Mountains has been proposed, based on the hypothesis that the historical range of this species in lowland Florida is a refuge from the last Ice Age (Barlow & Martin, 2008). During the previous interglacials it may have occurred in these mountains (the same could be true for *Taxus floridana*) but, for various reasons, in the current interglacial it 'missed the last bus' and was marooned in the cool microclimate of its present location, while other trees migrated north again. It will be doomed if that microclimate were to disappear with ongoing global warming. However, deliberately moving this species north into habitats from which it would have disappeared naturally if it ever occurred there has also been criticized (Schwartz, 2005/08).

IUCN: CR (A2a, c, e)

Uses

The hard and durable wood has been used for fence posts locally before it became too rare and protected under State and Federal Law. The use for Christmas trees has likewise ceased. It is rare in cultivation outside *ex situ* conservation programmes aiming at reintroduction in the wild. This species appears to be hardy in countries with mild winters (it apparently can withstand occasional hard frosts). Growing this tree in arboreta and botanic gardens should be encouraged, as it could help its conservation while being an attractive small conifer tree. It is apparently commercially available from tree nurseries in South Carolina, USA.

Tsuga (Endl.) Carrière, Traité Gén. Conif.: 185. 1855. Type: *Tsuga sieboldii* Carrière [*Abies tsuga* Siebold & Zucc.] (*Pinaceae*).

Hesperopeuce (Engelm.) Lemmon, [Pines Pacific Slope] Bienn. Rep. Calif. State Board Forest. 3: 126. 1890 [*Tsuga* sect. *Hesperopeuce* Engelm.]. Type: *Hesperopeuce mertensiana* (Bong.) Lemmon [*Pinus mertensiana* Bong.]; ×*Hesperotsuga* C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 389. 1989. Type: ×*Hesperotsuga jeffreyi* (A. Henry) C. N. Page [*Tsuga pattoniana* (Balf.) Sénécl. var. *jeffreyi* A. Henry].

Tsuga is the Japanese name for Hemlock (the conifer, not the poisonous herb *Conium maculatum* in *Apiaceae*).

Description

Monoecious evergreen trees, usually monopodial. Resin canals in leaves and seed cones. Bark rough and scaly, longitudinally fissured in lower part of trunk. Branches plagiotropic, growing in rhythmic pseudo-whorls, higher order branches in more or less horizontal or drooping sprays (Massart's model), sometimes with weak shoot dimorphism (*T. mertensiana*). Buds ovoid or globose and not or only slightly resinous. Leaves on spirally arranged pulvini, usually short petiolate, broadly ligulate linear, or narrowly ovate linear in some species, dorsiventrally flattened, entire or denticulate and with an obtuse acute or truncate emarginate apex, hypostomatic or amphistomatic (*T. mertensiana*). Pollen cones axillary, solitary, pedunculate, subglobular; microsporophylls with 2 pollen sacs containing pollen with a ring-shaped saccate structure near the distal pole. Seed cones solitary, subterminal on second year's shoots, sessile or short pedunculate, more or less erect at pollination but soon becoming pendulous, falling without the short peduncle. Bracts broadly rhombic and 1/6–1/5 the length of the seed scales, hidden in mature cones. Seed scales with short, petiolate, more or less auriculate bases, peltate to (sub)orbicular, persistent. Seeds small, covered on one side by a membranous cup, which extends a little over the other side and continues in an obliquely ovate, persistent, pale and thin seed wing. Seedlings with 3–6 cotyledons.

9 species

Distribution

North America: (disjunct) SE Alaska, British Columbia, northern Rocky Mountains, Cascade Range and Sierra Nevada of California; Great Lakes to Nova Scotia, Appalachian Mountains. Asia: Sino-Himalayan mountain system; Central and SE China; N Viet Nam; Taiwan; Japan (disjunct).

Synopsis

A total of 24 (25) species has been described in the genus *Tsuga*, one of these (*T.* ×*jeffreyi*) as a nothospecies; in addition to these 1 subspecies and (excluding cultivars in *T. canadensis* etc.) 3 varieties. Flous (1936) recognized 18 species, but generally about 10 species are accepted by contemporary authors: 4 in North America, 6–7 in Asia. *Tsuga longibracteata* Cheng has here been treated in a distinct genus *Nothotsuga*, and *T. mertensiana* (Bong.) Carrière in a distinct section within *Tsuga*. Beginning with Engelmann (1879) a division of the species of *Tsuga* in two sections has been commonplace, with *T. mertensiana* (sometimes together with *T. mertensiana* subsp. *mertensiana* var. *jeffreyi* as a species) in one section: *Hesperopeuce* Engelm., and all other species in the second section *Tsuga* (for which proposed names such as *Micropeuce* and *Eutsuga* are invalid under the rules of the Code). This will be followed here, as in spite of some more or less consistent differences involving entire or denticulate leaf margins, a further division of the genus *Tsuga* would in my opinion rest on a too narrow basis and is unlikely to be corroborated by a phylogenetic analysis.

Genus *Tsuga* (Endl.) Carrière
(Type: *T. sieboldii*)
- Sect. *Tsuga*
  - Species: *T. sieboldii* (type), *T. caroliniana, T. chinensis, T. diversifolia, T. forrestii, T. canadensis, T. dumosa, T. heterophylla*
- Sect. *Hesperopeuce* Engelm.
  - Species: *T. mertensiana*

Key to the sections, species and subspecies of *Tsuga*

1a. Leaves thick, 3–4 sided or with convex sides, with stomata on both faces, mostly assurgent on small lateral shoots and often glaucous. Seed cones large, ovoid-oblong to cylindrical **Sect. *Hesperopeuce* 2**

1b. Leaves distinctly flat, mostly with stomata on the abaxial side separated by a midrib, spreading or pectinately arranged, usually not assurgent, green above, whitish below. Seed cones small (max. 4 cm long), ovoid-oblong to subglobose **Sect. *Tsuga* 3**

2a. Seed cones 2–5.5 × 1.1–2.5 cm; seed scales small, 50–72, close together, usually dark brown ***T. mertensiana subsp. mertensiana***

2b. Seed cones 3.5–8.1 × 1.9–3.3 cm; seed scales large, 40–52, wide apart, usually light brown ***T. mertensiana subsp. grandicona***

3a. Margins of leaves denticulate; apex obtuse-acutish, not emarginate **4**

3b. Margins of leaves usually entire; apex emarginate or obtuse **6**

4a. Leaves short, 0.5–1.8 cm long, mostly parted and inversed (stomatal bands on underside); smallest leaves not inversed (stomatal bands on upperside) and pressed forward above shoot; bands of stomata with 5–6 lines each. Seed cones with acutish apex when closed ***T. canadensis***

4b. Leaves usually longer, but variable, up to 2.5 cm or longer, nearly all parted and inversed; bands of stomata with 8–10 lines each. Seed cones with obtuse apex when closed **5**

5a. Leaves narrowly ovate-linear (widest near base), denticulate towards apex. Young branchlets with scattered short hairs. Seed cones broadly ovoid when closed ***T. dumosa***

5b. Leaves narrowly elliptic, denticulate along the whole length of margins. Young branchlets lanate pubescent with short brown hairs, mixed with long whitish hairs. Seed cones (ovoid-) oblong when closed ***T. heterophylla***

6a. Seed cones ovoid-elliptic when closed, 2–4 cm long; oblong seed scales opening wide or reflexed when ripe. Leaf apex truncate or slightly emarginate ***T. caroliniana***

6b. Seed cones ovoid or ovoid-oblong when closed, usually not longer than 2.5(-3)cm; (mostly) nearly circular seed scales not opening wide. Leaf apex usually emarginate **7**

7a. Leaves short, usually 0.8–1.8 cm, widest near truncate-emarginate apex, pectinately arranged, but shortest leaves assurgent above shoot **8**

7b. Leaves longer, 1–2.5 cm, with parallel margins; all leaves pectinately arranged **9**

8a. Young shoots usually glabrous, shiny light brown. Leaves irregularly arranged, with dull white stomatal bands. Seed cone scales incurved (hooded), heavily striated, buff ***T. sieboldii***

8b. Young shoots pubescent, orange-brown, later dull brown. Leaves mostly parted and pectinate, with niveous white stomatal bands. Seed cone scales flat, smooth or finely wrinkled, dark brown ***T. diversifolia***

9a. Young shoots (remotely) pubescent. Leaves narrowly ovate-linear or curved-linear; margins entire; apex emarginate or obtuse ***T. forrestii***

9b. Young shoots usually glabrous. Leaves linear; margins (of young leaves) denticulate near emarginate (rarely entire) apex ***T. chinensis et vars.***

Tsuga canadensis (L.) Carrière, Traité Gén. Conif.: 189. 1855. *Pinus canadensis* L., Sp. Pl., ed. 2, 2: 1421. 1763. Type: ["Habitat in America septentrionali"], *J. Clayton 547* (lectotype BM).

Etymology

The species epithet means 'from Canada'.

Vernacular names

Eastern hemlock, Canada hemlock

Description

Trees to 30–40(–48) m tall, d.b.h. to 1.5–2 m; trunk straight, columnar, rarely forked. Bark scaly, becoming rough, fissured, light cinnamon brown, turning

dark grey with age. Branches spreading mostly horizontally; branches of second order drooping at ends; crown pyramidal in young trees, with drooping leader, in old trees often flat topped. Branchlets pale brown or grey-brown, soon grey, minutely ridged and grooved, lanate with yellowish brown pubescence; pulvini small, decurrent, nearly appressed or slightly raised. Vegetative buds conical, acute, 2–3 mm long, not or slightly resinous, red-brown. Leaves mostly spreading; small leaves above the shoot appressed, directed forward, not (!) inversed, showing white stomatal side; other leaves more or less pectinate, parted below shoot, (0.5–)0.8–1.5(–1.8) cm long, 1.5–2.2 mm wide, obliquely pedunculate and twisted at base, ligulate-linear or widest near base, denticulate at margins, grooved above, flattened, obtuse at apex; stomata in two white bands on the abaxial (lower) side; leaf colour dark green on upperside. Pollen cones numerous, 3–5 mm long, (orange-) yellow. Seed cones numerous on all outer branchlets, on delicate, pubescent, 4–5 mm long peduncles, ovoid-cylindrical with acute apex when closed, ovoid and obtuse when opened, 1.5–2.5(–3) cm long, 1–1.8(–2.2) cm wide with opened scales, ripening to light brown or grey-brown. Seed scales obovate-orbicular, convex, thin and papery (cones very light), 10–12 × 6–8 mm at mid-cone; exposed abaxial surface striated or wrinkled, glabrous, with impressions of two lower scales in lower part; upper margin entire or obscurely denticulate, often undulate; base narrowed, short pedicellate. Bracts 3–4 mm long, red-brown. Seeds ovoid-oblong or nearly reniform, 3 mm long, light brown; seed wings ovate or ovate-triangular, 6–7 × 4 mm, pale yellowish transparent.

Distribution

E North America: from Nova Scotia to N Georgia and N Alabama, westwards to Minnesota.
TDWG codes: 72 NBR NSC ONT PEI QUE 74 ILL MIN WIS 75 CNT INI MAI MAS MIC NWH NWJ NWY OHI PEN RHO VER WVA 76 GEO KTY NCA SCA TEN VRG 78 ALA MRY

Ecology

Tsuga canadensis occurs from near sea level (Nova Scotia) to 600 m in N Michigan, in the southern Appalachians between 600 and 1500 m a.s.l. The soils are of glacial, fluvio glacial, alluvial, or colluvial origin, podzolic and usually highly acidic (pH 3–4). The climate is cool and humid, with annual precipitation between 700 and 1500 mm. *Tsuga canadensis* grows locally pure, but is usually mixed with other conifers and broad-leaved trees: *Pinus strobus, P. resinosa, Abies balsamea, Picea rubens, P. glauca, Larix laricina, Betula* spp., *Acer saccharum, Quercus rubra, Fraxinus americana, F. nigra, Fagus grandifolia, Populus* spp., and other species. It is very shade tolerant and allows very little vegetation to develop under its own canopy.

Conservation

While very widespread, the population seems to be declining.
IUCN: NT

Uses

The slow growing Eastern hemlock produces lumber of good quality suitable for building (e.g. roofs, floors) and making crates or boxes, but until recently these kinds of use were completely overshadowed by its use in the paper pulp industry. Other former uses were to make telegraph poles and railway sleepers. In the past its bark was used in the tanning industry. Eastern hemlock is still in demand as an ornamental tree; it was introduced to Europe in 1736. In gardens and parks it often grows several trunks, but this is by no means a characteristic of the species in its natural habitat. A large number of cultivars has been produced, including variegated foliage plants and dwarf forms raised from cuttings, whereby the slow growth of this species is an obvious advantage over Western hemlock, of which few cultivars exist. Conversely, due to that slower growth Eastern hemlock is less preferred as a forestry plantation tree, giving way to Western hemlock.

Tsuga caroliniana Engelm., Bot. Gaz. 6: 223. 1881. Type: USA: South Carolina, *A. H. Curtiss s.n.* [*ex herb*. Engelmann] (lectotype MO).

Etymology

The species epithet refers to the States of North and South Carolina in the USA.

Vernacular names

Carolina hemlock

Description

Trees to 20–25 m tall; trunk to 50–60 cm d.b.h., straight, columnar. Bark becoming rough and scaly, fissured, with purplish grey outer bark and red-brown inner bark exposed in the fissures. Branches spreading horizontally, but lower branches curved downward; branches of second order drooping at ends; crown of young trees conical, with drooping leader, in old trees broader, open or dense and flat-topped. Branchlets red-brown, paler orange-brown below, shiny, with fine grooves and ridges and short, dark brown pubescence especially in the grooves; pulvini well developed, swollen, appressed and decurrent. Vegetative buds ovoid-conical, 3–4 × 1.5–2.5 mm, not or only slightly resinous, red-brown. Leaves pectinate at nearly right angles from shoot, remote, a few above shoot directed forward, of unequal length without a ranked order, 0.5–2 cm long, 1.8–2 mm wide, linear, with entire margins, flattened, grooved above, truncate, retuse or slightly emarginate at apex; stomata in two white bands on the underside (abaxial surface); leaf colour on upperside dark, lustrous green. Pollen cones ca. 5 mm long, yellow tinged with purple. Seed cones on 4–5 mm long, pubescent peduncles, ovoid-elliptical when closed, with opened scales irregular, more or less ovoid, 2–3.5(–4) cm long, 1.5–2.5(–3) cm wide, maturing to light brown or red-brown. Seed scales ovate-oblong to oblong, opening at right angles to rachis or recurved, 13–20 × 6–10 mm, abaxial surface striated on exposed part, slightly puberulent when green, but soon glabrous; adaxial side with two dark seed wing marks; upper margin entire, rounded, obtuse or tapering, sometimes undulate; base short pedicellate. Bracts 4–5 mm long, weakly trilobate, pale brown. Seeds ovoid-cuneate, 3–4.5 × 1.5–2.5 mm, light brown with dark spots; seed wings oblong, tapering to apex, 8–12 × 3.5–5 mm, light yellowish brown, transparent.

Distribution

USA: Appalachian Mountains in Georgia, North Carolina, South Carolina, Tennessee and Virginia.
TDWG codes: 78 GEO NCA SCA TEN VRG

Ecology

Tsuga caroliniana occurs in low to medium high mountains, at altitudes between 600 m and 1500 m a.s.l. (commonly 750 m to 1200 m), on rocky, moist N- or E-facing slopes or rocky ridges, also along streams in cool ravines. The climate is humid and cool, relatively warm at lower elevations, the annual precipitation exceeds 1000 mm and falls throughout the year; there is much cloudy weather in all seasons. It is a rare and scattered tree, which grows singly, mixed with broad-leaved trees and shrubs, or in small nearly pure groves of only a few individuals.

Conservation

This species has a sufficiently large range (extent of occurrence, EOO), but it occurs within that range only in scattered, small sub-populations at cool, moist or rocky sites where most other (angiosperm) trees and shrubs thrive less well. It could be at risk from succession by these angiosperms, if climate change were to affect these localities trending towards warmer and drier conditions in future.
IUCN: NT

Uses

The wood of Carolina hemlock has similar properties as that of Eastern hemlock, but the species is much less common and widespread, so its commercial value is limited. As an ornamental tree it is also less commonly used, being somewhat more difficult to establish from seed and growing rather slowly. A few cultivars have been selected, mostly of compact or dwarfish growth habits.

Tsuga chinensis (Franch.) E. Pritz., Bot. Jahrb. Syst. 29: 217. 1900.

Etymology

The species epithet refers to China.

Vernacular names

Chinese hemlock; tie shan (Chinese)

Description

Trees to 40–50 tall, d.b.h. to 1.5–2 m; trunk monopodial, often forked above 1/2 height. Bark on trunk rough and scaly, with numerous brown-grey plates. Branches assurgent, spreading more horizontally at ends; crown broad, conical, or flat topped in old trees. Branchlets pale yellowish brown, finely grooved between slightly swollen, appressed, decurrent and darker pulvini, with minute pubescence in grooves, soon glabrous. Vegetative buds ovoid-globose, 1–4 mm long, not resinous, dark brown or red-brown. Leaves mostly pectinate, but a few short leaves erect, (0.6–)1–2(–2.7) cm long, 1.8–3 mm wide, (broad) linear, flattened, grooved above, with near apical margins of young leaves denticulate, emarginate, sometimes entire at apex; stomata in two white bands on underside (abaxial side) separated by a midrib, leaf colour green on upperside. Pollen cones crowded near ends of branchlets, 3–5 mm long, yellow, with purple tinge. Seed cones numerous, short pedunculate or sessile, ovoid-oblong when closed, subglobular or ovoid-oblong when opened, 1.5–3(–4?) cm long, 1.3–2.2(–3.5?) cm wide, light green when immature, ripening to light, glossy brown. Seed scales nearly circular, convex, 8–12(–14) × 8–10(–12) mm; abaxial surface usually striated, shining, with imprints of two lower scales, glabrous; upper margin rounded, truncate or retuse; base short pedicellate. Bracts transversely rhombic, with denticulate upper margin, 1–2(–3) mm long. Seeds ovoid-oblong or ovoid-triangular, 3–4 × 2 mm, light brown; seed wings obliquely ovate, 6–7 × 3.5 mm, light yellowish, transparent.

Distribution

S and N Central and SE China, SE Xizang [Tibet] (?); Taiwan; N Viet Nam.

TDWG codes: 36 CHC-CQ CHC-GZ CHC-HU CHC-SC CHC-YN CHN-GS CHN-SA CHS-AH CHS-FJ CHS-GD CHS-GX CHS-HE CHS-HN CHS-JX CHS-ZJ 38 TAI 41 VIE

Ecology

Tsuga chinensis and its varieties occur at altitudes between (600–)1200–3200(–3500) m a.s.l. The soils are red and yellow earth, or mountain podzols at high elevations. The climate is cool temperate, moist (annual precipitation 1000 mm to 2000 mm) or very wet (Taiwan). This species is widely distributed and occurs in the mixed mesophytic forest formation (Wang, 1961) together with numerous broad-leaved trees and several conifers; on the Southwestern Plateau also in the montane coniferous forests with *Abies, Picea* and other conifers.

Uses

Chinese hemlock is a valuable timber tree in China and has been logged extensively in many parts of the country. The wood is hard and durable and used for construction, shingles for roofing, general carpentry, and joinery. This species was introduced by Ernest Wilson for the Veitch Nurseries in England in 1900, but it has remained uncommon in cultivation. No cultivars have been recorded. In plantation forestry, it is increasingly planted in the eastern USA as a substitute for *T. canadensis* and *T. caroliniana*, because it is resistant to an insect pest that adversely affects the native species.

3 varieties are recognized:

Tsuga chinensis (Franch.) E. Pritz. var. ***chinensis***.
Abies chinensis Franch., J. Bot. (Morot) 13 (8): 259. 1899. Type: China: Chongqing Municipality, Chengkou Xian, Daba Shan, *P. G. Farges 808* (holotype P). Fig. 350, 351

Tsuga formosana Hayata, Gard. Chron., ser. 3, 43: 194. 1908; *Tsuga chinensis* (Franch.) E. Pritz. var. *formosana* (Hayata) H. L. Li & H. Keng, Taiwania 5: 64. 1954.

Tsuga patens Downie, Notes Roy. Bot. Gard. Edinburgh 14: 16. 1923; *Tsuga chinensis* (Franch.) E. Pritz. subsp. *patens* (Downie) E. Murray, Kalmia 12: 26. 1982; *Tsuga chinensis* (Franch.) E. Pritz. var. *patens* (Downie) L. K. Fu & Nan Li, Novon 7 (3): 263. 1997.

Tsuga tchekiangensis Flous, Bull. Soc. Hist. Nat. Toulouse 69: 414. 1936; *Tsuga chinensis* (Franch.) E. Pritz. var. *tchekiangensis* (Flous) W. C. Cheng & L. K. Fu, Fl. Reipubl. Pop. Sin. 7: 119. 1978.

Tsuga chinensis (Franch.) E. Pritz. var. *daibuensis* S. S. Ying, Bull. Exp. Forest Natl. Taiwan Univ. 114: 150. 1974.

Description

Seed cones ovoid-oblong when closed, more or less subglobose when opened, 1.5–2.5 cm long, 1.3–2.2 cm wide; seed scales nearly circular, short petiolate, 8–12 × 8–10 mm.

Distribution

As for the species.

Conservation

IUCN: LC

Tsuga chinensis (Franch.) E. Pritz. var. ***oblongisquamata*** W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975. *Tsuga oblongisquamata* (W. C. Cheng & L. K. Fu) L. K. Fu & Nan Li, Novon 7 (3): 263. 1997. Type: China: Hubei, W Hubei, *Chinese collector 950* (holotype PE).

Description

Seed cones ovoid-oblong when opened, 1.8–2.8 × 1–1.5 cm; seed scales obovate-oblong, distinctly petiolate, 10–14 × 6–9 mm.

Distribution

China: Chongqing, Gansu (Zhouqu), W Hubei, Sichuan.
TDWG codes: 36 CHC-CQ CHC-HU CHC-SC CHN-GS

Conservation

IUCN: LC

Tsuga chinensis (Franch.) E. Pritz. var. ***robusta*** W. C. Cheng & L. K. Fu, Acta Phytotax. Sin. 13 (4): 83. 1975. Type: China: Hubei, Yangtse Gorges, *[?] Chen et al. 2000* (holotype PE).

Description

Seed cones ovoid-oblong when closed, more or less subglobose when opened, larger than in var. *chinensis* (possibly up to 4 × 3.5 cm); seed scales robust and thick.

Distribution

China: Hubei (Badong Xian), Sichuan (Yalong Valley).
TDWG codes: 36 CHC-HU CHC-SC

Conservation

IUCN: DD

Tsuga diversifolia (Maxim.) Mast., J. Linn. Soc., Bot. 18: 514. 1881. *Abies diversifolia* Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 12: 229. 1868. Type: not designated.

Tsuga blaringhemii Flous, Bull. Soc. Hist. Nat. Toulouse 69: 410. 1936; *Tsuga diversifolia* (Maxim.) Mast. subsp. *blaringhemii* (Flous) E. Murray, Kalmia 12: 26. 1982.

Etymology

The species epithet refers to the the different lengths of leaves on a shoot.

Vernacular names

Northern Japanese hemlock; kome-tsuga, kuro-tsuga (Japanese)

Description

Trees to 20–25 m tall, d.b.h. to 50–60 cm; trunk straight or curved, often forked above half of height.

Bark on trunk rough and scaly, longitudinally grooved, dark brown-grey. Branches spreading horizontally or ascending in top; crown of mature trees broad, domed and dense, more open in old trees. Branchlets orange-brown, later dull brown, ridged and grooved between appressed, decurrent pulvini, short pubescent, soon glabrous. Vegetative buds obovoid or globular, 2–3 × 2–2.5 mm, not or only slightly resinous, dark brown. Leaves pectinate or at least parted, but shorter leaves above shoot assurgent, (0.5–)0.8–1.5(–1.8) cm long, ca. 2 mm wide, ligulate-linear, slightly wider near truncate-emarginate apex, slightly curved or straight, flattened, grooved above; stomata in two broad, white bands separated by a midrib on the abaxial (under) side; leaf colour dark lustrous green on upperside. Pollen cones 3–5 mm long, yellow when shedding pollen. Seed cones numerous on outer branchlets of the entire crown, on 3–4 mm long, pubescent peduncles, ovoid when closed, subglobose when opened, (1.5–)2–2.5 cm long, 1.5–2 cm wide, green or purplish green, ripening to shiny, reddish brown or dark brown. Seed scales nearly circular to obovate, flat or slightly convex, spreading at ca. 90° from rachis, 8–12 × 7–10 mm; abaxial surface smooth or finely wrinkled, with imprints of two overlapping scales; base broad cuneate, sometimes short pedicellate. Bracts broad, truncate, with two small apical teeth, 2–3 mm long. Seeds ovoid, ca. 3 × 2 mm, (dark) brown; seed wings obliquely ovate, 6–8 × 3–4 mm, yellowish or orange-brown, transparent.

Distribution

Japan: N and Central Honshu, Kyushu, Shikoku.
TDWG codes: 38 JAP-HN JAP-KY JAP-SH

Ecology

Tsuga diversifolia occurs in the mountains at altitudes between 700 m and 2000 m a.s.l., on usually podzolic soils developed on volcanic or igneous rock. The climate is cool, with cold, snowy winters and abundant rainfall in summer (annual precipitation 1000 mm to 2500 mm). It is in many areas the most common tree species in mixed coniferous forests, being very shade tolerant. Other common conifers are *Picea jezoensis, Abies homolepis, A. veitchii, A. mariesii* (at high elevations), *Larix kaempferi, Pinus parviflora, Thuja standhisii*, and *Thujopis dolabrata* var. *hondai*; broad-leaved trees are e.g. *Betula ermanii, B. corylifolia, Sorbus japonica, Alnus hirsuta* var. *sibirica*, and *Quercus mongolica* var. *grosseserrata. Rhododendron* spp. and/or *Sasa* spp. may form a dense undergrowth in the shrub layer, in other, very wet areas only thick moss layers carpet fallen logs and the forest floor.

Conservation

IUCN: LC

Uses

Northern Japanese hemlock is exploited in Japan for timber. In the past it mainly provided pulp for paper, but now this commodity, requiring vast resources, mainly comes from abroad. Instead, the use of this species has largely shifted to construction, carpentry, and joinery and, as the wood is generally dense and moderately hard and sometimes attractively figured with reddish brown heartwood and lighter sapwood, it is used for furniture. As and ornamental tree it is planted in Japanese gardens and parks; it is also used in bonsai culture. In Europe and North America it is less commonly used, being slow growing. A dwarf form (cultivar) which grows very slow is used for rockeries. Hemlocks are unsuitable as Christmas trees, because when cut and taken indoors they loose their leaves sooner than any other conifer.

Tsuga dumosa (D. Don) Eichler, in Engler & Prantl, Nat. Pflanzenfam. 2 (1): 80. 1887. *Pinus dumosa* D. Don, in Lambert, Descr. Pinus 2: 55. 1824. Type: not designated.

Abies yunnanensis Franch., J. Bot. (Morot) 13 (8): 258. 1899; *Tsuga yunnanensis* (Franch.) E. Pritz., Bot. Jahrb. Syst. 29: 217. 1900; *Tsuga dumosa* (D. Don) Eichler var. *yunnanensis* (Franch.) Silba, Phytologia 68: 73. 1990.
Tsuga dura Downie, Notes Roy. Bot. Gard. Edinburgh 14: 16. 1923; *Tsuga yunnanensis* (Franch.) E. Pritz. subsp. *dura* (Downie) E. Murray, Kalmia 12: 26. 1982.
Tsuga wardii Downie, Notes Roy. Bot. Gard. Edinburgh 14: 17. 1923; *Tsuga chinensis* (Franch.)

E. Pritz. subsp. *wardii* (Downie) E. Murray, Kalmia 12: 26. 1982.
Tsuga leptophylla Hand.-Mazz., Akad. Wiss. Wien, Math.-Naturwiss. Kl., Anz. 61: 83. 1924; *Tsuga dumosa* (D. Don) Eichler subsp. *leptophylla* (Hand.-Mazz.) E. Murray, Kalmia 12: 26. 1982.

Etymology

'Dumosa' is a Japanese name for *Tsuga* (but not referring to this species).

Vernacular names

Himalayan hemlock; changa thasi, sula, thingia (Nepalese); tang shing (Bhutan); yun nan tieshan (Chinese)

Description

Trees to 40–50 m tall, d.b.h. to 1.5–2.5(–2.7) m; trunk monopodial, or multistemmed. Bark soon rough and scaly, deeply fissured, with large plates in old trees, pink-brown; outer bark grey. Branches ascending or nearly erect near tree top, spreading horizontally or downward below; branches of second order drooping at ends, forming flat, slanting planes of foliage; crown broad conical in young trees, becoming flat topped and irregular in old trees. Branchlets pale pinkish brown to brown, later grey, ridged and grooved between appressed, decurrent pulvini, with scattered pubescence. Vegetative buds obovoid to globular, 2–2.5 mm long, not resinous, brown. Leaves directed forward, rigid, spreading irregularly, more pectinate below shoot, (1–)1.5–2.5(–3.5) cm long, 1.5–3 mm wide, very narrowly ovate-linear, widest near base, straight or slightly curved, flattened; margins (mostly on the distal half) denticulate, but in older leaves becoming entire, grooved above, obtuse acutish at apex; stomata in 2 whitish bands separated by a midrib on abaxial (under) side; leaf colour green or glaucous green on upperside. Pollen cones numerous, 3–5 mm long, yellow at maturity. Seed cones numerous on outer branchlets of entire crown, very short pedunculate or nearly sessile, broadly ovoid, more globular when opened, (1.5–)2–3 cm long, 1.5–2.5(–3) cm wide, light green or purplish green to purple, ripening to lustrous light brown, but unexposed part of seed scales dark purplish brown. Seed scales broadly ovate-elliptic, convex, 11–14 × 9–12 mm at mid-cone; abaxial surface smooth, finely striated, with imprints of overlapping scales, glabrous; upper margin rounded, entire, slightly recurved or straight; base petiolate, slightly auriculate. Bracts broadly angular-ovate, ca. 3 mm long. Seeds ovoid-oblong, 3–4 × 2–2.5 mm, brown; seed wings obliquely ovate, 6–8 × 3.5–4 mm, light yellowish brown, transparent.

Distribution

Himalaya; China: mountains of SE Xizang [Tibet], NW Yunnan and SW Sichuan; N Myanmar [Burma]; N Viet Nam.
TDWG codes: 36 CHC-SC CHC-YN CHT 40 EHM-AP EHM-BH EHM-DJ EHM-SI NEP WHM-UT 41 MYA VIE

Ecology

Tsuga dumosa occurs in the Himalaya in a belt between 2600 m and 3200 m a.s.l., in a wide range of habitats, usually on alpine lithosols. In China it is most common between 2200 m and 2800 m a.s.l., but it occurs as low as 1700 m and up to 3500 m a.s.l. in Sichuan and Yunnan. The climate is moist monsoon, with abundant precipitation, wettest in the eastern Himalayas and Upper Burma, where it can receive up to 10,000 mm rain per year. It is an almost constant companion of conifers, e.g. *Abies* spp., *Picea* spp.; *Cedrus deodara* in the western Himalayas, and *Larix griffithii* in the eastern Himalayas; it is especially abundant on slopes with a northerly exposure, where it is the most shade tolerant tree.

Conservation

IUCN: LC

Uses

Himalayan hemlock is a timber tree of some importance locally, but considered by Indian foresters to be inferior to several other Himalayan conifers. Its wood can be split into shingles and together with the bark these are traditionally used in the roofing of wooden houses. The foliage is sometimes burnt as incense in Buddhist religious shrines. This species

has been introduced in Europe (England) in 1838, but is not common in cultivation; sometimes trees are listed under its synonym *T. yunnanensis* when coming from the Chinese part of its range. Its planting is usually limited to arboreta and botanic gardens with living collections of conifers in regions with mild winters and abundant rainfall.

Tsuga forrestii Downie, Notes Roy. Bot. Gard. Edinburgh 14: 18. 1923. *Tsuga chinensis* (Franch.) E. Pritz. var. *forrestii* (Downie) Silba, Phytologia 68: 72. 1990. Type: China: Yunnan, Lijiang Shan, *G. Forrest 17169* (holotype E). Fig. 352

Etymology

The species epithet commemorates the British plant collector George Forrest (1873–1932).

Vernacular names

Forrest's hemlock; li jiang tie shan (Chinese)

Description

Trees to 25–30 m tall, d.b.h. to 1 m; trunk straight, often forked or multistemmed above half of height. Bark soon rough and scaly, orange-brown, in old trees fissured below and brownish grey. Branches ascending, then spreading more horizontally; branches of second order drooping at ends; crown broadly conical in young trees, becoming domed, flat topped, or irregular in old trees. Branchlets (pale) reddish brown or pink-brown, turning grey-brown, ridged and grooved between appressed, apically thickened, decurrent pulvini, (remotely) pubescent, soon glabrous. Vegetative buds globular, 2–3 mm diam., not or slightly resinous, brown. Leaves irregularly pectinate, spreading at nearly 90° from shoot, but shortest leaves more or less erect above shoot, 1–2.5 cm long, ca 2 mm wide, narrowly ovate-linear, straight or curved, flattened, weakly grooved on upperside; margins entire, emarginate or obtuse at apex; stomata in two glaucous white bands separated by a prominent midrib; leaf colour lustrous green or glaucous on upperside. Pollen cones 3–5 mm long, yellow when shedding pollen. Seed cones numerous on outer branchlets of entire crown, short pedunculate or sessile, ovoid-oblong, becoming ovoid-globose when opened, (1.6–)2–3(–4?) cm long, 1.3–2(–3?) cm wide, green or greenish purple, ripening to light brown. Seed scales nearly circular to very broadly elliptic, slightly convex, 10–13 × 8–11 mm at mid-cone; abaxial surface finely striated, glabrous, lustrous; upper margin rounded, entire, or erose in old cones; base short pedicellate. Bracts broadly ovate, with denticulate margins, acutish, 3–4 mm long. Seeds ovoid-oblong, 3.5 × 2 mm, brown; seed wings obliquely ovate, 8 × 4 mm, yellowish brown, transparent.

Taxonomic notes

This species is very similar to *T. dumosa* and possibly only a subspecies of it. Its characters place it between *T. dumosa* and *T. chinensis*; it occurs in the area where the ranges of these two species meet: the Lijiang Shan and mountains to the northwest (NW Yunnan) and north (SW Sichuan). Cheng & Fu (1978) reported seed cones of max. 4 × 3 cm, but neither the type (*G. Forrest 17169*, holo. E, iso. K), nor other collections I have seen have such large cones. Perhaps trees with such cones are *T. chinensis* var. *robusta*. In Flora of China 4: 41 (1999), *T. forrestii* has been treated as a variety of *T. chinensis*.

Distribution

China: NE Guizhou (Jiangkou: Fanjing Shan), SW Sichuan, NW Yunnan.
TDWG codes: 36 CHC-SC CHC-YN

Ecology

Like the other two species occurring on the SW Plateau of China, *T. forrestii* is a high mountain species occurring between 2000 m and 3500 m a.s.l. The soils are mostly podzolized. The climate is temperate to cold temperate, with annual precipitation between 1000 mm and 2000 mm. It is a constituent of the montane boreal coniferous forest formation, where it is mixed with *Abies* spp., *Picea* spp., *Larix potaninii*, occasionally *Pseudotsuga sinensis, Cephalotaxus fortunei*, and broad-leaved trees, e.g. *Betula albosinensis, Acer* spp., *Sorbus* spp. *Quercus* spp., and *Magnolia* spp. *Tsuga forrestii* remains in most places a minor component of the forest (Wang, 1961).

Conservation

This species has a limited range separated into two or three disjunct areas. Deforestation and logging have substantially reduced the area of occupancy (AOO) of this species. A reassessment in 2010 considered that decline has slowed but not ceased in which case a suspected past reduction of ≥30% meets the criteria for Vulnerable under A2.
IUCN: VU (A2c, d)

Uses

Forrest's hemlock is a timber tree used for construction, aircraft, furniture and as props for mines. This species is present in several arboreta in Europe and North America, almost exclusively from early 20th century introductions made by the famous 'plant hunters' of the time. These planted trees usually bear a good crop of seed cones with viable seed and in sufficiently wet places like western Scotland's arboreta, they can be seen to self-propagate seedlings. However, since this species is rarely the only one of it's genus planted there, we cannot be sure, without specialized genetic research, that the seedlings are 'pure' *T. forrestii*. This creates a problem for the maintenance of the species in cultivation. If taken from cuttings, we base its propagation on a very narrow genetic basis; from seeds we may introduce 'alien' genes into the stock of young trees. Ideally, conifers like this are continually introduced from correctly identified natural sources. Under the current restrictive legislation pertaining to plant collecting and international traffic of the same and its propagules, this option has become much more difficult to realize. In the long term, ill-considered legislation may seriously hamper the perpetuation of laboriously assembled species collections in arboreta and botanic gardens.

Tsuga heterophylla (Raf.) Sarg., Silva N. Amer. 12: 73, t. 605. 1899. *Abies heterophylla* Raf., Atlantic J. 1: 119. 1832. Type: not designated. Fig. 353

Etymology

The species epithet describes the variable size of the leaves on a single shoot.

Vernacular names

Western hemlock, Pacific hemlock

Description

Trees to 60–70 m tall, d.b.h. to 1.5–2.5 m; trunk straight, often more or less buttressed at base (from originating on a 'nurse log'). Bark on trunk rough and scaly, fissured below, dark grey. Branches spreading horizontally, drooping at ends; crown in young trees conical, with drooping leader, in old trees broad conical. Branchlets reddish brown above, pale yellowish below, turning grey in second year, finely ridged and grooved between small, dark tipped, appressed, decurrent pulvini, lanate pubescent with short brown hairs, mixed with fewer long whitish hairs, glabrescent after third year. Vegetative buds ovoid-conical, 1.5–2 mm long, not resinous, densely pubescent, pale brown or reddish brown. Leaves of unequal length, with longer leaves spreading sideways or radially, parted below the shoot, 0.7–2(–2.3) cm long, 1.5–2 mm wide, (very) narrowly elliptic, flattened, grooved above; margins denticulate; apex obtuse or slightly emarginate; stomata in 2 white bands on abaxial (under) side separated by a midrib; leaf colour dark green on upperside. Pollen cones subglobular, 3–5 mm long, crimson or light red, yellow at anthesis. Seed cones numerous on all outer branchlets, on 4–6 mm long, pubescent peduncles, ovoid-oblong when closed, subglobular with opened seed scales, 1.4–2.2(–3) cm long, 1.5–2.5 cm wide, light green or grey-green, occasionally tinged violet, ripening to light brown, but unexposed part of seed scales turning dark brown. Seed scales suborbicular, ovoid-oblong or oblong, thin, opening wide, 6–13 × 5–9 mm at mid-cone; exposed part of abaxial surface striated or wrinkled, glabrous; upper margin rounded or obtuse; base short pedicellate. Bracts triangular, 2–4 mm long. Seeds ovoid-oblong, 2–3.5 mm long, (light) brown; seed wings ovate triangular, 4–10 mm long, light yellowish brown, transparent.

Distribution

W North America: along the coast from Alaska to N California and in the Cascade Range, also in

the northern Rocky Mountains (mainly in British Columbia and Idaho).

TDWG codes: 70 ASK 71 ABT BRC 73 IDA MNT ORE WAS 76 CAL

Ecology

Tsuga heterophylla occurs from sea level to 600 m a.s.l. along the Pacific coast, in the Rocky Mountains it reaches to 1800 m. It grows on a variety of soils with an acid organic top layer (pH 3.5–5). The climate is cool maritime along the coast, cold montane in the interior, the annual precipitation varies between (500–)900–3800 mm, decreasing towards the interior. Dry summers limit its range in the Rocky Mountains. It is highly sympatric with *Picea sitchensis* in most of the range. It is extremely shade tolerant, but has a shorter life span than *Pseudotsuga menziesii* or *Picea sitchensis*. Close along the coast it may form occasionally pure stands, but more commonly it is an important constituent of the (maritime) mesothermal coniferous forest. On the Olympic Peninsula of Washington it reaches maximum size, together with other giant conifers. Its tolerance to shade allows it to grow up under the canopy of other trees, but a thick moss layer usually prevents the light seeds from reaching the soil. Instead, seeds germinate massively on fallen trees ('nurse logs'), from where a few saplings are able to send roots down into the soil; as a result *T. heterophylla* often stands in rows ('collonades') long after the nurse log has rotten away.

Conservation

IUCN: LC

Uses

Western hemlock is an important timber tree in the Pacific Northwest (USA) and W Canada. Unlike its eastern sister species it is a fast grower even outperforming Douglas fir. The timber is used for pilings, poles and railway sleepers and especially for construction. A large proportion of the annual harvest goes to the wood pulp industry for various applications. This species has been introduced in Britain and other parts of NW Europe as a forestry plantation tree; in the wetter parts near the Atlantic coast it will regenerate spontaneously. As an extremely shade tolerant conifer it is suitable as an under planted tree in deciduous broad-leaved forest; however, as it in turn shades out every growth under it, this should not be done in (semi) natural woodland where the indigenous flora is valued. Although frequently planted as a specimen tree in arboreta and parks, mainly within its natural range and in the British Isles, this species is not much used in horticulture and few cultivars have been raised.

Tsuga mertensiana (Bong.) Carrière, Traité Gén. Conif., ed. 2, 1: 250. 1867.

Etymology

This species was named after Karl Heinrich Mertens (1796–1830), whose plant collections from the American Pacific coast were studied by A. H. von Bongard in St. Petersburg.

Vernacular names

Mountain hemlock

Description

Trees to 30–40(–45) m tall, d.b.h. to 1–1.5 m; trunk straight, but often curved or almost prostrate at tree limit. Bark deeply fissured in the lower part of the trunk, dark reddish brown. Branches spreading or assurgent; crown usually narrowly conical, but often deformed by wind. Branchlets yellowish or orange-brown, turning grey in 2–4 years, with ridges ending in decurrent pulvini with oval leaf scars, densely yellowish pubescent. Vegetative buds ovoid conical, 2–3 × 1–2 mm, not resinous, brown. Leaves densely covering shoot, directed forward, ascending above shoot, (0.5–)0.7–2(–2.5) cm long, 1–1.5 mm wide, short petiolate at base, linear, straight or curved, thick, 3–4 sided or with convex sides, shallowly grooved near base, obtuse or acutish at apex; stomata in several lines on all sides; leaf colour green or glaucous green. Pollen cones pendulous, ca. 1 cm long, at first purplish blue, then yellow with purple tinge. Seed cones mostly near top of tree, erect at

first, later mostly pendant, short pedunculate or sessile, ovoid-oblong to cylindrical, obtuse at apex, (2–)3–5.5(–8.1) cm long, (1.1–)1.5–2.5(–3.3) cm wide with opened scales, purplish blue when young, ripening to dark brown or light brown. Seed scales 40–72(–80?), obovate-cuneate, 10–13(–20) × 7–10(–15) mm at mid-cone, spreading very wide or reflexed when mature, puberulent when immature, but soon glabrous; upper margin rounded, entire; base short pedicellate. Bracts ligulate-cuspidate, 4–7 mm long, visible with opened seed scales. Seeds cuneate, 3–5 × 2–2.5 mm, brown; seed wings oval-oblong, 4–7 × 3–3.5 mm, light brown.

Distribution

Pacific Coast Region of NW North America: from Alaska to California, in the Cascade Range and Sierra Nevada, and isolated occurrences in the northern Rocky Mountains.
TDWG codes: 70 ASK 71 BRC 73 ORE WAS 76 CAL NEV

Ecology

Tsuga mertensiana is a subalpine species, occurring from near sea level in Alaska to 1500 m a.s.l. along the coast; in the Cascade Range between 1200 m and 2100 m a.s.l., and in the Sierra Nevada (subsp. *grandicona*) between 1800 m and 3350 m a.s.l. It grows on a variety of non-alcareous acidic soils, sometimes on peat, more commonly on mor humus (pH 3.1–3.9). Subsp. *mertensiana* is restricted to a climatic zone with high precipitation, in British Columbia between 2000 mm and 4000 mm per year, with long, snowy winters and short, cool summers. Subsp. *grandicona* grows in a much drier climate, but there primarily on high, N-facing slopes. The species is a major component of the Mountain hemlock-Subalpine fir forest, occurring in pure stands or mixed with *Abies lasiocarpa*, locally also with *A. amabilis, Picea glauca, P. sitchensis, P. engelmannii* (Rocky Mts.), *Pinus* spp., *Tsuga heterophylla, Xanthocyparis nootkatensis, Juniperus occidentalis*, and *Betula papyrifera*.

Uses

This slow growing species produces moderately strong wood, but its use is limited due to environmental considerations. It is soft and close-grained, with brown heartwood, sometimes pinkish, and lighter sapwood; its uses are now restricted to carpentry and some limited construction applications. In its natural habitat it is much appreciated by hikers for its picturesque appearance on mountain ridges. It also makes an excellent ornamental tree for gardens with its dense foliage growing from long and short shoots and naturally conical habit. Despite this, it is uncommon in gardens and only a limited number of cultivars is known. Among these the 'blue' or glaucous leaf forms or selections are especially valued. High altitude provenances may be susceptible to 'late' frost, but those from more coastal northern areas should not suffer from this kind of damage as much.

2 subspecies and 2 varieties are recognized:

Tsuga mertensiana (Bong.) Carrière subsp. ***mertensiana*** var. ***mertensiana***. *Pinus mertensiana* Bong., Mém. Acad. Imp. Sci. Saint-Pétersbourg, sér. 6, Sci. Math. 2: 163. 1832; *Hesperopeuce mertensiana* (Bong.) Rydb., Bull. Torrey Bot. Club 39: 100. 1912. Type: not designated. Fig. 354

Description

Short shoots apparent. Leaves usually crowded and ascending above shoots. Seed cones (2–)3–5.5 (–6) cm long; seed scales 50–72(–80?) in number, 10–13 × 7–10 mm, dark brown.

Distribution

Pacific Coast Region of North America: from Alaska to N California, also Rocky Mountains in interior British Columbia and Idaho.
TDWG codes: 70 ASK 71 BRC 73 IDA ORE WAS 76 CAL

Conservation

IUCN: LC

Tsuga mertensiana (Bong.) Carrière subsp. ***mertensiana*** (A. Henry) C. K. Schneid. var. ***jeffreyi***, in Silva-Tarouca, Uns. Freil.-Nadelhölzer: 294. 1913. *Tsuga pattoniana* (Balf.) Sénécl. var. *jeffreyi* A. Henry, in Elwes & Henry, Trees Gr. Brit. Ireland 2: 231. 1907; *Tsuga ×jeffreyi* (A. Henry) A. Henry, Proc. Roy. Irish Acad. 34: 55. 1919; *×Hesperotsuga jeffreyi* (A. Henry) C. N. Page, Notes Roy. Bot. Gard. Edinburgh 45: 389. 1989. Type: not designated.

Description

Foliage sprays short, asurgent; short shoots not distinct. Leaves more or less pectinately arranged. Seed cones as in var. *mertensiana* (?).

Taxonomic notes

This taxon was described from material said to have come from Vancouver Island; however, recently it has not been found there, nor on the mainland of British Columbia or in Washington, USA (Robert Van Pelt, University of Seattle, pers. comm. August 2005). It was at some time considered to be a hybrid between *T. heterophylla* and *T. mertensiana*, but no such hybrids have been confirmed to occur in nature by recent investigators.

Distribution

Canada: British Columbia (Vancouver Island).
TDWG codes: 71 BRC

Ecology

Presumably mixed coniferous forests in the Pacific Coast Region of North America.

Conservation

IUCN: DD

Tsuga mertensiana (Bong.) Carrière subsp. ***grandicona*** Farjon, Proc. Kon. Ned. Akad. Wetensch., C, Bot. 91 (1): 39. 1988. Type: USA: California, Mono Co., Mammoth Lakes, Twin Lakes, *B. Willard 54* (holotype RM).

Description

Short shoots apparent. Leaves usually crowded and ascending above shoots. Seed cones 3.5–8.1 cm long, 1.9–3.3 cm wide; seed scales (40–52)(–60?) in number, 12–18(–20) × 10–15 mm, light brown.

Distribution

USA: California (Siskiyou Mts., Sierra Nevada), W Nevada, S Oregon?
TDWG codes: 76 CAL NEV

Conservation

IUCN: LC

Tsuga sieboldii Carrière, Traité Gén. Conif.: 186. 1855. Type: Japan: ["in Japonia"], *P. F. von Siebold s.n.* [comm. 1842 *ex herb*. Zuccarini No. 265] (lectotype M).

Etymology

This species was named after Philipp Franz von Siebold (1796–1866), who studied the flora of Japan when stationed there in the employ of the Dutch East India Company.

Vernacular names

Southern Japanese hemlock; tsuga, toga-matsu (Japanese)

Description

Trees to 25–30 m tall, d.b.h. to 1.5–2.5 m; trunk straight or curved, rarely forked. Bark becoming rough and scaly, breaking into square plates, dark grey. Branches spreading horizontally or assurgent;

crown broad conical in young trees, with drooping leader, broadly domed or irregular, open and flat topped in old trees. Branchlets lustrous light brown, becoming grey with age, barely grooved between appressed, decurrent, orange-brown pulvini, glabrous or minutely pubescent. Vegetative buds ovoid or ovoid-conical, 2–2.5 mm long, not resinous, dark orange-brown. Leaves parted above shoot, of unequal length, with shortest leaves assurgent above shoot, some recurved, pectinate below the shoot, (0.5–)1–1.5(–2) cm long, 2–2.5 mm wide, usually widest near truncate-emarginate apex, linear or ligulate-linear, flattened, longitudinally grooved on upperside; stomata on the abaxial (under) side in two whitish bands separated by a midrib; leaf colour lustrous light green on upperside. Pollen cones crowded, 3–5 mm long, yellow when ripe. Seed cones numerous on outer branchlets of entire crown, short pedunculate or sessile, ovoid when closed, more globose with opened scales, (1.6–)2–2.5(–3) cm long, 1.4–2(–2.5) cm wide, green or purplish green, ripening to lustrous (pale) brown. Seed scales nearly circular, slightly convex, 8–10 × 8–12 mm at mid-cone; abaxial surface striated or wrinkled, with imprints of overlapping scales, glabrous; upper margin rounded or truncate, entire, undulate or (slightly) incurved; base auriculate-pedicellate. Bracts obtriangular, with denticulate upper margin, 2–3 mm long. Seeds ovoid, 2–3 × 1.5 mm, brown; seed wings ovate-oblong, 5–6 × 3 mm, light yellowish brown, transparent.

Distribution

Japan: S Honshu, Kyushu, Shikoku, Yakushima; South Korea (Ullung-Do [Dagelet Island]).
TDWG codes: 38 JAP-HN JAP-KY JAP-SH KOR-SK

Ecology

Tsuga sieboldii grows in hills and mountains at altitudes between (100?–)400 m and 1500 m a.s.l. (from 500 m to 950 m on Shikoku). It grows on various soils derived from granitic or volcanic rock. The climate is moist temperate, with annual precipitation between 1000 mm and 2000 mm, the winters are relatively mild. *Tsuga sieboldii* is usually associated with conifers such as *Abies firma, Pseudotsuga japonica, Chamaecyparis obtusa, Cryptomeria japonica, Pinus densiflora, P. parviflora*, and *Sciadopitys verticillata*, and with broad-leaved trees, e.g. *Stewartia monadelpha, Distylium racemosum* and *Trochodendron araliioides*. It rarely grows in pure stands.

Conservation

The species has been heavily logged in the past, especially in the northern lower altitude parts of its range.
IUCN: NT

Uses

The uses of the wood of Southern Japanese hemlock are mainly construction, carpentry and furniture making. It grows less abundantly than Northern Japanese hemlock and was therefore not used on such a large scale as a source for paper pulpwood. As an ornamental tree it is grown in Japanese gardens and parks, temple grounds and also in large pots. This species was introduced to Europe (the Netherlands) in 1850 by Von Siebold and is still in cultivation on both sides of the North Atlantic, but uncommon. It is slow growing and often makes a shrubby, spreading tree with a dense crown.

Widdringtonia Endl., Gen. Pl. Suppl. 2: 25. 1842. Type: *Widdringtonia nodiflora* (L.) Powrie [*Brunia nodiflora* L., lectotype by Powrie, 1972] (*Cupressaceae*).

Pachylepis Brongn., Ann. Sci. Nat. (Paris) 30: 189. 1833, *non* Less. (1832). Type: *Pachylepis cupressoides* (L.) Brongn. [*Thuja cupressoides* L.]; *Parolinia* Endl., Gen. Pl. Suppl. 1: 1372. 1841, *non* Webb (1840). Type: *Thuja cupressoides* L. [= *Widdringtonia nodiflora* (L.) Powrie].

Named after Samuel Edward Widdrington (1787–1856, formerly Cook), Commander of the Royal Navy.

Description

Shrubs or trees to 50 m tall, evergreen, monoecious; trunk monopodial or multistemmed, resprouting from base or not. Resin in leaves and seed cones. Bark becoming fibrous soft or hard and fissured, sometimes tesselated, exfoliating in long or short strips. Branches assurgent, ascending or spreading; foliage branches spreading to more or less erect. Leaves scale-like, decussate on smallest branchlets, becoming more or less spirally arranged (bijugate) on thicker, leading (whip) branchlets (by twisting of internodes), on ultimate branchlets appressed, ovate to rhombic, increasing in size and becoming long decurrent on leading branchlets, upper leaf margins minutely denticulate, apices often reflexed on leading, thicker branchlets; amphistomatic, scale leaves eglandular. Pollen cones terminal, solitary; microsporophylls 4–8, decussate, bearing 3–5 abaxial pollen sacs. Seed cones lateral, usually clustered (to 50 mature cones), sometimes terminal and solitary on short shoots, initially consisting of 4 decussate, wide spreading green bracts and numerous ovules, maturing in two growing seasons to irregular-globose, serotinous but eventually wide openening cones. Bract-scale complexes 4 (rarely 6), valvate, in two pairs of slightly unequal size and shape, thick woody, the two largest more or less truncate, the smaller pair more acute, outer surface smooth to rugose, not or variably verrucose, with an upcurved or recurved boss enclosing or exposing the bract apex, inner surface with whitish seed scars at base. Columella short, thick, angular, sometimes double. Seeds usually numerous, flattened or angular, with or without 2 wings of unequal size. Seedlings with 2–4 cotyledons.

4 species

Distribution

Southern Africa: from the Cape to Malawi.

Key to the species of *Widdringtonia*

1a. Seed cone scales strongly verrucose along margins only, rugose on abaxial surface, with a thick, robust boss (bract apex) **3**

1b. Seed cone scales smooth, rugose or irregularly verrucose, with a thin, flattened boss **2**

2a. Trees with monopodial stem and thick, fibrous, soft bark, never sprouting from base. Endemic to Mt. Mulanje, Malawi ***W. whytei***

2b. Trees monopodial or multi-stemmed, with thin, dense and hard bark, often sprouting from base. Widespread from the Cape to Malawi ***W. nodiflora***

3a. Seeds angular-ovoid, with rudimental wings or nearly wingless. Endemic to the Cedarberg Mountains in Cape Province ***W. cedarbergensis***

3b. Seeds ovoid-oblong, with two wings exceeding 3–4 mm beyond the seed apex. Endemic to the Willowmore District in Western Cape Province ***W. schwarzii***

Widdringtonia cedarbergensis J. A. Marsh, Bothalia 9 (1): 125. 1966. Type: South Africa: Cape Province, Clanwilliam Distr., Sederberge, near Middelberg West Peak, *H. A. Lückhoff s.n.* (holotype PRE).
Fig. 355

Etymology

The species epithet refers to the Cedarberg Mts. in Western Cape Province, where this species is endemic.

Vernacular names

Clanwilliam Cypress, Clanwilliam Cedar, Cape Cedar; Clanwilliamseder, Sederboom (Afrikaans)

Description

Small trees to 20–22 m tall, often only 5–7 m; trunk usually monopodial, stunted on exposed sites, to 70 cm d.b.h. Bark on trunks becoming tesselated, exfoliating in small flakes. Branches spreading, contorted, forming a pyramidal crown in young trees, spreading and irregular in older trees. Ultimate foliage branchlets 5–20 mm long, more or less quadrangular in cross section, 1.5 mm wide, persistent. Leaves on ultimate branchlets appressed, triangular-ovate to rhombic, ca. 1.5 × 1 mm, increasing in size on older branchlets to 15 × 4 mm, keeled at base; upper margins minutely denticulate; apex obtuse to acute; stomata on both sides in two marginal lines; leaf leaf colour dull light green. Pollen cones oblong, 3–5 × 1.5–2 mm; microsporophylls peltate, coriaceous, broadly triangular to ovate, bearing 3–4 abaxial pollen sacs near base. Seed cones clustered on foliage branchlets, on reduced dwarf shoot axillary to more or less spirally arranged leaves, sometimes terminal on short shoots, maturing in two growing seasons to irregular-globose, 20–30 mm diam., serotinous but eventually wide openening cones. Bract-scale complexes 4, thick woody, oblong, max. 25 × 15 × 10 mm, curved slightly inward; outer surface rugose, strongly verrucose along margins, with a prominent, 4–6 mm long, subapical, recurved boss enclosing bract apex, purplish brown or blackish brown; inner surface with angular, 4–6 mm long seed scars at base, yellow and lustrous brown. Columella short, thick, angular, to 6 mm tall. Seeds (8–)10–20(–23) per cone, angular-ovoid, to 10 × 6 mm, trigonous, slightly flattened, lustrous yellowish brown ripening blackish brown, with dull lighter hilum at base; wings 2, rudimental, forming thin, to 1 mm wide strips above widest part of seed, joining at seed apex.

Taxonomic notes

The name *Widdringtonia juniperoides* (L.) Endl., based on *Cupressus juniperoides* L., has been applied to this species (e.g. Dallimore & Jackson's A Handbook of Coniferae and Ginkgoaceae, ed. 4, 1966: 651). However, the true identity of that name is enigmatic because the original description is too vague, the origin of the plant unknown and no specimen or illustration exist that could help identification and serve as type. A new name was necessary, published in the same year 1966 (*op. cit.*). The basionym *Cupressus juniperoides* L., together with all combinations based on it, were listed with the *incertae cedis* in the recent Monograph of *Cupressaceae* and *Sciadopitys* (Farjon, 2005a).

Distribution

South Africa: Western Cape Province, Clanwilliam District, Cedarberg Mts., in several localities restricted to this small mountain range.
TDWG codes: 27 CPP-WC

Ecology

Remnant populations of this species are restricted to rocky ridges and cliffs ('krantzes' or 'kranse') of Table Mountain Sandstone, avoiding other formations below and above it. The altitudinal range is (915–)1000–1500(–1650) m a.s.l. The trees are often protected by large boulders from frequent brush fires in the surrounding (secondary) fynbos vegetation. The annual rainfall is between 500–1000 mm and occurs mostly in the cold winter months, while summers are dry and hot.

Conservation

There is a substantial literature concerned with the conservation aspects of this relict species (for a selection, see Schellevis & Schouten in Farjon & Page, 1999: 91). Reports of a once existing forest of Clanwilliam cedars on the Cederberg are, by the nature of European colonisation and the lack of earlier as well as contemporaneous written records, anecdotal. Yet it is very likely that a historical reduction of more than 75% and perhaps as much as 95% has occurred, resulting in a destroyed forest cover now replaced by fynbos, a highly flammable vegetation formation. The frequent fires prevent regeneration; surviving trees are restricted to rocky ridges, ledges, and outcrops mostly beyond reach of the flames. Attempts at

replanting are continually being made with low rates of success (Mustart *et al.*, 1995) and extensive *ex situ* conservation efforts are underway in South Africa, backed by smaller scale plantings elsewhere.
IUCN: CR (A2c, d)

Uses

Clanwillian cedar has been extensively logged for its dense, easily workable and durable timber by European settlers. It was used for fence posts, construction of farm houses and sheds and later for carpentry, furniture, and cabinet making, until the resource dwindled and the last stands were almost destroyed by fires. In the nearby town of Clanwilliam beautifully worked examples can be seen in the Anglican church (doors, pews, carved altar) and Courthouse. Today the few remaining trees are protected from cutting for any purposes. Cultivation is now undertaken primarily with a view of population restoration and the species is consequently grown in local nurseries as well as in several botanic gardens.

Widdringtonia nodiflora (L.) Powrie, J. S. African Bot. 38 (4): 303. 1972. *Brunia nodiflora* L., Sp. Pl.: 199. 1753. Type: South Africa: Cape Province, *leg. ign. s.n.* [Clifford Herbarium, 'Brunia 1'] (lectotype BM). Fig. 356

Thuja cupressoides L., Mant. Pl. 1: 125. 1767; *Widdringtonia cupressoides* (L.) Endl., Gen. Pl. Suppl. 2: 25. 1842. [Cat. Hort. Vindobon. 1: 209. 1842].
Widdringtonia dracomontana Stapf, Bull. Misc. Inform., Kew 6: 206. 1918; *Widdringtonia nodiflora* (L.) Powrie var. *dracomontana* (Stapf) Silba, Phytologia 68: 74. 1990.

Etymology

The species epithet means 'with flowers at nodes', but how Linnaeus could see this remains enigmatic.

Vernacular names

Mountain Cypress, Cape Cypress; Bergsipres, Bergsapree (Afrikaans); Thaululo (Venda); Nwelelwentaba (Zulu)

Description

Shrubs or trees to 20–25 m tall; trunk monopodial or multistemmed, resprouting from base, to 50 cm d.b.h. Bark on trunks becoming fibrous but hard, to 10–15 mm thick, when fissured forming anastomosing ridges, brown-grey, exfoliating in small strips. Branches assurging or ascending, forming a conical or pyramidal, eventually irregular crown. Ultimate foliage branchlets 5–15 mm long, more or less quadrangular in cross section, 1 mm wide, persistent. Leaves on ultimate branchlets appressed, ovate to rhombic, 1.5–2 × 1–1.5 mm, larger and decurrent to ca. 10 × 4 mm on older branchlets, weakly keeled at base; upper margins minutely denticulate; apex obtuse to acute, often reflexed on older branchlets and on branches with transitional leaves; stomata on both sides in two marginal lines; leaf colour dull light green. Pollen cones oblong, 3–5 × 1.5–2 mm; microsporophylls peltate, coriaceous, broadly triangular to ovate, bearing 3–5 abaxial pollen sacs near base. Seed cones clustered (to 50 mature cones) on foliage branchlets, sometimes terminal on short shoots, maturing in two growing seasons to irregular-globose, 10–20(–22) mm diam., serotinous but eventually wide openening cones. Bract-scale complexes 4, thick woody, oblong, max. 20 × 10 × 7 mm, curved slightly inward; outer surface smooth to rugose, not or variably verrucose, with a 1–4 mm long, subapical, upcurved or recurved boss enclosing or exposing the bract apex, (reddish) brown or blackish brown; inner surface with angular, 3–4 mm long, whitish seed scars at base, red-brown, blackish towards base. Columella short, thick, angular, to 5 mm tall, sometimes double. Seeds (3–)10–20(–30) per cone, ovoid, flattened, 5–6 × 3–4 mm without wings, apically curved with a cuspidate tip, blackish brown or black, with dull lighter hilum at base; wings 2, of unequal size, up to 3 mm wide near seed apex, not joining, brown, translucent.

Distribution

Southern Africa: Malawi (Mt. Mulanje), W Mozambique, South Africa, Zimbabwe, in mountainous areas from S Malawi to the Cape.
TDWG codes: 26 MLW MOZ ZIM 27 CPP-EC CPP-WC LES NAT OFS TVL-GA TVL-MP TVL-NP

Ecology

Predominantly in cool and wet mountain fynbos, often in rocky outcrops and among boulders on summits, or in montane grassland often near streams, and in canyon woodland ('kloofbos'), accompanied by numerous fynbos genera (e.g. *Leucadendron, Leucospermum, Metrosideros, Protea, Restio*) or *Pteridium, Myrica pilulifera*, and *Poaceae*, or forming pure stands. The altitude ranges from 100 m to 2590 m a.s.l. Soils are nutrient-poor, acidic, derived mostly from granite, quarzite or sandstone. The climate varies from Mediterranean in the Cape region to subtropical with summer rains and tropical montane in Malawi.

Conservation

This widespread species, which is capable of coppicing after above-ground destruction (fire), is not threatened with extinction.
IUCN: LC

Uses

No commercial uses have been recorded for this species. It may be readily coppiced and is probably used for firewood locally. Its only horticultural use seems to be limited to plantings in botanic gardens; under glass where frost occurs and outdoors in regions with a mild climate. It is suitable for planting in countries with a Mediterranean climate (and is planted in California) and should be used more often, provided it has first been assessed and found not likely to become invasive.

Widdringtonia schwarzii (Marloth) Mast., J. Linn. Soc., Bot. 37: 269. 1905. *Callitris schwarzii* Marloth, Bot. Jahrb. Syst. 36: 206. 1905. Type: South Africa: Cape Province, Willowmore Distr., Kougaberge, *R. Marloth 3614* (holotype SAM).

Etymology

This species was named after "Herr E. Schwarz" who drew Marloth's attention to this tree.

Vernacular names

Willowmore Cypress, Willowmore Cedar; Baviaanskloofseder, Sapreehout (Afrikaans)

Description

Trees to 20–25 m tall, now rarely to 40 m; trunk monopodial, to 1–1.5 m d.b.h. Bark on trunks fissured, exfoliating in angular plates. Branches spreading, contorted, forming a pyramidal crown in young trees, more irregular in older trees. Ultimate foliage branchlets 5–10 mm long, more or less quadrangular in cross section, 1 mm wide, persistent. Leaves on ultimate branchlets appressed, triangular-ovate to rhombic, ca. 1.5 × 1 mm, increasing in size on older branchlets to 10 × 4 mm, keeled at base; upper margins minutely denticulate; apex acute, incurved, often reflexed on thicker branchlets and on whip shoots; stomata on both sides in two marginal lines; leaf colour dull light green. Pollen cones oblong, 3–5 × 1.5–2 mm; microsporophylls peltate, coriaceous, narrowly triangular to ovate, bearing 3–4 abaxial pollen sacs near base. Seed cones clustered on foliage branchlets, sometimes terminal on short shoots, maturing in two growing seasons to irregular-globose, 20–30 mm diam., serotinous but eventually wide openening cones. Bract-scale complexes 4, thick woody, oblong, max. 25 × 15 × 10 mm, curved slightly inward; outer surface smooth or striate, strongly verrucose or tuberculate along margins, with a prominent subapical, 5–8 mm long, thick, recurved boss enclosing bract apex, purplish brown or brown; inner surface with angular, 2–3 mm long seed scars at base, yellow and lustrous brown. Columella short, thick, angular, to 6 mm tall. Seeds 14–18(–20?) per cone, ovoid-oblong, 5–6 × 3–4 mm, slightly flattened, curved towards cuspidate apex, yellowish brown ripening blackish brown, with dull lighter hilum at base; wings 2, on either side of seed, exceeding 3–4 mm beyond retuse seed apex, unequal, thin, more or less translucent.

Distribution

South Africa: Eastern Cape Province, Willowmore District, Kougaberge, in canyons ['kloofs'] draining into the Baviaanskloof and tributaries.
TDWG codes: 27 CPP-EC

Ecology

Widdringtonia schwarzii occurs in rocky ravines on steep slopes or cliffs ('krantzes' or 'kranse') and in (dry) river beds of canyons between (600–)900–1200 m a.s.l. Trees can attain large size in rocky streambeds of canyons, sheltered from 'veld fires', where they can form small groves. The climate is Mediterranean with mostly winter rain; the dry, hot summers are somewhat tempered by the sheltered microclimate in deep, shady canyons, where deeper ground water remains available under stream beds.

Conservation

In the past, settlers have exploited this species, which is capable of growing to large trees, to near extinction in all accessible areas. In recent years, new localities have been found in remote upper parts of canyons in the Kouga Mountains, some of which harbour large trees. There is now much awareness of its conservation value and an active management programme (largely to prevent wildfires) is being implemented. Further cutting of trees is prohibited.
IUCN: VU (A1c, d)

Uses

Willowmore Cedar was used in the past for construction timber of local farmsteads and for furniture making. Depletion of the resource to a few trees in inaccessible locations terminated this use and the remaining trees are now protected. In cultivation it is only present in a few botanic gardens and in some private gardens in California and Oregon. It should be tried more often in summer-dry regions.

Widdringtonia whytei Rendle, Trans. Linn. Soc. London, Bot., ser. 2, 4: 60, t. 19. 1894. *Widdringtonia nodiflora* (L.) Powrie var. *whytei* (Rendle) Silba, Phytologia 68: 74. 1990. Type: Malawi: Mulanje District, Mulanje Highlands, Mt. Mulanje, *A. Whyte s.n.* (holotype BM). Fig. 357

Etymology

This species was named after Alexander Whyte, who explored Mt. Mulanje, Malawi, in 1891.

Vernacular names

Mulanje Cypress, Mulanje Cedar; Nkungudza (Chichewa)

Description

Trees to 40–50 m tall; trunk monopodial, usually straight, to 1–1.5(–2?) m d.b.h. Bark on trunks becoming soft fibrous, to 2–4 cm thick, fissured, brown-grey, exfoliating in long strips. Branches spreading or ascending, forming a pyramidal, eventually irregular or flat-topped crown. Ultimate foliage branchlets (3–)7–20 mm long, more or less quadrangular in cross section, 1–1.5 mm wide, persistent. Leaves on ultimate sterile branchlets appressed or with some free apices, ovate to rhombic, 1.5–3.5 × 1–1.5 mm, increasing in size on leading branchlets (whip shoots) to ca. 10 × 4 mm, weakly keeled at base; upper margins minutely denticulate; apex obtuse to acute, often reflexed on older branchlets and on whip shoots; stomata on both sides in two marginal lines; leaf colour dull light green. Pollen cones oblong, 3–6 × 1.5–2 mm; microsporophylls peltate, coriaceous, broadly triangular to ovate, bearing 3–5 abaxial pollen sacs near base. Seed cones solitary or grouped (not clustered) on foliage branchlets, sometimes terminal on short shoots, maturing in two growing seasons to irregular-subglobose, 15–22 mm diam., serotinous but eventually wide openening cones. Bract-scale complexes 4 (rarely 6), thick woody, oblong, max. 25 × 15 × 8 mm, curved slightly inward; outer surface smooth to rugose, not or variably verrucose, with a 1–4 mm long, subapical, upcurved or recurved boss enclosing or exposing the bract apex, (reddish) brown or blackish brown; inner surface with angular, 3–4 mm long, whitish seed scars at base, red-brown, blackish towards base. Columella short, thick, angular, to 5 mm tall, sometimes double. Seeds 3–10(–18) per cone, ovoid, flattened, 5–7 × 2–3 mm without wings, blackish brown or black, with dull lighter hilum at base; wings 2, of unequal size, up to 3 mm wide near seed apex, not joining, brown, translucent.

Distribution

S Malawi (Mt. Mulanje).
TDWG codes: 26 MLW

Ecology

Widdringtonia whytei is an important to co-dominant species in the Afromontane forest on Mt. Mulanje, which also includes *Podocarpus milanjianus, Cassipourea malosana, Ekebergia capensis, Olea capensis, Polyscias fulva, Rapanea melanophloeos*, and *Xymalos monospora*, and in the more fire-prone ecotone (with ericaceous scrub) to grassland, the closely related species *Widdringtonia nodiflora*. It is a successional species after fire ("periodic fire climax"), but unlike its congener, it does not coppice from (fire-caused) stumps and has to regenerate from seed (Pauw & Linder, 1997). Thickets of *Erica benguelensis* which develop after fire offer protection for cedar seedlings, leading to *Widdringtonia whytei* becoming the dominant tree until invading angiosperms succeed; however these have been prevented from doing so by the next fire at a cycle of 100–200 years. Mt. Mulanje is a granitic batholith rising through surrounding older sediments. The soils are therefore largely rocky, acidic and shallow except in colluvial pockets in gorges and valleys. The altitudinal range is 1830–2550 m a.s.l. The climate is cool tropical montane, with abundant precipitation, much of it as fog.

Conservation

This species is acutely threatened with extinction because of excessive felling in the past 100+ years and increased fire frequency (Chapman, 1995). Certainly at present only moribund or severely exploited stands remain, mostly on less accessible sites. The species is now officially protected on Mt. Mulanje, but enforcement proves to be difficult as the timber fetches high prices (Chapman, 1995; Pauw & Linder, 1997). Population increase in villages surrounding the mountain massif indirectly affects the remaining populations through increased grazing of livestock and the incidence of fires. Illegal timber extraction continues to be a problem. Another potential threat is the invasive pine *Pinus patula*, which is now being found in both grassland and forest on the mountain. A more proactive strategy, involving the protection of natural regeneration and perhaps planting, is urgently needed to save this species from extinction. Ecologically it is at a disadvantage compared with its more adaptable congener on Mt. Mulanje, *W. nodiflora* (Pauw & Linder, 1997). In past plantings, no distinction seems to have been made between the two species and this has to change if future plantings are to successfully contribute to the restoration of *W. whytei*.

IUCN: CR [A4a, c–e; B2ab (i–v)]

Uses

The wood of this species is highly valued for construction and building of houses as it is the only sizable tree in the family *Cupressaceae* that occurs naturally in a large surrounding region. Its wood, as of other members of the family, is decay and insect resistant. Large timber yielding trees are becoming increasingly rare due to overexploitation of this valuable resource for more than a century (Chapman, 1995). Attempts at plantation forestry using this species have been made, but have been much less sucessful than the plantations of the exotic species *Cupressus lusitanica* which grows faster. It also appears that most of these plantations involve a mixture of two species (Pauw & Linder, 1997), often with *W. whytei* at a disadvantage as it grows slower. The wood of *W. whytei* is yellowish brown and of excellent quality for construction, general carpentry and joinery, wood panelling, flooring, and furniture making. In colonial times some of its wood found its way to English interiors, nowadays there is no export of this timber. This species does not appear to be in horticultural use, although it is present in a few botanic gardens in South Africa.

Wollemia W. G. Jones *et al.*, Telopea 6 (2–3): 173. 1995. Type: *Wollemia nobilis* W. G. Jones *et al.* (*Araucariaceae*).

Named after the Wollemi National Park (an Aboriginal name for the numerous canyons in the region).

Description

See the species description.

Distribution

As for the species.

Wollemia nobilis W. G. Jones *et al.*, Telopea 6 (2–3): 174. 1995. Type: Australia: New South Wales, Wollemi N. P., [exact locality kept secret], *W. G. Jones* NSW *362731* (holotype NSW). Fig. 358, 359, 360

Etymology

The species epithet *nobilis* is Latin for noble and communicates the impression the tree gave its describers, but also refers obliquely to the discoverer of the first population of the species, David Noble.

Vernacular names

Wollemi pine

Description

Evergreen monoecious trees to 40 m tall, frequently coppicing from base; trunks to 1.2 m diam, crown slender, columnar, broadest at about a third of total height. Bark peeling in thin, fragile, equi dimensional dark red-brown scales on younger stems, becoming densely covered with soft and spongy darkening nodules or tubercules to 10 mm in diam. Orthotropic shoots with helically arranged, decurrent, narrowly triangular leaves 3–10 mm long, 2–4 mm wide at base. Juvenile and lower canopy plagiotropic shoots horizontal, leaves opposite or subopposite, distichous and twisted to present adaxial surfaces uppermost, linear to narrowly triangular, chartaceous, rounded or obtuse, hypostomatic, deep green above, glaucous below, broad-based and decurrent; repetitive growth units commencing with short scale leaves to 3 mm long, leaves increasing to 2–8 cm long, 2–5 mm wide. Adult upper canopy plagiotropic shoots initially near-vertical, becoming horizontal and later pendulous, leaves opposite or subopposite tetrastichous and twisted to present adaxial surfaces uppermost, narrowly oblong, coriaceous, rounded, dull light to mid green, unequally amphistomatic, broad-based and decurrent; repetitive growth units commencing with short scale-like leaves to 3 mm long, leaves increasing to 1–4 cm long, 4–8 mm wide. Pollen cones terminal on first-order leafy plagiotropic shoots, to 11 cm long, 19 mm diam., subtended by ca. 8 helically arranged broadly triangular to semicircular bracts 3–5 mm long, 3–5 mm wide. Microsporophylls helically arranged, dark red-brown, peltate, with a raised angular termination, with 4–9 elongate, pendulous pollen sacs. Seed cones terminal on first-order leafy plagiotropic shoots, usually borne on ascending branches above pollen cones, globular to broadly ellipsoidal, mid green, becoming brown and shedding individual bract-scales at maturity, to 12.5 cm long, 10 cm diam. Bract-scales flattened, laterally winged, 12–17 mm long, 14–22 mm wide, 3–5 mm thick, with a narrowly triangular apical extension 6–12 mm long, 2–4 mm wide at base. Seed scales wholly fused with and indistinguishable from bracts. Seeds circumferentially winged, pale brown, 7–11 mm long, 5–7 mm wide, 6–9 mm wide including wing, remaining attached to the scale. Germination epigeal, cotyledons 2.

Taxonomic notes

The discovery in 1994 of this unknown conifer and the realization that it belonged to the family *Araucariaceae*, but did not fit with either of the two genera known in that family, caused considerable excitement among botanists. Further research indicated a slightly closer relationship with *Agathis* than with *Araucaria* (mainly based on molecular data), but many characters are distinct from either or similar to one but not the other in a combination unique to this new genus *Wollemia*. It soon became

apparent that a type of fossil pollen, *Dilwynites*, which had long been known to petroleum geologists in Australia, belonged to *Wollemia* and later some macrofossils were ascribed to it as well, taking the fossil record back to the Late Cretaceous (Turonian) as far as is presently known (Kunzmann, 2007). The fossil record for *Araucaria* is substantially older (middle Jurassic) and extinct representatives of the family *Araucariaceae* were present in the Triassic. The chance survival of *Wollemia* in a gorge surrounded by an environment hostile to it must count as one of the remarkable events in the history of life.

Distribution

Australia: New South Wales (Wollemi National Park).
TDWG codes: 50 NSW-NS

Ecology

Emergent trees above warm temperate rainforest dominated by *Ceratopetalum apetalum* and *Doryphora sassafras*, in a deep sheltered gorge surrounded by sandstone cliffs of the Triassic Narrabeen Group. Tall eucalypt woodland dominated by *Eucalyptus piperita* is adjacent on canyon walls and steep slopes, giving way to dry open woodland up-slope. The soil is sandstone-derived boulder alluvium, with high organic matter, some shale component, and a substantial basalt wash from higher reaches of small tributary canyons. The local microclimate is wet, with a permanent creek and an understorey dominated by ferns.

Conservation

This species was discovered in 1994 and since then three subpopulations, all within 2–3 km distance in a single canyon system, have been found. Extensive searches have not yielded any other, more distant stands of this tree, so it is likely that the total population does not exceed 100 mature trees and is probably smaller. Counting individuals is difficult as the trees readily coppice from base or root meristems and several trunks may belong to a single individual. Access is difficult and the site is still kept a secret, although by now (2016) there must be people who have unauthorized knowledge of it. The species occurs entirely within the undeveloped Wollemi Wilderness of Wollemi National Park. Regeneration occurs both from seeds and vegetatively and under entirely natural conditions the species seems able to survive. However, effects of human disturbance on site and, in the longer term, possible effects of climate change (e.g. drying of the permanent canyon bottom creek) make these small populations, the last to exist in a long declining trend as evidenced by the fossil record, critically endangered.
IUCN: CR [B1ab (iii), B2ab (iii)]

Uses

An extensive propagation and cultivation programme as well as marketing and PR have been launched shortly after the discovery of this species. It has been available for sale since 2005 as a 'living fossil' in other words a curiosity; however, it appears to be suitable for large gardens in milder climates (tolerating occasional light frosts, perhaps to zone 8 in Europe) and is an easy grower readily taking root from cuttings or scions. It is now well established in horticulture and available from nurseries in many countries.

Xanthocyparis Farjon & Hiep, Novon 12 (2): 179. 2002. Type: *Xanthocyparis vietnamensis* Farjon & Hiep (*Cupressaceae*).

Callitropsis Oerst., Vidensk. Meddel. Naturhist. Foren. Kjøbenhavn, ser. 2, 6: 32. 1864 (*nom. ut. rej.*, Art. 56). Type: *Callitropsis nootkatensis* (D. Don) D. P. Little [*Cupressus nootkatensis* D. Don].

Greek: *xanthos* = golden or yellow; *cyparis* = cypress.

Description

Evergreen trees, monoecious, with fibrous bark exfoliating in longitudinal strips; heart wood yellowish, slow growing. Resin in leaves. Foliage branches spreading in plagiotropic sprays or drooping, forming a pyramidal, conical or irregular flat-topped crown. Foliage of three types: juvenile linear leaves, transitional leaves and adult scale leaves. Juvenile leaves present on seedlings only or also in mature trees, radially disposed in alternating whorls of four; foliage branchlets with this type of leaves always sterile. Transitional leaves present on seedlings only or also in mature trees, decussate, divided in facials and laterals of nearly equal size; laterals weakly disposed in a plane; foliage branchlets with this type usually sterile. Adult leaves present in mature trees, decussate, dimorphic in shape and size with laterals strongly flattened and disposed in a plane; foliage branchlets with this type often fertile. Leaves in whorls of four or decussate. Pollen cones terminal and solitary on lateral branchlets with small scale leaves, small; microsporophylls 10–16, decussate, peltate, bearing 2 (or 3) relatively large pollen sacs. Seed cones terminal and solitary on lateral branchlets with unmodified scale leaves, opening wide. Bract-scale complexes 4 (or 6) in decussate pairs, fused at base, with connate upper pair(s), spreading wide to release the seeds, valvate to subpeltate, with a prominent central umbo. Central columella present or absent, small. Ovules axillary to bracts, 1 to 5 per bract; seeds usually fewer, concentrated on upper pair (if 2 pairs) or middle pair (if 3 pairs) of scales, flattened, with two thin lateral wings. Seedlings with 2 cotyledons.

2 species

Distribution

Pacific Coast Region of NW North America; one locality in N Viet Nam.

Taxonomic notes

Since the publication of this genus and the two species assigned to it (see below), more work has been done to evaluate this new taxonomy. Notable in this context are the molecular (DNA) analyses by Little *et al.* (2004) and Little (2006). The first of these cladistic analyses resulted in support for the unison of the two species, as proposed by Farjon *et al.* (2002), in a separate genus, related to *Cupressus*, but not closely related to *Chamaecyparis*. However, it was discovered that under the rules of the Botanical Code, an earlier name for the genus had been proposed and should have been taken up: *Callitropsis* Oerst. This obscure and ambiguous name, which later had been independently given to and often used for a conifer in New Caledonia, was subsequently proposed for rejection under the Code. The name *Xanthocyparis* has been conserved under the International Code of Botanical Nomenclature (ICBN) against the earlier and ambiguous name *Callitropsis*. Meanwhile, Little (2006) had published a second analysis, this time with a wider sampling of species. Adopting cladistic principles to use these new results in a classification, and apparently unaware of the formal proposal to reject the name for future use, Little now proceeded to rename all American species of *Cupressus* to also be included in *Callitropsis* Oerst. This sollicited a response (Farjon, 2007) rejecting this classification as a failure to consider the evolution of *Juniperus* (or other taxa) from a *Cupressus*(-like) ancestor. Under the (arbitrary) rule of cladistic classification, extant taxa cannot have an ancestor-descendant relationship, they are always 'sister' taxa.

Key to the species of *Xanthocyparis*

1a. Juvenile, linear leaves and adult, dimorphic scale leaves commonly on the same foliage branches of mature trees; facial scale leaves

eglandular or with an inconspicuous gland; apex pungent ***X. vietnamensis***

1b. Only adult, dimorphic scale leaves on foliage branches of young or mature trees; facial leaves with a conspicuous gland; apex acute ***X. nootkatensis***

Xanthocyparis nootkatensis (D. Don) Farjon & Harder, Novon 12 (2): 188. 2002. *Cupressus nootkatensis* D. Don, in Lambert, Descr. Pinus 2: 18. 1824; *Chamaecyparis nootkatensis* (D. Don) Spach, Hist. Nat. Vég. Phan. 11: 333. 1841; *Callitropsis nootkatensis* (D. Don) D. P. Little, Syst. Bot. 31 (3): 474. 2006. Type: Canada: British Columbia, Vancouver Island, Nootka Sound, *A. Menzies s.n.* (holotype not located, isotypes K, MO). Fig. 361

Etymology

The species epithet indicates the locality from where it was first described: Nootka Sound between Vancouver Island and the mainland.

Vernacular names

Alaska cedar, Alaska yellow-cedar, yellow-cedar, Nootka cypress, Sitka cypress, Yellow-cypress

Description

Trees to 40–45(–60) m tall; trunk monopodial, up to 4–4.5 m d.b.h., multistemmed trees from layering frequent at high altitudes or on bog margins. Bark soon flaky, on large trees exfoliating in thin strips, reddish brown weathering grey-brown. Branches spreading or curved down, higher order branches drooping or pendulous, but top shoot drooping; crown becoming broadly conical in large trees. Foliage branches drooping or pendulous, plagiotropic branchlets alternating, forming tapering planate sprays, turning red-brown with dying leaves; ultimate lateral branchlets partly deciduous after 4–5 years. Leaves decussate, imbricate, decurrent, scale-like, coriaceous, 1.5–3 × 1–1.5 mm on ultimate branchlets, up to 15 × 3 mm on leading shoots, dimorphic, of similar size; facials on branchlets narrowly rhombic to lanceolate, acuminate-acute, appressed, with a conspicous, depressed, oval, nonactive abaxial gland; laterals connate proximally, spreading at apex of facials, conduplicate, broadly falcate to lanceolate, recurved and incurved at acute, free apex, less conspicuously glandular or eglandular; margins entire; stomata inconspicuous; leaf colour lustrous light green, on underside of branchlets sometimes glaucous green. Pollen cones subglobose to ovoid-oblong, 3–5 2–2.5 mm; microsporophylls subcordate, with entire margins, with 2(–3) yellow or slightly reddish pollen sacs on lower margin. Seed cones maturing in 12–18 months, late caducous, subglobose, 7–10(–13) mm with closed scales, from glaucous green ripening to purplish brown. Bract-scale complexes 4(–6), decussate; upper pair usually larger than lower pair, parting and spreading wide when mature, subpeltate, thick, oblong to weakly pentagonal in outline, joining at base, up to 9 × 8 mm; abaxial surface smooth to rugose, slightly depressed, with a central large umbo; adaxial surface grooved and striated, brown, with light seed marks near base of upper pair(s). Columella more or less triangular or flattened, 1–2 × 1 mm. Seeds 6–10(–12) per cone, flattened, ovoid, 3–4 2–2.5 mm, reddish brown, with a whitish hilum at base, surrounded by 2 lateral, nearly equal thin wings 2–3 mm wide.

Taxonomic notes

This species has been united with a newly discoved cupressaceous conifer species in N Viet Nam in the new genus *Xanthocyparis*; the close relationship between the two species has been confirmed by research using DNA sequence data. Under a different taxonomy resulting from more recent molecular analyses, the Nootka cypress has been separated from *X. vietnamensis* as a monospecific genus to which the species name *Callitropsis nootkatensis* has been applied (Debreczy *et al.*, 2009).

Distribution

Pacific Coast Region of NW North America: from Prince William Sound in Alaska to the Siskyou Mountains in California near the border with Oregon.

TDWG codes: 70 ASK 71 BRC 73 ORE WAS 76 CAL

Ecology

Occurring across a vast latitudinal range, this species is associated with different conifers from N to S and also along its altitudinal gradient (1–2300 m a.s.l.). Common in Alaska are *Picea sitchensis* and, at higher altitudes, *Pinus contorta* and *Tsuga mertensiana*; in British Columbia *Abies amabilis, P. contorta, P. monticola, Thuja plicata* and *Tsuga heterophylla* and again at higher altitudes *T. mertensiana*; in the Cascades at lower altitudes *Abies amabilis* and *A. procera*, at higher altitudes *A. lasiocarpa, P. albicaulis and T. mertensiana*; and in its southernmost outlier the Siskiyou Mountains it is associated with *A. magnifica, Calocedrus decurrens* and *Picea breweriana*. A shrub-layer, in which ericaceous species often dominate, is usually well developed. Characteristic are stands, sometimes pure, or with *P. contorta* or *T. mertensiana*, forming a forest ecotone around bogs or near the tree line, with scrubby growth forms predominant on organic soils (derived from peat) in both habitats. As with all conifers in these forests, competition on better sites favours faster and taller growing species, which means *X. nootkatensis* is not codominant there and gets eventually pushed out to sites with shallow soils or nutrient deficient soils. However, it is also in much of its range probably the longest-lived conifer, with ages well over 1500 years verified and in excess of 2000 years, and probably even up to 3500 years (trees of this inferred age are found to be hollow). It could therefore well exhibit a strategy tied in with episodal disturbance events in which certain individuals outlive all competitors and only regenerate after this rare event. The climate, especially in the very maritime near coastal strip and on ocean-facing slopes and islands, is cool and very wet.

Conservation

Although 'dieback' (with largely unknown causes) has been reported in parts of its range, this species is widespread and occurs in many places that are still remote.
IUCN: LC

Uses

The wood of this slow growing species is extremely durable and valuable, being used for boat building and other maritime building and generally for outdoor construction in cool and wet climate. Most of the high quality logs are being exported and a large proportion of the timber goes to Japan. In horticulture usually known as Nootka cypress, this species is often used as an ornamental and a number of cultivars are known. It is also the maternal parent of the intergeneric hybrid *Xanthocyparis nootkatensis* (syn. *Chamaecyparis nootkatensis*) × *Cupressus macrocarpa* or Leyland cypress which originated in cultivation at Leighton Park in England in 1888. This has consequences for the botanical name of the Leyland Cypress. The International Code of Botanical Nomenclature (ICBN) requires it to be changed under the new taxonomy and it has become ×*Cuprocyparis leylandii* (A. B. Jackson & Dallimore) Farjon, as minimal a change as possible (Farjon *et al.*, 2002). This new name has now been adopted by the Royal Horticultural Society's (RHS) Conifer Register of recommended names for conifers in cultivation (Springate, 2009). The hybrid plants are sterile and must be propagated vegetatively as clones; their hybrid vigour (heterosis) has earned notoriety as they have been widely used for hedges that subsequently grew out of proportion and often control. Garden crosses with two other New World Cypresses (*Cupressus arizonica* var. *glabra, C. lusitanica*) are also in cultivation, but much less common.

Xanthocyparis vietnamensis Farjon & Hiep, Novon 12 (2): 180. 2002. *Callitropsis vietnamensis* (Farjon & Hiep) D. P. Little, Amer. J. Bot. 91: 1879. 2004, (*nom. ut. rej.*, Art. 56); *Cupressus vietnamensis* (Farjon) Silba, J. Int. Conifer Preserv. Soc. 12 (2): 100. 2005. Type: Viet Nam: Ha Giang Prov., Quan Ba District, Bat Dai Son Provincial Protected Area, *D. K. Harder et al. 6091* (holotype OBS). Pl. 42, Fig. 362

Etymology

The species epithet denotes Viet Nam, the country in which it is endemic.

Vernacular names

Golden cypress; Bách vàng (Vietnamese)

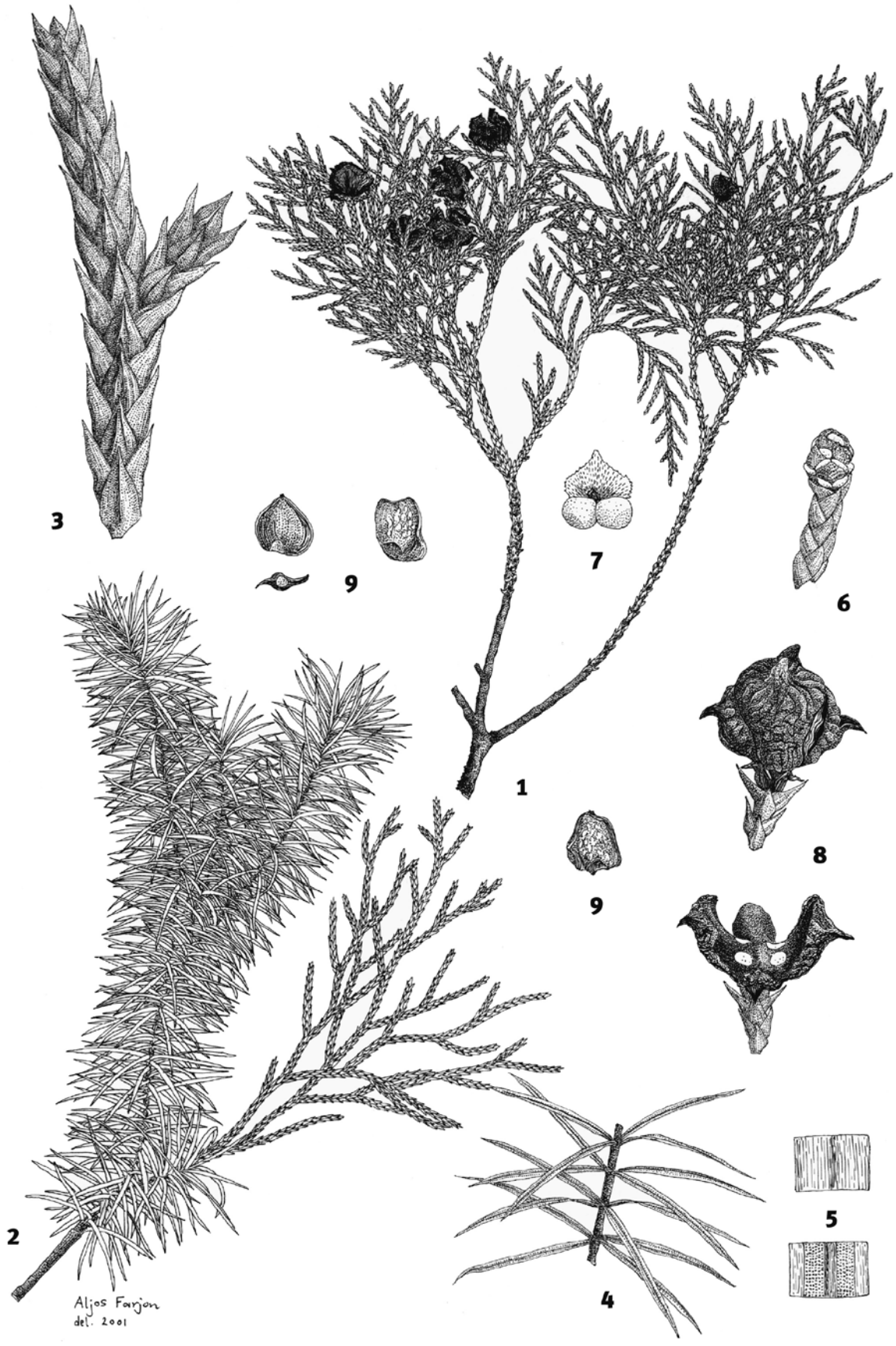

PLATE 42. *Xanthocyparis vietnamensis*. **1.** Branch with adult foliage and seed cones. **2.** Branch with juvenile and adult foliage. **3.** Adult leaves. **4.** Juvenile leaves. **5.** Surfaces of juvenile leaf. **6.** Pollen cone. **7.** Microsporophyll with pollen sacs. **8.** Seed cones. **9.** Seeds.

Description

Trees to 10–15 m tall; trunk monopodial, up to 50 cm d.b.h. Bark on the trunk of larger trees becoming soft and fibrous, brown to grey-brown, exfoliating in numerous thin strips. Branches spreading more or less horizontally; forming a pyramidal crown in young trees but a spreading, irregular or flat-topped crown in old trees. Foliage in crowns of both small and larger trees of two or three types: predominantly with adult leaves, also with juvenile leaves, often also with transitional leaves. Foliage sprays with adult leaves flattened; ultimate branchlets spreading at 30–45°, 5–20 mm long, 1.5–3 mm wide. Foliage sprays with juvenile leaves bushy, less branched; branchlets with transitional leaves more like those with adult leaves. Adult leaves decussate, short decurrent, imbricate, dimorphic, on (sub)ultimate branchlets 1.5–3 × 1–1.3 mm (the laterals slightly longer than the facials); facials narrowly ovate-rhombic, keeled, more or less appressed; laterals conduplicate, spreading free from the leaf above at ca. 30°, straight or falcate; margins of both types minutely denticulate except towards acute or pungent apex; stomata on adult leaves inconspicuous, mostly adaxial; glands inconspicuous. Transitional leaves similar to adult leaves but longer (5–7 mm), lanceolate; laterals spreading wider at 45°. Juvenile leaves in whorls of four, decurrent, with distal part spreading at nearly 90° and proximal decurrent part 4–5 mm long; distal free parts 15–20 × 1,5–2 mm, linear; margins entire, tapering to a fine point; stomata in two whitish bands on abaxial side only. Pollen cones 2.5–4 × 2–2.5 mm, oval-terete; microsporophylls 10–12, peltate, ca. 1 × 1 mm, each bearing abaxially 2(–3) yellow pollen sacs. Seed cones green, turning dark or dull brown, subglobose, 9–11 × 10–12 mm when open, some more or less persistent after seed dispersal. Bract-scale complexes 4(–6), decussate, fused at base; upper and larger pair connate distally, then spreading, valvate to subpeltate; lower pair oblong; all widest distally, with rounded but irregular upper margin; outer surface rugose or radiately furrowed from a prominent, 1–2.5 mm long, subapical umbo; inner surface reddish brown marked proximally with whitish seed scars; a small columella present or absent in the centre. Seeds up to 8–9 per cone, ovoid or irregular, flattened, 4.5–6 × 4–5 mm including two lateral wings, light brown or reddish brown, with whitish hilum at base; wings 0.5–1 mm wide, thin menbranous, lighter coloured.

Distribution

Viet Nam: N Viet Nam, Ha Giang Province, very localized in the Bat Dai Son mountain system near the Chinese border.
TDWG codes: 41 VIE

Ecology

This species occurs in mixed angiosperm-conifer forest with the conifers *Amentotaxus argotaenia, Nageia wallichiana, Pseudotsuga sinensis* (dominant), *Podocarpus brevifolius*, and *Taxus chinensis* and numerous, mostly small leaved angiosperms. The conifers appear to be restricted to the ridges and summits of the mountains. Dominant among angiosperms are species of *Acer, Carpinus, Lithocarpus, Quercus*, and *Ulmus*; frequent are *Pistacea weinmannifolia* and *Platycarya strobilacea*. In a second stratum under the ca. 20 m tall canopy occur frequently species of *Elaeocarpus, Eriobotrya, Sorbus, Schefflera*, and many others. Shrubs and herbs abound, among the latter are numerous species of *Orchidaceae*, terrestrial as well as epiphytic, sometimes determining the aspect of the ground cover vegetation (Averyanov *et al.*, 2002). Ferns and especially bryophytes are similarly abundant, both as lithophytes and as epiphytes. The limestone ridges on which *Xanthocyparis* occurs are extremely eroded, composed of hard, marble-like rock outcrops interspersed with thin soil pockets. The altitude of the ridges where this conifer grows is from 1050 m to 1330 m a.s.l. The climate is subtropical, but damp and wet much of the year (cloud forest).

Conservation

This species is restricted to a few localities in close proximity, mostly in inaccessible sites on steep limestone ridges. In some localities trees are cut, presumably for local use, in others no such disturbance could be found, possibly due to inaccessibility. The total extent of occurrence (EOO) appears to be less than 50 km² within which the species occupies ridge tops and summits only. Although difficult to assess precisely due to the difficult terrain, the total area

of occupancy (AOO) is estimated to be less than 10 km² (Averyanov *et al.*, 2002). Regeneration has been observed in habitat. An earlier estimate (Farjon *et al.*, 2002) put this species at Critically Endangered (CR), as did Averyanov *et al.* (2002), but objective evidence of serious decline has not been given.
IUCN: EN [B1ab (iii), B2ab (iii)]

Uses

The Golden cypress produces fine, yellowish brown, very hard, fragrant timber. The majority of trees seen on the ridges are small or contorted and would not be suitable for timber of any trade value other than local use. To date, no direct information of its actual or potential uses is available. Cultivation is being undertaken locally with an objective of *ex situ* conservation; a few botanic gardens in the UK and USA also grow it for this reason.

APPENDIX

In this appendix to the second edition of A Handbook of the World's Conifers newly described and accepted species are presented that were published between the appearances of the two editions. To present them in this place in the book avoids disruptive and complicated changes that would have to be made in an alphabetically arranged account of the species were they to be inserted in their appropriate place.

Podocarpaceae

Podocarpus orarius R. R. Mill & M. Whiting, Gard. Bull. Singapore 6 4 (1): 176. 2012. Type: Solomon Islands, Choiseul, Loloko District, mainland opp. Bembalama Island, *F. Pitisopa et al. 7* (holotype E).

Podocarpus spathoides de Laub. var. *solomonensis* Silba, J. Int. Conifer Preserv. Soc. 7 (1): 39. 2000.

Etymology

The epithet is Latin for 'coastal' and refers to the most common habitat observed by collectors of specimens.

Vernacular names

Dengali seems to be the name consistently applied to this species.

Description

Tree to 35 m tall, with a more or less narrow crown. Bark smooth, flaking, shallowly fissured, outer bark brown, inner bark pinkish brown. Terminal buds on pale green to brownish green shoots narrowly conical, 4–8 mm long, with narrowly lanceolate scales, with outer scales longer than inner scales, caudate or long-attenuate. Leaves petiolate, petiole 4–6 mm long, twisted; lamina tinged pink when flushing, not glaucous, turning glossy green above but much paler beneath, (sometimes narrowly) elliptic, oblong-elliptic to oblong (5–)7–19.5 cm long, (10.5–)12–20 mm wide, with little difference in size between leaves on juvenile and adult plants; midrib narrow (<0.5 mm wide) not or only slightly raised on both surfaces, not forming a groove on the adaxial (upper) surface; apex more or less obtuse or sub-acute, base acuneate. Pollen cones solitary or paired, grouped but not densely clustered with up to 3 close together, pedicellate, the pedicel of individual cones 3–9 mm long; pollen cones 20–36 x 2–3.5 mm, yellow(ish), narrowly cylindrical, curved, with numerous microsporophylls with a deltate free part. Seed cones paired, lateral on a reproductive shoot on long peduncles (to 15 mm) longer than the receptacle; foliola 2.5 mm long, soon caducous; receptacle asymmetrical, rectangular-ellipsoid when ripe, 10–13.5 mm long, 8.5–10.5 mm wide, turning yellow then deep red or vermillion at maturity. Seed subglobose, 11–12 x 9–9.5 mm, laterally compressed, not crested; seed coat and epimatium olive green, rugose when dry.

Distribution

Solomon Islands, Vanuatu (Erromango).
TDWG codes: 43 SOL-SO 60 VAN

Ecology

Mostly occurring on steep slopes in coastal rainforest (primary or also secondary) often associated with species of *Gymnostoma* (Casuarinaceae), from near sea level to around 450 m. Possibly also present in interior lower montane rainforest.

Conservation

The authors of this new species assessed its status at Near Threatened based on some evidence of exploitation and forest disturbance an potential for logging operations in the (near?) future.
IUCN: NT.

Uses

At present no commercial uses are recorded for this species.

GLOSSARY

abaxial In a position removed from an axis or stem (also dorsal).

acicular Needle-shaped; long, narrow, straight or slightly curved, slender, and not or only slightly flattened.

acroscopic Facing or directed towards the apex (here of the foliage branch).

acuminate Tapering gradually to a well defined, sharp point.

acute Sharply pointed.

adaxial In a position nearest an axis or stem.

adnate Joined with another organ of a different kind; e.g. the seed wing with a seed (compare **connate**).

adult leaves Here the type of green leaves that appears and is predominant on **primary** (or old) branches of mature trees, usually in the crown and fully exposed to sunlight (compare **juvenile leaves**).

afforestation The planting or seeding of trees in an attempt to create 'forest'. What is meant with the term forest has changed over time; in this context it now usually refers to plantations used as a source of timber.

aggregate Grouped closely or densely together, clustered.

allopatric The occurrence of populations or species in geographically separated areas.

amenity planting Planting of 'ornamentals' and trees for general use in public spaces, e.g. street trees, flower borders, and shrubs in parks, highway intersection plantings, etc.

amphistomatic Stomata on both **abaxial** and **adaxial** sides, on **equifacial** leaves on all three or four faces; equally distributed, or more often with two primary bands on two adjacent faces (compare **epistomatic** and **hypostomatic**).

ampulliform Shaped like a flask (Latin *ampulla*), with a wide body and a narrowing neck below the apex.

anastomosing Conneting so as to form a network (compare **reticulate**).

angiosperms Flowering seed plants with ovules attached to carpels, developing into seeds surrounded by a pericarp formed by the carpels; the seeds are consequently enclosed in an ovary which develops into a fruit of some kind (compare **gymnosperms**).

anthesis (in gymnosperms) The action or period of pollen dispersal and pollen reception ('flowering').

AOO (area of occupancy) Term used in IUCN Red List criteria to describe the estimated area (in hectares or square kilometres) actually covered or occupied by a species. Compare **EOO**.

apex In plant morphology, the terminal point of a growing structure like a shoot or a leaf. The adjective is apical; a conifer cone that is apical grows at the apex of a shoot (but very few are).

apiculate Ending abruptly in a small, distinct point.

apiculus A small, abrupt and/or distinct point at the apex.

apophysis The well defined apical part of **ovuliferous** scales in the seed cone marking the first stage of growth in *Pinus*; it is rarely differentiated in the other genera of *Pinaceae*.

appressed Pressed close to or lying flat against another organ (e.g. the shoot or other scales).

arboretum (plural: arboreta) A park or garden dedicated to a living collection of planted trees and shrubs.

archegonia (singular archegonium) In gymnosperms, the unfertilized female 'sex organs', i.e. the parts of the ovule that contain the female nuclei with a haploid number of chromosomes. Gymnosperms have several archegonia per ovule.

aril (Latin *arillus*) A fleshy or succulent (cup-like) structure that completely or partially envelops a seed and is derived from the **integument** (compare **epimatium** and **drupe**).

ascending Rising obliquely or curving upward.

a.s.l. Above sea level.

asperous Harsh to touch or handle; here due to rigidity of **pungent** leaves.

association (in vegetation science) A fundamental unit of vegetation, which can be distinguished from other such units on the grounds of its floristic composition.

assurgent Bent near the base, then steeply rising to a (nearly) vertical position.

auriculate (auricled) With ear-like lobes at the base or lower sides.

axil The angle between a **bract**, branch, or leaf and the axis from which it arises (i.e. rachis, shoot, branch, or stem).

axillary Positioned in the **axil**.

basionym The name-bringing or epithet-bringing synonym of a newly proposed combination.

bifacial With two distinct, opposite faces. If flattened in that way, the organ, e.g. a leaf, has its margins bordering these faces (see also **dorsiventral** and compare **bilateral**).

bifid Deeply cleft at apex, so as to form two sharp teeth.

bijugate An arrangement (of leaves) in which there is a doubling of the numbers 2 + 3 in normal (unijugate) spiral arrangements; the bijugate arrangement of 4 + 6 'parastichies' is in fact an opposite-decussate arrangement with a 'twist'.

bilateral A symmetry in which similar parts (sides) are arranged on opposite sides of a median axis; in leaves: flattened with two equal sides (not faces; compare **bifacial** and **dorsiventral**).

bilobate With two lobes; usually a terminal part divided in two.

binomial A name of a thing consisting of two separate words; in biology it refers to the names of species, which are always the name of a genus written with a capital first letter followed by an epithet written in lower case.

biodiversity The total number of **taxa** (or sometimes genetic diversity) known to exist in a given area; the greater this figure turns out to be, the higher the region's biodiversity.

biogeography The study or science of the geographical distribution of organisms and its causes and history.

biome A major ecological community type, related a to major climatic zone.

biota (Latinised form of Greek *biotē* = life) The totality of life (plants, animals, fungi etc.) in a region.

bisaccate (in **pollen**) Having two sacci or air bladders giving the corpus of the pollen buoyancy in the air.

bole The straight trunk of a tree.

boreal (Greek *Boreas* = god of the north wind) Of northern regions of the world.

bract A leaf-like or scale-like appendage, usually subtending a fertile structure such as a **seed scale**. In some conifers, the seed scale is fused with the bract, rudimentary, or altogether absent, by which the **ovules** (seeds) are situated in the **axil** of bract and cone axis, or sometimes solitary on the apex of the axis.

bract-scale complex Term used in *Cupressaceae* for the scales of seed cones; these are technically **bracts**, but transformed by **intercalary growth** to form the cone scales and enclose the seeds. In some complexes there is a rudimentary seed scale present (in related *Sciadopityaceae* it is fully developed), in most the true seed scale does not develop.

buttressed Shaped like a buttress; here the broadened base of a tree trunk, usually continued downward in the above-ground parts of roots.

caducous Falling off at an early stage.

callous Being hardened and thickened.

cambium Primary tissue (see **meristem**) forming secondary tissue. There are two cambia: one in the outer part of the stem (cork cambium) and one just outside the wood of the stem; it forms secondary wood on its inner side and secondary bark on its outer side.

canaliculate With a single, longitudinal groove.

candelabra crown A tree crown conforming to **Rauh's model** but with few first order branches in pseudo-whorls restricted to the upper part of the ited to the ends of these.

canopy The upper crown level in a closed forest, where the crowns of the tallest trees meet to form a more or less continuous cover.

capitula (Latin = small head; plural: *capitulae*) A dense, compact cluster of flowers. In conifers, this refers to pollen cones, not flowers.

carinate Keeled; ridged lengthwise.

cataphyll A reduced, scaly **primary leaf**; in pines they form winter buds, enclosing an entire shoot (with leaves and internodes not yet elongated) of the next growing season. On expansion of the shoot each cataphyll subtends a dwarf shoot with secondary leaves (needles).

caudate Elongated, resembling a tail, or tail-like appendage.

chaparral Term used in the southwest of the USA and Mexico to describe a dense vegetation of shrubs, some of which are evergreen, which grows in coastal regions with a dry summer and a moist winter climate, and often forms a distinct vegetation belt (see also **maquis**).

character A feature of an organism which has variable properties.

character state The variable property of a **character**. Leaf length is a character, the actual measurement given in cm or mm is the character state.

chlorophyll A green pigment, contained in **chloroplasts** in leaf or sometimes stem tissue of plants, responsible for **photosynthesis**.

chloroplast A microscopic body (organelle) inside a plant cell that contains **chlorophyll**.

chromosome A usually linear body of chromatids, containing nucleoprotein and DNA, the molecule responsible for the hereditary code, in the cell nucleus; the number of chromosomes usually remains constant in a species.

ciliate Fringed with regularly arranged hairs on the margin; the hairs are usually fine and of equal length.

CITES Convention on the International Trade in Endangered Species of Wild Fauna and Flora. The signatories to this convention (1976) are nation states; they decide at regular conferences of the parties to restrict or prohibit cross-border trade (= movement by people) of species listed on Appendices I, II, or III (with I the most restrictive).

clade A section of a cladogram which indicates a **monophyletic** (holophyletic) group of 'terminal' taxa (2–∞).

cladistics A formalised method of character comparison developed by the German entomologist Willi Hennig in 1950; it only considers shared derived characters to inform **phylogeny** and its aim is to construct a hypothesis of phylogenetic relationships between groups of organisms (usually recognized taxa).

cladode A branch-like or shoot-like organ not being a green leaf, but functioning as such (compare **phylloclade**). In *Sciadopitys* true leaves form small scales in the **axil** of which arise needle-like, seemingly paired, and fused cladodes, functioning as leaves.

cladogram A branching diagram resulting from a **cladistic** analysis of characters (i.e. discrete variables) of at least three different organisms (representing species or higher ranks of **taxa**), showing the inferred **phylogenetic** relationships of these characters based on cladistic principles.

clavate Club-shaped, i.e. with a broader or thicker **distal** part.

climax A supposedly terminal stage in the succession of vegetation types from pioneer colonizers to mature vegetation. In fact, all stages in the succession are temporary since they are all subjected to natural disturbances, including the terminal or **climax** stage.

cline A graded series of morphological (or physiological) differences exhibited by a group of related organisms, usually along a line of environmental or geographic transition.

codominant Dominating together with other species in a given vegetation; trees are codominant when they form part of the main canopy of a forest.

columella (Latin = little column) In **conifers** a spiky protrusion in the centre (axis) of the inside of a seed cone, especially prominent in those of the genus *Callitris* (*Cupressaceae*).

concave Hollowed or rounded inward like the inside of a bowl (compare **convex**).

conduplicate Folded together lengthwise.

cone In conifers, referring to a structure bearing either pollen sacs containing **pollen**, or **ovules**, which after fertilization may develop into seeds. Conifer cones can be simple, consisting of an axis with one type of scales, or compound, with two types of scales, only one of which bears the ovules. Pollen cones in conifers are simple; seed cones can be compound or simple.

congener A species in the same genus as another species.

conifers (cone-bearers) To this taxonomic group belong those woody **gymnospermous** plants (usually trees) of which the seed bearing scales are united in a cone. The conifers (including forms with extremely reduced cones, such as *Podocarpus*, or those with no apparent cones, such as *Taxus*) are a **monophyletic** group of plants derived from a single common ancestor.

connate Joined with another organ of a similar kind, e.g. a leaf with another leaf (compare **adnate**).

convergence The evolution towards similar morphology not as a result of common descent, but

of adaptation to similar environments or life strategies.

convex Curved or rounded like the exterior of a sphere or circle; here used for the shape of the cone scales as viewed from the abaxial side (compare **concave**).

copal A kind of resin; commercially referring to resins of leguminous and araucarian plants that produce hard varnishes.

coppice Regrowth from the stump of a tree after cutting (or burning), producing new stems and branches. The stump after cutting is called coppice stool; in many species the stems will regrow even after repeated cutting.

cordate Heart-shaped (subcordate = somewhat heart-shaped).

coriaceous (Latin *corium* = skin) Resembling leather: leaves with a leathery, tough texture, mainly from thickened **dermal** layers.

cortex Layer of` cells (**parenchyma**) in plant roots and stems, situated between the central vascular cylinder and the **epidermis** or surface layer.

costate Ribbed, having one or more primary veins or ridges.

cotyledons First, or embryo leaves, as found in the seed and which (usually) unfold after germination.

crenate (crenately lobed) Scalloped, lobed like the surface of a scallop.

cultivar A form of a plant (not a botanical variety!) in cultivation, the characteristics of which are perpetuated by vegetative propagation.

cuneate Wedge-shaped; in the descriptions often combinations are used, e.g. obovate-cuneate, to describe either a range of shapes or intermediates.

cupular Cup-like, similar in shape to the cupule of an acorn.

cusp The usually well defined pointed apical extension of a leaf (but here also of the bracts of seed cones).

cuspidate With a cusp, i.e. a (short or long) well defined and tapering apical point.

cuticular Referring to a usually waxy surface layer on the exterior of the **epidermis**, consisting of a protective substance (cutine); it causes the shine on conifer leaves.

cyathiform Shaped like a beaker (in outline) (Latin *cyathus* = beaker), i.e. a wide-mouthed and projecting-lipped drinking vessel supported on a standard.

d.b.h. Diameter at breast height; used to measure the girth of a tree trunk above a buttressed base or roots; for very large buttressed trees measurement should be taken at actually higher (than the usual ca. 1.3 m) levels.

deciduous Falling off or shed seasonally or at a certain stage of development in the life cycle.

decumbent (Latin = lie down) Growing low over the ground or surface of a rock.

decurrent Running down a stem from a leaf base.

decurved Curved downward (compare **recurved**).

decussate Occurring in alternating pairs; leaves are decussate if one opposite pair is placed slightly higher than the adjacent opposite pair and oriented ± 90° from it (compare **ternate**).

deflected (Latin *deflexus*) Bent or turned abruptly downwards.

dehiscent Referring to the manner of opening of a vessel containing seeds or spores; in conifers it pertains to the pollen sacs or to some types of globose seed cone.

deltoid triangular with the sides more or less equal and the apex uppermost.

dendrochronology The science of dating events and variations in the environment in former periods by comparative study of growth rings in the woody stems of trees.

dendrological Of dendrology, the science or study of trees.

dentate Having the margin cut with sharp, salient teeth, directed outward or straight.

denticulate Finely or minutely **dentate**.

dermal Of the skin (Greek *derma* = skin), in conifers it can refer to bark or more commonly to leaf surfaces or outer layers (see **epidermis**).

determinate Referring to growth of a structure which definitely ends with the completion of that structure. Conifer cones represent shoots with determinate growth, while foliage shoots can and often will resume growth in the next growing season. In some abnormal cases, cones are not determinate and a foliage shoot may grow from their apex (compare **proliferation**).

dichotomous Like a system of branching in which the main axis forks repeatedly into two branches (dichotomy).

dilated (Latin *dilatatus*) Expanded, broadened, or widened (sometimes also swollen).

dimorphic Of two forms or shapes; an organ, e.g. a leaf, has two different forms (2 **character** states) occurring on the same plant or shoot (compare **monomorphic** and **polymorphic**).

dioecious In **gymnosperms** this pertains to female and male reproductive organs, commonly cones, being present on different plants (see also **monoecious**).

diploid Cells containing two sets of chromosomes (2n = x). The nuclei of these cells contain sets of paired chromosomes of equal form and size. Such cells have a doubling of the base (haploid) number of chromosomes, the result of sexual fusion of female and male haploid nuclei. A rare further doubling of the diploid number leads to tetraploidy (Greek *tetra* = four) and in one species (*Sequoia sempervirens*) hexaploids (Greek *hexa* = six) were found, which amounts to a tripling of the diploid number.

disjunct (of distribution) Occurring in areas widely separated from each other.

dispersal The spreading of organisms to areas other than where they originated.

distal Occurring nearest the apex or terminal part (compare **proximal**).

distichous Disposed in two vertical or upright rows.

divaricate (from Latin *divaricare* = 'to straddle' as in riding a horse) Divergent branching, with two branches splitting from the apex of a single branch or stem.

DNA (deoxyribo nucleic acid) The macro-molecule in cells of organisms that contains the genetic information and acts as a template to build new cells and therby (multicellular) new organisms (compare **RNA**).

dolabriform Shaped like an axe.

dorsiventral The condition of possessing upper and lower faces of an organ. If flattened in that way, the organ, e.g. a leaf, has its margins bordering these faces (see also **bifacial**).

drupe A fleshy, one-seeded, indehiscent fruit with a stony endocarp (e.g. cherry, peach). It is derived from the carpels of **angiosperms** (compare **aril** and **epimatium**).

ecology The study or science of **ecosystems**, or of the functional relationships of organisms with their environment and with each other.

ecosystem The supposed totality of the functional relationships of organisms with their environment and with each other living in a given area and **habitat**.

ecotone The transitional zone between two types of vegetation or ecological communities, usually with (competing) species of both types and often with species not occurring in either of the two types.

ecotype A plant form with morphological characters that are modified by the environment in which the individual plant grows; such characters are not inherited and therefore are not a good basis for taxonomic distinction.

emarginate Shallowly notched at the apex.

embryo (in plants) The young sporophyte of a seed plant, usually consisting of a very small plant with a primary bud (plumule), radicle, and **cotyledons**.

emend. (Latin *emendavit* = changed by) Indicating an alteration of content or circumscription, followed by citation of the author(s) responsible for the change.

emergent In the context of trees referring to individuals rising above the forest **canopy**.

endemic (endemism) Referring to the occurrence of a **taxon** in a limited area – for example, on a single island. Taxa limited to a single country are also considered endemic, although the term becomes fairly meaningless biologically for widespread species limited to countries that cover nearly half a continent.

endophyte An organism that grows within (in the context of trees a branch, root, or stem).

entire Without teething or division, with even margin.

EOO (extent of occurrence). Term used in IUCN Red List criteria to estimate the total range (in km^2) within which a species is found to occur naturally (excluding introductions), usually by connecting the outermost points of present occurrence. Within the EOO is the **AOO**, which is always smaller.

epicormic (Sprouting) from dormant buds on the trunk lying within the bark.

epidermis The true cellular outer skin of a plant (leaf) below the cuticle, made up of a single layer of cells.

epigeal germination The **hypocotyl** of the seedling elongates and lifts the **cotyledons** above the soil surface, where they unfold (compare **hypogeal**).

epimatium The outer layer of tissue that (partly) covers a seed in many species of the family *Podocarpaceae*; it is derived from the **seed scale** (compare **aril** and **drupe**).

epiphyte A plant that grows upon another plant (usually a tree) using it for support only. Plants that are 'accidentally' growing on trees because seed germinated there, but of which the usual habitat is terrestrial, are not (obligate) epiphytes in an ecological sense. No obligate coniferous epiphytes are known.

episodal Occurring at irregular intervals in time (episodes). Here referring to stochastic disturbance events from natural causes that can reset the successional phases of forest regeneration in an area to a pioneer phase.

epistomatic Stomata (almost) restricted to the **adaxial** side of the leaves (the dorsal side morphologically); on **plagiotropic** lateral shoots the **stomata** are facing downward by orientation of the leaf bases, **petioles** or **pulvini** (compare **hypostomatic**).

epitype (Latin *epitypus*) A specimen or illustration selected in addition to a **holotype** (or **neotype** or **lectotype**) to serve as an interpretative type if the designated type material or other 'original material' cannot be identified for the purpose of precise application of the name of a **taxon**.

equifacial With equal faces; i.e. the 3 or 4 faces of those leaves that are quadrangular or rhombic in cross-section.

ericoid (as in *Erica*) Belonging to (or similar to) *Ericaceae*; also an adjective used to describe a vegetation dominated by such plants, or by those with a similar life form (i.e. evergreen winter hardy shrubs).

erose Irregularly toothed, as if gnawed; here often used in conjunction with **denticulate**.

eutrophic Adjective referring to an environment (usually a body of water) rich in dissolved nutrients available to plants.

evolution Gradual change (as contrasted with revolution). In biology the term is mostly used in a Darwinian sense and refers to (gradual) change of the genetic makeup of individuals in populations, primarily through genetic mutation, separation (isolation) and natural selection, resulting in new species. The overall tendency is divergence, interrupted by extinction, causing major change over geological time.

exfoliating Here: the dead outer layers of bark coming off in scales, sheets, or papery flakes.

exserted Protruding; here usually pertaining to the bracts of seed cones projecting beyond the upper margins of the seed scales.

ex situ (Latin = outside [its] place) In the context of plant species conservation, any effort to conserve individuals by growing them in localities outside the natural range of the species is considered *ex situ* conservation (compare ***in situ***).

exuding Issuing a substance, such as resin, through a surface layer of tissue; the product is called exudate.

facials (facial leaves) The paired, opposite scale leaves on a **plagiotropic** foliage branchlet (esp. in the family *Cupressaceae*) that face either up or down, they are flanked by the differently shaped **laterals**.

falcate Sickle-shaped (falcate-linear = with two nearly parallel sides).

fastigiate A branching habit in trees in which the branches are directed upwards (**ascending**), not spreading out from the trunk.

farinose Covered with a flowery or meal-like powder.

ferruginous With the reddish brown colour of rusty iron.

figured In sawn and planed or turned and polished wood the decorative patterns and shapes caused by growth rings and other structures in relation to the plane of sawing or turning.

fimbriate Fringed with long hairs.

flabellate Fan-shaped (though in cone scales of conifers not entirely flat but more or less concavo-convex).

flaccid Weak and lax, lacking firmness.

flexuous Latin *flexuosus*) Bent alternately in opposite directions, in 'zigzag' fashion.

flushing (of leaves) The more or less abrupt unfolding from winter buds or just growth of new foliage leaves. In tropical trees, these young leaves are often coloured pink or red, or a

different green from leaves that have been exposed longer.

foliate Leaf-like, i.e. shaped like a leaf as in a book (Latin *folio*). Leaves of plants (conifers) can have shapes different from foliate, such as **acicular**.

foliola (Latin sing. *foliolum*) Little leaves or leaflets. A term used to describe two bract-like appendages subtending the **receptacle** in seed cones of the genus *Podocarpus*.

frondose Resembling a **pinnately** compound fern leaf (frond).

fusiform Spindle-shaped; tapering at both ends.

fynbos A vegetation formation occurring in the Cape Province of South Africa, characterized by a low, open structure and the abundance of ericoid, proteoid, restioid and geophyte life forms on nutrient-poor soils.

gametophyte The generation (in spore-reproducing plants) that bears the sex organs; in **gymnosperms** strongly reduced to the microgametophyte in the pollen grain and the **megagametophyte** in an ovule or seed; the latter refers to the tissue that embeds the (female) archegonia within an ovule; after fertilization of the **archegonia** the ovule develops into a seed. The megagametophyte then has the same function as the endosperm in seeds of angiosperms, but it has a different origin (**homology**).

gene A bit of **DNA** (sequence of nucleotides) coding for a protein, or part of a protein.

genome The total of genetic or hereditary information present in the **DNA** of an organism in the form of the sequence of its nucleotides.

genotype The genetic constitution of an individual or a group of organisms.

GIS A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

glabrescent Becoming **glabrous** with age.

glabrous Devoid of hairs of any kind.

glandular Functioning as a gland, i.e. secreting a biochemical substance.

glaucous Covered with a blue-green or blue-white bloom (see also **pruinose**).

globose Nearly spherical (compare **globular**).

globular Spherical, round (compare **globose**).

glutinous Sticky, with the quality of glue.

graft The artificial growing connection of two parts of different plants, involving a root stock and the grafted cutting or **scion** with foliage. The resulting 'plant' minus the rootstock is also referred to as a graft.

Gregg's Paradox This paradox seems to violate the hierarchical structure of biological classification: *Ginkgo* = genus → *Ginkgo biloba* = species → *Ginkgo* = *Ginkgo biloba* → genus = species. The way out of this paradox is to postulate extinct species and only one surviving to the present. For *Ginkgo* there is abundant evidence of other species in the fossil record, for other genera with one extant species it is possible that these will be found in future. [From J. R. Gregg (1954). The Language of Taxonomy. Columbia University Press, New York.]

gymnosperms Non-flowering seed plants with ovules directly exposed to air ('naked'); the seeds may be exposed also but are usually enclosed within a **cone** or by an **aril** or **epimatium**; neither is technically a fruit (compare **angiosperms**).

habit (Latin *habitus* = condition, character) Characteristic mode of growth or occurrence.

habitat The place or type of site where a plant (or animal) naturally or normally grows and lives and to the natural conditions of which it is adapted.

hardpan A compact soil surface inhibiting percolation of rain water to deeper levels where tree roots could take it up. Such soils are common in (semi) arid regions.

heartwood The inner section of the wood of a tree, with dead wood cells through which no water is transported.

helical (Latin *helix*) Arranged or formed in an upward spiral (see also **spiral**).

heterosis A marked capacity for rapid growth often shown by cross-bred animals or plants ('hybrid vigour').

heterotypic (synonym) A synonym based on a different type. Such synonymy results from the merging of different taxa into one by taxonomists (compare **homotypic**).

hexagonal Shaped like a hexagon, i.e. a polygon with six angles and six sides.

hilum A mark on a seed left by its connection to the tissue from which it developed.

hirsute Covered with coarse or shaggy hairs.

holotype (Latin *holotypus*) The one specimen (or illustration) used or designated by an author as the nomenclatural **type** of a species or lesser **taxon** at the time of establishing it.

homologous Referring to shared characters in two or more species due to common descent, or to modifications evolved from such commonly inherited characters.

homonym A name of an organism spelled exactly the same as the name of another organism. Homonyms within the jurisdictions of the several codes of biological nomenclature are not allowed and the rule of priority dictates that the name shall be applied to the earliest named plant or fungus (in case of the Botanical Code) and that the other plant or fungus must be renamed.

homoplasy (homoplasious) A term for a character that is not a shared derived character (synapomorphy) in a **phylogenetic** sense. Homoplasious characters (or **character states**) appear in more than one clade of an inferred phylogenetic tree (**cladogram**) and their similarity may result from convergent or parallel evolution, rather than from common descent with modification or transformation.

homotypic (synonym) A synonym based on the same type. Such synonymy results either from the strict application of the Botanical Code (**ICBN**) or from a change in rank of a particular taxon. Only the latter procedure involves taxonomic decision making (compare **heterotypic**).

hort. (Latin *hortulanorum*) Of gardeners (horticulturally); here added to a name used in a (botanic) garden, but not formally published. If followed by "*ex*" and a name and reference, its subsequent formal publication is given.

hybrid A product of propagation between two individuals belonging to different taxonomic units; hybridization can be naturally or artificially induced. Some species of conifers are believed to be of hybrid origin; their botanical names are marked with a × sign.

hypocotyl Section of a seedling between radix (primary root) and **cotyledons**, developing into the stem.

hypodermis Layer of one or more rows of thick walled cells, situated directly beneath the **epidermis**; it is discontinuous at the **stomata** and otherwise continuous, intermittent or absent.

hypogeal germination The **hypocotyl** of the seedling does not elongate, the **cotyledons** remain infolded below the soil surface and only the true stem of the seedling emerges (compare **epigeal**).

hypostomatic Stomata (almost) restricted to the **abaxial** side of the leaves, with two primary bands separated by a midrib in most species; on **plagiotropic** lateral shoots the **stomata** are facing downward by a twisting of the leaf bases or **petioles** (compare **epistomatic**).

ICBN International Code of Botanical Nomenclature. A set of internationally accepted rules and regulations governing the naming of plant (and fungal) taxa, decided at International Botanical Congresses held at six year intervals and organised by the International Association for Plant Taxonomy (IAPT), which organisation publishes these rules in the Botanical Code (at the time of publication of this Handbook the 'Vienna Code' of 2006). Its rulings are binding in plant taxonomy.

igneous Referring to rock that was formed from molten material (magma) in the interior of the earth; it may have solidified below as well as on the surface.

imbricate Closely overlapping, as thatches or tiles on a roof (compare **tesselate** and **valvate**).

incertae sedis (Latin = place uncertain) A heading under which taxonomists place names of taxa for which the original description is unclear in the context of present knowledge and of which no good original material exists to determine their identity.

indehiscent Generally: a fruit that does not open. In conifer seed cones: the scales remain **connate**, so the cones will not open to release the seeds.

indigenous Naturally occurring in an area or a country, without having been transported there (intentionally or unintentionally) by people.

inflorescence A branching system supporting flowers but usually not leaves.

in litt. (Latin: *in litteris*) In a letter or written note. Citations given with this adjective are written but unpublished sources.

in sicco (Latin = in a dried state) Preserved as a herbarium specimen, of which the **character**

states may markedly differ from living or fresh material.

in situ (Latin = inside [its] place) In the context of plant species conservation, any effort to conserve individuals by protecting them or their habitat within the natural range of the species is considered *in situ* conservation (compare ***ex situ***).

integument Enveloping layer of the seed bud or **ovule**, which is open on one side (**micropyle**) and, after fertilization, develops into the seed coat.

intercalary growth Growth inserted between other parts; in the bract-scale complexes of the seed cones of *Cupressaceae* this occurs inside the bracts (i.e. between the **dermal** layers) enlarging them in various ways to form the cone scales.

internal (as of resin canals or ducts) Inwardly; here a position of the resin canals in the leaves bordering the **endodermis**.

introgression The entry or introduction of genes from one gene complex (e.g. a species) into another.

invers-dorsal A position of the leaves whereby the abaxial ('dorsal') side is inversed by twisting of the leaf basis or petiole to face downward ('below').

inverted A position turned about 90° from an earlier position; inverted seeds have turned their **apex** back towards their attachment point.

involucre (Latin *involucrum*) A whorl of bracts subtending a flower cluster (as in the heads of *Compositae*); in gymnosperms the whorl of scales (bud scales) subtending the **strobilus** in some species.

isotype (Latin *isotypus*) A duplicate specimen of the **holotype**.

IUCN International Union for the Conservation of Nature = The World Conservation Union. A non-governmental organisation (NGO) with both government and non-government (e.g. academic) membership dedicated to the conservation of natural resources, in particular biological species. Its Species Survival Commission (SSC) generates and updates the IUCN Red List of Threatened Species™; its categories and criteria are used in this Handbook.

juvenile leaves Here the type of leaves that appears on seedlings, saplings, or immature trees, or sometimes on **reiterations**; these leaves are distinct from **adult leaves**, but intermediate forms may occur.

karst A deeply eroded formation of marine limestone, of which surfaces are partly dissolved by rain water containing CO_2 and where acidic groundwater dissolves caves; drainage in karst landscapes is largely underground. In tropical climates karst landscapes develop tower hills or mountains.

kerangas 'Heath forest', i.e. a more or less stunted (but sometimes tall), open type of forest growing on nutrient-poor, sandy (often nearly white) soil in tropical lowlands of **Malesia**.

keystone species A species in an **ecosystem** upon which many species depend that characterize that ecosystem and make it function. Removal of the keystone species destroys that particular ecosystem.

knot In sawn wood the remainder of a branch in the stem of a tree, visible as a darker, rounded bit of wood with a different grain.

K-strategy Also known as "K-selection"; in plant ecology, this refers to trees with relatively slow growth rates but persistence (longevity) in later phases of vegetation succession. Its opposite, "r-selection" applies to trees that colonize early phases (pioneer species), grow rapidly but are later outcompeted by the slower, longer living trees.

lacerate Appearing as if irregularly torn or cleft.

laciniate Cut into narrow lobes or segments.

lamina (Latin = blade, leaf) Here mostly used for relatively broad, flat leaves of conifers that would by most people not be described as needles or scale leaves.

laminar Of the leaf; also referring to organs **homologous** to leaves.

laminated Divided into lobes (as of leaves).

lanate Woolly.

lanceolate Of a shape reminiscent of a lance point, i.e. much longer than wide and with the greatest width below the middle; commonly used to describe the shape of a leaf.

laterals (lateral leaves) The paired, opposite scale leaves on a **plagiotropic** foliage branchlet (esp. in the family *Cupressaceae*) that are positioned laterally, they flank and often partly enclose the differently shaped **facials** on either side.

laterite (Latin *later* = brick) A chemically weathered, earth-like type of rock rich in oxidized metals.

lauraceous With alternate entire leaves characteristic of the family *Lauraceae*.

layering The rooting of lower branches of a tree where they reach the soil; from these branches new plants may grow, which are for a time still part of the old plant but eventually become independent when the parent plant dies.

lectotype (Latin *lectotypus*) A specimen or illustration, designated from the 'original material' as the nomenclatural type if no **holotype** was indicated at the time of publication, or if it is missing, or if it is found to belong to more than one **taxon**.

leg. ign. (Latin *legitavit* = collected by, *ignotus* = unknown). The abbreviation is used here when the collector of a herbarium specimen was not stated.

lenticels Usually more or less raised, often somewhat corky spots on bark, of different shapes but often horizontally elongate to linear, where gaseous exchange takes place.

lenticular Shaped like a lentil, i.e. with sides as in a double-**convex** lens.

Life Zone A major altitudinal zone, characterized by specific plant species and communities (and to a lesser degree by specific animal species) in a mountain region; they are specifically recognized and named in Canada and the USA.

lignified (Latin *lignum* = wood) Converted into wood; become woody.

lignite An organic deposit from plant remains in an intermediate phase of being transformed from peat to bituminous black coal.

lignotuber An outgrowth or swelling on the basal root system of a tree, forming excess wood and capable of initiating new aerial stems with foliage and reproductive organs.

ligulate Tongue-shaped; also (in description of leaves) strap-shaped, resembling a ligulate flower in *Compositae*.

ligule (Latin *ligula* = small tongue) In the seed cone scale of *Araucaria* the apical free part of the **seed scale**, which is for the most part fused with the **bract**.

linear An elongated, narrow, flattened shape with parallel or nearly parallel sides for all or most of its length.

lithosol An azonal shallow soil consisting of imperfectly weathered rock-fragments.

Ma Million years ago.

maquis A thick, scrubby (underbrush) vegetation of predominantly **xerophytes** (e.g. **sclerophyllous** shrubs) characteristic of Mediterranean shores and mountain slopes. [In New Caledonia, similar vegetation (but with very different plant species) growing on **ultramafic** soil rich in metals is called 'maquis minier', as these substrates are often mined to extract nickel.]

Malesia A floristic region of mainly islands in SE Asia, defined (mapped) in Flora Malesiana as extending from the Isthmus of Kra on the Malay Peninsula to the end of the main archipelago of the Solomon Islands. The serial Flora Malesiana describes the plants of this region.

Massart's model A growth model in tree architecture with a **monopodial**, erect stem with apical dominance and branches placed in (pseudo) whorls at regular intervals; these branch again and all or most branching is directed in a more or less horizontal plane (**plagiotropic**), by suppression of all but the laterally placed **vegetative buds**.

median A position 'in the middle' or central part of an organ, e.g. a leaf.

megagametophyte In **gymnosperms** (conifers) the tissue inside the **integument** of an **ovule** or seed coat of a seed, in which the fertilized gamete develops into an embryo.

membranous Thin, rather soft and more or less translucent.

meristem A formative plant tissue usually made up of small cells, capable of dividing continually and giving rise to similar or differentiating cells.

mesa (Spanish = table) A flat topped mountain resulting from processes of erosion in ancient sandstone or other sedimentary formations.

mesic Characterized by or relating to a moderate amount of moisture (see also **mesophytic**).

mesophyll Leaf tissue, consisting of spongy parenchyma and **palisade parenchyma** (the latter type not in all species) and filling the leaf between the **hypodermis** and the **endodermis**.

mesophytic Growing under moist conditions; also of plants or plant communities growing under medium conditions of moisture, without (prolongated) periods of draught (see also **mesic**).

mesothermal Characterized by a moderate (cool) temperature without pronounced daily or seasonal fluctuations.

metamorphic Of a rock type that has been substantially altered due to high pressure and/or heat generated by earth crust movements.

micropyle The opening in an **ovule** through which **pollen** enters, in most conifers with the aid of a pollination drop of fluid.

microsporangium (plural: microsporangia) A sac-like structure that contains the microspores, it is **dehiscent** so it can release the ripe spores. In conifers this is usually termed **pollen sac** and it contains **pollen**.

microsporophyll A (modified) leaf-like structure bearing the **pollen sacs** containing **pollen** or male gametes (in **gymnosperms**); they are borne on the male **strobilus** or pollen cone.

molecular analysis In the present context a **phylogenetic** analysis using **DNA** sequence data as characters and **cladistic** methodology.

monoecious In **gymnosperms** this pertains to female and male reproductive organs, commonly cones, being present on the same plant. Plants with only one sex present are **dioecious**; both conditions occur in conifers, with some genera (or families) having one condition in all species, but others more variable.

monograph In biology the comprehensive taxonomic description of a natural group of species, usually a genus or a family, including all aspects pertinent to the **systematics** and classification of that group.

monomorphic Of single form or shape (= 1 **character state**); all similar organs (e.g. leaves) have the same shape (compare **dimorphic** and **polymorphic**).

monophyletic Adjective referring to a group of taxa; originally (Ernst Haeckel 1866) used in the sense of sharing a unique common ancestor, but now almost universally used in the **cladistic** sense (Willi Hennig 1950, 1966), in which it refers to an ancestor and all its descendants. [A more accurate term would be holophyletic.] Groups that do not include all descendants are then described as **paraphyletic**.

monopodial Having a single stem or trunk (**bole**), usually growing more or less straight up from the ground.

monospecific Referring to a **taxon** of higher rank containing a single species (see also **monotypic**).

monotypic Referring to a **taxon** containing only a single taxon of lower rank, such as a genus with only one species (see also **monospecific**).

montane Growing in, or being, the biogeographic zone that is made up of relatively moist cool upland slopes below timberline in mountainous areas.

morphology The detailed study of form; in systematic research of taxa this involves investigations into anatomy and development as well as comparison among individuals and taxa in order to understand characters and their states.

mossy forest A high montane to subalpine forest type in the tropics of SE Asia, characterized by a low canopy of flat-topped crowns of trees, some of them emergent, and draped with great quantities of epiphytic mosses, lichens and ferns.

mucronate Having a mucron, i.e. a narrow, abrupt point which is usually only a continuation of the midrib (or midvein).

muskeg (word of Algonquin origin) A *Sphagnum*-built bog of northern latitudes in North America, often with scattered and stunted tree growth.

mutant An organism that obtained a genetic character change (mutation) not present in other individuals of its species.

mutualism An ecological (or behavioral) relationship between two species that is beneficial to both.

mycelian Of the **mycelium**, the threadlike network of hyphae of fungi.

mycelium A mass of filamentous hyphae, usually underground or in wood, which forms the vegetative portion of a fungus.

mycorrhiza The thread-like hyphae of certain fungi that form intricate connections with the roots of plants and live in **symbiosis** with these plants.

mycropyle The small opening at the apex of an ovule, usually shaped somewhat like the neck of a flask, through which **pollen** can enter.

natural group A group of taxa that is based on a hypothesis of common descent from a nearest ancestor.

naviculate (Latin *navicula* = a boat) Boat shaped, referring to the shape of open boats with narrowing bow and stern and a more or less keeled bottom.

neotype (Latin *neotypus*) A specimen chosen and designated as the type of a **taxon** in a situation where no original material is extant.

niveous white Snow-white, without any tinge of different (underlying) colours.

nom. cons. (Latin *nomen conservandum* = retained name) A botanical name invalid under the rules of the Botanical Code (ICBN), but retained to avoid disadvantageous changes in the nomenclature by incorporation in the appended lists of *nomina conservanda* (*et rejicienda*) published in the ICBN.

nom. illeg. (Latin *nomen illegitimum* = illegitimate name) A botanical name invalid under the rules of the Botanical Code (ICBN), as specified under Art. 6.4 (Vienna Code, 2006).

nom. inval. (Latin *nomen invalidum* = invalid name) A botanical name that is not validly published under the rules of the Botanical Code (ICBN). Unlike an illegitimate name, it in fact does not exist for nomenclatural purposes unless and until it has been validated under the rules.

nom. nud. (Latin *nomen nudum*) A botanical name without a formal description and therefore invalidly published under the rules of the Botanical Code (ICBN).

nom. ut. rej. (Latin *nomen utique rejiciendum* = rejected name in any case) A botanical name ruled as rejected under Art. 56 of the Botanical Code (ICBN), listed in Appendix V and not to be used in any case.

nothospecies (nothotaxon) A species (or taxon) which originated from the hybridization of two other species (or taxa) and is found to form populations beyond the F1 generation with distinct and more or less stable characters.

nucleotide Any of the unit building blocks or bases of **DNA** and **RNA**, commonly represented by the letters A (adenine), C (cytosine), G (guanine) and T (thymine); in RNA U (uracil) replaces T. In the DNA chain, A links with T and C with G, forming sequences of nucleotides.

numerical taxonomy (phenetics) Taxonomy derived from the statistical analysis of variable data, i.e. the calculation of phenetic similarity between two taxa based on as many measurable variables (character variations) as possible, usually by applying one of many available 'clustering' algorithms and statistical probability tests. Greater overall similarity is assumed to mean closer relationship, thus directly informing the classification.

nutrient In the context of plants any of the basic elements such as nitrogen (N), potassium (K) and phosphor (P) necessary for growth and physiological processes.

n.v. (Latin *non vidi*) I have not seen it. Added to the citation of a (type) specimen one knows exists, but has not been able to see. Viewing a specimen can include seeing an image of it, e.g. on the Internet.

obcordate Inversely heart-shaped.

obdeltoid Shaped like an inversed capital Greek letter 'delta' (triangle).

oblanceolate Considerably longer than broad, inversely lance-shaped (the widest part above the middle, compare **lanceolate**).

oblong Considerably longer than broad, with nearly parallel sides.

obovate Inversely egg-shaped in outline (2-dimensional).

obovoid Inversely egg-shaped (3-dimensional, compare **pyriform**).

obtrullate Inversely **trullate**, i.e. shaped like a bricklayer's trowel with the two short sides at the apex.

obtuse Blunt, with a more or less rounded apex.

oligotraphent Adjective of a taxon, which predominantly grows in an **oligotrophic** environment.

oligotrophic Adjective of an environment (usually a body of water), which is poor in dissolved nutrients available to plants (compare **eutrophic**).

ontogenetically (ontogeny) Referring to the process of development or growth of an organism or its parts from fertilized egg to adult.

op. cit. (Latin *opus citatus*) Work cited. Referring here to the publication cited with a name of a **taxon** under the species to which the text applies; instead of to the list of references at the end of the Handbook.

orbicular Approximately circular in outline.

orthotropic Growing of the stem (sometimes the branches) in a vertical or near vertical direction, as opposed to the **plagiotropic** lateral branches growing in a (near) horizontal direction.

ovate Egg-shaped in outline (mostly for plane shapes).

ovoid Egg-shaped.

ovulate Referring to or having **ovules**.

ovule Seed bud, in **gymnosperms** (conifers) including the embryonic stages of a seed up to the event of fertilization, in which it is exposed to air and develops specialized features to capture pollen.

ovuliferous Bearing the **ovules** (Latin *ovulum*); which after pollination and fertilization become the seeds.

palaeobotany A branch of botany (or geology) concerned with the study of fossil plants or their remains.

palaeontology The science or study of fossil organisms.

palisade cells Perpendicular elongated **parenchyma** cells in the **mesophyll** near the surface of leaves.

palynology The science or study of **pollen** and spores, both of recent and fossil plants.

paniculate Arranged in a panicle, i.e. a compound, branching **raceme**.

papilliform Shaped like a nipple (Latin *papilla*).

parallelism In an evolutionary context, the development of a similar character in two or more lineages which do not share a nearest common ancestor; the character has therefore evolved more than once and independently.

paraphyletic Adjective referring to a group of **taxa** that share a nearest common ancestor but, as a group, does not include all of that ancestor's descendants (see also under **monophyletic**).

paratype (Latin *paratypus*) A specimen cited in the **protologue** that is neither the **holotype** nor an **isotype**, nor one of the **syntypes** if two or more specimens were simultaneously designated as types.

parenchyma A tissue of higher plants composed of thin-walled cells; especially such tissue as the pith and **mesophyll**.

passim (Latin *passus* = scattered) After a page number, indicating that the name (subject) subsequently appeared on several other pages.

pathogenic Referring to a pathogen, an agent or organism that causes disease.

pectinate Arranged as the leaflets of a compound, pinnate leaf; with the needles (leaves) arranged on both sides of the shoot, spreading sideways and more or less in a plane (compare **pinnate**).

pedicellate With a small flower stalk (Latin *pedicellus*); here used to describe the abruptly narrowed base of seed scales.

peduncle The stalk of a flower or inflorescence (Latin *pedunculus*); usage of this term to designate the stalk of a conifer (female) cone is morphologically incorrect insofar as such a cone is not an inflorescence, but a shoot with **ovuliferous** scales, but has been common practice and is maintained here for convenience (and likewise used for the stalk of male **strobili**).

peltate Shaped more or less like a shield, with an attachment more or less close to the centre.

pendant Hanging down (nearly) vertically (see also **pendulous**).

pendulous Hanging down (nearly) vertically (see also **pendant**).

permafrost A permanently frozen layer of sediments or soil, of variable thickness, formed in cold regions; of this layer the thin upper part on the surface thaws in summer.

pentagonal Shaped like a pentagon, i.e. a polygon with five angles and five sides.

perular scales The basal scales of buds which remain at the base of shoots or cones some time after elongation or maturity.

petiolate Having a leaf-stalk (petiole); also: shaped like a petiole.

phenotypic (phenotype) Relating to the anatomical and morphological appearance (characters) of an organism, in particular those determined by its genes (**DNA**, genotype) and a concomitant **ontogeny**.

photosynthesis Synthesis of chemical compounds with the aid of radiant energy (light), resulting in the formation of carbohydrates (assimilates) from carbon dioxide and water in chlorophyll-containing plant leaves (see also under **chlorophyll**).

phyletic Referring to both common ancestry relationships (**phylogeny**) and ancestor/descendant relationships (diversification of characters / character states through a hypothetical evolutionary lineage resolved in the phylogeny) (compare **phylogenetic**).

phylloclade (phyllode) (Greek *phyllos* = leaf, *clados* = branch) A leaf-like branch; in the genus *Phyllocladus* true leaves are rudimentary and foliage branchlets are strongly flattened, functioning as leaves.

phyllotaxis The arrangement of leaves on a shoot or stem and their position in relation to each other.

phylogenetic Referring to common ancestry relationships between extant species or taxa of higher ranks (see **phylogeny** and compare **phyletic**).

phylogeny A hypothesis of common ancestry relationships of **taxa**, usually depicted as a branching diagram or 'tree' ('Tree of Life') showing branching relationships from a hypothetical common ancestor to multiple descendants. **Cladograms**, although really only showing relationships of characters and character states, are usually interpreted as phylogenies by inserting **taxa** on the (terminal) branches, inferring their **phylogenetic** relationships from the branching pattern (topology) of the cladogram.

phytogeography The study of natural plant (usually species) distribution and its causes.

pilose Having straight, soft and spreading hairs.

pinetum (plural: pineta) A park or garden dedicated to a living collection of planted conifers.

pinnate Having the arrangement of a feather, with a single rachis from which leaflets arise on either side (compare **pectinate**).

plagiotropic Growing of (lateral) branches in a horizontal or near horizontal direction, away from the (near) vertical (**orthotropic**) stem or first order branches.

planation The transformation through evolution of a more or less **terete** shape of something in an ancestor into one that becomes flattened and wider in its descendants.

plate tectonics The formation and dynamics of the plates into which the crust of the Earth is divided.

podzolic (podzolized, Russian 'podzol' = 'under ashes') Referring to an infertile, sandy and acidic soil with minerals leached from its surface layers and deposited in a lower stratum. The leached part of the profile is ash-grey.

pollen (singular and plural) The (near) microscopic unit or 'grain' in seed plants that contains the male gamete enclosed by a hard and usually multi-layered wall and is dispersed to meet an **ovule** for fertilization.

pollen sac (microsporangium) A variously shaped sac-like vessel containing **pollen** and which is borne on the **microsporophyll** of a pollen cone in conifers.

pollination The transfer of pollen from a stamen (in angiosperms) to an ovule; in gymnosperms the pollen descends directly on the nucellus and germinates; the pollen tube begins to grow and penetrates the nucellus.

polymorphic Of various forms or shapes; similar organs on the same plant appear in > 2 **character states**, e.g. variable leaf forms (compare **dimorphic** and **monomorphic**).

polyphyletic Referring to a group of taxa that do not share a nearest common ancestor.

polytomy In a cladogram referring to lineages (clades) with unresolved relationships; such lineages all arise from a single node.

population The sum total of the individuals of a species (or lower taxon) which inhabit a certain area and are expected to interbreed (exchange genes).

p.p. (Latin *pro parte* = in part) adjective to a name indicating that only a certain part (including or excluding the type) of the original material mentioned in the **protologue** is (to be) connected with that name.

primary branches The branches that appear more or less rhythmically during the growth of a tree, from first to highest order. Secondary branches are the result of **reiteration**. The distinction between the two categories becomes increasingly blurred and often difficult to determine in old trees, in which much of the main branches may represent reiteration.

primary leaves The first leaves of a young plant, other than the **cotyledons**. In some genera (or species) these leaves differ markedly from later, adult types of leaves, e.g. in *Pinus* (**cataphylls**), in others the differences are gradual, e.g. in *Podocarpus* (compare **secondary leaves**).

primary (bud) scales The outer scales, which are often much longer than the inner (secondary) scales in foliage branches of the genus *Podocarpus*.

prismatic Shaped like a prism, i.e. with polygonal faces lying in parallel planes.

proliferation (in conifers) The development of a foliage shoot from a normally **determinate** organ, e.g. a seed cone.

protologue (Greek *protos* =first; *logos* = discourse) Everything associated with a name at its first valid publication, i.e. diagnosis, description, illustrations, references, synonymy, geographical data, citation of specimens, discussion, and comments.

provenance Information about the source of a plant or its seed used in forestry or horticulture.

proximal Occurring nearest the base or axis (compare **distal**).

pruinose Covered with a coarse, whitish, waxy bloom, more prominent than if **glaucous**.

pseudo-whorl An arrangement that is seemingly forming a whorl, but is in fact **helical** on a very short axis.

puberulent Minutely **pubescent**, i.e. covered with very small, soft hairs.

pubescent Covered with soft, short hairs.

pulverulent Being or looking dusty or powdery (from almost invisible short hairs).

pulvinus (plural: pulvini) Small, peg-like projection on the shoot supporting the leaf (needle) in several genera especially of *Pinaceae*.

pungent Ending in a rigid, sharp point or prickle.

pustulate Having pustules, i.e. low projections like a blister or pimple.

pyriform Shaped like a pear, i.e. with the broadest part near the apex (compare **obovoid**).

quadrate In fours, here pertaining to the **phyllotaxis**, with four leaves originating at exactly the same distance on the shoot. If one of the opposite pairs is slightly higer, the arrangement is **decussate**.

quadrate-rhombic Shaped between quadrangular and rhombic (compare **rhombic**).

raceme An inflorescence with the oldest flowers (**pollen cones** in conifers) the most **proximal** and a potentially continuously growing apex.

racemose In the form of a **raceme**.

rachis The axis (**homologous** to a shoot) of the cone of a conifer, from which **bracts**, **microsporophylls** or **seed scales** arise.

Rauh's model A growth model in tree architecture with a **monopodial**, erect stem with apical dominance and branches placed in (pseudo-) whorls at regular intervals; these and secondary branches are **assurgent** and by erecting themselves (becoming **orthotropic**) cause repetition of the first order branching in (pseudo-)whorls.

receptacle A fleshy or succulent structure subtending a free standing seed in *Podocarpus* and some other genera of the *Podocarpaceae*; it is formed from all remnants of the seed cone after fertilisation of usually a single egg (ovule) developing into the seed.

recurved Curved backward (compare **decurved**).

refugium (plural: refugia) A geographical area into which one or more species have retreated (or where they remained) from a much wider distribution in the past.

reiteration (Latin *reiterare* = to say or do repeatedly) The secondary initiation of branching from a primary branching system (or from the trunk) of a tree, activating dormant buds, usually as a response to damage.

rendzina A dark greyish brown intrazonal soil developed in usually grassy regions of high to moderate humidity from soft calcareous marl or chalk.

reniform Kidney-shaped; much wider than long.

repand With an undulating or wavy margin.

resin duct (resin canal) A tubular intercellular space, especially in gymnosperms, that is lined with cells which secrete resin.

resin vesicle A small cavity or bladder filled with resin.

reticulate Forming a network of connections or relationships between distinct entities.

retuse Notched shallowly at a rounded apex.

revolute Rolled downward or backward.

rheophyte A plant that completes its life cycle in streams, but is not aquatic; a rheophyte germinates out of water when the stream falls temporarily dry or recedes from normally higher levels.

rhombic Having the shape of a rhombus, i.e. an equilateral parallelogram usually having oblique angles (compare **rhomboid**).

rhombic-orbicular Shaped between **rhombic** and **orbicular**.

rhomboid shaped like a parallelogram in which the angles are oblique and adjacent sides are unequal (compare **rhombic**).

riparian Growing on the banks of rivers, subject to flooding, but not permanently in water.

RNA Ribonucleic acid. In its various forms, RNA acts as the intermediary by which the hereditary code of DNA is converted into proteins (compare **DNA**).

rostrate Shaped like a beak (Latin *rostrum*).

ruderal Referring to plants or vegetation growing in and adapted to continuously or repeatedly disturbed sites (dynamic **habitats**).

saccate With bladders (Latin *sacci*); some types of **pollen** in conifers have 2 (rarely more) hollow bladders, presumably to aid buoyancy.

sapwood The outer section of the wood of a tree, with 'living' wood cells through which water is transported.

scarious Thin, dry and membranous, not green (herbaceous).

scion A vegetative shoot cut from a plant and caused to produce roots or grafted onto a different rootstock.

sclereids (Greek *skleros* = hard) Inclusions in the **mesophyll** or below the surface of leaves consisting of 'stone cells', i.e. dense and hard bodies often with a random position and distribution.

sclerified Hardened by transformation or addition of cells with **lignified** walls.

sclerophyllous With hard leaves; leaves with a tough texture, mainly from **dermal** cells with lignified walls.

secondary leaves Leaves of the 'adult' type; in conifers these may appear soon on young plants, or they may be delayed for much longer and they are the forms that are usually associated with fertile branches and/or appear in the canopy of mature trees or shrubs (compare **primary leaves**).

seed scale Appendage in a conifer seed cone (situated in the **axil** of a **bract**) bearing one or more seeds.

sensu lato (Latin = in a broad sense) In **taxonomy** it follows a **taxon** name to indicate that it includes another taxon at the same rank, which some may recognize as distinct (abbreviated as *s.l.*). The opposite is ***sensu stricto***.

sensu stricto (Latin – in a strict or narrow sense). In **taxonomy** it follows a **taxon** name to indicate that it excludes another taxon at the same rank, which some may consider as synonymous (abbreviated as *s. str.*). The opposite is ***sensu lato***.

septal (Latin *septum* = enclosure) Here a position of the resin canals in the leaves wedged between the endodermis (enclosing the inner vascular cylinder) and the **hypodermis**.

sequencing (of **DNA**) A technique using biochemical methods to determine the sequence of the four nucleotides (the genetic code) in a particular section of the DNA strand of an organism. These sequences are copied through generations, but small changes (mutations) occur from time to time, which are again copied and so serve as markers of heredity. They can be identified and scored as derived characters for a **cladistic** analysis.

sere A successional sequence of plant associations or communities that replace each other over time at a given site, usually going from pioneer stages to later stages in which an ecological equilibrium is reached. The stages are called seral to emphasize their transitory nature.

serotinous (Latin *sero* = late) Late to appear or flower; in conifer seed cones pertaining to a delayed opening, usually associated with persistence on branches; both are adaptations to fire.

serrate Saw-toothed, the sharp teeth pointing forward.

serrulate Finely **serrate**.

sessile (Latin *sessilis* = sitting, attached) Without a **peduncle** or stalk, or in the case of conifer cones, with a very short one which is invisible under the basal scales so that the cone appears to be stalkless.**sister group** A **clade** in a **cladogram** that is nearest in relationship to another clade, or a **taxon** represented by such a clade. The term usually (but not necessarily) refers to the clade below the next one in a cladogram.

sister (group or taxon). In cladistic terminology a group or a **taxon** that is a **clade** next to another clade, of which it is the sister clade; within a particular **cladogram** these two are more closely related to each other **phylogenetically** than they are to any other clades (groups) represented.

s. l. (Latin *sensu lato*) In a broad sense; used in addition to a taxonomic name to differentiate it from the use of that name in a strict sense (see ***sensu lato***).

s.n. (Latin *sine numero*) Without a number. If collectors of botanical specimens did not give a number to them, such collections are cited with

the name of the collector and '*s.n.*' immediately following.

s. str. (Latin *sensu stricto*) In a strict or narrow sense (see ***sensu stricto***).

spathulate Spoon-shaped.

speciation To differentiate into new biological species through **evolution**, involving genetic separation of populations and divergence of characters (**character states**) through time.

species complex Term used to describe a group of closely related species, within which group speciation takes place (variation leading to genetic separation) and/or which is often characterized by **hybrids** (occurrence of hybrid-swarms, **reticulate** relationships between **taxa**).

speciose Counting or having many species.

spicate As in a **spike**, spike-like.

spike An inflorescence consisting of an axis and numerous flowers (pollen cones in conifers) arranged on it (see also **raceme**).

spinescent Shaped like a spine or thorn (compare **pungent**).

spiral Arranged or shaped in an outward going, circular fashion. On shoots, this will be an upward spiral and is more accurately termed **helical**, but "spirally arranged leaves" is often used, including in this book.

sporophyll Literally a leaf bearing spores (as in ferns); in **gymnosperms** it refers to leaf-like appendages bearing male (= microsporophyll) or female (= macrosporophyll) reproductive organs: **pollen** (in pollen sacs) or **ovules**.

squarrose With stiff or rigid branches or protrusions.

stele An axial cylinder of tissue in which the vascular tissue is developed; its outer layer of cells forms the endodermis.

stomata (sing. stoma) Breathing pores or apertures in the **epidermis**, surrounded by two guard cells (and subsidiary cells), leading into an intercellular space communicating with the internal tissue.

striated Marked with (longitudinal) lines or streaks.

strobilus (Greek *strobilos* = pine cone; plural: strobili) The technical term for the reproductive unit of a **gymnosperm** that bears male or female organs, regardless of whether it forms a distinct cone or not.

subalpine Referring to, or growing in the biogeographic zone between the **montane** zone and the tree limit in high mountains; it is the altitude of the highest growing tree species in a given area.

substrate The base on which an organism lives; for most vascular plants this is the soil.

subtending Occupying an adjacent and usually lower position to and often (partly) enclosing an organ.

subterete Almost **terete**, the shoot may be very slightly angular or ridged.

subulate Awl-shaped; linear and tapering to a fine point.

succession In ecology, the gradual and successive replacement of plant species by others in one locality due to development of the vegetation from a pioneer phase to a **climax** phase.

succulent Of a plant: having fleshy tissues adapted to conserve and store moisture (like the cactuses or cacti).

symbiosis A mutually beneficial physiological relationship between two or more different species, with give and take in equilibrium in the sense of an evolutionary stable strategy (ESS).

sympatric Occurring in (generally) the same area or with partly overlapping areas, but without loss of genetic identity by interbreeding.

syntype (Latin *syntypus*) Any specimen cited in the **protologue** when no **holotype** was designated, or any of two or more specimens simultaneously designated as **types**.

systematics The science of the diversity of and the relationships between taxa based on evolutionary principles, including (or sometimes seen as synonymous with) **taxonomy**.

synapomorphy (plural: synapomorphies) Shared derived character(s); i.e. a character originated in a common ancestor and inherited unaltered by its descendants; it could be lost subsequently in some descendants and transformed into a different character in others (see also **homologous**).

taiga (Russian = forest) Northern coniferous forest between tundra in the north and steppe in the south, particularly in Asia.

talus A slope formed especially by accumulation of rock debris from rock formations above it.

taxon (plural: taxa) Any group of organisms that is recognized at any of the ranks of classification used by taxonomists, such as family, genus, species.

taxonomy The science of classification of organisms and the identification and naming of taxa.

TDWG International Working Group on Taxonomic Databases for Plant Sciences (TDWG). The codes used in this Handbook are for politically defined geographical areas (countries, provinces etc.) according to the World Geographical Scheme for Recording Plant Distributions, compiled by R. K. Brummitt (2001). See with this reference for access.

terete Approximately cylindrical.

terminal Referring to the position of an organ or structure at the tip of a shoot.

ternate Occurring in threes; leaves are ternate only if all 3 leaves originate at exactly the same distance on the shoot, otherwise they are more likely to be alternate.

terpenoid (German: Turpentine) Referring to chemical compounds based on a five-carbon atom structure and present in conifer resins, also known as terpenes.

tesselate elements or pieces laid closely together as in a mosaic or like paving stones, joined only at the margins (compare **imbricate**).

tetragonal Having four sides or faces derived from a quadrangular base.

tetrastichous Arranged to forming 4 apparent rows from a **helical** leaf attachment on the shoot.

tomentose Densely covered with short, woolly hairs.

tracheid A dead cell in the wood of **gymnosperms** characterized by lateral pits in the cell walls connecting the lumen of one tracheid with that of another, allowing fluid transport; tracheids are structurally distinct from the equivalent cells in **angiosperms** (**vessels**).

translucent Of a substance or thing with a colour, density, or thickness that allows some light to penetrate, but insufficient to be seen through (compare **transparent**).

transparent Of a substance or thing with a colour, density, or thickness that allows it to be seen through (compare **translucent**).

transverse Made at right angles to the anterior-posterior axis of a body or structure; also set crosswise.

transversely rhombic Having the shape of a rhombus (see **rhombic**), which is transversely widened (see **transverse**).

triangulate Appearing as a triangle but not really shaped so.

tridentate Three-toothed; in the bract scales of cones of *Pinaceae* with a short, pointed central lobe flanked by two short, pointed lateral lobes (see also **trilobate**).

trigonal Having three sides or faces derived from a triangular base.

trilobate Three-lobed; in the bract scales of cones of *Pinaceae* with a long or rounded central lobe flanked by two long or rounded lateral lobes (see also **tridentate**).

trimerous In threes; i.e. made up of three separate, free parts (compare **tripartite**).

tripartite Made up of three separate but connected parts (compare **trimerous**).

trisaccate (in **pollen**) Having three sacci or air bladders (compare **bisaccate**).

trullate Shaped like a bricklayer's trowel.

truncate Ending abruptly, as if cut off transversely (but usually with rounded corners).

tussock In grassland, clumps formed by the constituent grasses that are raised above the general surface, such grassland is very uneven as a result.

type (type specimen) A specimen designated as the type of the name of a species or **taxon** with lower rank, fixing the application of that name by including its characters. The circumscription of a taxon can be widened or narrowed, but always must include that of the type specimen if it is to retain its name. Similar principles apply at higher ranks, where e.g. a species name becomes the 'type' of a genus, but in fact refers to the type specimen of that species name.

ultrabasic Referring to rock or soil with a high pH rich in metallic minerals (also **ultramafic**).

ultramafic Referring to rock or soil poor in silica, but extremely rich in iron and magnesium minerals and with a high pH value (also **ultrabasic**).

umbellate Borne in umbels, i.e. a (flower) cluster in which the **pedicels** or stalks (branches) arise from a common point.

umbilicate Depressed like a navel.

umbo (orig. Latin = the boss of a shield) In pine cones it is a prominence on the **apophysis** of the scales, often armed with a prickle or spine.

undulate Having a wavy surface, edge, or markings (see also **repand**).

utriculate Inflated, bladder-like.

valvate Parts connecting or touching with their edges (as in the two shells of an oyster), not overlapping (compare **imbricate**).

variegated Variably coloured in foliage or leaves, usually occurring in **cultivars** from a partial deficiency in the amount of **chlorophyll** in the leaves, causing a yellowish hue contrasting with normal green.

vascular bundle A unit of the vascular system of a vascular plant, consisting of vessels and sieve tubes, together with **parenchyma** cells and fibres; it has a function in transportation of water, nutrients and assimilates.

vegetative bud (vegetative apex) A bud which gives rise to the vegetative organs, i.e. the shoot, dwarf shoots and needles or leaves. In the descriptions of this Handbook usually the terminal buds at the end of branches are the only ones described (see also **winter bud**).

venation The number and distribution (pattern) of veins in a leaf.

verrucose Covered in numerous small, wart-like elevations (verrucae).

vessel (in wood) A cell in the wood of **angiosperms** (and some **gymnosperms**) with closed lateral walls and distal openings allowing fluid transport (compare **tracheid**).

vicariance (Latin *vicarius* = substitute) In **biogeography** referring to the distribution of taxa explained by the history of the separation of the areas in which these taxa occur. The term originally referred to a method of analysis in which area **cladograms** were substituted for **taxon** cladograms. This concept is intimately connected with **cladistic** methodology, under the assumption that distribution patterns and speciation are caused by the same historic events. It ignores (later) distribution of taxa caused by dispersal of organisms.

vicariant (Latin *vicarius* = substitute) A taxon occupying a similar niche as a different, but related taxon occurring in a separate area (vicariants are **allopatric**). The two taxa are inferred to have derived from an (extinct) common ancestor and their separation the result of the emergence of an ecological barrier between them.

whip shoot A relatively fast growing, leading foliage branchlet; due to its faster growth scale leaves, which grow with it, are longer and often also wider than those on short, lateral branchlets.

winter bud A terminal bud, which in conifers is covered with scales or **cataphylls** which can be resinous or non-resinous, and which contains the young shoot of which the internodes are not yet elongated; it will start growing at the beginning of the spring season (see also **vegetative bud**).

xeromorphic Structurally adapted for life and growth with a limited water supply, especially a morphology limiting transpiration (in **gymnosperms**) or providing for the storage of water; such plants are **xerophytes**.

xerophyte A plant structurally adapted for life and growth with a limited water supply; usually by means of **xeromorphic** adaptations that allow water storage and ensure limitation of transpiration.

zoochory The dispersal of plant propagules (e.g. seeds) by animals.

REFERENCES

Abdoun, F. & M. Beddiaf (2002). *Cupressus dupreziana* A. Camus: répartition, dépérissement et régénération au Tassili n'Ajjer, Sahara central. Compte Rendus Biologies 325: 617–627.

Adams, R. P. (1986). Geographic variation in *Juniperus silicicola* and *J. virginiana* of the southeastern United States: multivariate analyses of morphology and terpenoids. Taxon 35 (1): 61–75.

Adams, R. P. (1989). Biogeography and evolution of the junipers of the West Indies. In: Charles A. Woods (ed.). Biogeography of the West Indies, pp. 167–190. University Press of Florida, Gainsville, Fla.

Adams, R. P. (1995). Revisionary study of Caribbean species of *Juniperus* (Cupressaceae). Phytologia 78 (2): 134–150.

Adams, R. P. (2000). Systematics of smooth leaf margin *Juniperus* of the western hemisphere based on leaf essential oils and RAPD DNA finger printing. Biochemistry, Systematics and Ecology 28: 149–162.

Adams, R. P. (2004). Junipers of the world. The genus *Juniperus*. Trafford Publishing Co., Vancouver.

Adams, R. P. (2011). Junipers of the world. The genus *Juniperus*. Third Edition. Trafford Publishing Co., Bloomington, Indiana.

Adams, R. P., J. A. Bartel & R. A. Price (2009). A new genus, *Hesperocyparis*, for the Cypresses of the Western hemisphere (Cupressaceae). Phytologia 91 (1): 160–185.

Adams, R. P., A. E. Schwarzbach & S. Nguyen (2006). Re-examination of the taxonomy of *Juniperus flaccida* var. *martinezii* and var. *poblana* (Cupressaceae). Phytologia 88 (3): 233–241.

Adams, R. P. & A. E. Schwarzbach (2006). Infraspecific adjustments in *Juniperus deppeana* (Cupressaceae). Phytologia 88 (3): 227–232.

Alanis Flores, G. J. & S. Favela Lara (2002). The conservation status of *Taxodium* in Mexico. Fitzroya 5: 7. [newsletter of the IUCN Conifer Specialist Group]

Anderson, J. M., H. M. Anderson & C. J. Cleal (2007). Brief history of the gymnosperms: classification, biodiversity, phytogeography and ecology. Strelitzia 20. Pretoria, South Africa.

Andresen, J. W. (1966). A multivariate analysis of the *Pinus chiapensis – monticola – strobus* phylad. Rhodora 68: 1–24.

Aune, P. S. (tech. coord.) (1994). Proceedings of the symposium on Giant Sequoias: their place in the ecosystem and society, June 23–25, 1992, Visalia, California. U. S. D. A. Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-151.

Averyanov, L. V., Nguyen Tien Hiep, D. K. Harder & Phan Ke Loc (2002). The history of discovery and natural habitats of *Xanthocyparis vietnamensis* (Cupressaceae). Turczaninowia 5 (4): 31–39.

Averyanov, L. V., Nguyen Tien Hiep, Phan Ke Loc & Pham Van The (2005). Distribution, ecology and habitats of *Calocedrus rupestris* (Cupressaceae) in Viet Nam. Turczaninowia 8 (4): 19–35.

Baillie, J. E. M., C. Hilton-Taylor & S. N. Stuart (eds.) (2004). 2004 IUCN Red List of Threatened Species. A global species assessment. IUCN, Gland, Switzerland and Cambridge, UK.

Baker, R. T. & H. G. Smith (1910). A research on the pines of Australia. N. S. W., Technical Education Series, No. 16. Sydney.

Barker, N. P., E. M. Muller & R. R. Mill (2004). A yellowwood by any other name: molecular systematics and the taxonomy of *Podocarpus* and the Podocarpaceae in southern Africa. South African Journal of Science 100 (11–12): 629–632.

Barlow, C. & P. S. Martin (2008). Bring *Torreya taxifolia* north – now. (Assisted migration for an endangered tree). British Conifer Society Journal 10: 40–45. [earlier publ. in: Wild Earth fall/winter ed. 2004–05]

Bartholomew, B., D. E. Boufford & S. A. Spongberg (1983). *Metasequoia glyptostroboides*: its present

status in Central China. Journal of the Arnold Arboretum 64 (1): 105–128.

Bell, A. D. (1991). Plant form. An illustrated guide to flowering plant morphology. [with line drawings by A. Bryan] Oxford University Press, Oxford.

Bessey, C. E. (1907). A synopsis of plant phyla… Nebraska University Studies 7: 275–373.

Bevan-Jones, R. (2002). The ancient yew, a history of *Taxus baccata*. Windgather Press, Bollington, Cheshire, England.

Bitner, R. L. (2007). Conifers for gardens. An illustrated encyclopedia. Timber Press, Portland, Oregon.

Boratynski, A. & K. Browicz (1983). *Juniperus drupacea* in Greece. Arboretum Kórnickie 27: 3–16.

Briggs, J. D. & J. H. Leigh (1988). Rare and threatened Australian plants 1988 revised edition. Special Publication 14. Australian National Parks and Wildlife Service, Canberra.

Brummitt, R. K. (2001). World Geographical Scheme for Recording Plant Distributions. Plant Taxonomic Database Standards No. 2, ed. 2. International Working Group on Taxonomic Databases (TDWG). Hunt Institute for Botanical Documentation, Pittsburgh. [TDWG Standard] [Electronic version available under http://www.tdwg.org/geo2.htm.]

Brummitt, R. K. & C. E. Powell (1992). Authors of plant names. Royal Botanic Gardens, Kew, Richmond.

Brunsfeld, S. J., P. S. Soltis, D. E. Soltis, P. A. Gadek, C. J. Quinn, D. D. Strenge & T. A. Ranker (1994). Phylogenetic relationships among the genera of Taxodiaceae and Cupressaceae: evidence from rbcL sequences. Systematic Botany 19: 253–262.

Buchholz, J. T. & N. E. Gray (1948). A taxonomic revision of *Podocarpus*. I. The sections of the genus and their subdivisions, with special reference to leaf anatomy. Journal of the Arnold Arboretum 29: 49–63.

Burns, R. M. & B. H. Honkala, tech. coords. (1990). Silvics of North America. Vol. 1, Conifers. U. S. D. A. Forest Service Agricultural Handbook 654. Washington, D. C.

Businský, R. (1999). Study of *Pinus dalatensis* Ferré and of the enigmatic "Pin du Moyen Annam". Candollea 54: 125–143.

Businský, R. (2003). A new hard pine (*Pinus*, Pinaceae) from Taiwan. Novon 13 (3): 281–288.

Businský, R. (2004). A revision of the Asian *Pinus* subsection *Strobus* (Pinaceae). Willdenowia 34 (1): 209–257.

Businský, R. (2008). The genus *Pinus* L., pines; contribution to knowledge. Acta Pruhoniciana 88.

Carrière, E. A. (1855, ed. 2, 1867). Traité Général des Conifères, ou description de toutes les espèces et variétés,… By the author, Paris.

Chapman, J. D. (1995). The Mulanje cedar, Malawi's national tree. The Society of Malawi, Blantyre.

Chaw, S. M., A. Zharkikh, H. M. Sung, T. C. Lau & W. H. Li (1997). Molecular phylogeny of extant gymnosperms and seed plant evolution: analysis of nuclear 18S rRNA sequences. Molecular Biology and Evolution 14 (1): 56–68.

Chen, Z. K. & F. H. Wang (1990). On the embryology and relationship of the Cephalotaxaceae and Taxaceae. Cathaya 2: 41–52.

Cheng, W. C. & L. K. Fu (eds.). (1978). Flora Reipublicae Popularis Sinicae. Delectis florae reipublicae popularis sinicae agendae academiae sinicae edita. Tomus 7: Gymnospermae. Academica Sinica, Beijing.

Cheng, Y. C., R. G. Nicolson, K. Tripp & S. M. Chaw (2000). Phylogeny of Taxaceae and Cephalotaxaceae genera inferred from [the] chloroplast *mat*K gene and nuclear rDNA ITS region. Molecular Phylogenetics and Evolution 14 (3): 353–365.

Chii, K. L. & W. S. Cooper (1950). An ecological reconnaissance in the native home of *Metasequoia glyptostroboides*. Ecology 31: 260–278, f. 1–6.

Christensen, K. I. (1987). A morphometric study of the *Pinus mugo* Turra complex and its natural hybridization with *P. sylvestris* L. (Pinaceae). Fedde's Repertorium 98 (11–12): 623–635.

Christensen, K. I. & G. H. Dar (1997). A morphometric analysis of spontaneous and artificial hybrids of *Pinus mugo* × *sylvestris* (Pinaceae). Nordic Journal of Botany 17 (1): 77–86.

Conran, J. G., G. M. Wood, P. G. Martin, J. M. Dowd, C. J. Quinn, P. A. Gadek & R. A. Price (2000). Generic relationships within and between the gymnosperm families Podocarpaceae and Phyllocladaceae based on an analysis of the chloroplast gene *rbc*L. Australian Journal of Botany 48: 715–724.

Cooling, E. N. G. & H. Gaussen (1970). In Indochina: *Pinus merkusiana* sp. nov. et non *P. merkusii* Jungh. et De Vriese. Travaux du Laboratoire Forestier de Toulouse, T. 1, vol. 8, art. 7: 1–5.

Cope, E. A. (1998). Taxaceae: the genera and cultivated species. Bot. Rev. (Lancaster) 64 (4): 291–322.

Craib, W. G. (1919). *Abies delavayi* in cultivation. Notes of the Royal Botanic Garden Edinburgh 11 (55): 277–280, 3 pl.

Crane, P. R. (1985). Phylogenetic analysis of seed plants and the origins of angiosperms. Annals of the Missouri Botanical Garden 72: 716–793.

Dallimore, W. & A. B. Jackson (1966). A Handbook of Coniferae and Ginkgoaceae, ed. 4. Revised by S. G. Harrison. Edward Arnold & Co., London.

Darrow, W. K. & T. Zanoni (1991). Hispaniolan pine (*Pinus occidentalis* Swartz) a little known sub-tropical pine of economic potential. Commonwealth Forestry Review 69 (2): 133–146.

Davis, P. H. (ed.) (1965). Flora of Turkey and the east Aegean islands. Vol. 1. Edinburgh University Press, Edinburgh.

Debreczy, Z., K. Musial, R. A. Price & I. Rácz (2009). Relationships and nomenclatural status of the Nootka Cypress (*Callitropsis nootkatensis*, Cupressaceae). Phytologia 91 (1): 140–159.

Delgado, P., D. Piñero, A. Chaos, N. Pérez-Nasser & E. R. Alvarez-Buylla (1999). High population differentiation and genetic variation in the endangered Mexican pine *Pinus rzedowskii* (Pinaceae). Amer. J. Bot. 86 (5): 669–676.

Doyle, M. F. (1998). Gymnosperms of the SW Pacific – 1. Fiji. Endemic and indigenous species: changes in nomenclature, key, annotated checklist, and discussion. Harvard Papers in Botany 3 (1): 101–106.

Dudley, T. R. (1988). Chinese Firs: particularly *Abies beshanzuensis*. American Conifer Society Bulletin 5 (4): 84–93.

Dvorak, W. S. & J. K. Donahue (1992). CAMCORE cooperative research review 1980–1992. Department of Forestry, North Carolina State University.

Earle, C. (www.conifers.org). The Gymnosperm Database.

Eckenwalder, J. E. (1976). Re-evaluation of Cupressaceae and Taxodiaceae: a proposed merger. Madroño 23 (5): 237–256.

Ellenberg, H. (1988). Vegetation ecology of Central Europe. (4th edition). Cambridge University Press, Cambridge.

Endlicher, S. L. (1847). Synopsis Coniferarum. Scheitlin und Zollikofer, Sangalli (Sankt Gallen).

Engelmann, G. (1879). Abietinae. In: S. Watson. Botany of California 2: 117–128. University Press, Cambridge, Massachussetts.

Enright, N. J. & R. S. Hill (eds.). (1995). Ecology of the Southern Conifers. Melbourne University Press.

Ehrlich, P. & A. Ehrlich (1981). Extinction: The causes and consequences of the disappearance of species. Random House, New York.

Farjon, A. (1984). Pines: drawings and descriptions of the genus *Pinus*. E. J. Brill / W. Backhuys, Leiden.

Farjon, A. (1988). Taxonomic notes on Pinaceae I. Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Botanie, ser. C, 91 (1): 31–42.

Farjon, A. (1989). A second revision of the genus *Keteleeria* Carrière. (Taxonomic notes on Pinaceae II). Notes of the Royal Botanic Garden Edinburgh 46 (1): 81–99.

Farjon, A. (1990). Pinaceae: drawings and descriptions of the genera *Abies, Cedrus, Pseudolarix, Keteleeria, Nothotsuga, Tsuga, Cathaya, Pseudotsuga, Larix* and *Picea*. (Regnum Vegetabile Vol. 121), Königstein, Germany.

Farjon, A. (1994). *Cupressus cashmeriana* (Cupressaceae). Kew Magazin 11 (4): 156–166.

Farjon, A. (1995). Typification of *Pinus apulcensis* Lindley (Pinaceae), a misinterpreted name for a Latin American pine. Novon 5: 252–256.

Farjon, A. (1998, ed. 2, 2001). World checklist and bibliography of conifers. Royal Botanic Gardens, Kew.

Farjon, A. (1999). *Cryptomeria japonica* (Cupressaceae). Curtis's Botanical Magazine 16 (3): 212–228, pl. 371.

Farjon, A. (2005a). A monograph of Cupressaceae and *Sciadopitys*. Royal Botanic Gardens, Kew, Richmond.

Farjon, A. (2005b). Pines. Drawings and descriptions of the genus *Pinus*, ed. 2. E. J. Brill, Leiden.

Farjon, A. (2007). In defence of a conifer taxonomy which recognises evolution. Taxon 56 (3): 639–641.

Farjon, A. (2008). A Natural History of Conifers. Timber Press, Portland, Oregon.

Farjon, A., Nguyen Tien Hiep, D. K. Harder, Phan Ke Loc & L. Averyanov (2002). A new genus and species in Cupressaceae (Coniferales) from northern Viet Nam, *Xanthocyparis vietnamensis*. Novon 12 (2): 179–189.

Farjon, A. & C. N. Page (compilers) (1999). Conifers: Status survey and Conservation Action Plan. IUCN-SSC Conifer Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Farjon, A., C. N. Page & N. Schellevis (1993). A preliminary world list of threatened conifer taxa. Biodiversity and & Conservation 2 (3): 304–326.

Farjon, A. & K. D. Rushforth (1989). A classification of *Abies* Miller (Pinaceae). Notes of the Royal Botanic Garden Edinburgh 46 (1): 59–79.

Farjon, A. & B. T. Styles (1997). Flora Neotropica Monograph 75. *Pinus* (Pinaceae). (with accounts of wood anatomy by I. D. Gourlay, pollen morphology by M. H. Kurmann and monoterpenes by J. S. Birks). The New York Botanical Garden, New York.

Ferguson, D. K. (1985). A new species of *Amentotaxus* (Taxaceae) from northeastern India. Kew Bulletin 40 (1): 115–119.

Ferguson, D. K. (1989). On Vietnamese *Amentotaxus* (Taxaceae). Adansonia, sér. 4, 11 (3): 315–318.

Flora of Australia 48 (1998). P. M. McCarthy (volume editor). Flora of Australia. Volume 48: Ferns, Gymnosperms and Allied Groups. CSIRO, Melbourne, Australia.

Flora of China 4 (1999). Z. Y. Wu & P. H. Raven (co-chairs of the editorial committee). Flora of China. Volume 4: Cycadaceae through Fagaceae. Science Press, Beijing & Missouri Botanical Garden Press, St. Louis.

Flora Europaea 1 (1993). T. G. Tutin *et al.* (eds.). Flora Europaea, 2nd ed. Vol. 1 (Psilotaceae – Plantanaceae). Cambridge University Press, Cambridge.

Flora Malesiana 10 (1988). Series I – Spermatophyta. Flowering Plants Vol. 10, part 3 (Revisions). Kluwer Academic Publishers, Dordrecht. [see also Laubenfels, D. J. de (1988)]

Flora of North America 2 (1993). Flora of North America Editorial Committee (ed.). Flora of North America, North of Mexico. Vol. 2. Pteridophytes and gymnosperms. Oxford Univ. Press, New York, Oxford.

Flora of Southern Africa 1 (1966). L. E. Codd *et al.* (eds.). Flora of Southern Africa 1. Podocarpaceae (by O. A. Leistner) pp. 34–41. South African Government Printer, Pretoria.

Flora of Taiwan 1 (1994). Editorial Committee (T. C. Huang, gen. ed.). Flora of Taiwan, Vol. 1, ed. 2. The Committee (for the National Science Council of the Republic of China), Taipei.

Florin, C. R. (1931). Untersuchungen zur Stammesgeschichte der Coniferales und Cordaitales. Erster Teil: Morphologie und Epidermisstruktur der Assimilationsorgane bei den rezenten Koniferen. Konglige Svenska Vetenskapsakademiens Handlingar 10 (1): 1–588, t. 1–58.

Florin, C. R. (1934). Die von E. L. Ekman (†) in Westindien gesammelten Koniferen. Arkiv för Botanik, Band 25-A, No. 5: 1–22, pl. 1–3.

Florin, C. R. (1948). On the morphology and relationships of the Taxaceae. Botanical Gazette (Crawfordsville) 110 (1): 31–39.

Florin, C. R. (1951). Evolution in Cordaites and Conifers. Acta Horti Bergiani 15 (2): 285–388.

Florin, C. R. (1963). The distribution of conifer and taxad genera in time and space. Acta Horti Bergiani 20 (4): 121–312.

Florin, C. R. & J. B. Boutelje (1954). External morphology and epidermal structure of leaves in the genus *Libocedrus*, s. lat. Acta Horti Bergiani 17 (2): 7–37.

Flous, F. (1936). Révision du genre *Keteleeria*. Travaux du Laboratoire Forestier de Toulouse, T. 2, vol. 4, art. 1: 1–76.

Forbes, J. (1839). Pinetum woburnense: or, a catalogue of coniferous plants, in the collection of the Duke of Bedford, at Woburn Abbey; systematically arranged. James Moyes, London.

Fowells, H. A. (1965). Silvics of forest trees of the United States. U. S. D. A. Agricultural Handbook 271. Washington, D. C.

Franklin, J. F., T. Maeda, Y. Oshumi, M. Matsui & H. Yagi (1979). Subalpine coniferous forests of Central Honshu, Japan. Ecological Monographs 49 (3): 311–334.

Fu, L. K., T. Q. Chen, K. Y. Lang & T. Hong (eds.). (2000). Higher Plants of China, Vol. 3. Qingdao Publishing House, Qingdao, China. [in Chinese]

Fu, L. K. & J. M. Jin (eds.). (1992). China Plant Red Data Book. Rare and endangered plants. Vol. 1. Science Press, Beijing – New York.

Fu, L. K., Y. J. Lu & S. L. Mo (1980). The genus *Abies* discovered for the first time in Guangxi and Hunan. Acta Phytotaxonomica Sinica 18 (2): 205–210. (Chin. + Lat.).

Gadek, P. A., D. L. Alpers, M. M. Heslewood & C. J. Quinn (2000). Relationships within Cupressaceae sensu lato: a combined morphological and molecular approach. American Journal of Botany 87 (7): 1044–1057.

Gadek, P. A. & C. J. Quinn (1993). An analysis of relationships within the Cupressaceae sensu stricto based on rbcL sequences. Annals of the Missouri Botical Garden 80: 581–586.

Gantzel, O. L. (1982). Avaliação das florestas de *Araucaria angustifolia* (Bertol.) Kuntze do sul do Brasil, através de imagens do satélite Landsat-II. Revista Floresta 13: 38–? (summary pp. 38–39).

Garden, J. (1957). A revision of the genus *Callitris* Vent. Contributions from the New South Wales National Herbarium 2 (5): 363–392.

Gardner, M. F., P. Hechenleitner V., P. I. Thomas, C. Echeverría, B. Escobar, P. Brownless & C. Martínez A. (2006). Threatened plants of Central and South Chile. Distribution, conservation and propagation. Universidad Austral de Chile / Royal Botanic Garden Edinburgh.

Gaussen, H. (1968). Les Gymnospermes actuelles et fossiles. Fascicule 10: Les Cupressacées. Faculté des Sciences, Université de Toulouse.

Gaussen, H. (1974). Les gymnospermes actuelles et fossiles. Fascicule 13: Les Podocarpines sauf les *Podocarpus*. Faculté des Sciences, Université de Toulouse.

Gaussen, H. (1976). Les gymnospermes actuelles et fossiles. Fascicule 14: Genre *Podocarpus*, Conclusion des Podocarpines. Faculté des Sciences, Université de Toulouse.

Geada López, G., K. Kamiya & K. Harada (2002). Phylogenetic relationships of diploxylon pines (subgenus *Pinus*) based on plastid sequence data. International Journal of Plant Science 163 (5): 737–747.

Gilmore, S. & K. D. Hill (1997). Relationships of the Wollemi Pine (*Wollemia nobilis*) and a molecular phylogeny of the Araucariaceae. Telopea 7 (3): 275–291.

Golte, W. (1993). *Araucaria*. Verbreitung und Standortsansprüche einer Coniferengattung in vergleichender Sicht. Erdwissenschaftliche Forschung Vol. 27. Stuttgart.

Golte, W. (1996). Exploitation and conservation of *Fitzroya cupressoides* in southern Chile. In: D. Hunt (ed.). Temperate trees under threat. International Dendrology Society, Morpeth, United Kingdom.

Gray, N. E. (1958). A taxonomic revision of *Podocarpus* XI. The South Pacific species of section *Podocarpus*, subsection B. Journal of the Arnold Arboretum 39: 424–477.

Gray, N. E. & J. T. Buchholz (1948). A taxonomic revision of *Podocarpus* IV. The American species of Section *Eupodocarpus*, subsections C and D. Journal of the Arnold Arboretum 29: 123–151.

Grierson, A. J. C. & D. G. Long (1983). Flora of Bhutan. Vol. 1, Part 1. Royal Botanic Garden, Edinburgh.

Grilli Caiola, M., A. Travaglini & M. Giuliano (2000). Palynological study of *Cupressus sempervirens* L. var. *pyramidalis* and var. *horizontalis*. Plant Biosystems 134 (1): 99–109.

Grimshaw, J. & R. Bayton (2009). New Trees. Recent introductions to cultivation. Kew Publishing, Royal Botanic Gardens, Kew.

Hageneder, F. (2007). Yew, a history. Sutton Publishing, Stroud, Gloucestershire.

Hajibabaei, M., J. Xia & G. Drouin (2006). Seed plant phylogeny: Gnetophytes are derived conifers and a sister group to Pinaceae. Molecular Phylogenetics and Evolution 40: 208–217.

Harden, G. J. & J. Thompson (1990). Cupressaceae. In: G. J. Harden (ed.). Flora of New South Wales. Vol. 1. University of New South Wales Press, Sydney.

Havrylenko, M., P. H. A. Rosso & S. B. Fontenla (1989). *Austrocedrus chilensis*: contribución al estudio de su mortalidad en Argentina. Bosque 10 (1): 29–36.

Henry, A. & M. McIntyre (1926). The swamp cypresses, *Glyptostrobus* of China and *Taxodium* of America, with notes on allied genera.

Proceedings of the Royal Irish Academy 37, sect. B: 90–116, pl. 1–8.

Hill, R. S. & T. Brodribb (1999). Southern conifers in time and space. Australian Journal of Botany 47: 639–696.

Horikawa, Y. (1972). Atlas of the Japanese Flora: an introduction to plant sociology of East Asia. (3 vols.) Gakken, Tokyo.

Hu, H. H. (1951). Lecture material on the Classification of Seed Plants. [in Chinese]

Hu, S. Y. (1964). Notes on the flora of China. IV. Gymnospermae. Taiwania 10: 13–62.

Islebe, G. (1993). Will Guatemala's *Juniperus-Pinus* forests survive? Environmental Conservation 20 (2): 167–168.

IUCN (1994, 2001). IUCN Red List Categories and Criteria, versions 2.3 and 3.1. IUCN Gland, Switzerland and Cambridge, UK.

Jagel, A. & T. Stützel (2001). Untersuchungen zur Morphologie und Morphogenese der Samenzapfen von *Platycladus orientalis* (L.) Franco (= *Thuja orientalis* L.) und *Microbiota decussata* Kom. (Cupressaceae). Botanisches Jahrbuch der Systematik 123 (3): 377–404.

Johns, R. J. (1995). *Papuacedrus papuana* var. *papuana* – Cupressaceae. Curtis's Botanical Magazine 12 (2): 66–72.

Kelch, D. G. (1997). The phylogeny of the Podocarpaceae based on morphological evidence. Systematic Botany 22 (1): 113–131.

Keng, H. (1973). On the family Phyllocladaceae. Taiwania 18: 142–145.

Keng, H. (1963–79). A monograph of the genus *Phyllocladus* (Coniferae). Published by the author, Taipeh. [contains several papers earlier published separately]

Kershaw, P. & B. Wagstaff (2001). The southern conifer family Araucariaceae: history, status and value for palaeoenvironmental reconstruction. Annual Review of Ecology and Systematics 32: 397–414.

Klaus, W. (1988). Mediterranean pines and their history. In: F. Ehrendorfer (ed.). Woody Plants Evolution and Distribution since the Tertiary. Special Edition of Plant Systematics and Evolution, Vol. 162: 133–163. Wien, New York.

Knopf, P., H. Nimsch & T. Stützel (2007). *Dacrydium* × *suprinii*, sp. nova – a natural hybrid of *Dacrydium araucarioides* × *D. guillauminii*. Feddes Repertorium 118 (1–2): 51–59.

Koch, Z. & M. Celeste Corrêa (2002). Araucária. A floresta do Brasil Meridional / The Meridional Brazil Forest. Olhar Brasileiro, Curitiba, Brazil.

Kunzmann, L. (2007). Neue Untersuchungen zu *Araucaria* Jussieu aus der europäischen Kreide. Palaeontographica B, 276 (4–6): 97–131.

Lambert, A. B. (1803–24). A description of the genus *Pinus*; illustrated with figures, directions relative to the cultivation, and remarks on the uses of the several species… Vol. 1–2, Published by the author, London.

Langenheim, J. H. (2003). Plant Resins. Chemistry, evolution, ecology and ethnobotany. Timber Press, Portland – Cambridge.

Lanner, R. M. (2007). The Bristlecone book. (A natural history of the world's oldest trees). Mountain Press Publishing Company, Missoula, Montana.

Laubenfels, D. J. de (1959). Parasitic conifer found in New Caledonia. Science 130: 97.

Laubenfels, D. J. de (1969). A revision of the Malesian and Pacific Rainforest Conifers, 1: Podocarpaceae. Journal of the Arnold Arboretum 50 (2–3): 274–369.

Laubenfels, D. J. de (1972). Flore de la Nouvelle Calédonie et dependances no. 4, Gymnospermes. Muséum Nationale d'Histoire Naturelle, Paris.

Laubenfels, D. J. de (1979). The species of *Agathis* (Araucariaceae) of Borneo. Blumea 25: 531–541.

Laubenfels, D. J. de (1985). A taxonomic revision of the genus *Podocarpus*. Blumea 30 (2): 251–278.

Laubenfels, D. J. de (1988). Coniferales. In: Flora Malesiana ser. I, 10 (3): 337–453. Kluwer Academic Publishers, Dordrecht.

Laubenfels, D. J. de & J. Silba (1987). The *Agathis* of Espiritu Santo (Araucariaceae, New Hebrides). Phytologia 61: 448–452.

Laubenfels, D. J. de & J. Silba (1988). Notes on Asian-Pacific Podocarpaceae, I (*Podocarpus*). Phytologia 64: 290–292.

Lauria, F. (1996). The identity of *Pinus ponderosa* Douglas *ex* C. Lawson (Pinaceae). Linzer Biologische Beiträge 28 (2): 999–1052.

Lee, S. C. (1962). Taiwan Red- and Yellow-cypress and their conservation. Taiwania 8: 1–13.

Ledig, F. T., P. D. Hodgskiss, K. V. Krutovskii, D. B. Neale & T. Eguiluz-Piedra (2004). Relationships among the Spruces (*Picea*, Pinaceae) of

southwestern North America. Systematic Botany 29 (2): 275–295.

Le Duc, A., R. P. Adams & M. Zhong (1999). Using random amplification of polymorphic DNA for a taxonomic re-evaluation of Pfitzer junipers. HortScience 34 (6): 1123–1125.

LePage, B. A. & J. F. Basinger (1995). The evolutionary history of the genus *Larix* (Pinaceae). In: W. C. Schmidt & K. J. McDonald (comps.). Ecology and management of *Larix* forests: a look ahead. Proceedings of an international symposium. U. S. D. A. Forest Service, Gen. Tech. Rep. INT-GTR-319: 19–29. Intermountain Research Station, Ogden, Utah.

Leslie, A. C. (ed., 1992). The International Conifer Register. Part 3. The Cypresses. (*Chamaecyparis*, *Cupressus* and ×*Cupressocyparis*). [compiled by John Lewis] The Royal Horticultural Society, London.

Li, H. L. (1952). The genus *Amentotaxus*. J. Arnold Arbor. 33: 192–198.

Li, H. L. (1975). Gymnospermae. In: C. DeVol *et al.* (eds.). Flora of Taiwan. Vol. 1. Epoch Publishing Company, Taipei, Taiwan.

Lin, X. & S. Y. Zhang (1993). Gymnospermae. In: C. F. Zhang & S. Y. Zhang (eds.). Flora of Zhejiang 1. Pteridophyta – Gymnospermae. [in Chinese]

Linnaeus, C. (1753). Species plantarum. Laurent Salvius, Stockholm.

Little, D. P. (2006). Evolution and circumscription of the true Cypresses (Cupressaceae: *Cupressus*). Systematic Botany 31 (3): 461–480.

Little, D. P., A. E. Schwarzbach, R. P. Adams & C. F. Hsieh (2004). The circumscription and phylogenetic relationships of *Callitropsis* and the newly described genus *Xanthocyparis* (Cupressaceae). American Journal of Botany 91 (11): 1872–1881.

Little, E. L., Jr. (1979). Checklist of United States trees (native and naturalized). U. S. D. A. Agricultural Handbook 541. Washington, D. C.

Liu, T. S. (1971). A monograph of the genus *Abies*. National Taiwan University, Taipeh.

Liu, T. S. (1982). A New Proposal for the Classification of the Genus *Picea*. Acta Phytotaxonomica and Geobotanica 33: 227–244.

Lu, S. Y. (1996). Rare and Endangered Plants in Taiwan, vol. 1. Published by the author, Taipei.

Lu, S. Y., T. Z. Chiang, K. H. Hong & T. W. Hu (1999). Re-examination of the taxonomic status of *Cunninghamia konishii* and *C. lanceolata* based on the RFLPs of a chloroplast trnD-trnT spacer. Taiwan Journal of Forest Science 14 (1): 13–19.

Mabberley, D. J. (2008). Mabberley's plant-book, ed. 3. Cambridge University Press, Cambridge.

Maiden, J. H. (1907). The forest flora of New South Wales. Vol. 2, part 12, No. 44–51: The Cypress Pines of New South Wales. Government Printer, Sydney.

Martínez, M. (1945). Las pinaceas Méxicanas. Anales del Instituto de Biología de la Universidad Nacional de México 16: 1–345.

Martínez, M. (1948). Los Pinos méxicanos. Ed. 2, University of Mexico, Mexico-city.

Martínez, M. (1950). El Ahuehuete. (*Taxodium mucronatum* Ten.). Anales del Instituto de Biología de la Universidad Nacional de México 21 (1): 25–82.

Mathews, S. (2009). Phylogenetic relationships among seed plants: persistent questions and the limits of molecular data. American Journal of Botany 96 (1): 228–236.

Mayr, H. (1890). Monographie der Abietineen des Japanischen Reiches, (Tannen, Fichten, Tsugen, Lärchen und Kiefern). M. Rieger'sche Universitäts Buchhandlung, München.

Melle, P. J. van (1946). The junipers commonly included in *Juniperus chinensis*. Phytologia 2 (6): 185–195.

Mill, R. R. (ed.) (2003). Proceedings of the Fourth International Conifer Conference. Conifers for the future? Wye College, England, 23rd August–26th August 1999. Acta Horticulturae 615. International Society for Horticultural Science (ISHS).

Mill, R. R. & M. Whiting (2012). *Podocarpus orarius* (Podocarpaceae), a new species from the Solomon Islands and a taxonomic clarification of *Podocarpus spathoides* from Malaysia. Gard. Bull. Singapore 64 (1): 171–193.

Mitsopoulos, D. J. & C. P. Panetsos (1987). Origin of variation in fir forests of Greece. Silvae Genetica. 36 (1): 1–15.

Möller, M., L. M. Gao, R. R. Mill, D. Z. Li, M. L. Hollingsworth & M. Gibby (2007). Morphometric analysis of the *Taxus wallichiana* complex (Taxaceae) based on herbarium

material. Botanical Journal of the Linnean Society 155: 307–335.

Molloy, B. P. J. (1996). A new species name in *Phyllocladus* (Phyllocladaceae) from New Zealand. New Zealand Journal of Botany 34: 287–297.

Molur, S. & S. Walker (eds.). (1998). Conservation assessment and management plan. Workshop report for selected medicinal pants of northern, northeastern and central India. ZOO Outreach Organization India.

Morgan, C. S. (1999). *Platycladus orientalis* (Cupressaceae). Curtis's Botanical Magazine 16 (3): 185–192, pl. 368.

Mundry, I. (2000). Morphologische und morphogenetische Untersuchungen zur Evolution der Gymnospermen. Bibliotheca Botanica 152: 1–90.

Mustart, P., J. Juritz, C. Makua, S. W. van der Merwe & N. Wessels (1995). Restoration of the Clanwilliam Cedar *Widdringtonia cedarbergensis*: the importance of monitoring seedlings planted in the Cederberg, South Africa. Biological Conservation 72: 73–76.

Nadolny, C. & J. Benson (1993). The biology and management of the Pigmy Cypress Pine (*Callitris oblonga*) in NSW. New South Wales National Parks and Wildlife Service, Species management report No. 7.

Nedoluzhko, V. A. (1999). Endangered woody plants of the Russian Far East. In: Biodiversity and allelopathy: from organisms to ecosystems in the Pacific. Academia Sinica, Taipei.

Nguyen Tien Hiep, P. K. Loc, N. D. To Luu, P. I. Thomas, A. Farjon, L. Averyanov & J. Regalado Jr. (2004). Viet Nam Conifers. Conservation status review 2004. Fauna & Flora International, Viet Nam Programme, Hanoi.

Nguyen Tien Hiep & J. E. Vidal (1996). Gymnospermae: Cycadaceae, Pinaceae, Taxodiaceae, Cupressaceae, Podocarpaceae, Taxaceae, Gnetaceae. Flore du Cambodge, du Laos et du Vietnam 28: 1–166. Musée National d'Histoire Naturelle, Paris.

Nitzelius, T. G. (1969). *Abies*, a review of the firs in the Mediterranean. Lustgården 49 (1968), reprint pp. 146–189, Uppsala.

Orr, M. Y. (1944). The leaf anatomy of *Podocarpus*. Transactions and Proceedings of the Society of Edinburgh 34 (1): 1–54.

Ouden, P. den & B. K. Boom (1965). Manual of Cultivated Conifers, hardy in the cold- and warm-temperate zone. Nijhoff, The Hague.

Page, C. N. (1989). New and maintained genera in the Conifer families Podocarpaceae and Pinaceae. Notes of the Royal Botanic Garden Edinburgh 45 (2): 377–395 (1988 on t. p.).

Page, C. N. (1990). Gymnosperms: Coniferophytina (Conifers and Ginkgoids). pp. 279–361 in: K. Kubitzki (ed.). The families and genera of vascular plants. Vol. 1: Pteridophytes and gymnosperms. (ed. K. U. Kramer & P. S. Green). Springer Verlag, Berlin – Heidelberg.

Page, C. N. & K. D. Rushforth (1980). *Picea farreri*, a new temperate conifer from Upper Burma. Notes of the Royal Botanic Garden Edinburgh 38 (1): 129–136.

Palgrave, K. C. (1977–1988). Trees of Southern Africa. Struik Publishers, Cape Town.

Pardos, J. A. & M. Pardos (1997). *Tetraclinis articulata* Masters, 1893. Enzyklopädie der Holzgewächse III-1 (9): 1–6. Ecomed Verlag, Landsberg am Lech.

Parlatore, F. (1868). Coniferae. (Ordo CXCIX). In: A. P. de Candolle & Alph. de Candolle. Prodromus systematis naturalis regni vegetabilis. Vol. 16, part 2, pp. 361–521, 685. Victor Masson & fils, Paris.

Pauw, C. A. & H. P. Linder (1997). Tropical African cedars (*Widdringtonia*, Cupressaceae): systematics, ecology and conservation status. Botanical Journal of the Linnean Society 123 (4): 297–319.

Perry, J. P., Jr. (1991). The Pines of Mexico and Central America. Timber Press, Portland, Oregon.

Pilger, R. (1903). Taxaceae. In: A. Engler (ed.). Das Pflanzenreich IV.5 [18]. Engelmann, Berlin – Leipzig.

Pilger, R. (1926). Phylogenie und Systematik der Coniferae. In: A. Engler & K. A. E. Prantl (eds.). Die natürlichen Pflanzenfamilien XIII. 2. Aufl. W. Engelmann, Leipzig.

PROSEA (1993). I. Soerianegara and R. H. M. J. Lemmens (eds). Vol. 5 (1). Major commercial timbers. PROSEA, Bogor, Indonesia.

Quinn, C. J. (1982). Taxonomy of *Dacrydium* Sol. *ex* Lamb. emend. de Laub. (Podocarpaceae). Australian Journal of Botany 30 (3): 311–320.

Quinn, C. J. (1987). The Phyllocladaceae Keng – a critique. Taxon 36 (3): 559–565.

Quinn, C. J. & R. A. Price (2003). Phylogeny of the southern hemisphere conifers. In: R. R. Mill (ed.). Proceedings of the Fourth International Conifer Conference. Acta Horticulturae 615: 129–136. International Society for Horticultural Science (ISHS).

Quinn, C. J., R. A. Price & P. A. Gadek (2002). Familial concepts and relationships in the conifers based on *rbc*L and *mat*K sequence comparisons. Kew Bulletin 57 (3): 513–531.

Rai, H. S., P. A. Reeves, R. Peakall, R. G. Olmstead & S. W. Graham (2008). Inference of higher order conifer relationships from a multi-locus data set.

Rehder, A. & E. H. Wilson (1914). Taxaceae; Pinaceae. In: C. S. Sargent, Plantae Wilsonianae II: 3–62. The University Press, Cambridge, Mass.

Reynel, C., T. D. Pennington, R. T. Pennington, J. L. Marcelo & A. Daza (2006). Arboles útiles del Ande Peruano. Tarea Graphica Educativa, Peru. [Darwin Initiative Project 332]

Richardson, D. M. (ed.) (1998). Ecology and biogeography of *Pinus*. Cambridge University Press, Cambridge.

Rothwell, G. W. & G. Mapes (2001). *Barthelia furcata* gen. et sp. nov., with a review of Palaeozoic coniferophytes and a discussion of coniferophyte systematics. International Journal of Plant Science 162 (3): 637–667.

Rothwell, G. W. & R. Serbet (1994). Lignophyte phylogeny and the evolution of spermatophytes: a numerical cladistic analysis. Systematic Botany 19 (3): 443–482.

Rothwell, G. W., W. L. Crepet & R. A. Stockey (2009). Is the anthophyte hypothesis alive and well? New evidence from the reproductive structures of Bennetitales. American Journal of Botany 96 91): 296–322.

Royen, P. van (1979). The Alpine Flora of New Guinea. Vol. 2: Taxonomic Part – Cupressaceae to Poaceae. J. Cramer, Vaduz.

Rushforth, K. D. (1984). Notes on Chinese Silver Firs 2. Notes of the Royal Botanic Garden Edinburgh 41 (3): 535–540.

Rushforth, K. D. (1986). Mexico's Spruces – rare members of an important genus. The Kew Magazine 3 (3): 119–124.

Rushforth, K. D. (1987). Conifers. Facts on File, New York & Christopher Helm, London.

Rushforth, K. D. (2008). Spruces (*Picea*: Pinaceae) in the Yarlung Tsangpo drainage of southeast Tibet (Xizang, China). International Dendrology Society Yearbook 2007: 42–53.

Rushforth, K. D. (2009). The Tibetan silver fir. International Dendrology Society Yearbook 2008: 39–46.

Sahni, K. C. (1990). Gymnosperms of India and adjacent countries. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Salmon, J. T. (1996). The native trees of New Zealand. Rev. ed. 1996 (repr. 2001), Reed Books, Birkenhead, Auckland, N. Z.

Schmidt, P. A. (1989). Beitrag zur Systematik und Evolution der Gattung *Picea* A. Dietr. Flora 182: 435–461.

Schmidt, P. A. (1991). Beitrag zur Kenntnis der in Deutschland anbaufähigen Fichten (Gattung *Picea* A. Dietr.). Mitteilungen der Deutschen Dendrologischen Gesellschaft 80: 7–72.

Schmidt, P. A. (2002a). *Picea abies* (L.) H. Karst., 1881. Enzyklopädie der Holzgewächse III-1, 28: 1–18. Ecomed Verlag, Landsberg am Lech.

Schmidt, P. A. (2002b). *Picea obovata* Ledeb., 1833. Enzyklopädie der Holzgewächse III-1, 30: 1–14. Ecomed Verlag, Landsberg am Lech.

Schmidt-Vogt, H. (1977). Die Fichte; Ein Handbuch in zwei Banden. Band I: Taxonomie, Verbreitung, Morphologie, Ökologie, Waldgesellschaften. Paul Parey, Hamburg – Berlin.

Schwartz, M. W. (2008). Conservationists should not move *Torreya taxifolia*. British Conifer Society Journal 11: 42–45. (first published in Wild Earth, January 2005).

Semerikov, V. L., H. Q. Zhang, M. Sun & M. Lascoux (2003). Conflicting phylogenies of *Larix* (Pinaceae) based on cytoplasmic and nuclear DNA. Molecular Phylogenetics and Evolution 27: 173–184.

Setoguchi, H., T. A. Osawa, J.-C. Pintaud, T. Jaffré & J.-M. Veillon (1998). Phylogenetic relationships within Araucariaceae based on *rbc*L gene sequences. American Journal of Botany 85 (11): 1507–1516.

Sigurgeirsson, A. & A. E. Szmidt (1993). Phylogenetic and biogeographic implications of chloroplast DNA variation in *Picea*. Nordic Journal of Botany 13 (3): 233–246.

Silba, J. (1984). An International Census of the Coniferae, I. Phytologia Memoirs VII. H. N. & A. L. Moldenke, Plainfield, N. J.

Silba, J. (1986). Encyclopaedia Coniferae. Phytologia Memoirs VIII. Corvallis, Oregon.

Silba, J. (1990). A supplement to the International Census of the Coniferae, II. Phytologia 68 (1): 7–78.

Singh, H. (2007). Himalayan yew (*Taxus wallichiana* Zucc.): a multipurpose rare gymnosperm in India. Indian Forester 133 (5): 690–696.

Spjut, R. W. (2007). Taxonomy and nomenclature of *Taxus* (Taxaceae). Journal of the Botanical Research Institute of Texas 1 (1): 203–289.

Springate, L. (2009). A new name for the Leyland cypress. The Plantsman, new series 8: 35–37.

Stapf, O. (1923). *Picea brachytyla*. Curtis's Botanical Magazine 148: pl. 8969.

Stearn, W. T. (1983). Botanical Latin, ed. 4. David & Charles, London.

Stefanovic, S., M. Jager, J. Deutsch, J. Broutin & M. Masselot (1998). Phylogenetic relationships of conifers inferred from partial 28S rRNA gene sequences. American Journal of Botany 85 (5): 688–697.

Stewart, W. N. & G. W. Rothwell (1993). Paleobotany and the evolution of plants, ed. 2. Cambridge University Press, Cambridge.

Strandby, U., K. I. Christensen & M. Sørensen (2009). A morphometric study of the *Abies religiosa-hickelii-guatemalensis* complex (Pinaceae) in Guatemala and Mexico. Plant Syst. Evol. 280: 59–76.

Stuessy, T. F. (2009). Plant taxonomy. The systematic evaluation of comparative data, ed. 2. Columbia University Press, New York.

Taylor, R. J. & T. F. Patterson (1980). Biosystematics of Mexican Spruce Species and populations. Taxon 29 (4): 421–469.

Terry, R. G., R. S. Nowak & R. J. Tausch (2000). Genetic variation in chloroplast and nuclear ribosomal DNA in Utah juniper (*Juniperus osteosperma*, Cupressaceae): evidence for interspecific gene flow. American Journal of Botany 87 (2): 250–258.

Thomas, P. & B. LePage (2011). The end of an era? – The conservation status of redwoods and other members of the former Taxodiaceae in the 21st century. Japan. J. Hist. Bot. 19 (1–2): 1–12.

Tomaru, N., Y. Tsumura & K. Ohba (1994). Genetic variation and population differentiation in natural populations of *Cryptomeria japonica*. Plant Sp. Biol. 9: 191–199.

Tomback, D. F. & Y. B. Linhart (1990). The evolution of bird-dispersed pines. Evolutionary Ecology 4: 185–219.

Tomlinson, P. B. & T. Takaso (1989). Developmental shoot morphology in *Phyllocladus* (Podocarpaceae). Botanical Journal of the Linnean Society 99: 223–248.

Tomlinson, P. B., T. Takaso & J. A. Rattenbury (1989). Cone and ovule ontogeny in *Phyllocladus* (Podocarpaceae). Botanical Journal of the Linnean Society 99: 209–221.

Tomlinson, P. B., J. E. Braggins & J. A. Rattenbury (1997). Contrasted pollen capture mechanisms in Phyllocladaceae and certain Podocarpaceae (Coniferales). American Journal of Botany 84 (2): 214–223.

Tomlinson, P. B. & E. H. Zacharias (2001). Phyllotaxis, phenology and architecture in *Cephalotaxus*, *Torreya* and *Amentotaxus* (Coniferales). Botanical Journal of the Linnean Society 135 (3): 215–228.

Tripp, K. E. (1995). *Cephalotaxus*: The Plum Yews. Arnoldia 55 (1): 24–39.

Van Pelt, R. (2001). Forest giants of the Pacific coast. Global Forest Society / University of Washington Press, Vancouver – Seattle.

Vidaković, M. (1991). Conifers. Morphology and variation. 2nd ed. Grafički Zavod Hrvatske, Zagreb.

Wang, C. W. (1961). The forests of China; with a survey of grassland and desert vegetation. Publication of the Maria Moors Cabot Foundation, Botanical Research 5. (Harvard University) Cambridge, Massachusetts.

Wang, K. & Y. Yang (2007). Taxonomic study on *Pseudotaxus* (Taxaceae). Acta Phytotaxonomica Sinica 45 (6): 862–869.

Wang, X. Q. & B. X. Guo (2009). Protection of *Metasequoia glyptostroboides* Hu et Cheng in China. Forest. Stud. China 11 (4): 249–257.

Wang, X. Q., D. C. Tank & T. Sang (2000). Phylogeny and divergence times in Pinaceae: evidence from three genomes. Molecular Biology and Evolution 17 (5): 773–781.

Wang, X. R., Y. Tsumura, H. Yoshimaru, K. Nagasaka & A. E. Szmidt (1999). Phylogenetic relationships of Eurasian pines (*Pinus*, Pinaceae) based on chloroplast *rbc*L, *mat*K, *rpl*20-*rps*18 spacer, and *trn*V intron sequences. American Journal of Botany 86 (12): 1742–1753.

Warming, J. E. B. (1884). Haandbog i den systematiske Botanik. Ed. 2. Kjøbenhavn. (German ed. 1890, Eng. ed. 1895).

Wei, X. X. & X. Q. Wang (2003). Phylogenetic split of *Larix*: evidence from [the] paternally inherited cpDNA *trn*T-*trn*F region. Plant Systematics and Evolution 239: 67–77.

Wei, X. X. & X. Q. Wang (2004). Recolonization and radiation in *Larix* (Pinaceae): evidence from nuclear ribosomal DNA paralogues. Molecular Ecology 13: 3115–3123.

Welch, H. J. & G. Haddow (1993). The World Checklist of Conifers. Landsman's Bookshop Ltd., Buchenhill, Bromyard, United Kingdom.

Wheeler, Q. D. & R. Meier (eds.). (2000). Species concepts and phylogenetic theory – a debate. Columbia University Press, New York.

Whitmore, T. C. (1980). A monograph of *Agathis*. Plant Systematics and Evolution 135: 41–69.

Wilde, M. H. (1975). A new interpretation of microsporangiate cones in Cephalotaxaceae and Taxaceae. Phytomorphology 25: 434–450.

Willkomm, M. (1887). Forstliche Flora von Deutschland, Österreich und der Schweiz. 2. Aufl. C. F. Winter, Leipzig.

Wilson, E. H. (1912). Vegetation of Western China; A series of 500 photographs, with index and introduction by C. S. Sargent. Publications of the Arnold Arboretum 2, London.

Wilson, E. H. (1916). The Conifers and Taxads of Japan. Publications of the Arnold Arboretum 8, University Press, Cambridge, Massachusetts.

Wilson, E. H. (1926). The Taxads and Conifers of Yunnan. Journal of the Arnold Arboretum 7: 37–68.

Wilson, E. O. (1992). The diversity of life. Harvard University Press, Cambridge, Massachussetts.

Wolf, C. B. & W. W. Wagener (1948). The New World cypresses. Aliso 1.

Woltz, P., R. A. Stockey, M. Gondran & J.-F. Cherrier (1995). Interspecific parasitism in the gymnosperms: unpublished data on two endemic New Caledonian Podocarpaceae using scanning electron microscopy. Acta Botanica Gallica 141 (6/7): 731–746.

Wright, J. W. (1955). Species crossability in spruce in relation to distribution and taxonomy. Forest Science 1: 319–349.

Wu, M. H. (1976). *Abies beshanzuensis* M. H. Wu, sp. nov. Acta Phytotaxonomica Sinica 14 (2): 16–17, t. 1, f. 1.

Wunderlin, R. P. & B. F. Hansen (2000). Flora of Florida. Vol. 1. University Press of Florida, Gainsville, Fla.

Xiang, Q. P., A. Farjon, Z. Y. Li, L. K. Fu & Z. Y. Liu (2002). *Thuja sutchuenensis*: a rediscovered species of the Cupressaceae. Botanical Journal of the Linnean Society 139 (3): 305–310.

Xiang, Q. P., Q. Y. Xiang, A. Liston & X. C. Zhang (2004). Phylogenetic relationships in *Abies* (Pinaceae): evidence from PCR-RFLP of the nuclear ribosomal DNA internal transcribed spacer region. Botanical Journal of the Linnean Society 145: 425–435.

Xiang, Q. P., Q. Y. Xiang, Y. Y. Guo & X. C. Zhang (2009). Phylogeny of *Abies* (Pinaceae) inferred from nrITS sequence data. Taxon 58 (1): 141–152.

Yamazaki, T. (1995). Pinaceae. In: K. Iwatsuki, T. Yamazaki, D. Boufford & H. Ohba (eds.). Flora of Japan. Pteridophyta and Gymnospermae, vol 1: 266–277. Kodansha, Tokyo.

Yang, J. C. & F. J. Pan (1996). The current status of woody vegetation in Taiwan. In: D. Hunt (ed.). Temperate trees under threat (symposium proceedings). International Dendrology Society, Morpeth, United Kingdom.

Ying, T. S., M. L. Chew & H. C. Chang (2004). Atlas of the Gymnosperms of China. China Science and Technology Press, Beijing.

LISTS OF ILLUSTRATIONS

Map showing the global distribution of conifers *23*

List of line drawings (plates)

1. *Abies bracteata* *69*
2. *Abies mariesii* *104*
3. *Abies nephrolepis* *108*
4. *Abies nordmanniana* *110*
5. *Agathis borneensis* *154*
6. *Araucaria angustifolia* *195*
7. *Araucaria scopulorum* *220*
8. *Callitris monticola* *239*
9. *Callitris verrucosa* *251*
10. *Cedrus deodara* *264*
11. *Chamaecyparis obtusa* var. *obtusa* *287*
12. *Cupressus macnabiana* *319*
13. *Dacrydium beccarii* *353*
14. *Fokienia hodginsii* *385*
15. *Juniperus drupacea* *422*
16. *Juniperus excelsa* subsp. *polycarpos* *427*
17. *Juniperus monosperma* *441*
18. *Juniperus recurva* var. *recurva* *458*
19. *Keteleeria fortunei* *494*
20. *Larix potaninii* *512*
21. *Lepidothamnus laxifolius* *519*
22. *Nothotsuga longibracteata* *550*
23. *Picea alcoquiana* *575*
24. *Picea neoveitchii* *605*
25. *Picea torano* *621*
26. *Pinus arizonica* *640*
27. *Pinus canariensis* *665*
28. *Pinus dalatensis* *680*
29. *Pinus flexilis* *696*
30. *Pinus krempfii* *715*
31. *Pinus lambertiana* *718*
32. *Pinus pinceana* *759*
33. *Pinus pseudostrobus* *766*
34. *Pinus torreyana* subsp. *torreyana* *799*
35. *Podocarpus brassii* *842*
36. *Podocarpus elatus* *859*
37. *Podocarpus lambertii* *875*
38. *Podocarpus pendulifolius*; *P. salicifolius* *906*
39. *Podocarpus steyermarkii* *931*
40. *Podocarpus urbanii* *941*
41. *Tetraclinis articulata* *1020*
42. *Xanthocyparis vietnamensis* *1067*

List of colour photographs (figures)

The colour photographs have been grouped into six sections.

First section (Fig. 1–59) *183–190*

1. *Abies alba* in the Forêt de la Joux, Jura Mts., France
2. *Abies amabilis* in Wenatchee N. F., Washington, USA
3. *Abies bracteata* in the Santa Lucia Mts., California, USA
4. *Abies cephalonica* flushing leaves
5. *Abies delavayi* var. *delavayi* seed cones
6. *Abies delavayi* var. *delavayi* seed cone
7. *Abies delavayi* var. *nukiangensis* seed cones
8. *Abies homolepis* pollen cones
9. *Abies kawakamii* stand in Taroko N. P., Taiwan
10. *Abies koreana* young seed cones
11. *Abies magnifica* in the Sierra Nevada, California, USA
12. *Abies nebrodensis* seed cone
13. *Abies numidica* tree with seed cones
14. *Abies pinsapo* helically arranged leaves
15. *Abies pinsapo* seed cone
16. *Abies procera* seed cones (photo W. Milliken)
17. *Abies recurvata* var. *ernestii* seed cones (photo X. C. Zhang)

18. *Abies spectabilis* mature seed cone
19. *Abies squamata* bark of young tree (photo P. de Spoelberch)
20. *Abies squamata* bark of old tree (photo P. de Spoelberch)
21. *Acmopyle pancheri* foliage and see cones (© Bedgebury Pinetum)
22. *Actinostrobus arenarius* along Hwy. 123, Western Australia
23. *Actinostrobus arenarius* seed cones
24. *Afrocarpus falcatus* foliage and seeds (photo D. Luscombe)
25. *Afrocarpus gracilior* tree in Ethiopia (photo J. Grimshaw)
26. *Afrocarpus gracilior* foliage and seeds (photo Forest & Kim Starr)
27. *Agathis australis* in Trounson Park, North Island, New Zealand
28. *Agathis australis* The Tane Mahuta (Lord of the Forest), New Zealand
29. *Agathis australis* seed cones
30. *Agathis borneensis* leaves
31. *Agathis kinabaluensis* on the Mesilau River, Mt. Kinabalu, Borneo
32. *Agathis kinabaluensis* sapling on the Mesilau River, Mt. Kinabalu, Borneo
33. *Agathis lenticula* tree at Kinabalu Park H. Q., Borneo
34. *Agathis lenticula* trunk in Crocker Range, Borneo
35. *Agathis microstachya* trees at Lake Barrine, Queensland, Australia
36. *Agathis ovata* trees near Yaté, New Caledonia
37. *Agathis ovata* leaves and pollen cone
38. *Amentotaxus formosana* tree in southern Taiwan (photo C. N. Page)
39. *Amentotaxus formosana* leaves underside
40. *Amentotaxus yunnanensis* in Ha Giang, Viet Nam (photo P. Cribb)
41. *Araucaria araucana* in Chile (photo M. Gardner)
42. *Araucaria araucana* pollen cones
43. *Araucaria araucana* seed cones
44. *Araucaria bernieri* in New Caledonia
45. *Araucaria bidwillii* emergent trees in the Bunya Mts. Queensland, Australia
46. *Araucaria bidwillii* tree in the Bunya Mts. Queensland, Australia
47. *Araucaria columnaris* on the Île des Pins, New Caledonia
48. *Araucaria columnaris* seedlings
49. *Araucaria cunninghamii* var. *cunninghamii* tree in the Bunya Mts. Queensland, Australia
50. *Araucaria heterophylla* seed cones
51. *Araucaria laubenfelsii* foliage with pollen cones
52. *Araucaria muelleri* in New Caledonia
53. *Araucaria scopulorum* seed cones in New Caledonia
54. *Araucaria scopulorum* foliage
55. *Athrotaxis cupressoides* at Dove Lake, Tasmania, Australia
56. *Athrotaxis selaginoides* at Dove Lake, Tasmania, Australia
57. *Athrotaxis selaginoides* seed cones
58. *Austrocedrus chilensis* forest on lava, Chile (photo M. Gardner)
59. *Austrocedrus chilensis* seed cones

Second section (Fig. 60–120) *339-346*

60. *Austrotaxus spicata* tree in New Caledonia (photo M. Gardner)
61. *Callitris canescens* in Western Australia
62. *Callitris columellaris* in Kings Canyon N. P., Northern Territories, Australia
63. *Callitris macleayana* trees in the Herberton Range, Queensland, Australia
64. *Callitris macleayana* seed cones
65. *Callitris muelleri* in New South Wales, Australia
66. *Callitris muelleri* seed cones
67. *Callitris preissii* at Woodman Point, Western Australia
68. *Callitris rhomboidea* seed cones, Grampian Mts., Victoria, Australia
69. *Callitris roei* in Fitzgerald River N. P., Western Australia
70. *Callitris roei* seed cones and foliage
71. *Calocedrus decurrens* tree in the Sierra Nevada, California, USA
72. *Calocedrus decurrens* trunk in the Sierra Nevada, California, USA
73. *Calocedrus formosana* foliage and seed cones
74. *Calocedrus macrolepis* foliage and pollen cones

75. *Calocedrus rupestris* foliage and pollen cones (photo L. Aveyanov)
76. *Cathaya argyrophylla* tree in Sichuan (photo H. Nimsch)
77. *Cathaya argyrophylla* seed cones (photo S. X. Yu)
78. *Cedrus atlantica* pollen cones
79. *Cedrus deodara* seed cones
80. *Cedrus libani* var. *libani* in the Taurus Mts., Turkey
81. *Cephalotaxus fortunei* var. *fortunei* pollen cones and foliage
82. *Cephalotaxus fortunei* var. *fortunei* ripe seeds
83. *Cephalotaxus harringtonii* var. *harringtonii* pollen cones
84. *Cephalotaxus harringtonii* var. *harringtonii* ripe seeds
85. *Cephalotaxus mannii* leaves and seeds (photo L. Averyanov)
86. *Chamaecyparis formosensis* and *C. obtusa* in Chilan Shan, Taiwan
87. *Chamaecyparis formosensis* foliage and seed cones
88. *Chamaecyparis lawsoniana* pollen cones
89. *Chamaecyparis lawsoniana* seed cones
90. *Chamaecyparis thyoides* var. *thyoides* trunk in North Carolina, USA
91. *Cryptomeria japonica* seed cones
92. *Cunninghamia konishii* foliage
93. *Cunninghamia lanceolata* seed cones
94. *Cupressus arizonica* var. *arizonica* seed cones
95. *Cupressus dupreziana* tree in the Sahara (Tassili n'Ajjer, Algeria)
96. *Cupressus guadalupensis* var. *forbesii* in California, USA
97. *Cupressus lusitanica* var. *benthamii* seed cones
98. *Cupressus macrocarpa* near Monterey, California, USA
99. *Cupressus torulosa* var. *torulosa* seed cones
100. *Dacrycarpus cinctus* foliage and cones (photo T. Utteridge)
101. *Dacrycarpus dacrydioides* tree in North Island, New Zealand
102. *Dacrycarpus dacrydioides* trunk
103. *Dacrycarpus dacrydioides* seed cones
104. *Dacrycarpus imbricatus* var. *imbricatus* flushing foliage
105. *Dacrycarpus kinabaluensis* tree on Mt Kinabalu, Borneo
106. *Dacrycarpus kinabaluensis* seed cones
107. *Dacrydium araucaroides* in New Caledonia
108. *Dacrydium araucarioides* foliage and pollen cones
109. *Dacrydium beccarii* foliage with pollen cones
110. *Dacrydium comosum* canopy at Gunung Ulu Kali, Malaysia
111. *Dacrydium comosum* at Gunung Ulu Kali, Malaysia
112. *Dacrydium comosum* foliage
113. *Dacrydium cupressinum* in North Island, New Zealand
114. *Dacrydium elatum* at Gunung Ledang, Malaysia
115. *Dacrydium gibbsiae* small tree on Mt Kinabalu, Borneo
116. *Dacrydium gracile* at Bukit Tupai, Mt Kinabalu, Borneo
117. *Dacrydium guillauminii* in New Caledonia (photo A. Schmidt)
118. *Dacrydium xanthandrum* tree in the Crocker Range, Borneo
119. *Dacrydium xanthandrum* trunk in the Crocker Range, Borneo
120. *Diselma archeri* in Cradle Mountain N. P., Tasmania, Australia

Third section (Fig. 121–176) *465–472*

121. *Falcatifolium falciforme* trees in the Crocker Range, Borneo
122. *Falcatifolium falciforme* flushing leaves
123. *Falcatifolium falciforme* seedling at Fraser's Hill, Malaysia
124. *Falcatifolium taxoides* on Mt. Panié, New Caledonia
125. *Fitzroya cupressoides* in the N. P. Alerce Andino, Chile (photo P. Woltz)
126. *Fitzroya cupressoides* foliage and seed cones
127. *Fokienia hodginsii* foliage and cones
128. *Glyptostrobus pensilis* pollen cones and seed cones (photo D. White)
129. *Halocarpus bidwillii* in North Island, New Zealand

130. *Halocarpus bidwillii* foliage
131. *Halocarpus biformis* foliage
132. *Juniperus californica* in Anza Borrego Desert State Park, California, USA
133. *Juniperus californica* seed cones
134. *Juniperus chinensis* var. *sargentii* foliage and seed cones
135. *Juniperus communis* var. *communis* foliage and seed cones
136. *Juniperus communis* var. *saxatilis* in Mt. Rainier N. P., Washington, USA
137. *Juniperus deppeana* var. *deppeana* in Puebla, Mexico
138. *Juniperus deppeana* var. *deppeana* trunk with bark
139. *Juniperus flaccida* var. *flaccida* tree in Oaxaca, Mexico
140. *Juniperus occidentalis* var. *australis* tree in the Sierra Nevada, California, USA
141. *Juniperus oxycedrus* subsp. *macrocarpa* foliage and seed cones
142. *Juniperus phoenicea* subsp. *phoenicea* at Cape St. Vincent, Portugal
143. *Juniperus phoenicea* subsp. *phoenicea* foliage and cones
144. *Juniperus pseudosabina* in the Alaj Mountains, Kirgyzstan
145. *Juniperus pseudosabina* seed cones in Kirgyzstan
146. *Juniperus sabina* var. *sabina* in Kirgyzstan
147. *Juniperus semiglobosa* in Kirgyzstan
148. *Juniperus semiglobosa* foliage and seed cones
149. *Juniperus semiglobosa* pollen cones
150. *Juniperus virginiana* var. *virginiana* tree in North Carolina, USA
151. *Keteleeria davidiana* var. *davidiana* foliage and seed cones
152. *Keteleeria davidiana* var. *davidiana* seed cone
153. *Lagarostrobos franklinii* tree at Riveaux Creek, Tasmania, Australia
154. *Lagarostrobos franklinii* foliage and pollen cones
155. *Larix decidua* var. *decidua* in the Alps, Switzerland
156. *Larix decidua* var. *decidua* bark
157. *Larix decidua* var. *decidua* seed cones
158. *Larix gmelinii* var. *principis-rupprechtii* seed cones
159. *Larix griffithii* var. *griffithii* seed cone
160. *Larix kaempferi* seed cones
161. *Larix lyallii* in the Wenatchee Mts., Washington, USA
162. *Lepidothamnus fonkii* in Chile (photo M. Gardner)
163. *Libocedrus bidwillii* in North Island, New Zealand
164. *Libocedrus bidwillii* foliage and seed cones
165. *Libocedrus plumosa* foliage
166. *Manoao colensoi* seed cones (photo B. P. J. Molloy)
167. *Metasequoia glyptostroboides* bark
168. *Metasequoia glyptostroboides* seed cones
169. *Microbiota decussata* foliage
170. *Microcachrys tetragona* foliage and seed cones
171. *Nageia fleuryi* leaves and seed cones (photo L. Averyanov)
172. *Nageia nagi* flushing leaves
173. *Nageia wallichiana* tree in Viet Nam (photo L. Averyanov)
174. *Nageia wallichiana* leaves and seed cones (photo L. Averyanov)
175. *Neocallitropsis pancheri* in New Caledonia
176. *Neocallitropsis pancheri* foliage

Fourth section (Fig. 177–239) *643–650*

177. *Nothotsuga longibracteata* in Nan Ling Mts. Hunan, China
178. *Nothotsuga longibracteata* seed cones (photo Y. Liu)
179. *Papuacedrus papuana* var. *papuana* pollen cones (photo D. White)
180. *Papuacedrus papuana* leaves and seed cones (photo D. White)
181. *Parasitaxus usta* in New Caledonia (photo W. Baker)
182. *Parasitaxus usta* foliage and seed cones (photo W. Baker)
183. *Pherosphaera hookeriana* in Tasmania, Australia
184. *Phyllocladus aspleniifolius* foliage and pollen cones
185. *Phyllocladus hypophyllus* canopy on Mt Kinabalu, Borneo

186. *Phyllocladus hypophyllus* glaucous foliage on Mt. Kinabalu, Borneo at 3100 m
187. *Phyllocladus trichomanoides* var. *alpinus* foliage
188. *Picea chihuahuana* green and ripe seed cones
189. *Picea likiangensis* var. *likiangensis* young seed cones
190. *Picea likiangensis* var. *likiangensis* seed cones (photo P. de Spoelberch)
191. *Picea likiangensis* var. *likiangensis* seed cones
192. *Picea morrisonicola* tree in Taroko N. P., Taiwan
193. *Picea morrisonicola* trunk with bark
194. *Picea orientalis* foliage and pollen cones
195. *Picea orientalis* seed cones
196. *Picea schrenkiana* subsp. *tianschanica* in Kirgyzstan
197. *Picea schrenkiana* subsp. *tianschanica* tree in Kirgyzstan
198. *Picea sitchensis* tree in Olympic N. P., Washington, USA
199. *Picea smithiana* pollen cones
200. *Picea smithiana* seed cone from bud
201. *Picea smithiana* seed cone
202. *Picea wilsonii* pollen cones
203. *Pilgerodendron uviferum* pollen cones
204. *Pilgerodendron uviferum* foliage and seed cones
205. *Pinus albicaulis* foliage and pollen cones
206. *Pinus aristata* foliage
207. *Pinus armandii* var. *armandii* seed cone
208. *Pinus attenuata* seed cones
209. *Pinus ayacahuite* var. *veitchii* foliage and seed cones
210. *Pinus balfouriana* in the Sierra Nevada, California, USA
211. *Pinus bungeana* trunk with bark
212. *Pinus bungeana* seed cone
213. *Pinus cembra* in the Alps, Switzerland
214. *Pinus cembra* foliage and seed cones
215. *Pinus cembroides* var. *cembroides* in Hidalgo, Mexico
216. *Pinus cembroides* var. *cembroides* bark
217. *Pinus cembroides* subsp. *orizabensis* seed cones
218. *Pinus contorta* var. *murrayana* in the Sierra Nevada, California, USA
219. *Pinus coulteri* pollen cones
220. *Pinus coulteri* foliage and seed cones
221. *Pinus culminicola* foliage
222. *Pinus devoniana* foliage
223. *Pinus durangensis* in Durango, Mexico (photo C. Hughes)
224. *Pinus engelmannii* foliage
225. *Pinus hartwegii* on Pico de Orizaba, Veracruz, Mexico
226. *Pinus heldreichii* seed cones
227. *Pinus latteri* forest in Thailand (photo H. Hazebroek)
228. *Pinus longaeva* on Telescope Peak, Death Valley N. P., California, USA
229. *Pinus maximartinezii* in Zacatecas, Mexico
230. *Pinus maximartinezii* seed cone and seedling
231. *Pinus monophylla* foliage and seed cones
232. *Pinus monophylla* leaves
233. *Pinus muricata* pollen cones
234. *Pinus muricata* seed cones
235. *Pinus nelsonii* seed cone
236. *Pinus nigra* subsp. *laricio* trunk with bark
237. *Pinus nigra* subsp. *salzmannii* seed cones
238. *Pinus patula* var. *patula* tree in Oaxaca, Mexico
239. *Pinus patula* var. *patula* leaves

Fifth section (Fig. 240–303) *809–815*

240. *Pinus pinaster* subsp. *pinaster* pollen cones
241. *Pinus pinaster* subsp. *pinaster* seed cones of two ages
242. *Pinus pinea* in Algarve, Portugal
243. *Pinus pinea* seed cone
244. *Pinus ponderosa* var. *ponderosa* pollen cones
245. *Pinus pungens* seed cones
246. *Pinus quadrifolia* in California, USA
247. *Pinus rzedowskii* tree in Michoacán, Mexico
248. *Pinus rzedowskii* seed cones
249. *Pinus sylvestris* var. *sylvestris* trees
250. *Pinus taiwanensis* var. *taiwanensis* in Hehuan Shan, Taiwan
251. *Pinus virginiana* seed cones
252. *Pinus wallichiana* var. *wallichiana* seed cones
253. *Platycladus orientalis* foliage and seed cones (photo D. Mabberley)
254. *Platycladus orientalis* seed cones
255. *Podocarpus acutifolius* foliage and pollen cones
256. *Podocarpus brassii* var. *brassii* seed cone (photo T. Waters)
257. *Podocarpus brevifolius* on the Mesilau River, Mt. Kinabalu, Borneo

258. *Podocarpus brevifolius* leaves
259. *Podocarpus chingianus* foliage and seed cone
260. *Podocarpus costalis* foliage
261. *Podocarpus cunninghamiii* foliage and seed cones
262. *Podocarpus dispermus* leaves
263. *Podocarpus elatus* foliage
264. *Podocarpus elatus* seed cone
265. *Podocarpus grayae* small sapling at Cape Tribulation, Queensland, Australia

1110

266. *Podocarpus grayae* tree at Lake Eacham, Queensland, Australia
267. *Podocarpus grayae* trunk, Herberton Range, Queensland, Australia
268. *Podocarpus henkelii* leaves
269. *Podocarpus laubenfelsii* seedling on Mt. Kinabalu, Borneo
270. *Podocarpus latifolius* in the Drakensberg, South Africa (photo J. Grimshaw)
271. *Podocarpus lawrencei* seed cones
272. *Podocarpus macrophyllus* var. *macrophyllus* foliage
273. *Podocarpus macrophyllus* var. *macrophyllus* foliage and pollen cones
274. *Podocarpus matudae* leaves and young seed cone
275. *Podocarpus milanjianus* on Mt. Elgon, Uganda (photo D. L. Roberts)
276. *Podocarpus nakaii* flushing leaves
277. *Podocarpus nakaii* foliage and seed cones
278. *Podocarpus neriifolius* var. *neriifolius* in Papua New Guinea (photo T. Utteridge)
279. *Podocarpus neriifolius* var. *neriifolius* seed cones (photo T. Utteridge)
280. *Podocarpus nivalis* in North Island, New Zealand
281. *Podocarpus nivalis* foliage and seed cones
282. *Podocarpus novae-caledoniae* in New Caledonia
283. *Podocarpus novae-caledoniae* foliage and young seed cones
284. *Podocarpus nubigenus* leaves (upperside)
285. *Podocarpus nubigenus* leaves (underside)
286. *Podocarpus polystachyus* pollen cones
287. *Podocarpus rumphii* seed cones
288. *Podocarpus salignus* foliage and young seed cones
289. *Podocarpus spinulosus* on North Stradbroke Island, Queensland, Australia
290. *Podocarpus spinulosus* unripe seed cone (photo G. Garruthers
291. *Podocarpus spinulosus* ripe seed cones (photo G. Garruthers)
292. *Podocarpus sprucei* foliage buds (photo P. Cribb 1425)
293. *Podocarpus totara* tree in North Island, New Zealand
294. *Podocarpus totara* bark
295. *Podocarpus totara* foliage and pollen cones
296. *Prumnopitys andina* foliage and pollen cones
297. *Prumnopitys andina* seed cones
298. *Prumnopitys ferruginoides* foliage on Mt. Mou, New Caledonia
299. *Prumnopitys ladei* trunk on Mt. Lewis, Queensland, Australia
300. *Prumnopitys ladei* foliage
301. *Pseudolarix amabilis* pollen cones
302. *Pseudolarix amabilis* seed cones
303. *Pseudotaxus chienii* foliage and buds of seed cones

Sixth section (Fig. 304–362) *993–1000*

304. *Pseudotsuga japonica* foliage and young seed cone
305. *Pseudotsuga japonica* seed cones
306. *Pseudotsuga menziesii* tree in Mt. Rainier N. P., Washington, USA
307. *Pseudotsuga menziesii* giant trunk in Olympic N. P., Washington, USA
308. *Pseudotsuga menziesii* var. *menziesii* seed cones
309. *Pseudotsuga sinensis* var. *sinensis* trees in Taroko N. P., Taiwan
310. *Pseudotsuga sinensis* var. *sinensis* fallen seed cones
311. *Retrophyllum comptonii* young tree on Mt. Panié, New Caledonia
312. *Retrophyllum comptonii* foliage and seed (photo M. Gardner)
313. *Retrophyllum minus* in Rivière des Lacs, New Caledonia
314. *Retrophyllum minus* foliage and seed cones
315. *Saxegothaea conspicua* tree (photo C. N. Page)

316. *Saxegothaea conspicua* foliage with pollen cones and seed cones
317. *Sciadopitys verticillata* foliage and pollen cone buds
318. *Sciadopitys verticillata* seed cone (photo C. N. Page)
319. *Sequoia sempervirens* at Bull Creek, California, USA (photo R. Van Pelt)
320. *Sequoia sempervirens* seed cones
321. *Sequoiadendron giganteum* in California, USA (photo E. Parker)
322. *Sequoiadendron giganteum* pollen cones and seed cones
323. *Sundacarpus amarus* trunk and bark, Lake Barrine, Queensland, Australia
324. *Sundacarpus amarus* foliage
325. *Sundacarpus amarus* pollen cones
326. *Taiwania cryptomerioides* in Yunnan, China (photo D. Long)
327. *Taiwania cryptomerioides* tree (photo P. Thomas)
328. *Taiwania cryptomerioides* trunk in Taiwan
329. *Taxodium distichum* swamp forest in North Carolina, USA
330. *Taxodium distichum* var. *distichum* foliage and seed cones
331. *Taxodium mucronatum* in Oaxaca, Mexico
332. *Taxus baccata* ancient tree on ruined wall of Waverley Abbey, England
333. *Taxus baccata* foliage and pollen cones
334. *Taxus baccata* foliage and seeds
335. *Taxus brevifolia* in the Wenatchee Mts., Washington, USA
336. *Taxus brevifolia* foliage and seeds
337. *Taxus cuspidata* var. *cuspidata* in Korea (photo Y. S. Kim)
338. *Taxus cuspidata* var. *cuspidata* foliage and seeds
339. *Tetraclinis articulata* seed cones (photo M. Gardner)
340. *Thuja koraiensis* in Korea (photo Y. S. Kim)
341. *Thuja koraiensis* foliage branch (upperside)
342. *Thuja koraiensis* foliage branch (underside)
343. *Thuja plicata* foliage and seed cones
344. *Thuja sutchuenensis* in Daba Shan, China (© Bedgebury Pinetum)
345. *Thujopsis dolabrata* var. *dolabrata* foliage (upperside)
346. *Thujopsis dolabrata* var. *dolabrata* foliage (underside)
347. *Torreya californica* foliage with pollen cones
348. *Torreya californica* foliage with seeds
349. *Torreya nucifera* foliage with seeds
350. *Tsuga chinensis* var. *chinensis* in the mountains of Taiwan
351. *Tsuga chinensis* var. *chinensis* foliage and seed cones
352. *Tsuga forrestii* foliage and seed cones
353. *Tsuga heterophylla* on a 'nurse log' in Olympic N. P., Washington, USA
354. *Tsuga mertensiana* var. *mertensiana* foliage and seed cones
355. *Widdringtonia cedarbergensis* seed cones
356. *Widdringtonia nodiflora* seed cones
357. *Widdringtonia whytei* on Mt. Mulanje, Malawi (photo P. Cribb)
358. *Wollemia nobilis* trees in Wollemi N. P., New South Wales, Australia (photo J. Plaza)
359. *Wollemia nobilis* bud and foliage
360. *Wollemia nobilis* foliage and pollen cones
361. *Xanthocyparis nootkatensis* trunk in Olympic N. P., Washington, USA
362. *Xanthocyparis vietnamensis* foliage

INDEX TO BOTANICAL NAMES OF CONIFERS

Names are listed at the ranks of family, genus, species, subspecies, variety and forma. Names in bold italics are accepted names with a descriptive account in this handbook, other names are synonyms or names of taxa that occur only in cultivation. Page numbers are in bold where an account of the taxon begins, in italics to the nearest page where an illustration is given.

A

Abies Mill. 19, 27, 40, 51, 52, 53, **57**, 58, 59, 80, 93, 98, 101, 113, 119, 122, 129, 131, 269, 270, 273, 317, 416, 417, 432, 437, 438, 451, 459, 474, 479, 511, 571, 591, 595, 598, 610, 678, 687, 688, 778, 785, 820, 963, 982, 1017, 1046, 1049, 1050

Abies alba Mill. 57, 58, 59, **61**, 62, 67, 68, 71, 107, 116, *183*, 571, 609, 755

Abies alba Mill. var. *acutifolia* Turrill 67, 71

Abies alba Mill. subsp. *apennina* Brullo 61

Abies alba Mill. subsp. *borisii-regis* (Mattf.) Kozuharov & N. Andreev 67

Abies alba Mill. var. *cephalonica* (Loudon) Richt. 70

Abies alba Mill. subsp. *equi-trojani* (Asch. & Sint. *ex* Boiss.) Asch. & Graebn. 111

Abies alba Mill. subsp. *nebrodensis* (Lojac.) Nitz. 105

Abies alba Mill. var. *nebrodensis* (Lojac.) Svoboda 105

Abies alcoquiana Veitch *ex* Lindl. 573

Abies alpestris Brügger 572

Abies amabilis Douglas *ex* J. Forbes 58, 59, **63**, 91, 117, *183*, 617, 1026, 1053, 1066

Abies arizonica Merriam 101

Abies balsamea (L.) Mill. 58, 59, **64**, 65, 415, 507, 599, 615, 1024, 1042

Abies balsamea (L.) Mill. var. ***balsamea*** **65**

Abies balsamea (L.) Mill. subsp. *fraseri* (Pursh) E. Murray 89

Abies balsamea (L.) Mill. subsp. *lasiocarpa* (Hook.) Boivin 101

Abies balsamea (L.) Mill. subsp. *lasiocarpa* (Hook.) Boivin var. *arizonica* (Merriam) Boivin 101

Abies balsamea (L.) Mill. f. *phanerolepis* (Fernald) Rehd. 65

Abies balsamea (L.) Mill. subsp. *phanerolepis* (Fernald) E. Murray 65

Abies balsamea (L.) Mill. var. ***phanerolepis*** **65**

Abies beshanzuensis M. H. Wu 58, 60, **66**, 132, 1095

Abies beshanzuensis M. H. Wu var. *ziyuanensis* (L. K. Fu & S. L. Mo) L. K. Fu & Nan Li 131

Abies bicolor Maxim. 573

Abies bifolia A. Murray bis var. *arizonica* (Merriam) O'Kane & K. D. Heil 101

Abies ×borisii-regis Mattf. 58, 59, **67**, 68, 71, 755

Abies ×borisii-regis Mattf. var. *pungenti-pilosa* Viguié & Gaussen 67

Abies bornmuelleriana Mattf. 109, 111

Abies brachyphylla Maxim. 97

Abies brachyphylla Maxim. var. *umbellata* (Mayr) Dallim. & A. B. Jacks. 97

Abies brachytyla Franch. 579

Abies bracteata (D. Don) A. Poit. 58, **68**, *69*, 70, *183*

Abies cephalonica Loudon 58, 59, 67, **70**, 71, 116, *183*, 423, 426, 430

Abies chayuensis W. C. Cheng & L. K. Fu 88

Abies chengii Rushforth 87, 88

Abies chensiensis Tiegh. 58, 60, **71**, 72, 73, 84, 132, 578, 605, 614

Abies chensiensis Tiegh. subsp. ***chensiensis*** **72**

Abies chensiensis Tiegh. var. *ernestii* (Rehd.) T. S. Liu 119

Abies chensiensis Tiegh. subsp. ***salouenensis*** (Bordères & Gaussen) Rushforth **73**, 87
Abies chensiensis Tiegh. var. *salouenensis* (Bordères & Gaussen) Silba 73
Abies chensiensis Tiegh. subsp. ***yulongxueshanensis*** Rushforth **73**
Abies chensiensis Tiegh. var. *yulongxueshanensis* (Rushforth) Silba 73
Abies chinensis Franch. 1046
Abies cilicica (Antoine & Kotschy) Carrière 58, 59, **73**, 74, 266, 423, 426, 430
Abies cilicica (Antoine & Kotschy) Carrière var. *borisii-regis* (Mattf.) Silba 67
Abies cilicica (Antoine & Kotschy) Carrière subsp. ***cilicica*** **74**
Abies cilicica (Antoine & Kotschy) Carrière subsp. ***isaurica*** Coode & Cullen 74, **75**
Abies cilicica (Antoine & Kotschy) Carrière var. *pyramidalis* Boydak & Erdogrul 74
Abies coahuilensis I. M. Johnst. 81
Abies colimensis Rushforth & Narave 119
Abies concolor (Gordon) Lindl. *ex* Hildebr. 58, 60, **75**, 76, 102, 254, 284, 300, 304, 581, 711, 737, 961, 982
Abies concolor (Gordon) Lindl. *ex* Hildebr. f. *atroviolacea* Cinovskis 75
Abies concolor (Gordon) Lindl. *ex* Hildebr. var. *bajacalifornica* Silba 75
Abies concolor (Gordon) Lindl. *ex* Hildebr. subsp. *lowiana* (Gordon) E. Murray 75
Abies concolor (Gordon) Lindl. *ex* Hildebr. var. *lowiana* (Gordon) Lemmon 75, 76
Abies concolor (Gordon) Lindl. *ex* Hildebr. var. *martinezii* Silba 75
Abies dayuanensis Q. X. Liu 131
Abies delavayi Franch. 58, 61, **76**, 77, 78, 79, 88, 1095
Abies delavayi Franch. var. ***delavayi*** **77**, *183*
Abies delavayi Franch. var. *fabri* (Mast.) D. R. Hunt 82
Abies delavayi Franch. subsp. ***fansipanensis*** (Q. P. Xiang) Rushforth **78**
Abies delavayi Franch. var. *faxoniana* (Rehd. & E. H. Wilson) A. B. Jacks. 85
Abies delavayi Franch. var. *forrestii* (Coltm.-Rog.) A. B. Jacks. 88
Abies delavayi Franch. var. *georgei* (Orr) Melville 88
Abies delavayi Franch. var. ***motuoensis*** W. C. Cheng & L. K. Fu **78**
Abies delavayi Franch. var. ***nukiangensis*** (W. C. Cheng & L. K. Fu) Farjon & Silba **78**, *183*
Abies delavayi Franch. var. *smithii* (Viguié & Gaussen) T. S. Liu 89
Abies densa Griff. 58, 61, **78**, 79, 460, 504, 579, 620, 805
Abies diversifolia Maxim. 1047
Abies durangensis Martínez 58, 60, **80**, 130, 582
Abies durangensis Martínez var. ***coahuilensis*** (I. M. Johnst.) Martínez **81**
Abies durangensis Martínez var. ***durangensis*** **81**
Abies equi-trojani (Asch. & Sint. *ex* Boiss.) Mattf. 109, 111
Abies ernestii Rehd. 73, 119
Abies ernestii Rehd. var. *salouenensis* (Bordères & Gaussen) W. C. Cheng & L. K. Fu 73
Abies excelsior Franco 90
Abies fabri (Mast.) Craib 58, 61, 66, **81**, 82, 118
Abies fabri (Mast.) Craib var. *beshanzuensis* (M. H. Wu) Silba 66
Abies fabri (Mast.) Craib subsp. ***fabri*** **82**
Abies fabri (Mast.) Craib subsp. ***minensis*** (Bordères & Gaussen) Rushforth **82**
Abies fabri (Mast.) Craib var. *ziyuanensis* (L. K. Fu & S. L. Mo) Silba 131
Abies fanjingshanensis W.L. Huang 58, 61, **83**
Abies fansipanensis Q. P. Xiang 78
Abies fargesii Franch. 58, 61, 83, **84**, 612
Abies fargesii Franch. var. *fanjingshanensis* (W. L. Huang) Silba 83
Abies fargesii Franch. var. ***fargesii*** **85**
Abies fargesii Franch. var. ***faxoniana*** (Rehd. & E. H. Wilson) T. S. Liu 82, 84, **85**, 118, 126
Abies fargesii Franch. var. *hupehensis* Silba 85
Abies fargesii Franch. var. ***sutchuenensis*** Franch. 72, **85**
Abies faxoniana Rehd. & E. H. Wilson 85
Abies ferreana Bordères & Gaussen 88
Abies ferreana Bordères & Gaussen var. *longibracteata* L. K. Fu & Nan Li 88
Abies firma Siebold & Zucc. 58, 60, 66, 67, **85**, 86, 97, 286, 293, 960, 978, 1039, 1055
Abies firma Siebold & Zucc. var. *brachyphylla* (Maxim.) Bertrand 97
Abies flinckii Rushforth 93

Abies fordei Rushforth 78, 79, 505
Abies forrestii Coltm.-Rog. 58, 61, 77, **87**, 88, 130, 131, 460, 579, 986
Abies forrestii Coltm.-Rog. var. *chayuensis* (W. C. Cheng & L. K. Fu) Silba 88
Abies forrestii Coltm.-Rog. var. *chengii* (Rushforth) Silba 88
Abies forrestii Coltm.-Rog. var. ***ferreana*** (Bordères & Gaussen) Farjon & Silba **88**
Abies forrestii Coltm.-Rog. var. ***forrestii*** **88**
Abies forrestii Coltm.-Rog. var. ***georgei*** (Orr) Farjon **88**
Abies forrestii Coltm.-Rog. var. ***smithii*** Viguié & Gaussen **89**
Abies fraseri (Pursh) Poir 58, 60, 65, **89**, 90, 615
Abies gamblei Hickel 114
Abies georgei Orr 88
Abies georgei Orr var. *smithii* (Viguié & Gaussen) W. C. Cheng & L. K. Fu 89
Abies glehnii F. Schmidt 589
Abies gmelinii Rupr. 502
Abies gracilis Kom. 122
Abies grandis (Douglas *ex* D. Don) Lindl. 58, 60, 63, 75, 76, **90**, 117, 254, 284, 510, 719, 737, 980, 1026
Abies grandis (Douglas *ex* D. Don) Lindl. var. *idahoensis* Silba 90
Abies grandis (Douglas *ex* D. Don) Lindl. var. *lowiana* (Gordon) Hoopes 75
Abies griffithiana Lindl. & Gordon 504
Abies guatemalensis Rehd. 58, 60, **91**, 92, 129, 704, 735, 796, 1014
Abies guatemalensis Rehd. var. ***guatemalensis*** **92**, 93
Abies guatemalensis Rehd. var. ***jaliscana*** Martínez **93**
Abies guatemalensis Rehd. var. *longibracteata* Debreczy & Rácz 92
Abies guatemalensis Rehd. var. *tacanensis* (Lundell) Martínez 92
Abies heterophylla Raf. 1051
Abies hickelii Flous & Gaussen 58, 61, 92, **93**, 95
Abies hickelii Flous & Gaussen var. ***hickelii*** **94**
Abies hickelii Flous & Gaussen var. *macrocarpa* Martínez 94
Abies hickelii Flous & Gaussen var. ***oaxacana*** (Martínez) Farjon & Silba **94**
Abies hidalgensis Debreczy, Rácz & Guízar 58, 61, **94**, 95
Abies holophylla Maxim. 58, 60, **95**, 96, 502, 714
Abies holophylla Maxim. var. *aspericorticea* Y. Y. Sun 95
Abies homolepis Siebold & Zucc. 58, 60, 86, **96**, 97, 132, *184*, 506, 622, 1027, 1030, 1048
Abies homolepis Siebold & Zucc. var. ***homolepis*** **97**
Abies homolepis Siebold & Zucc. var. ***umbellata*** (Mayr) E.H. Wilson **97**
Abies intermedia Fulling 65
Abies jezoensis Siebold & Zucc. 591
Abies kaempferi Lindl. 954
Abies kansouensis Bordères & Gaussen 85
Abies kawakamii (Hayata) T. Itô 57, 58, 60, **98**, *184*, 295, 684
Abies koreana E. H. Wilson 58, 60, **99**, 100, *184*
Abies koreana E. H. Wilson f. *nigrocarpa* Hatus. 99
Abies lasiocarpa (Hook.) Nutt. 58, 60, 63, **100**, 102, 117, 415, 477, 508, 510, 584, 599, 617, 637, 674, 697, 737, 963, 1026, 1053, 1066
Abies lasiocarpa (Hook.) Nutt. subsp. *arizonica* (Merriam) E. Murray 101
Abies lasiocarpa (Hook.) Nutt. var. ***arizonica*** (Merriam) Lemmon **101**
Abies lasiocarpa (Hook.) Nutt. var. *fallax* (Engelm.) Franco 101
Abies lasiocarpa (Hook.) Nutt. var. ***lasiocarpa*** **101**
Abies likiangensis Franch. 596
Abies lowiana (Gordon) A. Murray bis 75
Abies lowiana (Gordon) A. Murray bis var. *viridula* Debreczy & Rácz 75
Abies macrocarpa Vasey 961
Abies magnifica A. Murray bis 58, 61, 63, 76, **102**, 103, *184*, 254, 443, 581, 711, 719, 737, 982, 1066
Abies magnifica A. Murray bis var. ***magnifica*** **103**
Abies magnifica A. Murray bis var. ***shastensis*** Lemmon **103**
Abies mariana Mill. 599
Abies mariesii Mast. 58, 59, **103**, *104*, 105, 128, 573, 1030, 1048
Abies mariesii Mast. var. *kawakamii* Hayata 98
Abies marocana Trab. 116
Abies mayriana (Miyabe & Kudô) Miyabe & Kudô 122
Abies menziesii Mirb. 959, 963
Abies mexicana Martínez 130
Abies minensis Bordères & Gaussen 82

Abies nebrodensis (Lojac.) Mattei 58, 59, 549, **105**, 106, *184*
Abies nemorensis (Mayr) Miyabe & Kudô 123
Abies neodurangensis Debreczy, Rácz & Salazar 81
Abies nephrolepis (Trautv. *ex* Maxim.) Maxim. 58, 60, 96, **107**, *108*, 502, 533, 576, 593, 603, 1010, 1023
Abies nephrolepis (Trautv. *ex* Maxim.) Maxim. subsp. *sachalinensis* (F. Schmidt) V. N. Voroshilov 122
Abies nordmanniana (Steven) Spach 58, 59, 71, **109**, *110*, 111, 116, 426, 430, 610
Abies nordmanniana (Steven) Spach subsp. *bornmuelleriana* (Mattf.) Coode & Cullen 111
Abies nordmanniana (Steven) Spach var. *bornmuelleriana* (Mattf.) Silba 111
Abies nordmanniana (Steven) Spach subsp. ***equi-trojani*** (Asch. & Sint. *ex* Boiss.) Coode & Cullen **111**, 112
Abies nordmanniana (Steven) Spach var. *equi-trojani* (Asch. & Sint. *ex* Boiss.) Guin. & Maire 111
Abies nordmanniana (Steven) Spach subsp. ***nordmanniana*** **111**
Abies nukiangensis W. C. Cheng & L. K. Fu 78
Abies numidica de Lannoy *ex* Carrière 58, 61, **112**, 113, 116, *184*, 263
Abies oaxacana Martínez 94
Abies pectinata Gilib. var. *equi-trojani* Asch. & Sint. *ex* Boiss. 111
Abies pectinata Gilib. var. *nebrodensis* Lojac. 105
Abies pectinata Guss. 105
Abies ×phanerolepis (Fernald) T. S. Liu 65
Abies pindrow (Royle *ex* D. Don) Royle 58, 60, **113**, 114, 116, 125, 265, 428, 478, 618
Abies pindrow (Royle *ex* D. Don) Royle var. ***brevifolia*** Dallim. & A.B. Jacks **114**
Abies pindrow (Royle *ex* D. Don) Royle subsp. *gamblei* (Hickel) Rushforth 114
Abies pindrow (Royle *ex* D. Don) Royle var. ***pindrow*** **114**
Abies pinsapo Boiss. 58, 61, 71, **115**, 116, *185*
Abies pinsapo Boiss. var. ***marocana*** (Trab.) Ceballos & Bolaño **116**, 263, 757
Abies pinsapo Boiss. subsp. *numidica* (de Lannoy *ex* Carrière) E. Murray 112
Abies pinsapo Boiss. var. *numidica* (de Lannoy *ex* Carrière) Salomon 112
Abies pinsapo Boiss. var. ***pinsapo*** 115, **116**
Abies pinsapo Boiss. subsp. *tazaotana* (S. Côzar *ex* Villar) R. Govaerts 116
Abies pinsapo Boiss. var. *tazaotana* (S. Côzar *ex* Villar) Pourtet 116
Abies polita Siebold & Zucc. 620
Abies procera Rehd. 58, 61, 76, 102, 103, **116**, 117, *185*, 719, 737, 1026, 1066
Abies recurvata Mast. 58, 60, 73, 84, **118**, 119, 126, *185*, 578
Abies recurvata Mast. var. ***ernestii*** (Rehd.) C. T. Kuan **119**
Abies recurvata Mast. var. ***recurvata*** **119**
Abies recurvata Mast. var. *salouenensis* (Bordères & Gaussen) C. T. Kuan 73
Abies religiosa (Kunth) Schltdl. & Cham. 58, 61, 92, 93, **119**, 120, 129, 731, 735, 753
Abies religiosa (Kunth) Schltdl. & Cham. var. *emarginata* Loock *ex* Martínez 93
Abies sachalinensis (F. Schmidt) Mast. 58, 60, **121**, 122, 273, 590, 1010
Abies sachalinensis (F. Schmidt) Mast. f. *corticosa* (Tatew.) Hayashi 122
Abies sachalinensis (F. Schmidt) Mast. var. *corticosa* Tatew. 122
Abies sachalinensis (F. Schmidt) Mast. var. ***gracilis*** (Kom.) Farjon **122**
Abies sachalinensis (F. Schmidt) Mast. var. ***mayriana*** Miyabe & Kudô **122**
Abies sachalinensis (F. Schmidt) Mast. var. ***nemorensis*** Mayr **123**
Abies sachalinensis (F. Schmidt) Mast. var. ***sachalinensis*** **122**, 501
Abies salouenensis Bordères & Gaussen 73
Abies semenovii B. Fedtsch. 124
Abies shastensis (Lemmon) Lemmon 103
Abies sibirica Ledeb. 58, 60, 107, 109, **123**, 416, 501, 515, 608, 616, 783
Abies sibirica Ledeb. var. *gracilis* (Kom.) Patschke 122
Abies sibirica Ledeb. var. *nephrolepis* Trautv. *ex* Maxim. 107
Abies sibirica Ledeb. subsp. ***semenovii*** (B. Fedtsch.) Farjon **124**, 616
Abies sibirica Ledeb. var. *semenovii* (B. Fedtsch.) T. S. Liu 124
Abies sibirica Ledeb. subsp. ***sibirica*** **124**
Abies ×sibiriconephrolepis Taken. & J. J. Chien 107
Abies sikokiana Nakai 128

Abies spectabilis (D. Don) Mirb. 58, 61, 79, 80, 130, **124**, 125, *185*, 265, 504, 618, 805
Abies spectabilis (D. Don) Spach var. *brevifolia* (A. Henry) Rehd. 124
Abies spectabilis (D. Don) Spach var. *densa* (Griff.) Silba 78
Abies spectabilis (D. Don) Spach var. *langtangensis* Silba 125
Abies spinulosa Griff. 619
Abies squamata Mast. 58, 59, 118, **126**, *185*, 578, 614
Abies subalpina Engelm. var. *fallax* Engelm. 101
Abies sutchuenensis (Franch.) Rehd. & E. H. Wilson 85
Abies tacanensis Lundell 92, 129
Abies tazaotana S. Côzar *ex* Villar 116
Abies torano Siebold *ex* K. Koch 620
Abies tsuga Siebold & Zucc. 1042
Abies umbellata Mayr 97
Abies veitchii Lindl. 58, 60, 97, 105, **127**, 506, 573, 1048
Abies veitchii Lindl. var. *komagatakensis* Hayashi 128
Abies veitchii Lindl. f. *olivacea* (Shiras.) Cinovskis 128
Abies veitchii Lindl. var. *olivacea* Shiras. 128
Abies veitchii Lindl. var. *sachalinensis* F. Schmidt 122
Abies veitchii Lindl. var. ***sikokiana*** (Nakai) Kusaka **128**
Abies veitchii Lindl. var. ***veitchii*** **128**
Abies vejarii Martínez 58, 59, 61, **128**, 129, 130, 582, 601, 701
Abies vejarii Martínez var. ***macrocarpa*** Martínez **130**
Abies vejarii Martínez subsp. *mexicana* (Martínez) Farjon 130
Abies vejarii Martínez var. ***mexicana*** (Martínez) T. S. Liu 129, **130**
Abies vejarii Martínez var. ***vejarii*** **129**
Abies ×vilmorinii Matf. 116
Abies webbiana (Wall. *ex* D. Don) Lindl. var. *brevifolia* A. Henry 124
Abies webbiana (Wall. *ex* D. Don) Lindl. var. *pindrow* (Royle *ex* D. Don) Brandis 114
Abies yuanbaoshanensis Y. J. Lu & L. K. Fu 58, 61, **130**, 132
Abies yunnanensis Franch. 1048
Abies zapotekensis Debreczy 92, 129
Abies ziyuanensis L. K. Fu & S. L. Mo 58, 60, **131**, 132
Abietia A. H. Kent 959
Abietia douglasii (Sabine *ex* D. Don) A. H. Kent 959
Acmopyle Pilg. 42, 53, 54, **133**, 134, 347
Acmopyle alba J. T. Buchholz 133
Acmopyle pancheri (Brongn. & Gris) Pilg. **133**, 134, *185*, 968
Acmopyle sahniana J. T. Buchholz & N. E. Gray 133, **134**, 135
Actinostrobus Miq. 39, 48, 50, **136**, 139
Actinostrobus acuminatus Parl. **136**, 138
Actinostrobus arenarius C. A. Gardner 136, **137,** 138, 139, *185, 186*
Actinostrobus pyramidalis Miq. 136, **138**, 139
Actinostrobus pyramidalis Miq. subsp. *arenarius* (C. A. Gardner) Silba 137
Actinostrobus pyramidalis Miq. var. *arenarius* (C. A. Gardner) Silba 137
Afrocarpus (J. T. Buchholz & N. E. Gray) C. N. Page 20, 24, 28, 31, 42, 53, 54, **140**, 144, 870
Afrocarpus dawei (Stapf) C. N. Page **141**
Afrocarpus falcatus (Thunb.) C. N. Page 140, 141, **142**, 143, 144, *186*, 871, 877
Afrocarpus gaussenii (Woltz) C. N. Page 142
Afrocarpus gracilior (Pilg.) C. N. Page 141, **143**, 144, *186*, 454
Afrocarpus mannii (Hook. f.) C. N. Page **145**
Afrocarpus usambarensis (Pilg.) C. N. Page 141, **146**, 871
Agathis Salisb. 21, 28, 31, 35, 46, **148**, 149, 153, 155, 156, 157, 158, 163, 169, 171, 173, 192, 331, 352, 358, 526, 542, 556, 563, 837, 892, 896, 934, 936, 968, 984, 1062
Agathis atropurpurea B. Hyland 149, **150**, 151, 165
Agathis australis (D. Don) Lindl. 21, 148, 149, **151**, 152, 164, *186*, 332, 356, 392, 525, 564, 566, 853, 937, 947
Agathis borneensis Warb. 150, **153**, *154*, 155, 156, 157, 158, 162, 163, *186*, 377, 877
Agathis brownii (Lem.) L. H. Bailey 163
Agathis celebica (Koord.) Warb. 155, 156
Agathis celebica (Koord.) Warb. subsp. *flavescens* (Ridl.) Veldkamp & Whitmore 157
Agathis corbassonii de Laub. 166, 167
Agathis dammara (Lamb.) Rich. & A. Rich. 148, 150, 153, **155**, 156, 157, 158, 159, 162, 378

Agathis dammara (Lamb.) Rich & A. Rich. subsp. *dammara* 159
Agathis dammara (Lamb.) Rich. & A. Rich. subsp. *flavescens* (Ridl.) Whitmore 157
Agathis endertii Meijer Drees 153
Agathis flavescens Ridl. 149, **157**, 158, 159
Agathis hypoleuca (C. Moore *ex* Henkel & W. Hochst.) Warb. 169
Agathis kinabaluensis de Laub. 150, **158**, 159, 168, *187*
Agathis labillardierei Warb. 150, **159**, 160, 835, 973
Agathis lanceolata (Sèbert & Pancher) Warb. 149, **161**, 202, 221, 338
Agathis lenticula de Laub. 150, **162**, 169, *187*
Agathis macrophylla (Lindl.) Mast. 149, **163**, 173, 973
Agathis macrophylla (Lindl.) Mast. var. *obtusa* (Lindl.) Silba 163
Agathis microstachya J. F. Bailey & C. T. White 149, **164**, 165, *187*
Agathis montana de Laub. 149, **166**, 218, 381
Agathis moorei (Lindl.) Mast. 149, **166**, 167, 168
Agathis obtusa (Lindl.) Mast. 163
Agathis orbicula de Laub. 149, **168**, 169
Agathis ovata (C. Moore *ex* Vieill.) Warb. 134, 149, **169**, 170, *187*, 216, 350, 351, 544, 900
Agathis philippinensis Warb. 155, 156
Agathis robusta (C. Moore *ex* F. Muell.) F. M. Bailey 149, 150, **170**, 171
Agathis robusta (C. Moore *ex* F. Muell.) F. M. Bailey subsp. ***nesophila*** Whitmore 171, **172**
Agathis robusta (C. Moore *ex* F. Muell.) F. M. Bailey subsp. ***robusta*** **171**
Agathis silbae de Laub. 149, 163, **172**, 173
Agathis spathulata de Laub. 172
Agathis vitiensis (Seem.) Benth. & Hook. f. 163
Amentotaxus Pilg. 22, 44, 47, 55, **174**, 181, 277
Amentotaxus argotaenia (Hance) Pilg. **174**, 175, 176, 178, 179, 182, 1068
Amentotaxus argotaenia (Hance) Pilg. var. ***argotaenia*** **175**
Amentotaxus argotaenia (Hance) Pilg. var. ***brevifolia*** K. M. Lan & F. H. Zhang **176**
Amentotaxus argotaenia (Hance) Pilg. var. *cathayensis* (H. L. Li) P. C. Keng 175
Amentotaxus argotaenia (Hance) Pilg. var. *yunnanensis* (H. L. Li) P. C. Keng 181
Amentotaxus assamica D. K. Ferguson 174, **176**, 177
Amentotaxus cathayensis H. L. Li 175
Amentotaxus formosana H. L. Li 174, **177**, 178, *188*
Amentotaxus hatuyenensis Hiep 174, **179**, 180, 181, 258
Amentotaxus poilanei (Ferré & Rouane) D. K. Ferguson 174, **180**, 181
Amentotaxus yunnanensis H. L. Li 174, 175, 177, 179, 180, **181**, 182, *188*, 258
Amentotaxus yunnanensis H. L. Li var. *formosana* (H. L. Li) Silba 177
Amentotaxus yunnanensis H. L. Li var. *poilanei* Ferré & Rouane 180
Americus Hanford 981
Americus gigantea (Lindl.) Hanford 981
Apinus Neck. *ex* Rydb. 626
Apinus cembra Neck. *ex* Rydb. 626
Araucaria Juss. 21, 24, 29, 35, 46, 134, 170, **191**, 192, 193, 197, 207, 209, 216, 218, 350, 542, 556, 881, 910, 934, 968, 1062, 1063
Araucaria angustifolia (Bertol.) Kuntze 21, 192, 193, **194**, *195*, 196, 198, 1097
Araucaria angustifolia (Bertol.) Kuntze var. *dependens* J. R. de Mattos 194
Araucaria angustifolia (Bertol.) Kuntze var. *vinacea* J. R. de Mattos 194
Araucaria araucana (Molina) K. Koch 21, 29, *188*, 191, 192, 193, 194, **197**, 198, 199, 206
Araucaria bernieri J. T. Buchholz *188*, 192, 194, **199**, 200, 219
Araucaria bernieri J. T. Buchholz var. *pumilio* Silba 218, 219
Araucaria bidwillii Hook. 21, 29, 46, *188*, *189*, 191, 192, 193, 197, **200**, 201, 205
Araucaria biramulata J. T. Buchholz 192, 193, **202**
Araucaria columnaris (J. R. Forst.) Hook. *189*, 192, 194, **203**, 204, 212, 215, 216
Araucaria columnaris (G. Forst.) Hook. f. *luxurians* (Brongn. & Gris) E. H. Wilson 211
Araucaria cookii R. Br. *ex* Lindl. var. *luxurians* Brongn. & Gris 211
Araucaria cunninghamii Aiton *ex* A. Cunn. *189*, 192, 193, 201, **204**, 205, 209, 840
Araucaria cunninghamii Aiton *ex* A. Cunn. var. ***cunninghamii*** **205**
Araucaria cunninghamii Aiton *ex* A. Cunn. var. ***papuana*** Lauterb. **206**, 553
Araucaria heterophylla (Salisb.) Franco *189*, 192, 194, **206**, 207

Araucaria humboldtensis J. T. Buchholz 192, 194, **207**, 211, 363, 381, 522
Araucaria hunsteinii K. Schum. 191, 192, 193, 205, **208**, 209, 210
Araucaria hunsteinii K. Schum. var. *klinkii* (Lauterb.) Silba 208
Araucaria klinkii Lauterb. 208, 209
Araucaria laubenfelsii Corbasson *189*, 192, 193, 208, **210**, 211, 363, 381
Araucaria luxurians (Brongn. & Gris) de Laub. 192, 193, **211**, 212
Araucaria montana Brongn. & Gris 192, 193, 208, 211, **213**, 381
Araucaria muelleri (Carrière) Brongn. & Gris *189*, 192, 193, **214**, 350
Araucaria nemorosa de Laub. 192, 193, 204, **215**
Araucaria rulei F. Muell. 192, 193, **216**
Araucaria schmidii de Laub. 166, 192, 193, **217**, 218
Araucaria schumanniana Warb. 208, 209
Araucaria scopulorum de Laub. *190*, 192, 194, **218**, 219, *220*
Araucaria subulata Vieill. 161, 192, 193, 200, **219**, 221
Araucariaceae Henkel & W. Hochst. 17, 18, 21, 24, 28, 35, 45, **46**, 148, 191, 542, 947, 968, 1062, 1063, 1097, 1098, 1101
Arceuthos Antoine & Kotschy 393, 421
Arceuthos drupacea (Labill.) Antoine & Kotschy 393, 421
Arthrotaxis Endl. 218
Athrotaxis D. Don 36, 48, 49, **222**
Athrotaxis cupressoides D. Don *190*, **222**, 224, 374, 534, 559, 561
Athrotaxis ×laxifolia Hook. 222, **223**, 561
Athrotaxis selaginoides D. Don *190*, 221, 222, 223, **224**, 561
Athrotaxis tetragona Hook. 534
Austrocedrus Florin & Boutelje 38, 48, 50, **226**
Austrocedrus chilensis (D. Don) Pic. Serm. & Bizzarri *190*, 198, **226**, 227, 945, 1097
Austrotaxus R. H. Compton 44, 55, **228**
Austrotaxus spicata R. H. Compton **228**, *339*

B

Biota (D. Don) Endl. 817
Biota orientalis (L.) Endl. 817
Bracteocarpus A. V. Bobrov & Melikyan 327, 330
Bracteocarpus cinctus (Pilg.) A. V. Bobrov & Melikyan 328
Bracteocarpus compactus (Wasscher) A. V. Bobrov & Melikyan 329
Bracteocarpus cumingii (Parl.) A. V. Bobrov & Melikyan 330
Bracteocarpus dacrydiifolius (Wasscher) A. V. Bobrov & Melikyan 328
Bracteocarpus expansus (de Laub.) A. V. Bobrov & Melikyan 332
Bracteocarpus imbricatus (Blume) A. V. Bobrov & Melikyan 327, 334
Bracteocarpus kawaii (Hayata) A. V. Bobrov & Melikyan 334
Bracteocarpus kinabaluensis (Wasscher) A. V. Bobrov & Melikyan 335
Bracteocarpus leptophyllus (Wasscher) A. V. Bobrov & Melikyan 362
Bracteocarpus papuanus (Ridl.) A. V. Bobrov & Melikyan 335
Bracteocarpus steupii (Wasscher) A. V. Bobrov & Melikyan 337
Brownetera Rich. *ex* Tratt. 560
Brownetera aspleniifolia (Labill.) Tratt. 560
Brunia nodiflora L. 1056, 1058

C

Callitris Vent. 21, 39, 48, 50, **230**, 231, 238, 245, 248, 543, 1097
Callitris baileyi C. T. White 230, **231**
Callitris canescens (Parl.) S. T. Blake 230, 231, **232**, *339*
Callitris columellaris F. Muell. 230, 231, **233**, 234, 245, *339*
Callitris columellaris F. Muell. var. *campestris* Silba 233
Callitris columellaris F. Muell. var. *intratropica* (R. T. Baker & H. G. Smith) Silba 233
Callitris columellaris F. Muell. var. *microcarpa* (Benth.) Govaerts 233
Callitris drummondii (Parl.) F. Muell. 230, 231, **235**
Callitris endlicheri (Parl.) F. M. Bailey 230, 231, 234, **236**, 245, 246
Callitris glaucophylla J. Thompson & L. A. S. Johnson 233, 234
Callitris gracilis R. T. Baker subsp. *murrayensis* (J. Garden) K. D. Hill 244, 245, 307

Callitris intratropica R. T. Baker & H. G. Smith 233, 234
Callitris macleayana (F. Muell.) F. Muell. 230, 231, **237**, 248, *339*
Callitris monticola J. Garden 230, 231, **238**, *239*
Callitris muelleri (Parl.) Benth. & Hook. f. *ex* F. Muell. 230, 231, **240**, *339*
Callitris neocaledonica Dummer 208, 230, 231, **241**, 544
Callitris oblonga Rich. & A. Rich. 230, 231, **242**, 243, 1100
Callitris oblonga Rich. & A. Rich. subsp. *corangensis* K. D. Hill 242
Callitris oblonga Rich. & A. Rich. subsp. *parva* K. D. Hill 242
Callitris preissii Miq. 138, 139, 230, 231, **244**, 245, 246, 247, 249, 250, *340*
Callitris preissii Miq. subsp. *murrayensis* J. Garden 244
Callitris preissii Miq. var. *murrayensis* (J. Garden) Silba 244
Callitris preissii Miq. subsp. *verrucosa* (A. Cunn. *ex* Endl.) J. Garden 249
Callitris preissii Miq. var. *verrucosa* (A. Cunn. *ex* Endl.) Silba 249
Callitris rhomboidea R. Br. *ex* Rich. & A. Rich. 230, 231, 237, 240, 245, **246**, *340*
Callitris roei (Endl.) F. Muell. 138, 139, 230, 231, **247**, *340*
Callitris schwarzii Marloth 1025
Callitris sulcata (Parl.) Schltr. 230, 231, **248**, 249
Callitris tuberculata R. Br. *ex* R. T. Baker & H. G. Smith 244, 245, 250
Callitris verrucosa (A. Cunn. *ex* Endl.) F. Muell. 231, 245, **249**, 250, *251*
Callitropsis Oerst. 298, 543, 1064, 1099
Callitropsis R. H. Compton 543
Callitropsis abramsiana (C. B. Wolf) D. P. Little 314
Callitropsis araucarioides R. H. Compton 543
Callitropsis arizonica (Greene) D. P. Little 301
Callitropsis bakeri (Jeps.) D. P. Little 303
Callitropsis benthamii (Endl.) D. P. Little 318
Callitropsis forbesii (Jeps.) D. P. Little 316
Callitropsis glabra (Sudw.) D. P. Little 301
Callitropsis goveniana (Gordon) D. P. Little 313
Callitropsis guadalupensis (S. Watson) D. P. Little 315
Callitropsis lusitanica (Mill.) D. P. Little 317
Callitropsis macnabiana (Hartw.) D. P. Little 318
Callitropsis macrocarpa (Hartw.) D. P. Little 320
Callitropsis montana (Wiggins) D. P. Little 302
Callitropsis nevadensis (Abrams) D. P. Little 302
Callitropsis nootkatensis (D. Don) D. P. Little 1064, 1065
Callitropsis pigmaea (Lemmon) D. P. Little 313
Callitropsis sargentii (Jeps.) D. P. Little 321
Callitropsis stephensonii (C. B. Wolf) D. P. Little 303
Callitropsis vietnamensis (Farjon & Hiep) D. P. Little 1066
Calocedrus Kurz 37, 48, 50, **253**, 257, 521
Calocedrus decurrens (Torr.) Florin 91, 102, 227, **253**, 254, 257, 300, 304, *340*, 443, 581, 711, 719, 737, 982, 1026, 1066
Calocedrus formosana (Florin) Florin 217, **255**, 257, 282, 286, 288, 295, *340*, 986
Calocedrus macrolepis Kurz 253, 255, **256**, 258, *340*
Calocedrus macrolepis Kurz var. *formosana* (Florin) W. C. Cheng & L. K. Fu 255
Calocedrus rupestris Aver., Hiep & L. K. Phan 253, **257**, 258, *340*, 1093
Caryopitys Small 626
Caryopitys edulis (Engelm.) Small 626
Caryotaxus Henkel & W. Hochst. 1032
Caryotaxus nucifera (L.) Henkel & W. Hochst. 1032
Cathaya Chun & Kuang 20, 40, 52, **259**
Cathaya argyrophylla Chun & Kuang **259**, 260, *341*
Cedrus Trew 41, 51, 52, 53, 113, **261**, 265, 310, *341*, 482, 552, 954
Cedrus atlantica (Endl.) Manetti *ex* Carrière 113, 115, **261**, 262, 265, 266, 309, *341*, 482, 757, 1021
Cedrus brevifolia (Hook. f.) A. Henry 267
Cedrus deodara (Lamb.) G. Don 114, 261, **263**, *264*, 265, *341*, 428, 478, 618, 778, 805, 1017, 1099
Cedrus libani A. Rich. 74, 261, 262, 263, **265**, 266, 267, *341*, 423, 426, 430, 446
Cedrus libani A. Rich. subsp. *atlantica* (Endl.) Batt. & Trab. 261
Cedrus libani A. Rich. var. *atlantica* (Endl.) Hook. f. 261
Cedrus libani A. Rich. subsp. *brevifolia* (Hook. f.) Meikle 267
Cedrus libani A. Rich. var. ***brevifolia*** Hook. f. **267**
Cedrus libani A. Rich. subsp. *deodara* (Lamb.) P. D. Sell 263
Cedrus libani A. Rich. var. ***libani*** **267**, *341*

Cedrus libani A. Rich. subsp. *stenocoma* (O. Schwarz) P. H. Davis 267
Cedrus libani A. Rich. var. *stenocoma* (O. Schwarz) Frankis 267
Cedrus libanitica Trew *ex* Pilg. subsp. *stenocoma* O. Schwarz 267
Cephalotaxaceae Neger 18, 22, 24, 26, 35, 45, **46**, 47, 258, 268, 1094, 1103
Cephalotaxus Siebold & Zucc. *ex* Endl. 16, 35, 46, 47, 175, **268**, 272, 277, 511
Cephalotaxus alpina (H. L. Li) L. K. Fu 270
Cephalotaxus argotaenia (Hance) Pilg. 175
Cephalotaxus celebica Warb. 1016
Cephalotaxus drupacea Siebold & Zucc. 272, 273, 279
Cephalotaxus drupacea Siebold & Zucc. var. *harringtonii* (Knight *ex* J. Forbes) Pilg. 273
Cephalotaxus drupacea Siebold & Zucc. var. *sinensis* Rehd. & E. H. Wilson 279
Cephalotaxus fortunei Hook. 268, **269**, 275, 276, 297, *341*, 386, 491, 492, 541, 885, 986, 1038, 1050
Cephalotaxus fortunei Hook. var. ***alpina*** H. L. Li 269, **270**
Cephalotaxus fortunei Hook. var. ***fortunei*** 269, **270**, *341*
Cephalotaxus fortunei Hook. var. *globosa* S. Y. Hu 270
Cephalotaxus fortunei Hook. var. *lanceolata* (K. M. Feng) Silba 274
Cephalotaxus griffithii Hook. f. 277, 278
Cephalotaxus hainanensis H. L. Li 268, 269, **271**, 277
Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch 268, 269, **272**, 273, 274, 276, 280, *341*
Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. ***harringtonii*** **273**, *341, 342*
Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. ***nana*** (Nakai) Rehd. **273**
Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. *sinensis* (Rehd. & E. H. Wilson) Rehd. 279
Cephalotaxus harringtonii (Knight *ex* J. Forbes) K. Koch var. ***wilsoniana*** (Hayata) Kitam. **274**
Cephalotaxus koreana Nakai 272, 273
Cephalotaxus lanceolata K. M. Feng 268, **274**
Cephalotaxus latifolia L. K. Fu & R. R. Mill 269, **275**, 276
Cephalotaxus mannii Hook. f. 180, 182, 258, 269, 271, **277**, 278, *342*, 1017
Cephalotaxus nana Nakai 273
Cephalotaxus oliveri Mast. 268, 276, **278**, 279
Cephalotaxus sinensis (Rehd. & E. H. Wilson) H. L. Li 268, 274, 276, **279**, 280
Cephalotaxus sinensis (Rehd. & E. H. Wilson) H. L. Li var. *latifolia* W. C. Cheng & L. K. Fu 275
Cephalotaxus sinensis (Rehd. & E. H. Wilson) H. L. Li var. *wilsoniana* (Hayata) L. K. Fu & NanLi 274
Cephalotaxus sumatrana Miq. 1016
Cephalotaxus wilsoniana Hayata 274
Chamaecyparis Spach 37, 48, 49, 272, **281**, 299, 312, 384, 1064
Chamaecyparis formosensis Matsum. **281**, 282, 286, 295, *342*, 986
Chamaecyparis funebris (Endl.) Franco 311
Chamaecyparis henryae H. L. Li 291
Chamaecyparis hodginsii (Dunn) Rushforth 384
Chamaecyparis lawsoniana (A. Murray bis) Parl. 254, 281, **283**, 284, *342*, 617, 737, 1026
Chamaecyparis nootkatensis (D. Don) Spach 63, 1065, 1066
Chamaecyparis obtusa (Siebold & Zucc.) Endl. 86, 281, 282, **285**, 286, 293, 960, 978, 1027, 1030, 1039, 1055
Chamaecyparis obtusa (Siebold & Zucc.) Endl. subsp. *formosana* (Hayata) H. L. Li 286
Chamaecyparis obtusa (Siebold & Zucc.) Endl. var. ***formosana*** (Hayata) Hayata 98, 282, 285, **286**, 288, 604, 986
Chamaecyparis obtusa (Siebold & Zucc.) Endl. var. ***obtusa*** 285, **286**, *287*
Chamaecyparis obtusa (Siebold & Zucc.) Endl. var. *obtusa* f. *formosana* Hayata 286
Chamaecyparis pisifera (Siebold & Zucc.) Endl. 281, 282, 283, 286, **288**, 978, 1027, 1030
Chamaecyparis sphaeroidea (Spreng.) Spach 281
Chamaecyparis taiwanensis Masam. & S. Suzuki 286
Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. 281, **289**, *342*, 599, 615, 691, *777*
Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. subsp. *henryae* (H. L. Li) E. Murray 291
Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. var. ***henryae*** (H. L. Li) Little **291**

Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. var. ***thyoides*** **290**
Chrysolarix H. E. Moore 954
Chrysolarix amabilis (J. Nelson) H. E. Moore 954
Columbea Salisb. 191
Columbea angustifolia Bertol. 194
Cryptomeria D. Don 37, 48, 49, **292**, 293, 405
Cryptomeria fortunei Hooibr. 292
Cryptomeria japonica (Thunb. *ex* L. f.) D. Don 21, 28, 86, 178, 274, 286, **292**, 297, *342*, 492, 960, 978, 1030, 1055, 1102
Cryptomeria japonica (Thunb. *ex* L. f.) D. Don var. *fortunei* (Hooibr.) Henry 292
Cryptomeria japonica (Thunb. *ex* L. f.) D. Don subsp. *sinensis* (Miq.) P. D. Sell 292
Cryptomeria japonica (Thunb. *ex* L. f.) D. Don var. *sinensis* Miq. 292
Cunninghamia R. Br. 36, 48, 257, 288, **294**, 295, 296
Cunninghamia konishii Hayata 282, 286, **294**, 295, 296, *343*, 986
Cunninghamia lanceolata (Lamb.) Hook. 268, 294, 295, **296**, 297, *343*, 386, 489, 491, 728, 885, 955
Cunninghamia sinensis R. Br. 294
Cunninghamia unicanaliculata D. Y. Wang & H. L. Liu 296
Cunninghamia unicanaliculata D. Y. Wang & H. L. Liu var. *pyramidalis* D. Y. Wang & H. L. Liu 296
Cuprespinnata J. Nelson 988
Cuprespinnata disticha (L.) J. Nelson 988
Cupressaceae Gray 11, 17, 18, 20, 21, 22, 24, 26, 27, 28, 35, 45, **47**, 48, 136, 180, 222, 226, 227, 230, 234, 235, 238, 243, 244, 253, 258, 281, 292, 294, 298, 300, 317, 325, 373, 382, 384, 387, 393, 394, 436, 437, 452, 464, 521, 527, 530, 532, 543, 552, 559, 624, 817, 879, 953, 978, 979, 981, 985, 988, 1019, 1022, 1026, 1056, 1057, 1061, 1064, 1074, 1075, 1078, 1081
Cupressus L. 21, 26, 37, 47, 48, 50, **298**, 299, 310, 312, 355, 382, 384
Cupressus abramsiana C. B. Wolf 314, 582
Cupressus arizonica Greene 80, 81, 129, 130, **299**, 300, *343*, 582
Cupressus arizonica Greene var. ***arizonica*** **301**
Cupressus arizonica Greene var. ***glabra*** (Sudw.) Little **301**, 1066
Cupressus arizonica Greene var. ***montana*** (Wiggins) Little **302**
Cupressus arizonica Greene var. ***nevadensis*** (Abrams) Little **302**
Cupressus arizonica Greene var. *revealiana* Silba 303
Cupressus arizonica Greene var. ***stephensonii*** (C. B. Wolf) Little **303**
Cupressus atlantica Gaussen 311
Cupressus austrotibetica Silba 325
Cupressus bakeri Jeps. 299, **303**
Cupressus bakeri Jeps. subsp. *matthewsii* C. B. Wolf 303
Cupressus benthamii Endl. 318
Cupressus cashmeriana Royle *ex* Carrière 299, **304**
Cupressus chengiana S. Y. Hu 299, **306**
Cupressus chengiana S. Y. Hu var. ***chengiana*** **307**
Cupressus chengiana S. Y. Hu var. ***jiangensis*** (N. Zhao) Silba **307**
Cupressus columnaris J. R. Forst. 203
Cupressus disticha L. 988, 990
Cupressus disticha L. var. *imbricaria* Nutt. 990
Cupressus disticha L. var. *nutans* Aiton 990
Cupressus duclouxiana Hickel 299, **307**
Cupressus dupreziana A. Camus 298, 299, **309**, *343*, 1093
Cupressus dupreziana A. Camus var. ***atlantica*** (Gaussen) Silba **311**
Cupressus dupreziana A. Camus var. ***dupreziana*** **310**
Cupressus fallax Franco 307
Cupressus forbesii Jeps. 316
Cupressus funebris Endl. 297, 298, 299, **311**, 312, 489
Cupressus gigantea W. C. Cheng & L. K. Fu 325
Cupressus glabra Sudw. 301
Cupressus goveniana Gordon 299, **312**
Cupressus goveniana Gordon var. ***abramsiana*** (C. B. Wolf) Little **314**
Cupressus goveniana Gordon var. ***goveniana*** **313**
Cupressus goveniana Gordon subsp. *pigmaea* (Lemmon) A. Camus 313
Cupressus goveniana Gordon var. *pigmaea* Lemmon 313
Cupressus guadalupensis S. Watson 299, **314**
Cupressus guadalupensis S. Watson subsp. *forbesii* (Jeps.) Beauch. 316
Cupressus guadalupensis S. Watson var. ***forbesii*** (Jeps.) Little **316**, *343*

Cupressus guadalupensis S. Watson var. ***guadalupensis*** 314, **315**
Cupressus himalaica Silba 304, 305
Cupressus hodginsii Dunn 384
Cupressus horizontalis Mill. 322, 323
Cupressus japonica Thunb. *ex* L. f. 292
Cupressus jiangensis N. Zhao 307
Cupressus juniperoides L. 1057
Cupressus karnaliensis Silba 325
Cupressus karnaliensis Silba var. *mustangensis* Silba 325
Cupressus lawsoniana A. Murray bis 283
Cupressus lindleyi Klotzsch *ex* Endl. 317, 582
Cupressus lusitanica Mill. 80, 92, 94, 95, 299, **316**, *343*, 582, 687, 688, 701, 704, 722, 735, 796, 1014, 1061, 1066
Cupressus lusitanica Mill. var. ***benthamii*** (Endl.) Carrière **318**
Cupressus lusitanica Mill. var. *hondurensis* Silba 317
Cupressus lusitanica Mill. var. ***lusitanica*** **317**
Cupressus lusitanica Mill. subsp. *torulosa* (D. Don) Silba 325
Cupressus macnabiana A. Murray bis 299, **318**, *319*
Cupressus macrocarpa Hartw. *ex* Gordon 298, **320**
Cupressus montana Wiggins 302
Cupressus nevadensis Abrams 302
Cupressus nootkatensis D. Don 1064, 1065
Cupressus pakistanensis Silba 325
Cupressus pendula Griff. 304, 305
Cupressus pendula Thunb. 305
Cupressus pigmaea (Lemmon) Sarg. 313
Cupressus sargentii Jeps. 299, **321**
Cupressus sempervirens L. 298, 299, 309, 310, **322**, 660, 1097
Cupressus sempervirens L. var. *atlantica* (Gaussen) Silba 311
Cupressus sempervirens L. var. *dupreziana* (A. Camus) Silba 310
Cupressus sempervirens L. subsp. *horizontalis* (Mill.) A. Camus 322
Cupressus sempervirens L. var. *horizontalis* (Mill.) Loudon 322
Cupressus sempervirens L. var. *pyramidalis* auct. 323
Cupressus stephensonii C. B. Wolf 303
Cupressus thyoides L. 281, 289
Cupressus tongmaiensis Silba 325
Cupressus tongmaiensis Silba var. *ludlowii* Silba 325
Cupressus tonkinensis Silba 324, 325
Cupressus tortulosa Griff. 304
Cupressus torulosa D. Don 265, 299, **324**, 325, 343, 437
Cupressus torulosa D. Don var. ***gigantea*** (W. C. Cheng & L. K. Fu) Farjon **325**, 326, 484
Cupressus torulosa D. Don var. ***torulosa*** **325**
Cupressus vietnamensis (Farjon) Silba 1066
×*Cuprocyparis leylandii* (A. B. Jackson & Dallimore) Farjon 1066

D

Dacrycarpus (J. J. Bennett) de Laub. 28, 42, 53, 54, **327**, 329, 330, 352, 358, 362, 377, 379, 542, 563, 837, 912, 984
Dacrycarpus cinctus (Pilg.) de Laub. 327, **328**, 329, *344*
Dacrycarpus compactus (Wassch.) de Laub. 327, **329**, 330, 840
Dacrycarpus cumingii (Parl.) de Laub. 327, **330**, 331
Dacrycarpus dacrydioides (A. Rich.) de Laub. 152, 327, **331**, 332, *344*, 356, 392, 525, 566, 853, 937, 947, 953
Dacrycarpus expansus de Laub. 327, **332**, 333
Dacrycarpus imbricatus (Blume) de Laub. 182, 258, 277, 328, 329, 331, **333**, 334, 335, 336, 337, *344*, 359, 360, 366, 377, 896, 973, 1017
Dacrycarpus imbricatus (Blume) de Laub. var. ***curvulus*** (Miq.) de Laub. **335**
Dacrycarpus imbricatus (Blume) de Laub. var. ***imbricatus*** **334**, 335
Dacrycarpus imbricatus (Blume) de Laub. var. *patulus* de Laub. 334, 335
Dacrycarpus imbricatus (Blume) de Laub. var. ***robustus*** de Laub. 329, **335**
Dacrycarpus kinabaluensis (Wassch.) de Laub. 328, **335**, 336, *344*, 360, 843
Dacrycarpus leptophyllus (Wasscher) Gaussen 362
Dacrycarpus steupii de Laub. 335
Dacrycarpus steupii (Wasscher) de Laub. 328, **337**
Dacrycarpus vieillardii (Parl.) de Laub. 328, **338**, 544
Dacrydium Sol. *ex* G. Forst. 20, 28, 42, 53, 54, 331, 334, **347**, 348, 349, 358, 362, 372, 377, 378, 379, 542, 553, 555, 563, 837, 896, 912, 919, 984

Dacrydium araucarioides Brongn. & Gris 134, 170, 214, 249, 338, *345*, 347, **350**, 351, 370, 544, 900, 1098
Dacrydium balansae Brongn. & Gris 249, 348, **351**
Dacrydium beccarii Parl. *345*, 348, 350, **352**, *353*
Dacrydium beccarii Parl. var. *kinabaluense* Corner 359
Dacrydium beccarii Parl. var. *rudens* de Laub. 364
Dacrydium beccarii Parl. var. *subelatum* Corner 365
Dacrydium bidwillii Hook. f. *ex* Kirk 389, 390
Dacrydium biforme (Hook.) Pilg. 390
Dacrydium colensoi Hook. 528
Dacrydium comosum Corner *345*, 349, **354**
Dacrydium cornwallianum de Laub. 349, **354**
Dacrydium cupressinum Sol. *ex* G. Forst. 152, 332, *345*, 347, **355**, 356, 392, 516, 523, 525, 566, 853, 937, 947, 953
Dacrydium elatum (Roxb.) Wall. *ex* Hook. 182, 258, *346*, 348, **357**, 358, 679, 717
Dacrydium ericoides de Laub. 348, **358**, 370
Dacrydium falciforme (Parl.) Pilg. 378
Dacrydium fitzgeraldii F. Muell. 557
Dacrydium fonkii (Phil.) Benth. & Hook. f. 516
Dacrydium franklinii Hook. f. 495
Dacrydium gibbsiae Stapf 336, *346*, **359**, 360, 843, 863
Dacrydium gracile de Laub. 336, *346*, **360**, 878
Dacrydium guillauminii J. T. Buchholz *346*, **361**, 970
Dacrydium hookerianum (W. Archer) Eichler 558
Dacrydium intermedium Kirk 517
Dacrydium intermedium Kirk var. *gracilis* Kirk 517, 518
Dacrydium kirkii F. Muell. ex Parl. 391
Dacrydium laxifolium Hook. f. 518
Dacrydium leptophyllum (Wasscher) de Laub. *ex* Silba 349, **362**
Dacrydium lycopodioides Brongn. & Gris 348, **363**, 367
Dacrydium magnum de Laub. 348, **364**, 367
Dacrydium medium de Laub. 348, **365**
Dacrydium nausoriense de Laub. 348, **365**, 366, 973
Dacrydium nidulum de Laub. 348, **366**, 367, 973
Dacrydium nidulum de Laub. var. *araucarioides* de Laub. 354, 355
Dacrydium novoguineense Gibbs **367**, 835
Dacrydium pancheri Brongn. & Gris 133
Dacrydium papuanum (de Laub.) Whitmore 379
Dacrydium pectinatum de Laub. 155, 349, **368**, 369
Dacrydium pectinatum de Laub. var. *robustum* de Laub. 368
Dacrydium pierrei Hickel 357
Dacrydium plumosum D. Don 521, 525
Dacrydium spathoides de Laub. 349, 358, **369**, 370
Dacrydium ×suprinii Nimsch 348, **370**, 371
Dacrydium taxifolium Banks & Sol. *ex* D. Don 952
Dacrydium taxoides Brongn. & Gris 380
Dacrydium tetragonum (Hook.) Parl. 534
Dacrydium ustum Vieill. 555
Dacrydium xanthandrum Pilg. *346*, 348, 349, **371**, 372
Dammara (Rumph.) Lam. 148
Dammara australis D. Don 151
Dammara brownii hort. ex Lem. 163
Dammara celebica Koord. 155
Dammara hypoleuca C. Moore *ex* Henkel & W. Hochst. 169
Dammara lanceolata Sébert & Pancher 161
Dammara loranthifolia Link 148
Dammara macrophylla Lindl. 163
Dammara moorei Lindl. 166
Dammara motleyi Parl. 539
Dammara obtusa Lindl. 163
Dammara ovata C. Moore *ex* Vieill. 169
Dammara robusta C. Moore *ex* F. Muell. 171
Dammara vitiensis Seem. 163
Decussocarpus de Laub. 538, 967
Decussocarpus comptonii (J. T. Buchholz) de Laub. 967
Decussocarpus falcatus (Thunb.) de Laub. 142
Decussocarpus fleuryi (Hickel) de Laub. 537
Decussocarpus gracilior (Pilg.) de Laub. 143
Decussocarpus mannii (Hook.) de Laub. 145
Decussocarpus maximus de Laub. 538
Decussocarpus minus (Carrière) de Laub. 969
Decussocarpus motleyi (Parl.) de Laub. 539
Decussocarpus nagi (Thunb.) de Laub. 540, 967
Decussocarpus nagi (Thunb.) de Laub. var. *formosensis* (Dummer) Silba 540
Decussocarpus piresii Silba 970
Decussocarpus rospigliosii (Pilg.) de Laub. 971
Decussocarpus vitiensis (Seem.) de Laub. 944
Decussocarpus wallichianus (C. Presl) de Laub. 541
Diselma Hook. f. 39, 48, 50, **373**

Diselma archeri Hook. f. 21, 223, 225, *346*, **373**, 374, 534, 559, 561, 879
Dolophyllum Salisb. 1030
Dolophyllum dolabrata (L. f.) Salisb. 1030
Dombeya Lam. 191
Ducampopinus A. Chev. 626, 716
Ducampopinus krempfii (Lecomte) A. Chev. 626, 716

E

Eutacta Link 191
Eutacta muelleri Carrière 214
Eutacta pancheri Carrière 543
Eutassa Salisb. 191
Eutassa heterophylla Salisb. 206

F

Falcatifolium de Laub. 42, 53, 54, 347, 358, **375**, 377
Falcatifolium angustum de Laub. **375**, 376
Falcatifolium falciforme (Parl.) de Laub. 155, 360, 375, **376**, 377, *465*, 542, 878
Falcatifolium gruezoi de Laub. 352, 375, **378**, 984
Falcatifolium papuanum de Laub. 375, **379**, 380, 835
Falcatifolium sleumeri de Laub. & Silba 375, **380**
Falcatifolium taxoides (Brongn. & Gris) de Laub. 20, 43, 208, 211, 363, 375, **380**, 381, *465*, 522, 555, 556, 968
Falcatifolium usan-apuense de Laub. & Silba 376
Fitzroya Lindl. 39, 48, 50, **382**, 383, 625
Fitzroya cupressoides (Molina) I. M. Johnst. 227, **382**, 383, *465*, 517, 625, 900, 1097
Foetataxus J. Nelson 1032
Foetataxus montana J. Nelson 1032
Fokienia A. Henry & H. H. Thomas 38, 48, 49, **384**
Fokienia hodginsii (Dunn) A. Henry & H. H. Thomas 182, 258, 270, 277, **384**, *385*, 386, *466*, 537, 541, 551, 679, 681, 717, 885, 986, 1008
Frenela Mirb. 230
Frenela canescens Parl. 232
Frenela drummondii Parl. 235
Frenela endlicheri Parl. 236
Frenela muelleri Parl. 240
Frenela robusta A. Cunn. *ex* Endl. var. *microcarpa* Benth. 233
Frenela roei Endl. 242
Frenela sulcata Parl. 248
Frenela triquetra Spach 230
Frenela verrucosa A. Cunn. *ex* Endl. 249

G

Gigantabies J. Nelson 979
Gigantabies taxifolia J. Nelson 979
Glyptostrobus Endl. 21, 37, 48, 49, **387**, 388
Glyptostrobus lineatus (Poir.) Druce 387
Glyptostrobus pensilis (Staunton *ex* D. Don) K. Koch **387**, 388, *466*

H

Halocarpus Quinn 42, 53, 54, 347, **389**
Halocarpus bidwillii (Hook. f. *ex* Kirk) Quinn 332, **389**, 390, *466*, 520, 898
Halocarpus biformis (Hook.) Quinn **390**, 391, *466*, 520, 523, 566, 853
Halocarpus kirkii (F. Muell. *ex* Parl.) Quinn 356, 389, **391**, 392, 525, 528, 853, 953
Hesperocyparis Bartel & R. A. Price 298, 299
Hesperocyparis abramsiana (C. B. Wolf) Bartel 314
Hesperocyparis arizonica (Greene) Bartel 301
Hesperocyparis bakeri (Jeps.) Bartel 303
Hesperocyparis benthamii (Endl.) Bartel 318
Hesperocyparis forbesii (Jeps.) Bartel 316
Hesperocyparis glabra (Sudw.) Bartel 301
Hesperocyparis goveniana (Gordon) Bartel 313
Hesperocyparis guadalupensis (S. Watson) Bartel 315
Hesperocyparis lusitanica (Mill.) Bartel 317
Hesperocyparis macnabiana (A. Murray bis) Bartel 318
Hesperocyparis macrocarpa (Hartw. *ex* Gordon) Bartel 298, 320
Hesperocyparis montana (Wiggins) Bartel 302
Hesperocyparis nevadensis (Abrams) Bartel 302
Hesperocyparis pigmaea (Lemmon) Bartel 313
Hesperocyparis sargentii (Jeps.) Bartel 321
Hesperocyparis stephensonii (C. B. Wolf) Bartel 303
Hesperopeuce (Engelm.) Lemmon 1042
Hesperopeuce mertensiana (Bong.) Lemmon 1042
Hesperopeuce mertensiana (Bong.) Rydb. 1053
×*Hesperotsuga* C. N. Page 1042
×*Hesperotsuga jeffreyi* (A. Henry) C. N. Page 1042, 1054

Juniperus L. 21, 25, 26, 28, 38, 48, 49, 92, 100, 138, 298, 317, 324, **393**, 406, 411, 425, 430, 450, 473, 479, 502, 504, 532, 670, 690, 693, 721, 722, 723, 789, 1064
Juniperus africana (Maire) Villar 482
Juniperus angosturana R. P. Adams 396, **397**
Juniperus arenaria (E. H. Wilson) Florin 464
Juniperus arizonica (R. P. Adams) R. P. Adams 396, **398**
Juniperus ashei J. T. Buchholz 396, **399**, 485, 774
Juniperus ashei J. T. Buchholz var. ***ashei*** **400**
Juniperus ashei J. T. Buchholz var. ***ovata*** R. P. Adams **400**
Juniperus ashei J. T. Buchholz var. *saltillensis* (M. T. Hall) Silba 473
Juniperus baimashanensis Y. F. Yu & L. K. Fu 478
Juniperus barbadensis L. 396, **400**, 401, 475
Juniperus barbadensis L. var. ***barbadensis*** **401**
Juniperus barbadensis L. var. ***lucayana*** (Britton) R. P. Adams **401**
Juniperus barbadensis L. subsp. *saxicola* (Britton & P. Wilson) Borhidi 475
Juniperus barbadensis L. var. *saxicola* (Britton & P. Wilson) Silba 475
Juniperus barbadensis L. subsp. *urbaniana* (Pilg. & Ekman) Borhidi 434
Juniperus barbadensis L. var. *urbaniana* (Pilg. & Ekman) Silba 434
Juniperus bermudiana L. 396, **402**
Juniperus blancoi Martínez 396, **403**, 404, 476
Juniperus blancoi Martínez var. ***blancoi*** **403**
Juniperus blancoi Martínez var. ***huehuentensis*** R. P. Adams **404**
Juniperus blancoi Martínez var. ***mucronata*** (R. P. Adams) Farjon **404**
Juniperus brevifolia (Seub.) Antoine 394, **404**, 407
Juniperus californica Carrière 300, **405**, *466*, 734, 771
Juniperus californica Carrière f. *lutheyana* J. T. Howell & Twisselm. 405
Juniperus californica Carrière subsp. *osteosperma* (Torr.) E. Murray 444
Juniperus canariensis Guyot & Mathou 449
Juniperus carinata (Y. F. Yu & L. K. Fu) R. P. Adams 452
Juniperus cedrus Webb & Berthel. 394, **406**, 407
Juniperus cedrus Webb & Berthel. subsp. *maderensis* (Menezes) Rivas Mart. *et al.* 406
Juniperus chengii L. K. Fu & Y. F. Yu 452
Juniperus chinensis L. 396, **408**, 409, 463, 466, 475, 476, 485, 487, 1097
Juniperus chinensis L. var. *arenaria* E. H. Wilson 464
Juniperus chinensis L. var. ***chinensis*** **409**
Juniperus chinensis L. var. *procumbens* Siebold *ex* Endl. 454
Juniperus chinensis L. var. ***sargentii*** A. Henry **409**
Juniperus chinensis L. var. ***tsukusiensis*** (Masam.) Masam. **410**
Juniperus chinensis Roxb. 886
Juniperus coahuilensis (Martínez) Gaussen *ex* R. P. Adams 396, 398, **410**, 411
Juniperus coahuilensis (Martínez) Gaussen *ex* R. P. Adams var. *arizonica* R. P. Adams 398
Juniperus comitana Martínez 396, **411**, 412
Juniperus communis L. 29, 106, 113, 263, 393, 394, **412**, 413, 416, 432, 435, *467*
Juniperus communis L. var. *charlottensis* R. P. Adams 416
Juniperus communis L. var. ***communis*** 413, **414**, *467*
Juniperus communis L. subsp. *depressa* (Pursh) Franco 414
Juniperus communis L. var. ***depressa*** Pursh **414**
Juniperus communis L. var. ***megistocarpa*** Fernald & H. St. John **415**
Juniperus communis L. var. *montana* Aiton 413, 416
Juniperus communis L. var. *nana* (Willd.) Baumg. 413
Juniperus communis L. var. ***nipponica*** (Maxim.) E. H. Wilson 105, **415**, 416
Juniperus communis L. subsp. *pygmaea* (K. Koch) Imkhan. 416
Juniperus communis L. var. ***saxatilis*** Pall. 413, **416**, *467*, 478, 502
Juniperus compacta (Martínez) R. P. Adams 442
Juniperus conferta Parl. 461
Juniperus convallium Rehd. & E. H. Wilson 395, **417**, 474, 484
Juniperus convallium Rehd. & E. H. Wilson var. ***convallium*** **417**

Juniperus convallium Rehd. & E. H. Wilson var. ***microsperma*** (W. C. Cheng & L. K. Fu) Silba **418**
Juniperus coxii A. B. Jacks. 460
Juniperus davurica Pall. 464
Juniperus davurica Pall. subsp. *maritima* Urussov 464
Juniperus deltoides R. P. Adams 446
Juniperus deppeana Steud. 80, 396, **418**, 424, 429, 432, *467*, 642, 688, 1093
Juniperus deppeana Steud. var. ***deppeana*** **419**, 432
Juniperus deppeana Steud. var. *gamboana* (Martínez) R. P. Adams 432
Juniperus deppeana Steud. var. ***pachyphlaea*** (Torr.) Martínez 300, **419**
Juniperus deppeana Steud. var. *patoniana* (Martínez) Zanoni 420
Juniperus deppeana Steud. var. ***robusta*** Martínez 404, **420**, 424, 432
Juniperus deppeana Steud. var. ***sperryi*** Correll **420**
Juniperus deppeana Steud. f. *zacatensis* (Martínez) R. P. Adams 420
Juniperus deppeana Steud. var. ***zacatecensis*** Martínez **420**
Juniperus depressa (Pursh) Raf. 414
Juniperus distans Florin 483, 484
Juniperus drupacea Labill. 323, 393, 394, **421**, *422*, 423, 430, 1094
Juniperus durangensis Martínez 396, **423**
Juniperus ekmanii Florin 434
Juniperus elata Roxb. 357
Juniperus erectopatens (W. C. Cheng & L. K. Fu) R. P. Adams 409
Juniperus erythrocarpa Cory 449
Juniperus erythrocarpa Cory var. *coahuilensis* Martínez 410
Juniperus excelsa M.-Bieb. 74, 266, 323, 397, 423, **424**, 425, 430, 446, 661
Juniperus excelsa M.-Bieb. subsp. ***excelsa*** **426**
Juniperus excelsa M.-Bieb. subsp. ***polycarpos*** (K. Koch) Takht. **426**, *427*, 478
Juniperus excelsa M.-Bieb. var. *polycarpos* (K. Koch) Silba 426
Juniperus excelsa M.-Bieb. subsp. *polycarpos* (K. Koch) Takht. var. *pendula* (Mulk.) Imkhan. 426
Juniperus excelsa M.-Bieb. subsp. *seravschanica* (Kom.) Imkhan. 426
Juniperus excelsa M.-Bieb. subsp. *turcomanica* (B. Fedtsch.) Imkhan. 426
Juniperus flaccida Schltdl. 396, 398, 419, **428**, 467, 642, 701, 760, 767, 1093
Juniperus flaccida Schltdl. var. ***flaccida*** **429**, 430, *467*
Juniperus flaccida Schltdl. var. ***martinezii*** (Pérez de la Rosa) Silba **429**, 430
Juniperus flaccida Schltdl. var. ***poblana*** Martínez **429**
Juniperus foetidissima Willd. 266, 323, 397, 423, 426, **430**, 446
Juniperus formosana Hayata 77, 297, 394, **431**
Juniperus formosana Hayata var. *mairei* (Lemee & Lev.) R. P. Adams & C. F. Hsieh 431
Juniperus gamboana Martínez **432**, 433
Juniperus gaussenii W. C. Cheng **486**, 487
Juniperus gracilior Pilg. 396, **433**
Juniperus gracilior Pilg. var. ***ekmanii*** (Florin) R. P. Adams **434**
Juniperus gracilior Pilg. var. ***gracilior*** **434**
Juniperus gracilior Pilg. var. ***urbaniana*** (Pilg. & Ekman) R. P. Adams 433, **434**
Juniperus grandis R. P. Adams 444
Juniperus horizontalis Moench 397, **435**, 436, 485
Juniperus horizontalis Moench subsp. *hamptonensis* Silba 435
Juniperus horizontalis Moench subsp. *neopangaea* Silba 435
Juniperus indica Bertol. 21, 395, **436**, 437, 479
Juniperus indica Bertol. var. ***caespitosa*** Farjon **437**
Juniperus indica Bertol. var. ***indica*** **437**
Juniperus jaliscana Martínez 396, **438**
Juniperus komarovii Florin 395, **438**
Juniperus lucayana Britton 401
Juniperus lutchuensis Koidz. 481
Juniperus macrocarpa Sibth. & Sm. 447
Juniperus macropoda Boiss. 426, 478
Juniperus mairei Lemée & Lév 431
Juniperus maritima R. P. Adams 476
Juniperus martinezii Pérez de la Rosa 429
Juniperus media V. D. Dmitriev 409, 477
Juniperus microsperma (W. C. Cheng & L. K. Fu) R. P. Adams 418

Juniperus monosperma (Engelm.) Sarg. 396, 397, 398, **439**, *441*, 690, 774
Juniperus monosperma (Engelm.) Sarg. var. *gracilis* Martínez 397
Juniperus monosperma (Engelm.) Sarg. var. *pinchotii* (Sudw.) Melle 449
Juniperus montana (Aiton) Lindl. & Gordon 416
Juniperus monticola Martínez 396, **440**
Juniperus monticola Martínez var. *monticola* f. *compacta* Martínez 440
Juniperus morrisonicola Hayata 478
Juniperus mucronata R. P. Adams 404
Juniperus navicularis Gand. 447
Juniperus nipponica Maxim. 415
Juniperus occidentalis Hook. 102, 395, 398, 439, **442**, 467, 657, 711, 734, 781, 1053
Juniperus occidentalis Hook. subsp. *australis* Vasek 444
Juniperus occidentalis Hook. var. ***australis*** (Vasek) P. Lebreton & N. H. Holmgren **444**, *467*
Juniperus occidentalis Hook. var. *monosperma* Engelm. 439
Juniperus occidentalis Hook. var. ***occidentalis*** **443**
Juniperus osteosperma (Torr.) Little 396, 398, 399, 440, **444**, 445, 477, 690, 734
Juniperus oxycedrus L. 71, 395, 407, 423, 426, 430, **445**
Juniperus oxycedrus L. subsp. ***badia*** (H. Gay) Debeaux **447**
Juniperus oxycedrus L. var. *badia* H. Gay 447
Juniperus oxycedrus L. var. *fastigiata* Jovan. 446
Juniperus oxycedrus L. subsp. ***macrocarpa*** (Sibth. & Sm.) Ball 423, **447**, 462, *467*
Juniperus oxycedrus L. subsp. *maderensis* Menezes 406
Juniperus oxycedrus L. subsp. ***oxycedrus*** **446**
Juniperus oxycedrus L. var. *oxycedrus* f. *parvifolia* Novak 446
Juniperus oxycedrus L. subsp. ***oxycedrus*** var. ***spilinanus*** Yaltirik, Eliçin & Terzioglu **446**
Juniperus oxycedrus L. var. *parvifolia* (Novak) Jovan. 446
Juniperus oxycedrus L. subsp. ***transtagana*** Franco **447**
Juniperus oxycedrus L. var. *transtagana* (Franco) Silba 447
Juniperus patoniana Martínez 420
Juniperus ×pfitzeriana (Späth) Schmidt 409
Juniperus phoenicea L. 310, 323, 393, 395, **448**, 1021
Juniperus phoenicea L. subsp. *eu-mediterranea* P. Lebreton & S. Thivend 449
Juniperus phoenicea L. subsp. ***phoenicea*** **449**, 468
Juniperus phoenicea L. subsp. ***turbinata*** (Guss.) Nyman **449**
Juniperus pinchotii Sudw. 396, 398, **449**, 450
Juniperus pinchotii Sudw. var. *erythrocarpa* (Cory) Silba 449
Juniperus pingii W. C. Cheng 395, **450**, 474
Juniperus pingii W. C. Cheng var. *carinata* Y. F. Yu & L. K. Fu 452
Juniperus pingii W. C. Cheng var. ***chengii*** (L. K. Fu & Y. F. Yu) Farjon **452**
Juniperus pingii W. C. Cheng var. ***miehei*** Farjon **452**
Juniperus pingii W. C. Cheng var. ***pingii*** **451**
Juniperus pingii W. C. Cheng var. ***wilsonii*** (Rehd.) Silba 451, **452**, 453, 459, 479
Juniperus poblana (Martínez) R. P. Adams 429
Juniperus polycarpos K. Koch 426, 478
Juniperus polycarpos K. Koch var. *pendula* Mulk. 426
Juniperus polycarpos K. Koch var. *seravschanica* (Kom.) Kitam. 426
Juniperus polycarpos K. Koch var. *turcomanica* (B. Fedtsch.) R. P. Adams 426
Juniperus procera Hochst. *ex* Endl. 144, 397, **453**, 454
Juniperus procumbens (Siebold *ex* Endl.) Miq. 395, **454**
Juniperus przewalskii Kom. 395, **455**, 456
Juniperus pseudosabina Fisch. & C. A. Mey. 395, 425, 437, **456**, 463, *468*, 478, 616
Juniperus pseudosabina Fisch. & C. A. Mey. var. *turkestanica* (Kom.) Silba 456
Juniperus pygmaea K. Koch 416
Juniperus recurva Buch.-Ham. *ex* D. Don 395, 451, 453, **457**, 459, 479
Juniperus recurva Buch.-Ham. *ex* D. Don var. *coxii* (A. B. Jacks.) Melville 459, **460**
Juniperus recurva Buch.-Ham. *ex* D. Don var. ***recurva*** *458*, **459**
Juniperus rigida Siebold & Zucc. 394, **460**, 602, 627, 629, 818
Juniperus rigida Siebold & Zucc. subsp. ***conferta*** (Parl.) Kitam. 455, **461**, 462

Juniperus rigida Siebold & Zucc. var. *conferta* (Parl.) Patschke 461
Juniperus rigida Siebold & Zucc. subsp. *litoralis* Urussov 461
Juniperus rigida Siebold & Zucc. var. *litoralis* (Urussov) Kozhevnikova 461
Juniperus rigida Siebold & Zucc. subsp. *nipponica* (Maxim.) Franco 415
Juniperus rigida Siebold & Zucc. subsp. ***rigida*** **461**
Juniperus sabina L. 393, 396, 409, 425, 457, **462**, 463, 464, 475, 476, 478
Juniperus sabina L. var. ***arenaria*** (E. H. Wilson) Farjon **464**
Juniperus sabina L. var. ***davurica*** (Pall.) Farjon 109, **464**, 533
Juniperus sabina L. var. *erectopatens* (W. C. Cheng & L. K. Fu) Y. F. Yu & L. K. Fu 409
Juniperus sabina L. var. *mongolensis* R. P. Adams 464
Juniperus sabina L. var. *monosperma* C. Y. Yang 463
Juniperus sabina L. var. ***sabina*** **463**, *468*
Juniperus sabina L. var. *yulinensis* (T. C. Chang & C. G. Chen) Y. F. Yu & L. K. Fu 463
Juniperus saltillensis M. T. Hall 396, 429, **473**, 460
Juniperus saltuaria Rehd. & E. H. Wilson 395, 417, **474**, 479
Juniperus sargentii (A. Henry) Takeda *ex* Nakai 409
Juniperus saxicola Britton & P. Wilson 397, **475**
Juniperus scopulorum Sarg. 396, 440, 445, **476**, 485
Juniperus semiglobosa Regel 397, 409, 425, 457, *468*, *469*, 476, **477**, 478, 479
Juniperus seravschanica Kom. 426
Juniperus sibirica Burgsd. 416
Juniperus silicicola (Small) L. H. Bailey 485, 486
Juniperus sphaerica Lindl. 409
Juniperus squamata Buch.-Ham. *ex* D. Don 80, 125, 265, 395, 428, 432, 437, 451, 452, 453, 474, **478**, 479, 487, 511
Juniperus squamata Buch.-Ham. *ex* D. Don var. *fargesii* Rehd. & E. H. Wilson 478
Juniperus squamata Buch.-Ham. *ex* D. Don var. *hongxiensis* Y. F. Yu & L. K. Fu 478
Juniperus squamata Buch.-Ham. *ex* D. Don var. *morrisonicola* (Hayata) H. L. Li & H. Keng 98, 478, 604
Juniperus squamata Buch.-Ham. *ex* D. Don var. *parvifolia* Y. F. Yu & L. K. Fu 478
Juniperus squamata Buch.-Ham. *ex* D. Don f. *wilsonii* Rehd. 452
Juniperus standleyi Steyerm. 397, **480**, 704
Juniperus taxifolia Hook. & Arn. 394, **481**
Juniperus tetragona Schltdl. var. *osteosperma* Torr. 444
Juniperus texensis Melle 449
Juniperus thurifera L. 397, **482**
Juniperus thurifera L. subsp. *africana* (Maire) Romo & Borantinsky 482
Juniperus thurifera L. var. *africana* Maire 482
Juniperus tianschanica Sumnev. 477
Juniperus tibetica Kom. 395, 417, **483**, 484
Juniperus tsukusiensis Masam. 410
Juniperus turbinata Guss. 449
Juniperus turbinata Guss. subsp. *canariensis* (Guyot & Mathou) Rivas-Martínez *et al.* 449
Juniperus turcomanica B. Fedtsch. 426
Juniperus turkestanica Kom. 456
Juniperus urbaniana Pilg. & Ekman 434
Juniperus uvifera D. Don 624
Juniperus virginiana L. 396, 402, 435, 436, **484**, 485
Juniperus virginiana L. subsp. *silicicola* (Small) E. Murray 486
Juniperus virginiana L. var. ***silicicola*** (Small) E. Murray **486**
Juniperus virginiana L. var. ***virginiana*** *469*, **485**, 486
Juniperus wallichiana Hook. f. & Thomson *ex* E. Brandis 125, 437

K

Keteleeria Carrière 41, 52, 257, 269, **488**, 490, 549
Keteleeria calcarea W. C. Cheng & L. K. Fu 490
Keteleeria davidiana (Bertrand) Beissn. 258, **489**, 728
Keteleeria davidiana (Bertrand) Beissn. var. *calcarea* (W. C. Cheng & L. K. Fu) Silba 490
Keteleeria davidiana (Bertrand) Beissn. var. ***davidiana*** *469*, **490**
Keteleeria davidiana (Bertrand) Beissn. subsp. *formosana* (Hayata) E. Murray 490
Keteleeria davidiana (Bertrand) Beissn. var. ***formosana*** (Hayata) Hayata **490**

Keteleeria davidiana (Bertrand) Beissn. var. *pubescens* (W. C. Cheng & L. K. Fu) Silba 490
Keteleeria evelyniana Mast. **490**, 491, 808, 1017
Keteleeria evelyniana Mast. var. *hainanensis* (Chun & Tsiang) Silba 490
Keteleeria evelyniana Mast. var. *pendula* J. R. Xue 490
Keteleeria fabri Mast. 82
Keteleeria formosana Hayata 490
Keteleeria fortunei (A. Murray bis) Carrière 270, 488, 490, **492**, *494*, 541
Keteleeria fortunei (A. Murray bis) Carrière var. *oblonga* (W. C. Cheng & L. K. Fu) L. K. Fu & Nan Li 492
Keteleeria fortunei (A. Murray bis) Carrière var. *xerophila* (J. R. Xue & S. H. Hao) Silba 490
Keteleeria hainanensis Chun & Tsiang 490
Keteleeria oblonga W. C. Cheng & L. K. Fu 477, 492
Keteleeria pubescens W. C. Cheng & L. K. Fu 490
Keteleeria xerophila J. R. Xue & S. H. Hao 490

L

Lagarostrobos Quinn 42, 53, 54, 347, **495**
Lagarostrobos colensoi (Hook.) Quinn 528
Lagarostrobos franklinii (Hook. f.) Quinn *469*, **495**
Laricopsis Kent 954
Laricopsis kaempferi (Lindl.) Kent 954
Larix Mill. 17, 19, 20, 40, 52, 270, 416, 438, 451, 479, **497**, 506, 514, 586, 591, 598, 602, 652, 789, 954
Larix alaskensis W. F. Wight 506
Larix amabilis J. Nelson 954
Larix chinensis Beissn. 513
Larix ×czekanowskii Szafer 497, **498**
Larix dahurica Turcz. *ex* Trautv. 502
Larix dahurica Turcz. *ex* Trautv. var. *japonica Maxim. ex Regel* 502
Larix decidua Mill. 27, 40, 497, **499**, 506, 572, 669
Larix decidua Mill. var. ***carpatica*** Domin **500**
Larix decidua Mill. var. ***decidua*** *470*, **500**
Larix decidua Mill. var. ***polonica*** (Racib. *ex* Wóycicki) Ostenf. & Syrach **500**
Larix decidua Mill. subsp. *sibirica* (Ledeb.) Domin 514
Larix decidua Mill. var. *sibirica* (Ledeb.) Regel 514
Larix ×eurolepis Henry 506
Larix gmelinii (Rupr.) Kuzen. 19, 109, 124, 464, 497, **501**, 608, 769
Larix gmelinii (Rupr.) Kuzen. f. *genhensis* (S. Y. Li & Adair) L. K. Fu & Nan Li 502
Larix gmelinii (Rupr.) Kuzen. var. *genhensis* S. Y. Li & Adair 502
Larix gmelinii (Rupr.) Kuzen. var. ***gmelinii*** **502**
Larix gmelinii (Rupr.) Kuzen. subsp. *japonica* (Maxim. *ex* Regel) E. Murray 502
Larix gmelinii (Rupr.) Kuzen. var. ***japonica*** (Maxim. *ex* Regel) Pilg. **502**
Larix gmelinii (Rupr.) Kuzen. var. ***olgensis*** (A. Henry) Ostenf. & Syrach 96, **503**, 593, 1010
Larix gmelinii (Rupr.) Kuzen. f. *pendula* (D. S. Zhang & Y. M. Chen) L. K. Fu & Nan Li 503
Larix gmelinii (Rupr.) Kuzen. subsp. *principis-rupprechtii* (Mayr) E. Murray 503
Larix gmelinii (Rupr.) Kuzen. var. ***principis-rupprechtii*** (Mayr) Pilg. *470*, **503**, 603
Larix griffithiana hort. ex Carrière 80, 504
Larix griffithii Hook. f. 460, 497, 498, **503**, 504, 620, 1049
Larix griffithii Hook. f. var. ***griffithii*** *470*, **504**
Larix griffithii Hook. f. var. *mastersiana* (Rehd. & E. H. Wilson) Silba 508
Larix griffithii Hook. f. var. ***speciosa*** (W. C. Cheng & Y. W. Law) Farjon **505**
Larix himalaica W. C. Cheng & L. K. Fu 513
Larix kaempferi (Lamb.) Carrière 97, 128, *470*, 497, 498, **505**, 506, 573, 594, 622, 1010, 1027, 1048
Larix kongboensis R. R. Mill 504
Larix laricina (Du Roi) K. Koch 497, 498, **506**, 599, 658, 1024, 1044
Larix laricina (Du Roi) K. Koch var. *alaskensis* (W. F. Wight) Raup 506
Larix lyallii Parl. *470*, 497, 498, **507**, 508, 510
Larix ×marschlinsii Coaz 506
Larix mastersiana Rehd. & E. H. Wilson 497, 498, **508**, 509
Larix occidentalis Nutt. 91, 117, 497, 498, **509**, 510, 584, 737, 1026
Larix olgensis A. Henry 503
Larix polonica Racib. *ex* Woycicki 500
Larix potaninii Batalin 72, 82, 84, 87, 118, 126, 460, 474, 497, 498, 509, **511**, *512*, 578, 579, 595, 612, 986, 1050
Larix potaninii Batalin var. ***chinensis*** (Beissn.) L. K. Fu & Nan Li **513**

Larix potaninii Batalin var. ***himalaica*** (W. C. Cheng & L. K. Fu) Farjon & Silba **513**
Larix potaninii Batalin var. ***macrocarpa*** Y. W. Law **513**
Larix potaninii Batalin var. ***potaninii*** **513**
Larix principis-rupprechtii Mayr 503
Larix principis-rupprechtii Mayr var. *pendula* D. S. Zhang & Y. M. Chen 503
Larix russica (Endl.) Sabine *ex* Trautv. 514
Larix sibirica Ledeb. 124, 497, 498, 499, **514**, 515, 783
Larix speciosa W. C. Cheng & Y. W. Law 505
Lepidothamnus Phil. 20, 43, 53, 54, 347, **516**, 517
Lepidothamnus fonkii Phil. 383, *471*, **516**, 517, 625
Lepidothamnus intermedius (Kirk) Quinn 516, **517**, 518
Lepidothamnus laxifolius (Hook. f.) Quinn 516, **518**, *519*, 520
Leucopitys Nieuwl. 626
Leucopitys strobus (L.) Nieuwl. 626
Libocedrus Endl. 21, 38, 48, 50, 226, **521**, 624
Libocedrus arfakensis Gibbs 554
Libocedrus austrocaledonica Brongn. & Gris 521, **522**
Libocedrus bidwillii Hook. f. *471*, 521, **523**, 526, 566, 853
Libocedrus chevalieri J. T. Buchholz 521, **524**
Libocedrus chilensis (D. Don) Endl. 226
Libocedrus decurrens Torr. 253
Libocedrus decurrens Torr. var. *columnaris* Beissn. 254
Libocedrus formosana Florin 255
Libocedrus macrolepis (Kurz) Benth. & Hook. f. 256
Libocedrus papuana F. Muell. 552, 553
Libocedrus papuana F. Muell. var. *arfakensis* (Gibbs) de Laub. 554
Libocedrus plumosa (D. Don) Sarg. *471*, 521, 524, **525**
Libocedrus uvifera (D. Don) Pilg. 624
Libocedrus yateensis Guillaumin **526**, 527

M

Manoao Molloy 43, 53, 54, 347, 391, **528**
Manoao colensoi (Hook.) Molloy 332, 356, 390, *471*, 525, **528**, 529, 566, 853, 947, 953
Margbensonia A. V. Bobrov & Melikyan 819
Margbensonia archboldii (N. E. Gray) A. V. Bobrov & Melikyan 835
Margbensonia atjehense (Wasscher) A. V. Bobrov & Melikyan 836
Margbensonia chingiana (N. E. Gray) A. V. Bobrov & Melikyan 846
Margbensonia degeneri (N. E. Gray) A. V. Bobrov & Melikyan 897
Margbensonia disperma (C. T. White) A. V. Bobrov & Melikyan 855
Margbensonia drouyniana (F. Muell.) A. V. Bobrov & Melikyan 856
Margbensonia elata (R. Br. *ex* Endl.) A. V. Bobrov & Melikyan 858
Margbensonia koordersii (Pilg. *ex* Koord. & Valeton) A. V. Bobrov & Melikyan 919
Margbensonia macrophylla (Thunb.) A. V. Bobrov & Melikyan 819, 886
Margbensonia maki (Siebold & Zucc. *ex* Endl.) A. V. Bobrov & Melikyan 886
Margbensonia neriifolia (D. Don) A. V. Bobrov & Melikyan 896
Margbensonia philippinense (Foxw.) A. V. Bobrov & Melikyan 919
Margbensonia polystachya (R. Br. *ex* Endl.) A. V. Bobrov & Melikyan 910
Margbensonia ridleyi (Wasscher) A. V. Bobrov & Melikyan 915
Margbensonia rumphii (Blume) A. V. Bobrov & Melikyan 919
Margbensonia spinulosa (Sm.) A. V. Bobrov & Melikyan 928
Margbensonia thevetiifolia (Blume) A. V. Bobrov & Melikyan 910
Marywildea A. V. Bobrov & Melikyan 191
Marywildea bidwillii (Hook.) A. V. Bobrov & Melikyan 200
Metadacrydium Baum.-Bod. 347
Metadacrydium araucarioides (Brongn. & Gris) Baum.-Bod. 347, 350
Metadacrydium balansae (Brongn. & Gris) Baum.-Bod. 351
Metasequoia Hu & W. C. Cheng 17, 21, 36, 48, 49, **530**, 531, 953
Metasequoia glyptostroboides Hu & W. C. Cheng 17, *471*, **530**
Metasequoia glyptostroboides Hu & W. C. Cheng var. *caespitosa* Y. H. Long & Y. Wu 530

Microbiota Kom. 38, 48, 49, **532**, 817
Microbiota decussata Kom. 21, *471*, **532**, 533
Microcachrys Hook. f. 20, 41, 43, 53, 54, 373, 374, **534**
Microcachrys W. Archer 373
Microcachrys tetragona (Hook.) Hook. f. 20, *472*, **534**, 559, 879
Microstrobos J. Garden & L. A. S. Johnson 557
Microstrobos fitzgeraldii (F. Muell.) J. Garden & L. A. S. Johnson 557
Microstrobos niphophilus J. Garden & L. A. S. Johnson 558
Myrica nagi Thunb. 536, 540, 967

N

Nageia Gaertn. 20, 28, 42, 53, 175, 334, 378, **536**, 539, 870
Nageia amara (Blume) F. Muell. 983
Nageia argotaenia (Hance) Kuntze 175
Nageia comptonii (J. T. Buchholz) de Laub. 967
Nageia falcata (Thunb.) Kuntze 142
Nageia fleuryi (Hickel) de Laub. 180, 258, 277, 472, **537**, 1008
Nageia formosensis (Dummer) C. N. Page 540
Nageia latifolia (Wall.) Gordon 541
Nageia mannii (Hook. f.) Kuntze 145
Nageia maxima (de Laub.) de Laub. **538**, 890
Nageia minor Carrière 969
Nageia motleyi (Parl.) de Laub. **539**
Nageia nagi (Thunb.) Kuntze 269, 472, **536**, 540
Nageia nagi (Thunb.) Kuntze var. *formosensis* (Dummer) Silba 540
Nageia nagi (Thunb.) Kuntze var. *koshuensis* (Kaneh.) D. Z. Fu 540
Nageia nankoensis (Hayata) R. R. Mill 540
Nageia pancheri (Brongn. & Gris) Kuntze 133
Nageia piresii (Silba) de Laub. 970
Nageia rospigliosii (Pilg.) de Laub. 971
Nageia usta (Vieill.) Kuntze 555
Nageia vitiensis (Seem.) Kuntze 972
Nageia wallichiana (Presl) Kuntze 17, 24, 155, 181, 182, 277, 352, 377, 378, *472*, **541**, 542, 1017, 1068
Neocallitropsis Florin 39, 48, 50, **543**
Neocallitropsis araucarioides (R. H. Compton) Florin 543
Neocallitropsis pancheri (Carrière) de Laub. 249, 350, *472*, 522, 527, **543**
Nothocallitris A. V. Bobrov & Melikyan 249
Nothocallitris neocaledonica (Dummer) A. V. Bobrov & Melikyan 241
Nothocallitris sulcata (Parl.) A. V. Bobrov & Melikyan 230, 248
Nothotaxus Florin 957
Nothotaxus chienii (W. C. Cheng) Florin 957
Nothotsuga Hu *ex* C. N. Page 41, 52, 53, **549**, 954, 1042
Nothotsuga longibracteata (W. C. Cheng) Hu *ex* C. N. Page 260, 386, **549**, *550*, *643*

O

Octoclinis F. Muell. 230
Octoclinis macleayana F. Muell. 230, 237

P

Pachylepis Brongn. 1056
Pachylepis cupressoides (L.) Brongn. 1056
Papuacedrus H. L. Li 38, 48, 50, 330, **552**, 553
Papuacedrus arfakensis (Gibbs) H. L. Li 554
Papuacedrus papuana (F. Muell.) H. L. Li 21, 329, 330, 333, 337, **552**, *643*, 835, 852
Papuacedrus papuana (F. Muell.) H. L. Li var. ***arfakensis*** (Gibbs) R. J. Johns 552, **554**
Papuacedrus papuana (F. Muell.) H. L. Li var. ***papuana*** 552, **553**, *643*
Parasitaxus de Laub. 43, 53, 54, 347, **555**
Parasitaxus usta (Vieill.) de Laub. 20, 381, **555**, 556, *643*
Parolinia Endl. 1056
Pherosphaera W. Archer 43, 53, 54, **557**
Pherosphaera fitzgeraldii (F. Muell.) Hook. f. **557**, 558
Pherosphaera hookeriana Hook. f. 534
Pherosphaera hookeriana W. Archer 223, 225, 374, 534, 557, **558**, 559, 561, *643*, 879
Pherosphaera niphophila (J. Garden & L. A. S. Johnson) Florin 558
Phyllocladaceae Bessey 18, 21, 24, 26, 35, 39, 45, **50**, 51, 560
Phyllocladus Rich. *ex* Mirb. 39, 50, 51, 358, 379, **560**, 563, 564, 565, 837
Phyllocladus alpinus Hook. f. 565, 566
Phyllocladus aspleniifolius (Labill.) Hook. f. 223, 225, 374, 560, **561**, *643*
Phyllocladus aspleniifolius (Labill.) Hook. f. var. *alpinus* (Hook. f.) H. Keng 566

Phyllocladus billardieri Mirb. 560
Phyllocladus glaucus Kirk 563, 564
Phyllocladus hypophyllus Hook. f. 334, 336, 359, 360, 553, **562**, 563, *644*, 843, 852, 863, 909, 984
Phyllocladus toatoa Molloy **563**, 564, 566
Phyllocladus trichomanoides D. Don 152, 332, 356, 525, **564**, 565, 566, 853, 896, 937, 953
Phyllocladus trichomanoides D. Don var. ***alpinus*** (Hook. f.) Parl. 390, 391, 523, **566**, *644*, 853, 898
Phyllocladus trichomanoides D. Don var. ***trichomanoides*** **566**
Picea A. Dietr. 19, 27, 40, 52, 64, 72, 269, 270, 416, 417, 431, 451, 459, 463, 474, 479, 484, 511, **567**, 568, 569, 570, 571, 572, 576, 585, 587, 608, 610, 652, 687, 740, 789, 963, 1017, 1046, 1049, 1050
Picea abies (L.) H. Karst. 27, 62, 68, 499, 567, **571**, 572, 576, 587, 609, 669, 755, 789, 803
Picea abies (L.) H. Karst. var. ***abies*** 569, **572**
Picea abies (L.) H. Karst. var. ***acuminata*** (Beck) Dallim. & A. B. Jacks. 569, 571, **572**
Picea abies (L.) H. Karst. var. *alpestris* (Brügger) P. A. Schmidt 572
Picea abies (L.) H. Karst. subsp. *obovata* (Ledeb.) Hulten 607
Picea abies (L.) H. Karst. var. *obovata* (Ledeb.) Lindq. 571, 607
Picea acicularis Maxim. *ex* Beissn. 574
Picea ajanensis Fisch. *ex* Carrière 591
Picea albertiana S. Br. 589
Picea albertiana S. Br. var. *densata* (L. H. Bailey) W. L. Strong & Hills 589
Picea albertiana S. Br. subsp. *ogilviei* W. L. Strong & Hills 589
Picea albertiana S. Br. var. *porsildii* (Raup) W. L. Strong & Hills 589
Picea alcoquiana (Veitch *ex* Lindl.) Carrière **573**, *575*, 602
Picea alcoquiana (Veitch *ex* Lindl.) Carrière var. ***acicularis*** (Maxim. *ex* Beissn.) Fitschen **574**, *575*, 594
Picea alcoquiana (Veitch *ex* Lindl.) Carrière var. ***alcoquiana*** **573**, *575*
Picea alcoquiana (Veitch *ex* Lindl.) Carrière var. ***reflexa*** (Shiras.) Fitschen **574**, *575*
Picea alpestris (Brügger) Stein 572
Picea amabilis Douglas *ex* Loudon 63
Picea ascendens Patschke 580
Picea asperata Mast. 84, 118, 126, 439, 567, **574**, 576, 578, 583, 605, 612, 614, 623
Picea asperata Mast. var. ***asperata*** 569, **576**, 613
Picea asperata Mast. var. *aurantiaca* (Mast.) Boom 577
Picea asperata Mast. var. ***notabilis*** Rehd. & E. H. Wilson 569, **577**
Picea asperata Mast. var. ***ponderosa*** Rehd. & E. H. Wilson 569, **577**
Picea asperata Mast. var. *retroflexa* (Mast.) W. C. Cheng 613
Picea aurantiaca Mast. 567, 569, **577**, 578, 613, 614
Picea aurantiaca Mast. var. *retroflexa* (Mast.) C. T. Kuan & L. J. Zhou 613
Picea austromandshurica Silba 591
Picea balfouriana Rehd. & E. H. Wilson 597
Picea bicolor (Maxim.) Mayr 573
Picea bicolor (Maxim.) Mayr var. *acicularis* (Maxim. *ex* Beissn.) Shiras. 574
Picea bicolor (Maxim.) Mayr var. *reflexa* Shiras. 574
Picea brachytyla (Franch.) E. Pritz. 84, 567, 570, **578**, 579, 580, 595, 986
Picea brachytyla (Franch.) E. Pritz. var. *ascendens* (Patschke) Silba 580
Picea brachytyla (Franch.) E. Pritz. var. ***brachytyla*** *77*, **579**
Picea brachytyla (Franch.) E. Pritz. var. ***complanata*** (Mast.) W. C. Cheng *ex* Rehd. 118, **580**, 965
Picea brachytyla (Franch.) E. Pritz. var. *pachyclada* (Patschke) Silba 579
Picea brachytyla (Franch.) E. Pritz. var. *rhombisquamea* Stapf 580
Picea breweriana S. Watson 284, 567, 570, **580**, 581, 1066
Picea chihuahuana Martínez 80, 567, 569, **581**, 582, 600, 601, *644*
Picea complanata Mast. 580
Picea concolor Gordon 75
Picea crassifolia Kom. 456, 567, 569, **582**, 583
Picea engelmannii Parry *ex* Engelm. 101, 117, 415, 477, 508, 510, 568, 570, **583**, 584, 585, 589, 627, 633, 641, 642, 670, 674, 688, 697, 722, 737, 749, 785, 797, 963, 1026
Picea engelmannii Parry *ex* Engelm. subsp. ***engelmannii*** **584**
Picea engelmannii Parry *ex* Engelm. var. *glabra* Goodman 584

Picea engelmannii Parry *ex* Engelm. subsp. ***Mexicana*** (Martínez) P. A. Schmidt 129, 130, 570, **585**
Picea engelmannii Parry *ex* Engelm. var. *mexicana* (Martínez) Silba 585
Picea excelsa (Lam.) Link var. *acuminata* Beck 572
Picea farreri C. N. Page & Rushforth 567, 570, **585**, 586, 1100
Picea ×fennica (Regel) Kom. 567, 571, **586**, 587, 607
Picea ×fennica (Regel) Kom. subsp. *uralensis* (Tepl.) P. A. Schmidt 586
Picea fortunei A. Murray bis 492
Picea glauca (Moench) Voss 415, 507, 567, 568, 584, **587**, 591, 598, 599, 615, 658, 674, 1026, 1044, 1053
Picea glauca (Moench) Voss subsp. a*lbertiana* (S. Br.) P. A. Schmidt 589
Picea glauca (Moench) Voss var. ***albertiana*** (S. Br.) Sarg. 588, **589**
Picea glauca (Moench) Voss var. *densata* L. H. Bailey 589
Picea glauca (Moench) Voss subsp. e*ngelmannii* (Engelm.) T. M. C. Taylor 584
Picea glauca (Moench) Voss var. *engelmannii* (Engelm.) Boivin 584
Picea glauca (Moench) Voss var. ***glauca*** **589**
Picea glauca (Moench) Voss var. *porsildii* Raup 589
Picea glehnii (F. Schmidt) Mast. 121, 567, 569, **589**, 590, 1010
Picea hirtella Rehd. & E. H. Wilson 596
Picea hondoensis Mayr 592
Picea intercedens Nakai 593
Picea jezoensis (Siebold & Zucc.) Carrière 100, 109, 121, 501, 502, 533, 568, **590**, 591, 1010, 1027, 1048
Picea jezoensis (Siebold & Zucc.) Carrière var. *ajanensis* (Fisch. *ex* Carrière) W. C. Cheng & L. K. Fu 591
Picea jezoensis (Siebold & Zucc.) Carrière f. *kamtchatkensis (Lacass.) S. L. Tung & Y. L. Chou* 591
Picea jezoensis (Siebold & Zucc.) Carrière subsp. ***hondoensis*** (Mayr) P. A. Schmidt 86, 128, 506, 570, 573, 591, **592**
Picea jezoensis (Siebold & Zucc.) Carrière var. *hondoensis* (Mayr) Rehd. 105, 592
Picea jezoensis (Siebold & Zucc.) Carrière subsp. ***jezoensis*** var. ***jezoensis*** **591**
Picea jezoensis (Siebold & Zucc.) Carrière subsp. ***jezoensis*** var. ***komarovii*** (V. N. Vassil.) W. C. Cheng & L. K. Fu **592**
Picea kamtchatkensis Lacass. 591
Picea komarovii V. N. Vassil. 592
Picea koraiensis Nakai **592**, 593, 1023
Picea koraiensis Nakai var. *intercedens* (Nakai) Y. L. Chou 593
Picea koraiensis Nakai var. ***koraiensis*** **593**
Picea koraiensis Nakai var. ***pungsanensis*** (Uyeki *ex* Nakai) Farjon **593**
Picea koyamae Shiras. 567, 568, 593, **594**, 602
Picea likiangensis (Franch.) E. Pritz. 77, 82, 87, 460, 568, 570, 579, **595**, 597, 598, 612, 613
Picea likiangensis (Franch.) E. Pritz. subsp. *balfouriana* (Rehd. & E. H. Wilson) Rushforth 597
Picea likiangensis (Franch.) E. Pritz. var. *balfouriana* (Rehd. & E. H. Wilson) Hillier 597
Picea likiangensis (Franch.) E. Pritz. var. *bhutanica* Silba 596
Picea likiangensis (Franch.) E. Pritz. var. *forrestii* Silba 596
Picea likiangensis (Franch.) E. Pritz. var. ***hirtella*** (Rehd. & E. H. Wilson) W. C. Cheng **596**
Picea likiangensis (Franch.) E. Pritz. var. ***likiangensis*** **596**, 612, *644*
Picea likiangensis (Franch.) E. Pritz. var. *linzhiensis* W. C. Cheng & L. K. Fu 597
Picea likiangensis (Franch.) E. Pritz. var. ***montigena*** (Mast.) W. C. Cheng **596**
Picea likiangensis (Franch.) E. Pritz. var. *purpurea* (Mast.) Dallim. & A. B. Jacks. 611
Picea likiangensis (Franch.) E. Pritz. var. ***rubescens*** Rehd. & E. H. Wilson 118, 126, 578, **597**, 614
Picea linzhiensis (W. C. Cheng & L. K. Fu) Rushforth 126, 505, 568, 570, **597**
Picea lowiana Gordon 75
Picea ×lutzii Little 568, **598**
Picea mariana (Mill.) Britton *et al.* 436, 507, 567, 570, 591, **599**, 615, 658, 1024
Picea martinezii T. F. Patt. 567, 569, **600**, 601
Picea maximowiczii Regel *ex* Mast. 567, 568, **601**, 602
Picea maximowiczii Regel *ex* Mast. var. ***maximowiczii*** **602**
Picea maximowiczii Regel *ex* Mast. var. ***senanensis*** Hayashi **602**
Picea mexicana Martínez 585

Picea meyeri Rehd. & E. H. Wilson 567, 569, **603**, 623
Picea meyeri Rehd. & E. H. Wilson var. *mongolica* H. Q. Wu 603
Picea meyeri Rehd. & E. H. Wilson f. *pyramidalis* (H. W. Jen & C. G. Bai) L. K. Fu & Nan Li 603
Picea meyeri Rehd. & E. H. Wilson var. *pyramidalis* H. W. Jen & C. G. Bai 603
Picea montigena Mast. 596
Picea morinda Link subsp. *tianschanica* (Rupr.) Berezin 616
Picea morrisonicola Hayata 98, 567, 568, **604**, 627, 636, 638, *644*, 695, 986
Picea neoveitchii Mast. 84, 567, 568, **605**, *606*
Picea notabilis (Rehd. & E. H. Wilson) Lacass. 577
Picea obovata Ledeb. 96, 109, 124, 464, 498, 501, 502, 515, 567, 569, 571, 587, 593, **607**, 608, 783, 1101
Picea obovata Ledeb. var. *fennica* (Regel) A. Henry 586
Picea omorika (Pancić) Purk. 567, 568, **608**, 609
Picea orientalis (L.) Peterm. 111, 567, 569, **609**, 610, *645*, 818
Picea pachyclada Patschke 579
Picea polita (Siebold & Zucc.) Carrière 620
Picea ponderosa (Rehd. & E. H. Wilson) Lacass. 577
Picea prostrata Isakov 616
Picea pungens Engelm. 568, 570, **610**, 611, 627, 629, *775*, *777*
Picea pungsanensis Uyeki *ex* Nakai 593
Picea purpurea Mast. 84, 118, 568, 570, **611**, 612, 623
Picea purpurea Mast. var. *balfouriana* (Rehd. & E. H. Wilson) Silba 597
Picea purpurea Mast. var. *hirtella* (Rehd. & E. H. Wilson) Silba 596
Picea retroflexa Mast. 567, 569, 578, **613**
Picea rubens Sarg. 90, 415, 567, 570, **614**, 615, 823, 824, 919, 1044
Picea schrenkiana Fisch. & C. A. Mey. 416, 425, 457, 478, 567, 569, **615**
Picea schrenkiana Fisch. & C. A. Mey. subsp. ***schrenkiana*** **616**
Picea schrenkiana Fisch. & C. A. Mey. subsp. ***tianschanica*** (Rupr.) Bykov **616**, *645*
Picea schrenkiana Fisch. & C. A. Mey. var. *tianschanica* (Rupr.) W. C. Cheng & S. H. Fu 616
Picea shirasawae Hayashi 574
Picea sitchensis (Bong.) Carrière 19, 63, 91, 117, 284, 568, 570, 591, 598, 609, **617**, *645*, *737*, 1026, 1033, 1052, 1053, 1066
Picea smithiana (Wall.) Boiss. 114, 125, 265, 567, 568, **618**, *645, 646*
Picea smithiana (Wall.) Boiss. var. *nepalensis* Franco 618
Picea spinulosa (Griff.) Beissn. 79, 460, 504, 567, 570, 597, 598, **619**
Picea spinulosa (Griff.) Beissn. var. *yatungensis* Silba 619
Picea tianschanica Rupr. 616
Picea torano (Siebold *ex* K. Koch) Koehne 567, 568, **620**, *621*, 622
Picea vulgaris Link var. *uralensis* Tepl. 586
Picea watsoniana Mast. 622
Picea wilsonii Mast. 567, 568, 603, 612, **622**, 623, *646*
Picea wilsonii Mast. var. *shanxiensis* Silba 622
Picea wilsonii Mast. var. *watsoniana* (Mast.) Silba 622
Pilgerodendron Florin 38, 48, 50, 383, 521, **624**
Pilgerodendron uviferum (D. Don) Florin 382, 517, **624**, *646*, 900
Pinaceae Spreng. *ex* F. Rudolphi 18, 19, 20, 24, 27, 28, 35, 39, 41, 45, **51**, 57, 62, 65, 87, 88, 122, 124, 130, 258, 259, 261, 274, 488, 491, 497, 504, 514, 549, 567, 586, 593, 599, 612, 626, 705, 741, 954, 959, 975, 979, 988, 1001, 1032, 1042
Pinea Wolf 626
Pinus L. 15, 20, 26, 27, 29, 35, 39, 40, 51, 52, 57, 76, 90, 101, 115, 129, 196, 226, 227, 257, 263, 284, 288, 290, 296, 416, 425, 437, 451, 462, 463, 478, 480, 486, 491, 564, 571, 578, 586, 591, 601, **626**, 627, 628, 630, 631, 632, 633, 634, 635, 653, 658, 673, 688, 694, 697, 698, 702, 705, 708, 716, 727, 729, 734, 736, 743, 746, 748, 750, 776, 780, 793, 803, 805, 819, 820, 865, 874, 885, 895, 901, 922, 936, 946, 952, 955, 963, 978, 979, 989, 1025, 1048, 1053, 1065
Pinus abies L. 567, 572
Pinus abies L. var. *fennica* Regel 586
Pinus albicaulis Engelm. 19, 443, 508, 627, 635, **636**, 637, 638, 641, *646*, 657, 697, *737*, 755, 963, 1066
Pinus amamiana Koidz. 627, 635, **638**, 639
Pinus apulcensis Lindl. 768
Pinus araucana Molina 191, 197

Pinus aristata Engelm. 101, 627, 634, **639**, 641, *646*, 697, 724, 725
Pinus aristata Engelm. subsp. *longaeva* (D. K. Bailey) E. Murray 724
Pinus aristata Engelm. var. *longaeva* (D. K. Bailey) Little 724
Pinus arizonica Engelm. 300, 627, 633, 641, **642**, 670, 688, 722, 727, 762, 785, 797
Pinus arizonica Engelm. var. ***arizonica*** *640*, **642**
Pinus arizonica Engelm. var. *cooperi* (C. E. Blanco) Farjon **651**
Pinus arizonica Engelm. var. ***stormiae*** Martínez **651**, 701, 774
Pinus armandii Franch. 118, 586, 598, 604, 605, 627, 635, 638, **651**, 652, 653, 682, 808, 818
Pinus armandii Franch. var. *amamiana* (Koidz.) Hatus. 638
Pinus armandii Franch. var. ***armandii*** *646*, **652**
Pinus armandii Franch. var. ***dabeshanensis*** (W. C. Cheng & Y. W. Law) Silba **652**
Pinus armandii Franch. subsp. *mastersiana* (Hayata) Businský 653
Pinus armandii Franch. var. ***mastersiana*** (Hayata) Hayata 98, **653**
Pinus attenuata Lemmon 313, 314, 320, 322, 406, 627, 629, *646*, **653**, 772
Pinus × *attenuradiata* Stockwell & Righter 654
Pinus ayacahuite Ehrenb. *ex* Schltdl. 19, 92, 94, 317, 582, 627, 636, **654**, 655, 687, 688, 727, 731, 753, 786, 796
Pinus ayacahuite Ehrenb. *ex* Schltdl. var. ***ayacahuite*** **655**
Pinus ayacahuite Ehrenb. *ex* Schltdl. var. *novogaliciana* Carvajal 785
Pinus ayacahuite Ehrenb. *ex* Schltdl. subsp. *strobiformis* (Engelm.) E. Murray 785
Pinus ayacahuite Ehrenb. *ex* Schltdl. var. ***veitchii*** (Roezl) Shaw *646*, 655, **656**
Pinus bahamensis Griseb. 667
Pinus balfouriana Balf. 627, 634, *647*, **656**, 657, 724, 737
Pinus balfouriana Balf. subsp. *aristata* (Engelm.) Engelm. 639
Pinus balfouriana Balf. var. *aristata* (Engelm.) Engelm. 639
Pinus balfouriana Balf. subsp. *austrina* Bruijn & J. Mastrog. 656, 657
Pinus balfouriana Balf. var. *austrina* (Bruijn & J. Mastrog.) Silba 656
Pinus balfouriana Balf. subsp. *longaeva* (D. K. Bailey) E. Murray 724
Pinus balsamea L. 65
Pinus banksiana Lamb. 19, 65, 415, 436, 507, 599, 627, 630, **658**, 674, 775, 1024
Pinus bhutanica Grierson *et al.* 627, 636, **659**
Pinus bracteata D. Don 68
Pinus brutia Ten. 266, 323, 423, 426, 430, 446, 447, 448, 627, 628, 631, **660**, 661, 662, 703, 745
Pinus brutia Ten. var. ***brutia*** **661**
Pinus brutia Ten. var. *densifolia* F. Yaltirik & M. Boydak 661
Pinus brutia Ten. var. ***eldarica*** (Medw.) Silba **661**
Pinus brutia Ten. var. ***pendulifolia*** Frankis **662**
Pinus brutia Ten. var. ***pityusa*** (Steven) Silba **662**
Pinus brutia Ten. var. *stankewiczii* (Sukaczev) Frankis 662
Pinus bungeana Zucc. *ex* Endl. 29, 489, 627, 635, *647*, **662**, 663, 699, 784
Pinus californiarum D. K. Bailey 733
Pinus californiarum D. K. Bailey subsp. *fallax* (Little) D. K. Bailey 733
Pinus canadensis L. 1043
Pinus canariensis C. Sm. 627, 630, **663**, 664, *665*
Pinus caribaea Morelet 19, 627, 628, **666**, 748, 750, 801, 869
Pinus caribaea Morelet var. ***bahamensis*** (Griseb.) W. H. Barrett & Golfari 401, **667**
Pinus caribaea Morelet var. ***caribaea*** 401, **667**, 801
Pinus caribaea Morelet var. ***hondurensis*** (Sénécl.) W. H. Barrett & Golfari 666, **668**
Pinus catarinae Rob.-Pass. 773
Pinus ceciliae Llorens & L. Llorens 702
Pinus cembra L. 19, 499, 572, 626, 627, 635, 637, 638, *647*, **668**, 669, 755, 783
Pinus cembra L. var. *pumila* Pall. 768
Pinus cembra L. subsp. *sibirica* (Du Tour) Krylov 782
Pinus cembra L. var. *sibirica* (Du Tour) G. Don 782
Pinus cembroides Zucc. 29, 300, 398, 403, 419, 420, 429, 445, 450, 473, 627, 634, **669**, 670, 686, 693, 701, 723, 727, 743, 760, 767, 774
Pinus cembroides Zucc. subsp. ***cembroides*** var. ***bicolor*** Little **671**
Pinus cembroides Zucc. subsp. ***cembroides*** var. ***cembroides*** *647*, **671**

Pinus cembroides Zucc. subsp. *edulis* (Engelm.) E. Murray 689
Pinus cembroides Zucc. var. *edulis* (Engelm.) Voss 689
Pinus cembroides Zucc. var. *juarezensis* (Lanner) Silba 770
Pinus cembroides Zucc. subsp. ***lagunae*** (Rob.-Pass.) D. K. Bailey **671**
Pinus cembroides Zucc. var. *lagunae* Rob.-Pass. 671
Pinus cembroides Zucc. subsp. *monophylla* (Torr. & Frém.) E. Murray 733
Pinus cembroides Zucc. subsp. ***orizabensis*** D. K. Bailey *648*, **672**
Pinus cembroides Zucc. var. *orizabensis* (D. K. Bailey) Silba 672
Pinus cembroides Zucc. var. *quadrifolia* (Parl. *ex* Sudw.) Silba 770
Pinus cembroides Zucc. var. *remota* Little 773
Pinus chiapensis (Martínez) Andresen 636, 787
Pinus chihuahuana Engelm. 723
Pinus cilicica Antoine & Kotschy 74
Pinus clausa (Chapm. *ex* Engelm.) Sarg. 627, 630, **672**, 673
Pinus clausa (Chapm. *ex* Engelm.) Sarg. subsp. *immuginata* (D. B. Ward) E. Murray 672
Pinus clausa (Chapm. *ex* Engelm.) Sarg. var. *immuginata* D. B. Ward 672, 673
Pinus clusiana Clemente 313, 443, 510, 747
Pinus contorta Douglas *ex* Loudon 477, 599, 611, 627, 630, 637, **673**, 674, 697, 711, 737, 963, 1026, 1066
Pinus contorta Douglas *ex* Loudon var. ***contorta*** **674**
Pinus contorta Douglas *ex* Loudon subsp. *latifolia* (Engelm.) Critchf. 675
Pinus contorta Douglas *ex* Loudon var. ***latifolia*** Engelm. 510, **675**
Pinus contorta Douglas *ex* Loudon subsp. *murrayana* (Balf.) Engelm. 675
Pinus contorta Douglas *ex* Loudon var. ***murrayana*** (Balf.) Engelm. *648*, 674, **675**, 719
Pinus cooperi C. E. Blanco 651
Pinus coulteri D. Don 70, 254, 300, 627, 633, *648*, **675**, 711, 712, 781, 961
Pinus crassicorticea Y. C. Zhong & K. X. Huang 729
Pinus cubensis Griseb. 627, 628, **676**, 677
Pinus culminicola Andresen & Beaman 19, 627, 634, *648*, **677**, 678
Pinus culminicola Andresen & Beaman var. *discolor* (D. K. Bailey & Hawksw.) Silba 671
Pinus culminicola Andresen & Beaman var. *johannis* (Rob.-Pass.) Silba 671
Pinus cupressoides Molina 382
Pinus dabeshanensis W. C. Cheng & Y. W. Law 652
Pinus dalatensis Ferré 627, 636, **679**, *680*, 717, 752, 806
Pinus dalatensis Ferré subsp. ***dalatensis*** var. ***bidoupensis*** Businský **681**
Pinus dalatensis Ferré subsp. ***dalatensis*** var. ***dalatensis*** **681**
Pinus dalatensis Ferré subsp. ***procera*** Businský **681**
Pinus dalmatica Vis. 745
Pinus dammara Lamb. 148, 155, 156
Pinus densa (Little & K. W. Dorman) Silba 692
Pinus densa (Little & K. W. Dorman) Silba var. *austrokeysensis* Silba 692
Pinus densata Mast. 308, 386, 627, 632, **682**, 807
Pinus densata Mast. var. *pygmaea* J. R. Xue 808
Pinus densiflora Siebold & Zucc. 86, 97, 286, 461, 506, 602, 622, 627, 632, 682, **683**, 684, 794, 1055
Pinus densiflora Siebold & Zucc. var. ***densiflora*** 684
Pinus densiflora Siebold & Zucc. var. *funebris* (Kom.) T. N. Liou & Q. L. Wang *ex* Silba 683
Pinus densiflora Siebold & Zucc. f. *sylvestriformis* Taken. 683
Pinus densiflora Siebold & Zucc. var. *sylvestriformis* (Taken.) Q. L. Wang 683
Pinus densiflora Siebold & Zucc. var. *ussuriensis* T. N. Liou & Q. L. Wang 684
Pinus densiflora Siebold & Zucc. var. *zhangwuensis* S. J. Zhang & *et al.* 683, 684
Pinus densi-thunbergii Uyeki 683
Pinus* × *densithunbergii Uyeki 627, **683**
Pinus deodara Lamb. ***263***
Pinus devoniana Lindl. 92, 627, 633, *648*, **685**, 686, 687, 731, 749, 764, 765
Pinus discolor D. K. Bailey & Hawksw. 671
Pinus divaricata (Aiton) Dum.-Cours. var. *latifolia* (Engelm.) Boivin 675
Pinus donnell-smithii Mast. 703

Pinus douglasiana Martínez 627, 633, **686**, 687, 710, 722, 727, 732, 749, 765
Pinus douglasiana Martínez var. *martinezii* (E. Larsen) Silba 687
Pinus douglasiana Martínez var. *maximinoi* (H. E. Moore) Silba 731
Pinus douglasii Sabine *ex* D. Don 959
Pinus dumosa D. Don 1048
Pinus durangensis Martínez 80, 627, 633, *648*, **687**, 688, 722, 785, 797
Pinus echinata Mill. 486, 627, 629, **688**, 689, 700, 750, 777, 804
Pinus edulis Engelm. 29, 300, 440, 445, 477, 626, 627, 634, **689**, 690
Pinus edulis Engelm. var. *fallax* Little 733
Pinus eldarica Medw. 661
Pinus elliottii Engelm. 28, 486, 627, 630, **691**, 700, 750, 782
Pinus elliottii Engelm. subsp. *densa* (Little & K. W. Dorman) E. Murray 692
Pinus elliottii Engelm. var. ***densa*** Little & K. W. Dorman **692**
Pinus elliottii Engelm. var. ***elliottii*** **692**
Pinus engelmannii Carrière 627, 642, *648*, **692**, 693
Pinus engelmannii Carrière var. *blancoi* (Martínez) Martínez 692
Pinus eremitana Businský 694
Pinus escarena Risso 757
Pinus estevezii (Martínez) J. P. Perry 767
Pinus × *fallax* (Little) Businský 733
Pinus fenzeliana Hand.-Mazz. 180, 260, 537, 551, 627, 636, 638, 652, **694**, 752, 806, 1008
Pinus fenzeliana Hand.-Mazz. var. *annamiensis* Silba 694
Pinus fenzeliana Hand.-Mazz. var. *dabeshanensis* (W. C. Cheng & Y. W. Law) L. K. Fu & Nan Li 652
Pinus flexilis E. James 101, 415, 477, 508, 627, 635, 655, **695**, *696*, 697, 698, 724, 737, 786, 963
Pinus flexilis E. James var. ***flexilis*** **697**
Pinus flexilis E. James var. *macrocarpa* Engelm. 697
Pinus flexilis E. James subsp. *reflexa* (Engelm.) E. Murray 697
Pinus flexilis E. James var. ***reflexa*** Engelm. **697**
Pinus formosana Hayata 738
Pinus fragilissima Businský 794, 795
Pinus fraseri Pursh 89
Pinus funebris Kom. 683, 684
Pinus gerardiana Wall. *ex* D. Don 29, 428, 627, 635, **698**, 699, 784
Pinus glabra Walter 627, 628, 629, **699**, 1040
Pinus glauca Moench 589
Pinus gordoniana Hartw. *ex* Gordon 736
Pinus grandis Douglas *ex* D. Don 90
Pinus greggii Engelm. *ex* Parl. 627, 629, **700**, 753
Pinus greggii Engelm. *ex* Parl. var. ***australis*** Donahue & Lopez **701**
Pinus greggii Engelm. *ex* Parl. var. ***greggii*** **701**
Pinus × ***hakkodensis*** Makino 627, **702**
Pinus halepensis Mill. 29, 446, 448, 627, 631, 661, **702**, 703, 745, 761
Pinus halepensis Mill. subsp. *brutia* (Ten.) Holmboe 661
Pinus halepensis Mill. var. *brutia* (Ten.) A. Henry 661
Pinus halepensis Mill. var. *ceciliae* (Llorens & L. Llorens) Roselló & *et al.* 702
Pinus hamata (Steven) Sosn. 790
Pinus hartwegii Lindl. 92, 120, 317, 442, 480, 627, 633, *649*, 678, 686, **703**, 704, 705, 785
Pinus hartwegii Lindl. var. *rudis* (Endl.) Silba 703
Pinus ×*hayatana* Businský 738
Pinus heldreichii H. Christ 627, 628, 630, 631, *649*, **705**, 706, 745
Pinus heldreichii H. Christ subsp. *leucodermis* (Antoine) E. Murray 705
Pinus heldreichii H. Christ var. *leucodermis* (Antoine) Markgr. *ex* Fitschen 705
Pinus henryi Mast. **706**, 707
Pinus herrerae Martínez **707**
Pinus hingganensis H. J. Zhang 782
Pinus ×*holfordiana* A. B. Jacks. 655
Pinus hondurensis Sénécl. 668
Pinus hwangshanensis W.Y. Hsia 627, 632, **708**, 709, 794
Pinus inops Aiton var. *clausa* Chapm. *ex* Engelm. 672
Pinus insignis Douglas *ex* Loudon var. *binata* Engelm. 773
Pinus insularis Endl. 713, 807, 824, 826
Pinus insularis Endl. var. *khasyana* (Griff.) Silba 713
Pinus insularis Endl. var. *langbianensis* (A. Chev.) Silba 713
Pinus insularis Endl. var. *tenuifolia* (W. C. Cheng & Y. W. Law) Silba 808

Pinus insularis Endl. var. *yunnanensis* (Franch.) Silba 808
Pinus jaliscana Pérez de la Rosa 627, 629, **709**, 710
Pinus jeffreyi Balf. 254, 300, 304, 443, 627, 633, **710**, 711, 712, 719, 734, 737, 763, 771, 961, 982
Pinus jeffreyi Balf. var. *baja-californica* Silba 710
Pinus johannis Rob.-Pass. 671
Pinus juarezensis Lanner 770
Pinus kaempferi Lamb. 505
Pinus kesiya Royle *ex* Gordon 19, 28, 627, 628, 632, 681, **712**, 713, 733, 807, 808
Pinus kesiya Royle *ex* Gordon subsp. *insularis* (Endl.) D. Z. Li 713
Pinus kesiya Royle *ex* Gordon var. ***kesiya*** **713**
Pinus kesiya Royle *ex* Gordon var. ***langbianensis*** (A. Chev.) Gaussen *ex* N.-S. Bui **713**, 807
Pinus kesiya Royle *ex* Gordon subsp. *yunnanensis* (Franch.) Businský 808
Pinus kochiana Klotzsch *ex* K. Koch 790
Pinus koraiensis Siebold & Zucc. 29, 96, 100, 109, 461, 464, 533, 567, 569, 627, 635, **713**, 714, 1010, 1023
Pinus krempfii Lecomte 626, 627, 634, 679, *715*, **716**, 717
Pinus krempfii Lecomte var. *poilanei* Lecomte 716
Pinus kwangtungensis Chun & Tsiang 175, 258, 260, 277, 537, 551, 694, 752, 806, 1008
Pinus kwangtungensis Chun & Tsiang var. *variifolia* Nan Li & Y. C. Zhong 694
Pinus lagunae (Rob.-Pass.) Passini 671
Pinus lambertiana Douglas 19, 254, 300, 322, 581, 627, 636, 711, **717**, *718*, 737, 982, 1026
Pinus lambertiana Douglas var. *martirensis* Silba 717
Pinus lanceolata Lamb. 294, 296
Pinus langbianensis A. Chev. 713
Pinus laricina Du Roi 506
Pinus laricio Poir. 746
Pinus laricio Poir. subsp. *calabrica* (Loudon) Cesca & Peruzzi 746
Pinus laricio Poir. var. *angustisquama* Willk. 747
Pinus laricio Poir. var. *calabrica* Loudon 746
Pinus laricio Poir. var. *caramanica* Loudon 746
Pinus laricio Poir. var. *latisquama* Willk. 747
Pinus larix L. var. *russica* Endl. 506, 514
Pinus lasiocarpa Hook. 101
Pinus latteri Mason 627, 631, *649*, **719**, 720, 732, 733
Pinus lawsonii Roezl *ex* Gordon 627, 630, 687, **721**, 722, 765
Pinus lawsonii Roezl *ex* Gordon var. *gracilis* Debreczy & Rácz 721
Pinus leiophylla Schiede *ex* Schltdl. & Cham. 300, 419, 627, 628, 687, 688, 693, 721, **722**, 723, 726, 749, 797
Pinus leiophylla Schiede *ex* Schltdl. & Cham. subsp. *chihuahuana* (Engelm.) E. Murray 723
Pinus leiophylla Schiede *ex* Schltdl. & Cham. var. ***chihuahuana*** (Engelm.) Shaw 80, 670, 722, **723**, 730, 785
Pinus leiophylla Schiede *ex* Schltdl. & Cham. var. ***Leiophylla*** 722, **723**
Pinus leucodermis Antoine 705, 706
Pinus longaeva D. K. Bailey 19, 627, 634, 641, *649*, 657, 697, **724**, 725, 734, 743
Pinus ×*longipedunculata* (Loock *ex* Martínez) Businský 754
Pinus luchuensis Mayr 627, 632, 709, **725**, 794
Pinus luchuensis Mayr subsp. *hwangshanensis* (W. Y. Hsia) D. Z. Li 708
Pinus luchuensis Mayr var. *hwangshanensis* (W. Y. Hsia) C. L. Wu 708
Pinus lumholtzii B.L. Rob & Fernald 627, 628, 693, **726**, 727, 764, 785
Pinus lumholtzii B. L. Rob & Fernald var. *microphylla* Carvajal 723
Pinus luzmariae Pérez de la Rosa 627, 629, **727**
Pinus macrophylla Engelm. var. *blancoi* Martínez 692
Pinus macvaughii Carvajal 709
Pinus maestrensis Bisse 676
Pinus martinezii E. Larsen 627, 687
Pinus massoniana Lamb. 28, 297, 386, 489, 551, 627, 632, 684, 707, **727**, 728
Pinus massoniana Lamb. var. ***hainanensis*** W. C. Cheng & L. K. Fu **729**
Pinus massoniana Lamb. var. *henryi* (Mast.) C. L. Wu 706
Pinus massoniana Lamb. var. ***massoniana*** **729**
Pinus massoniana Lamb. var. *shaxianensis* D. X. Zhou 729
Pinus massoniana Lamb. var. *wulingensis* C. J. Qi & Q. Z. Lin 706
Pinus mastersiana Hayata 653

Pinus maximartinezii Rzed. 19, 627, 635, *649*, **729**, 730
Pinus maximinoi H. E. Moore 317, 627, 633, 686, 710, **731**, 749, 753, 765, 796
Pinus merkusii Jungh. & de Vriese 627, 631, 720, **732**, 733
Pinus merkusii Jungh. & de Vriese subsp. *latteri* (Mason) D. Z. Li 719
Pinus merkusii Jungh. & de Vriese var. *latteri* (Mason) Silba 719
Pinus merkusii Jungh. & de Vriese subsp. *ustulata* Businský 732
Pinus mertensiana Bong. 1042, 1053
Pinus mesogeensis Fieschi & Gaussen 756, 757
Pinus michoacana Martínez 685
Pinus monophylla Torr. & Frém. 29, 300, 445, 627, 631, *649*, *650*, **733**, 734, 771
Pinus monophylla Torr. & Frém. var. *fallax* (Little) Silba 733
Pinus monophylla Torr. & Frém. var. *californiarum* (D. K. Bailey) Silba 733
Pinus montezumae Lamb. 92, 94, 120, 317, 398, 627, 633, 686, 688, 701, 703, 704, 721, 722, **734**, 735, 797
Pinus montezumae Lamb. var. ***gordoniana*** (Hartw. *ex* Gordon) Silba **736**
Pinus montezumae Lamb. var. *mezambrana* Carvajal 736
Pinus montezumae Lamb. var. ***montezumae*** **736**
Pinus montezumae Lamb. var. *rudis* (Endl.) Shaw 703
Pinus monticola Douglas *ex* D. Don 254, 443, 510, 581, 627, 636, 655, 711, 719, **736**, 737, 763, 805, 1026, 1066
Pinus morrisonicola Hayata 627, 636, 695, **738**, 752
Pinus mugo Turra 416, 627, 631, 678, **739**, 740, 745, 776, 802
Pinus mugo Turra subsp. ***mugo*** **740**
Pinus mugo Turra subsp. *rostrata* (Antoine) E. Murray 802
Pinus mugo Turra var. *rostrata* (Antoine) Hoopes 802
Pinus mugo Turra subsp. ***rotundata*** (Link) Janch. & H. Neumayer 739, **740**, 802
Pinus mugo Turra subsp. *rotundata* (Link) Janch. & H. Neumayer var. *pseudopumilio* (Willk.) P. Schmidt 740
Pinus mugo Turra subsp. uncinata (Ramond ex DC) Domin 802
Pinus mukdensis Uyeki *ex* Nakai 792
Pinus muricata D. Don 313, 627, 628, *650*, 654, **741**
Pinus muricata D. Don var. *borealis* Axelrod *ex* Farjon 741
Pinus muricata D. Don var. *cedrosensis* J. T. Howell 773
Pinus muricata D. Don var. *stantonii* Axelrod *ex* Farjon 741
Pinus murrayana Balf. 675
Pinus* ×*neilreichiana Reichardt 627, **742**
Pinus nelsonii Shaw 450, 627, 634, *650*, 670, **742**, 743
Pinus nigra J. F. Arnold 71, 74, 266, 423, 426, 430, 446, 572, 609, 627, 630, 632, 684, 705, 742, **744**, 746, 798
Pinus nigra J. F. Arnold var. *angustisquama* (Willk.) Laguna Lumbreras 747
Pinus nigra J. F. Arnold subsp. *calabrica* (Loudon) E. Murray 746
Pinus nigra J. F. Arnold var. *calabrica* (Loudon) C.K. Schneid. 746
Pinus nigra J. F. Arnold subsp. *caramanica* (Loudon) Businský 746
Pinus nigra J. F. Arnold var. *caramanica* (Loudon) Rehd. 746
Pinus nigra J. F. Arnold subsp. *clusiana* (Clemente) Rivas-Martínez 747
Pinus nigra J. F. Arnold var. *columnaris-pendula* Boydak 746
Pinus nigra J. F. Arnold subsp. *croatica* Lovric 745
Pinus nigra J. F. Arnold subsp. ***dalmatica*** (Vis.) Franco **745**
Pinus nigra J. F. Arnold var. *dalmatica* (Vis.) Businský 745
Pinus nigra J. F. Arnold subsp. ***laricio*** (Poir.) Maire *650*, **746**
Pinus nigra J. F. Arnold var. *latisquama* (Willk.) Laguna Lumbreras 747
Pinus nigra J. F. Arnold subsp. ***nigra*** 705, 742, **745**
Pinus nigra J. F. Arnold subsp. ***pallasiana*** (Lamb.) Holmboe 447, **746**
Pinus nigra J. F. Arnold subsp. ***pallasiana*** (Lamb.) Holmboe var. *fastigiata* Businský **746**
Pinus nigra J. F. Arnold subsp. ***pallasiana*** (Lamb.) Holmboe var. ***pallasiana*** **746**

Pinus nigra J. F. Arnold var. *pyramidata* A. Acatay *(nom. inval.)* 747
Pinus nigra J. F. Arnold subsp. ***salzmannii*** (Dunal) Franco *650*, **747**, *757*
Pinus nigra J. F. Arnold var. *salzmannii* (Dunal) Laguna Lumbreras 747
Pinus nigra J. F. Arnold var. *yaltirikiana* C.U. Alptekin 746
Pinus nigra J. F. Arnold var. ***fastigiata*** Businský **746**
Pinus nordmanniana Steven 111
Pinus novaemexicana P. Landry 697
Pinus nubicola J. P. Perry 768
Pinus oaxacana Mirov 768
Pinus oaxacana Mirov var. *diversiformis* Debreczy & Rácz 768
Pinus occidentalis Sw. 401, 627, 629, **747**, 748
Pinus occidentalis Sw. var. *baorucoensis* Silba 747
Pinus occidentalis Sw. var. *cubensis* (Griseb.) Silba 676
Pinus occidentalis Sw. var. *maestrensis* (Bisse) Silba 676
Pinus omorika Pančić 608
Pinus oocarpa Schiede *ex* Schltdl. 433, 627, 629, 668, 686, 687, 688, 710, 721, 722, 727, 731, **748**, 749, 764, 765, 779, 796, 797, 869
Pinus oocarpa Schiede *ex* Schltdl. var. *macvaughii* (Carvajal) Silba 709
Pinus oocarpa Schiede *ex* Schltdl. var. *manzanoi* Martínez 748
Pinus oocarpa Schiede *ex* Schltdl. var. *ochoterenae* Martínez 795
Pinus oocarpa Schiede *ex* Schltdl. f. *trifoliata* Martínez 727
Pinus oocarpa Schiede *ex* Schltdl. var. *trifoliata* Martínez 727
Pinus orientalis L. 609
Pinus orizabensis (D. K. Bailey) D. K. Bailey & Hawksw. 672
Pinus orthophylla Businský 694
Pinus pallasiana Lamb. 746
Pinus pallasiana Lamb. subsp. *caramanica* (Loudon) Chrtek & B. Slavik 746
Pinus palustris Mill. 19, 28, 627, 629, 686, **750**, 751, 777, 1013
Pinus parviflora Siebold & Zucc. 86, 128, 286, 573, 627, 636, 738, **751**, 752, 806, 978, 1027, 1030, 1048, 1055
Pinus parviflora Siebold & Zucc. var. *fenzeliana* (Hand.-Mazz.) C.L. Wu 694
Pinus parviflora Siebold & Zucc. var. *morrisonicola* (Hayata) C. L. Wu 738
Pinus parviflora Siebold & Zucc. var. ***parviflora*** **752**
Pinus parviflora Siebold & Zucc. subsp. *pentaphylla* (Mayr) Businský 752
Pinus parviflora Siebold & Zucc. var. ***pentaphylla*** (Mayr) A. Henry 702, **752**
Pinus patula Schiede *ex* Schltdl. & Cham. 95, 317, 627, 628, 701, 722, 731, **753**, 765, 797, 1061
Pinus patula Schiede *ex* Schltdl. & Cham. var. *jaliscana* (Pérez de la Rosa) Silba 709
Pinus patula Schiede *ex* Schltdl. & Cham. var. ***longipedunculata*** Loock *ex* Martínez **754**
Pinus patula Schiede *ex* Schltdl. & Cham. var. ***patula*** *650*, **754**
Pinus patula Schiede *ex* Schltdl. & Cham. subsp. *tecunumanii* (Eguiluz & J. P. Perry) Styles 795
Pinus pentaphylla Mayr 752
Pinus pentaphylla Mayr var. *hakkodensis* (Makino) Kusaka 702
Pinus peuce Griseb. 627, 636, 745, **754**, 755
Pinus peuce var. *vermiculata* Christ 755
Pinus picea L. 57
Pinus pinaster Aiton 28, 115, 627, 628, 630, **756**, 757, 758
Pinus pinaster Aiton subsp. *acutisquama* (Boiss.) Rivas-Martínez 757
Pinus pinaster Aiton var. *acutisquama* Boiss. 757
Pinus pinaster Aiton subsp. *atlantica* Villar 756, 757
Pinus pinaster Aiton subsp. ***escarena*** (Risso) K. Richt. **757**
Pinus pinaster Aiton var. *mesogeensis* (Fieschi & Gaussen) Silba 757
Pinus pinaster Aiton subsp. ***pinaster*** **757**, *809*
Pinus pinaster Aiton subsp. ***renoui*** (Villar) Maire 756, **758**
Pinus pinaster Aiton var. *renoui* Villar 758
Pinus pinceana Gordon 450, 627, 635, 670, 743, **758**, *759*
Pinus pindrow Royle *ex* D. Don 114
Pinus pinea L. 29, 446, 627, 631, 626, 745, **760**, 761, *809*
Pinus pityusa Steven 662
Pinus pityusa Steven var. *stankewiczii* Sukaczev 662

Pinus ponderosa Douglas *ex* C. Lawson 70, 254, 300, 304, 313, 314, 320, 420, 443, 477, 510, 581, 627, 628, 632, 633, 642, 690, 711, 712, 719, 721, 734, 737, **761**, 762, 763, 961, 963, 982, 1026
Pinus ponderosa Douglas *ex* C. Lawson subsp. *arizonica* (Engelm.) E. Murray 642
Pinus ponderosa Douglas *ex* C. Lawson var. *arizonica* (Engelm.) Shaw 642
Pinus ponderosa Douglas *ex* C. Lawson subsp. *coulteri* (D. Don) E. Murray 675
Pinus ponderosa Douglas *ex* C. Lawson var. ***ponderosa*** **763**, *809*
Pinus ponderosa Douglas *ex* C. Lawson subsp. *scopulorum* (Engelm.) E. Murray 763
Pinus ponderosa Douglas *ex* C. Lawson var. ***scopulorum*** Engelm. **763**
Pinus ponderosa Douglas *ex* C. Lawson var. *stormiae* (Martínez) Silba 651
Pinus ponderosa Douglas *ex* C. Lawson subsp. *washoensis* (Mason & Stockw.) E. Murray 763
Pinus praetermissa Styles & McVaugh 627, 629, **764**
Pinus pringlei Shaw 627, 630, 721, 722, **764**, 765
Pinus prokoraiensis Y. T. Zhao 713
Pinus pseudostrobus Lindl. 92, 94, 95, 317, 582, 627, 633, 670, 686, 687, 693, 701, 721, 722, 731, 732, 753, 764, **765**, *766*, 767, 779, 796
Pinus pseudostrobus Lindl. subsp. *apulcensis* (Lindl.) Stead 768
Pinus pseudostrobus Lindl. var. *apulcensis* (Lindl.) Martínez 768
Pinus pseudostrobus Lindl. var. ***apulcensis*** (Lindl.) Shaw **768**
Pinus pseudostrobus Lindl. var. *estevezii* Martínez 767
Pinus pseudostrobus Lindl. var. *laubenfelsii* Silba 768
Pinus pseudostrobus Lindl. var. *oaxacana* (Mirov) S. G. Harrison 768
Pinus pseudostrobus Lindl. var. ***pseudostrobus*** **767**
Pinus pumila (Pall.) Regel 19, 105, 109, 121, 128, 464, 501, 502, 533, 591, 627, 635, 678, 702, **768**, 1023
Pinus pungens Lamb. 568, 570, 627, 629, **769**, 770, 775, 777, *809*
Pinus quadrifolia Parl. *ex* Sudw. 627, 635, 734, **770**, 771, *809*
Pinus radiata D. Don 25, 236, 313, 315, 321, 627, 629, 654, 701, 742, **771**, 772, 923
Pinus radiata D. Don subsp. *binata* (Engelm.) E. Murray 773
Pinus radiata D. Don var. ***binata*** (Engelm.) Lemmon 315, **773**
Pinus radiata D. Don var. *cedrosensis* (J. T. Howell) Silba 773
Pinus radiata D. Don var. ***radiata*** **773**
Pinus remota (Little) D. K. Bailey & Hawksw. 399, 627, 634, 743, **773**, 774
Pinus reflexa (Engelm.) Engelm. 697
Pinus religiosa Kunth 119
Pinus renoui (Villar) Gaussen 758
Pinus resinosa Aiton 627, 632, 658, **774**, 775, 1044
Pinus* ×*rhaetica Brügger 627, **776**
Pinus rigida Mill. 627, 629, 770, 775, **776**, 781, 782, 804
Pinus rotundata Link 740
Pinus roxburghii Sarg. 627, 630, 660, **777**, 778, 779, 805
Pinus rudis Endl. 703
Pinus rzedowskii Madrigal & M. Caball. 627, 635, **779**, *810*, 1095
Pinus sabiniana Douglas *ex* D. Don 300, 320, 322, 406, 627, 633, **780, 781**
Pinus salzmannii Dunal 747
P. ×*schwerinii* Fitschen 805
Pinus scopulorum (Engelm.) Lemmon 763
Pinus serotina Michx. 627, 629, 691, **781**, 782
Pinus sibirica Du Tour 109, 124, 457, 515, 593, 627, 635, **782**, 783, 1023
Pinus sibirica Du Tour var. *hingganensis* (H. J. Zhang) Silba 782
Pinus sitchensis Bong. 617
Pinus smithiana Wall. 618
Pinus sosnowskyi Nakai 790
Pinus spectabilis D. Don 124
Pinus squamata X. W. Li 627, 635, **783**
Pinus strobiformis Engelm. 80, 81, 582, 627, 636, 642, 656, 698, **785**, 786
Pinus strobiformis Englem. subsp. *veitchii* (Roezl) Frankis 656
Pinus strobiformis Engelm. var. *carvajalii* Silba 785
Pinus strobiformis Engelm. var. *potosiensis* Silba 697
Pinus strobus L. 64, 317, 582, 615, 626, 627, 636, 653, 655, 737, 765, 775, 785, **786**, 1024, 1044

Pinus strobus L. subsp. *chiapensis* (Martínez) E. Murray 787
Pinus strobus L. var. ***chiapensis*** Martínez 737, **787**, 796, 1014
Pinus strobus L. subsp. *monticola* (Douglas *ex* D. Don) E. Murray 736
Pinus strobus L. var. *monticola* (Douglas *ex* D. Don) Nuttall 736
Pinus strobus L. var. ***strobus*** **787**
Pinus stylesii Frankis *ex* Businský 697
Pinus sylvestris L. 19, 27, 62, 111, 414, 498, 500, 501, 515, 571, 587, 608, 626, 627, 682, 684, 742, 744, 745, 769, 776, 783, **788**, 789, 803, 825, 883, 1094, 1109
Pinus sylvestris L. subsp. *hamata* (Steven) Fomin 790
Pinus sylvestris L. subsp. *kochiana* (Klotzsch *ex* K. Koch) Eliçin 790
Pinus sylvestris L. var. *manguiensis* S. Y. Li & Adair 790
Pinus sylvestris L. var. *scotica* Beissn. 789
Pinus sylvestris L. var. *sylvestriformis* (Taken.) W. C. Cheng & C. D. Chu 683
Pinus sylvestris L. var. ***hamata*** Steven **790**
Pinus sylvestris L. var. ***mongolica*** Litv. **790**
Pinus sylvestris L. var. ***sylvestris*** 788, **789**, *810*
Pinus tabuliformis Carrière 297, 627, 632, 663, 682, 707, **790**, 791, 807, 808, 818
Pinus tabuliformis Carrière var. *brevifolia* S. Y. Wang & C. L. Chang 791
Pinus tabuliformis Carrière var. *densata* (Mast.) Rehd. 682
Pinus tabuliformis Carrière subsp. *henryi* (Mast.) Businský 706
Pinus tabuliformis Carrière var. *henryi* (Mast.) C. T. Kuan 706
Pinus tabuliformis Carrière subsp. *mukdensis* (Uyeki *ex* Nakai) Businský 792
Pinus tabuliformis Carrière var. ***mukdensis*** (Uyeki *ex* Nakai) Uyeki **792**
Pinus tabuliformis Carrière var. *pygmaea* (J. R. Xue) Silba 808
Pinus tabuliformis Carrière var. ***tabuliformis*** **791**
Pinus tabuliformis Carrière var. ***umbraculifera*** T. N. Liou & Q. L. Wang **792**
Pinus tabuliformis Carrière var. *yunnanensis* Dallim. & A.B. Jacks. 808
Pinus taeda L. 627, 629, 689, 691, 700, 750, 781, **792**, 804, 1040
Pinus taiwanensis Hayata 295, 627, 632, 709, **793**, 794
Pinus taiwanensis Hayata var. *damingshanensis* W. C. Cheng & L. K. Fu 708, 709
Pinus taiwanensis Hayata var. ***fragilissima*** (Businský) Farjon **795**
Pinus taiwanensis Hayata var. ***taiwanensis*** **794**, *810*
Pinus tecunumanii Eguiluz & J. P. Perry 627, 629, 668, 731, 749, **795**, 796
Pinus tenuifolia Benth 731
Pinus teocote Schiede *ex* Schltdl. & Cham. 29, 95, 419, 627, 688, 701, 721, 722, 727, **796**
Pinus teocote Schiede *ex* Schltdl. & Cham. var. *herrerae* (Martínez) Silba 707
Pinus thunbergiana Franco 797
Pinus thunbergii Parl. 627, 631, 683, 684, **797**, 798
Pinus torreyana Parry *ex* Carrière 627, 633, **798**, *799*
Pinus torreyana Parry *ex* Carrière subsp. ***insularis*** J. R. Haller **800**
Pinus torreyana Parry *ex* Carrière var. *insularis* (J. R. Haller) Silba 800
Pinus torreyana Parry *ex* Carrière subsp. ***Torreyana*** *799*, **800**
Pinus tropicalis Morelet 401, 627, 632, **801**, 802
Pinus uliginosa Neuman *ex* Wimm. 740
Pinus uncinata Ramond *ex* DC. 627, 631, 740, **802**, 803
Pinus uncinata Ramond *ex* DC. var. *ancestralis* Businský 802
Pinus uncinata Ramond *ex* DC. var. *pseudopumilio* Willk. 740
Pinus uncinata Ramond *ex* DC. var. *rostrata* Antoine 802
Pinus uncinata Ramond *ex* DC. subsp. *uliginosa* (Neumann *ex* Wimm.) Businský 740
Pinus uyematsui Hayata 738
Pinus veitchii Roezl 656
Pinus virginiana Mill. 486, 627, 630, 770, 775, 777, **803**, 804, *810*
Pinus wallichiana A. B. Jacks. 114, 125, 265, 428, 457, 460, 478, 504, 579, 618, 620, 627, 636, 655, 659, 660, 681, 778, **804**, *810*
Pinus wallichiana A. B. Jacks. subsp. *bhutanica* (Grierson *et al.*) Businský 659
Pinus wallichiana A. B. Jacks. var. *manangensis* H. Ohba & M. Suzuki 805

Pinus wallichiana A. B. Jacks. var. ***parva*** K. C. Sahni **805**
Pinus wallichiana A. B. Jacks. var. ***wallichiana*** **805**
Pinus wangii Hu & W. C. Cheng 627, 636, 694, 752, **806**, 807
Pinus wangii Hu & W. C. Cheng subsp. *kwangtungensis* (Chun & Tsiang) Businský 694
Pinus wangii Hu & W. C. Cheng var. *kwangtungensis* (Chun & Tsiang) Silba 694
Pinus wangii Hu & W. C. Cheng subsp. *variifolia* (Nan Li & Y. C. Zhong) Businský 694
Pinus washoensis Mason & Stockw. 763
Pinus yecorensis Debreczy & Rácz 768
Pinus yecorensis Debreczy & Rácz var. *sinaloensis* Debreczy & Rácz 768
Pinus yunnanensis Franch. 627, 632, 682, 784, **807,** 808
Pinus yunnanensis Franch. var. ***pygmaea*** (J. R. Xue) J. R. Xue **808**
Pinus yunnanensis Franch. var. *tenuifolia* W. C. Cheng & Y. W. Law 807, 808
Pinus yunnanensis Franch. var. ***yunnanensis*** 807, **808**
Platycladus Spach 38, 48, 50, 532, **817**, 818
Platycladus chengii (Bordères & Gaussen) A. V. Bobrov 817
Platycladus orientalis (L.) Franco 409, *810*, **817**, 818, 1098, 1100, 1109
Platycyparis A. V. Bobrov & Melikyan 298
Platycyparis funebris (Endl.) A. V. Bobrov & Melikyan 298, 311
Podocarpaceae Endl. 13, 14, 17, 18, 20, 21, 24, 26, 28, 35, 41, 45, 50, 51, **53**, 133, 140, 210, 214, 258, 327, 347, 364, 372, 373, 375, 379, 389, 495, 516, 528, 529, 534, 536, 555, 557, 563, 819, 877, 879, 912, 943, 947, 951, 953, 967, 968, 975, 983, 1078, 1071, 1087, 1093, 1094, 1096, 1098, 1100, 1102
Podocarpus L'Hér. *ex* Pers. 15, 20, 24, 28, 41, 53, 54, 140, 143, 144, 155, 208, 228, 327, 329, 330, 333, 334, 347, 358, 491, 522, 542, 553, 555, 563, **819**, 820, 821, 822, 823, 825, 826, 827, 828, 837, 844, 854, 869, 870, 873, 889, 896, 913, 929, 968, 973, 983
Podocarpus acuminatus de Laub. **830**
Podocarpus acutifolius Kirk *811*, 829, **830**, 831
Podocarpus affinis Seem. **831**, 832
Podocarpus allenii Standl. 868
Podocarpus alpinus R. Br. *ex* Hook. f. 878
Podocarpus alpinus R. Br. *ex* Hook. f. var. *arborescens* Brongn. & Gris 866
Podocarpus alpinus R. Br. *ex* Hook. f. var. *caespitosus* Pancher *ex* Brongn. & Gris 866
Podocarpus alpinus R. Br. *ex* Hook. f. var. *lawrencei* (Hook. f.) Hook. f. 878
Podocarpus amarus Blume 983
Podocarpus andinus Poepp. *ex* Endl. 943, 944
Podocarpus angustifolius Griseb. **832**, 833, 858
Podocarpus angustifolius Griseb. var. *aristulatus* (Parl.) Staszk. 832
Podocarpus angustifolius Griseb. subsp. *buchii* (Urb.) Staszk. 843
Podocarpus angustifolius Griseb. subsp. *buchii* (Urb.) Staszk. var. *latifolius* (Florin) Staszk. 843
Podocarpus angustifolius Griseb. var. *leonii* (Carabia) Staszk. 832
Podocarpus angustifolius Griseb. var. *leonii* (Carabia) Staszk. f. *victorinianus* (Carabia) Staszk. 832
Podocarpus angustifolius Parl. 904
Podocarpus annamiensis N. E. Gray 895, 897
Podocarpus annamiensis N.E. Gray var. *hainanensis* Gaussen 897
Podocarpus aracensis de Laub. & Silba **834**
Podocarpus archboldii N. E. Gray **835**
Podocarpus archboldii N. E. Gray var. *crassiramosus* N. E. Gray 912
Podocarpus argotaenia Hance 174, 175
Podocarpus aristulatus Parl. 832, 833
Podocarpus aristulatus Parl. var. *buchii* (Urb.) Silba 843
Podocarpus aspleniifolius Labill. 560, 561
Podocarpus atjehensis (Wasscher) de Laub. *ex* Silba **836**
Podocarpus ballivianensis Silba 901
Podocarpus barretoi de Laub. & Silba 839
Podocarpus beecherae de Laub. 898, 899
Podocarpus biformis Hook. 390
Podocarpus borneensis de Laub. **837**
Podocarpus bracteatus Blume **838**
Podocarpus brasiliensis de Laub. **839**
Podocarpus brassii Pilg. **840**, *842*
Podocarpus brassii Pilg. var. ***brassii*** *811*, **841**
Podocarpus brassii Pilg. var. ***humilis*** de Laub. **841**
Podocarpus brevifolius (Stapf) Foxw. 336, 360, *811*, **841**, 843, 1068

Podocarpus brownii C. E. Bertrand 856
Podocarpus buchholzii de Laub. 916
Podocarpus buchholzii de Laub. var. *neblinensis* Silba 916
Podocarpus buchii Urb. **843**, 844
Podocarpus buchii Urb. var. *latifolius* Florin 843
Podocarpus capuronii de Laub. **844**, 845
Podocarpus capuronii de Laub. var. *woltzii* (Gaussen) Silba 844
Podocarpus cardenasii J. T. Buchholz & N. E. Gray 865
Podocarpus celatus de Laub. 828, **845**, 846
Podocarpus celebicus Warb. 908
Podocarpus chinensis Wall. *ex* J. Forbes 886
Podocarpus chinensis Wall. *ex* J. Forbes var. *wardii* de Laub. & Silba 886
Podocarpus chingianus (N. E. Gray) S. Y. Hu *811*, 821, **846**, 847, 885
Podocarpus cinctus Pilg. 328
Podocarpus colliculatus (N. E. Gray) de Laub 933
Podocarpus compactus Wasscher 329
Podocarpus comptonii J. T. Buchholz 967
Podocarpus confertus de Laub. 823, **847**
Podocarpus coriaceus Rich. 826, **848**, 939
Podocarpus costalis C. Presl *811*, 821, 829, **849**, 914
Podocarpus costalis C. Presl var. *taiwanensis* Gaussen 849
Podocarpus costaricensis de Laub. *ex* Silba 826, **850**, 851
Podocarpus crassigemma de Laub. 824, **851**, 852
Podocarpus cumingii Parl. 327
Podocarpus cunninghamii Colenso 332, 392, 523, 525, 566, *811*, 826, 831, **852**, 853, 937
Podocarpus cupressinus R. Br. *ex* G. Benn. var. *curvulus* Miq. 335
Podocarpus dacrydiifolius Wasscher 328
Podocarpus dacrydioides A. Rich. 327, 331
Podocarpus dawei Stapf 141
Podocarpus decipiens N. E. Gray 897
Podocarpus decumbens N. E. Gray 825, **853**
Podocarpus deflexus Ridl. 822, **854**, 855
Podocarpus degeneri (N. E. Gray) de Laub. *ex* Silba 366, 897
Podocarpus dispermus C. T. White *811*, 825, **855**, 856, 984
Podocarpus distichus J. T. Buchholz 947
Podocarpus distichus J. T. Buchholz var. *maialis* J. T. Buchholz 947
Podocarpus drouynianus F. Muell. 825, **856**, 857, 892
Podocarpus ekmanii Urb. 826, **857**, 858
Podocarpus elatus R. Br. *ex* Endl. 238, *812*, 825, 829, 831, **858**, *859*, 860
Podocarpus elongatus (Aiton) L'Herit. *ex* Pers. 819, 820, 829, **860**, 861
Podocarpus ensiculus Melville 870
Podocarpus epiphyticus de Laub. & Silba 896, 897
Podocarpus expansus (de Laub.) Whitmore 332
Podocarpus falcatus (Thunb.) Endl. 142
Podocarpus falciformis Parl. 375, 376
Podocarpus fasciculus de Laub. 821, 807, **862**, 863, 932
Podocarpus ferrugineus G. Benn. *ex* D. Don 946
Podocarpus ferruginoides R. H. Compton 947
Podocarpus filicifolius N. E. Gray 972
Podocarpus fleuryi Hickel 537
Podocarpus formosensis Dummer 540
Podocarpus formosensis Dummer var. *koshuensis* (Kaneh.) Merr. & Yamam. 540
Podocarpus gaussenii Woltz 142, 143
Podocarpus gibbsiae N. E. Gray 359, 823, **863**
Podocarpus glaucus Foxw. 564, 822, 824, **864**, 873
Podocarpus globulus de Laub. 823, **865**
Podocarpus glomeratus D. Don 827, **865**, 866
Podocarpus gnidioides Carrière 825, **866**, 867
Podocarpus gnidioides Carrière var. *caespitosus* Pancher *ex* Carrière 866
Podocarpus gracilimus Stapf 142, 143
Podocarpus gracilior Pilg. 143
Podocarpus grayae de Laub. *812*, **867**, 868
Podocarpus guatemalensis Standl. 827, 828, **868**, 869
Podocarpus guatemalensis Standl. var. *allenii* (Standl.) J. T. Buchholz & N. E. Gray 868
Podocarpus guatemalensis Standl. var. *pinetorum* (Bartlett) J. T. Buchholz & N. E. Gray 868
Podocarpus hallii Kirk 852, 853
Podocarpus harmsianus Pilg. 948
Podocarpus henkelii Stapf *ex* Dallim. & A.B. Jacks. 140, *812*, 820, **870**
Podocarpus hispaniolensis de Laub. 827, **871**
Podocarpus humbertii de Laub. 820, **872**
Podocarpus idenburgensis N. E. Gray 879
Podocarpus imbricatus Blume 327, 334
Podocarpus imbricatus Blume var. *kinabaluensis* Wasscher 335
Podocarpus indonesiensis de Laub. & Silba 918, 919

Podocarpus ingensis de Laub. 901, 902
Podocarpus insularis de Laub. **873**
Podocarpus kawaii Hayata 334
Podocarpus koordersii Pilg. *ex* Koord. & Valeton 919
Podocarpus koshunensis (Kaneh.) Kaneh. 540
Podocarpus ladei F. M. Bailey 949
Podocarpus lambertii Klotzsch *ex* Endl. 196, 828 **874**, *875*, 925, 938, 939
Podocarpus lambertii Klotzsch *ex* Endl. var. *transiens* Pilg. 938
Podocarpus latifolius Blume 143, 541, *812*, 820, 829, **876**,
Podocarpus latifolius (Thunb.) R. Br. *ex* Mirb. **876**
Podocarpus latifolius (Thunb.) R. Br. *ex* Mirb. var. *latior* Pilg. 876
Podocarpus latifolius Wall. 541
Podocarpus latior (Pilg.) Gaussen 876
Podocarpus laubenfelsii Tiong 360, *812*, 821, 823, **877**, 878
Podocarpus lawrencei Hook. f. 374, 534, 561, *813*, 825, 829, 867, **878**, 879
Podocarpus ledermannii Pilg. 824, **879**, 880
Podocarpus leonii Carabia 832
Podocarpus leptophyllus Wasscher 362
Podocarpus levis de Laub. 822, 823, 824, **880**, 881
Podocarpus longifoliolatus Pilg. 826, **881**
Podocarpus lophatus de Laub. 822, **882**
Podocarpus lucienii de Laub. 825, **883**
Podocarpus macrocarpus de Laub. 822, **883**, 884
Podocarpus macrophyllus (Thunb.) Sweet 175, 273, 819, 821, 829, 846, 847, 862, 863, **884**, 885, 893, 894, 1039, 1110
Podocarpus macrophyllus (Thunb.) Sweet var. *chingii* N. E. Gray 847, 885
Podocarpus macrophyllus (Thunb.) Sweet f. *grandifolius* Pilg. 862
Podocarpus macrophyllus (Thunb.) Sweet var. *liukiuensis* Warb. 862, 863
Podocarpus macrophyllus (Thunb.) Sweet var. ***macrophyllus*** *813*, **886**, 894
Podocarpus macrophyllus (Thunb.) Sweet subsp. *maki* (Siebold & Zucc.) Pilg. **886**
Podocarpus macrophyllus (Thunb.) Sweet var. ***maki*** Siebold & Zucc. 885, **886**, 894
Podocarpus macrophyllus (Thunb.) Sweet var. *nakaii* (Hayata) H. L. Li & Keng 893
Podocarpus macrophyllus (Thunb.) Sweet var. *piliramulus* Z. X. Chen & Z. Q. Li 886
Podocarpus macrostachyus Parl. 901, 902
Podocarpus madagascariensis Baker 820, **887**
Podocarpus madagascariensis Baker var. ***madagascariensis*** **888**
Podocarpus madagascariensis Baker var. ***procerus*** de Laub. **888**
Podocarpus madagascariensis Baker var. ***rotundus*** L. Laurent **888**
Podocarpus magnifolius J. T. Buchholz & N. E. Gray 827, 828, 845, 846, **889**
Podocarpus maki (Siebold & Zucc.) Gaussen 886
Podocarpus mannii Hook. f. 145
Podocarpus matudae Lundell *813*, 826, 829, 851, **890**, 891, 1014
Podocarpus matudae Lundell var. *jaliscanus* de Laub. & Silba 890, 891
Podocarpus matudae Lundell var. *macrocarpus* J.T. Buchholz & N.E. Gray 890, 891
Podocarpus matudae Lundell var. *reichei* (J. T. Buchholz & N. E. Gray) de Laub. & Silba 890
Podocarpus micropedunculatus de Laub. 823, **891**, 892
Podocarpus milanjianus Rendle 146, 454, *813*, 820, 871, **892**, 893, 1061
Podocarpus minus (Carrière) Parl. 969
Podocarpus montanus (Humb. & Bonpl. *ex* Willd.) Lodd. *ex* Britton 950
Podocarpus montanus (Willd.) Lodd. var. *densifolius* J. T. Buchholz & N. E. Gray 950
Podocarpus montanus (Willd.) Lodd. var. *diversifolius* Dallim. & A. B. Jacks. 950
Podocarpus montanus (Willd.) Lodd. var. *meridensis* J. T. Buchholz & N. E. Gray 950
Podocarpus monteverdeensis de Laub. 901, 902
Podocarpus nagi (Thunb.) Pilg. var. *koshunensis* Kaneh. 540
Podocarpus nakaii Hayata 174, 489, *813*, 821, **893**, 894
Podocarpus nankoensis Hayata 540
Podocarpus neriifolius D. Don 175, 180, 182, 258, 277, 334, 821, 822, 823, 824, 826, 830, 836, 838, 868, 873, 874, 885, **895**, 896, 897, 915, 920, 932, 933, 973, 1017
Podocarpus neriifolius D. Don var. *atjehensis* Wasscher 836

Podocarpus neriifolius D. Don var. *bracteatus* (Blume) Wasscher 838
Podocarpus neriifolius D. Don var. *brevifolius* Stapf 841
Podocarpus neriifolius D. Don var. *decipiens* (N. E. Gray) Silba 897
Podocarpus neriifolius D. Don var. ***degeneri*** N. E. Gray 895, 896, **897**
Podocarpus neriifolius D. Don var. ***neriifolius*** *813*, **896**
Podocarpus neriifolius D. Don var. *penibukanensis* Silba 897
Podocarpus neriifolius D. Don var. *polyanthus* Wasscher 896
Podocarpus neriifolius D. Don var. *ridleyi* Wasscher 915
Podocarpus neriifolius D. Don var. *staintonii* Silba 897
Podocarpus neriifolius D. Don var. *teysmannii* (Miq.) Wasscher 935
Podocarpus neriifolius D. Don var. *timorensis* Wasscher 918
Podocarpus nivalis Hook. 390, 391, 520, *814*, 826, 829, 867, **897**, 898
Podocarpus novae-caledoniae Vieill. 544, *814*, 825, **898**, 899, 933
Podocarpus novae-caledoniae Vieill. var. *colliculatus* N. E. Gray 933
Podocarpus nubigenus Lindl. 382, 625, *814*, 828, 829, **900**, 901, 976
Podocarpus oleifolius D. Don 827, 828, 846, 869, **901**, 902
Podocarpus oleifolius D. Don var. *costaricensis* J. T. Buchholz & N. E. Gray 901
Podocarpus oleifolius D. Don var. *equadorensis* Silba 901
Podocarpus oleifolius D. Don var. *macrostachyus* (Parl.) J. T. Buchholz & N. E. Gray 901
Podocarpus oleifolius D. Don var. *trujillensis* J. T. Buchholz & N. E. Gray 901
Podocarpus orarius R. R. Mill & M. Whiting **1073**
Podocarpus palawanensis de Laub. & Silba 822, **902**
Podocarpus pallidus N. E. Gray 826, **903**, 904
Podocarpus palustris J. T. Buchholz 969
Podocarpus papuanus Ridl. 329, 335
Podocarpus parlatorei Pilg. 828, **904**, 905, 921
Podocarpus pectinatus Pancher *ex* Brongn. & Gris 133
Podocarpus pendulifolius J. T. Buchholz & N. E. Gray 828, **905**, *906*, 907
Podocarpus perrieri Gaussen & Woltz 820, **907**, 908
Podocarpus philippinensis Foxw. 919
Podocarpus pilgeri Foxw. 175, 180, 277, 821, 822, 823, 824, 832, 840, **908**, 909, 914, 1008
Podocarpus pilgeri Foxw. var. *thailandensis* Gaussen 908
Podocarpus pinetorum Bartlett 868, 869
Podocarpus pittieri J. T. Buchholz & N. E. Gray 921
Podocarpus polyanthus (Wasscher) Gaussen 896
Podocarpus polyspermus de Laub. 826, **910**
Podocarpus polystachyus R.Br. *ex* Endl. *814*, 821, 822, 823, 824, 829, 850, 903, **910**, 911, 912
Podocarpus polystachyus R. Br. *ex* Endl. var. *rigidus* Wasscher 837
Podocarpus polystachyus R. Br. *ex* Endl. var. *thevetiifolius* (Zipp. *ex* Blume) Silba 910
Podocarpus pseudobracteatus de Laub. 824, **912**
Podocarpus purdieanus Hook. 827, **913**
Podocarpus ramosii R. R. Mill 822, 823, **914**, 915
Podocarpus reichei J. T. Buchholz & N. E. Gray 890, 891
Podocarpus ridleyi (Wasscher) N. E. Gray 822, **915**, 927
Podocarpus roraimae Pilg. 828, **916**, 917, 930, 935
Podocarpus rospigliosii Pilg. 971
Podocarpus rostratus L. Laurent 820, 845, 908, **917**
Podocarpus rostratus L. Laurent var. *perrieri* (Gaussen & Woltz) Silba 907
Podocarpus rotundus de Laub. 914
Podocarpus rubens de Laub. **918**, 919
Podocarpus rubens de Laub. var. *pabinamaensis* Silba 918
Podocarpus rubens de Laub. var. *sumatrana* Silba 918
Podocarpus rumphii Blume *814*, 821, 823, 824, 884, **919**, 920
Podocarpus rumphii Blume var. *arbainii* Silba 919
Podocarpus rumphii Blume var. *aruensis* Silba 919
Podocarpus rusbyi J. T. Buchholz & N. E. Gray 827, **920**, 921
Podocarpus salicifolius Klotzsch & H. Karst. *ex* Endl. 827, *906*, **921**, 922
Podocarpus salignus D. Don 382, *815*, 828, 829, **922**, 923

Podocarpus salomoniensis Wasscher 824, **923**
Podocarpus sellowii Klotzsch *ex* Endl. 196, 827, 874, **924**, 925
Podocarpus sellowii Klotzsch *ex* Endl. var. angustifolius Pilg. **926**
Podocarpus sellowii Klotzsch *ex* Endl. var. sellowii **925**
Podocarpus smithii de Laub. 825, **926**, 927, 950
Podocarpus spathoides de Laub. 822, 823, 824, **927**, 928
Podocarpus spathoides de Laub. var. *solomonensis* Silba 1071
Podocarpus spicatus Poepp. 944
Podocarpus spinulosus (Sm.) R. Br. *ex* Mirb. *815*, 825, **928**
Podocarpus sprucei Parl. *815*, 828, **929**
Podocarpus standleyi J. T. Buchholz & N. E. Gray 951
Podocarpus steupii Wasscher 337
Podocarpus steyermarkii J. T. Buchholz & N. E. Gray 827, 917, **930**, *931*, 935
Podocarpus subtropicalis de Laub. 821, 830, 895, 896, **932**
Podocarpus subtropicalis de Laub. var. *medogensis* Silba 932
Podocarpus sylvestris J. T. Buchholz 161, 221, **933**
Podocarpus tepuiensis J. T. Buchholz & N. E. Gray 828, 917, 930, **934**, 935
Podocarpus teysmannii Miq. 821, 823, **935**, 936
Podocarpus thevetiifolius Zipp. *ex* Blume 910
Podocarpus tixieri Gaussen 908
Podocarpus tixieri Gaussen *ex* Silba 908
Podocarpus totara G. Benn. *ex* D. Don 20, 28, 143, 152, 332, 356, 525, 566, *815*, 826, 829, 853, **936**, 937, 947, 953
Podocarpus totara G. Benn. *ex* D. Don var. *hallii* (Kirk) Pilg. 852
Podocarpus totara G. Benn. *ex* D. Don var. *waihoensis* Wardle 936
Podocarpus transiens (Pilg.) de Laub. *ex* Silba 828, **938**
Podocarpus transiens (Pilg.) de Laub. *ex* Silba var. *harleyi* Silba 938
Podocarpus trinitensis J. T. Buchholz & N. E. Gray 827, **939**, 940
Podocarpus urbanii Pilg. 826, **940**, *941*, 942
Podocarpus usambarensis Pilg. 146
Podocarpus ustus (Vieill.) Brongn. & Gris 555
Podocarpus utilior Pilg. 948, 949
Podocarpus victorinianus Carabia 832, 833
Podocarpus vieillardii Parl. 338
Podocarpus vitiensis Seem. 967, 972
Podocarpus wallichianus C. Presl 541
Podocarpus woltzii Gaussen 844, 845
Prumnopitys Phil. 20, 43, 53, 54, **943**, 949, 953, 972, 984
Prumnopitys amara (Blume) de Laub. 983
Prumnopitys andina (Poepp. *ex* Endl.) de Laub. 382, *816*, 943, **944**, 945
Prumnopitys andina (Poepp. *ex* Endl.) de Laub. subsp. *blijdensteinii* Silba 944
Prumnopitys elegans Phil. 943, 944
Prumnopitys exigua de Laub. ex Silba 943, **945**, 953
Prumnopitys ferruginea (G. Benn. *ex* D. Don) de Laub. 152, 332, 356, 390, 392, 525, 566, 853, 937, 944, **946**, 947
Prumnopitys ferruginoides (R. H. Compton) de Laub. 208, 211, 363, 522, *816*, **947**, 948
Prumnopitys harmsiana (Pilg.) de Laub. 944, **948**, 949
Prumnopitys ladei (F.M. Bailey) de Laub. *816*, **949**, 950
Prumnopitys montana (Humb. & Bonpl. *ex* Willd.) de Laub. 944, 946, **950**, 951
Prumnopitys spicata (Poepp.) Molloy & Muñoz-Schick 944
Prumnopitys standleyi (J. T. Buchholz & N. E. Gray) de Laub. **951**, 952
Prumnopitys taxifolia (Banks & Sol. *ex* D. Don) de Laub. 152, 332, 356, 390, 394, 525, 566, 943, 947, **952**, 953
Pseudolarix Gordon 17, 19, 41, 51, 52, **954**
Pseudolarix amabilis (J. Nelson) Rehd. 280, *816*, **954**, 955
Pseudolarix kaempferi (Lindl.) Gordon 954
Pseudolarix pourtetii Ferré 954
Pseudotaxus W. C. Cheng 44, 55, **957**
Pseudotaxus chienii (W. C. Cheng) W. C. Cheng 297, *816*, **957**, 958
Pseudotaxus chienii (W.C. Cheng) W. C. Cheng subsp. *liana* (Silba) Silba 957
Pseudotaxus liana Silba 957
Pseudotsuga Carrière 19, 40, 52, 259, 652, 678, 708, 785, **959**, 965
Pseudotsuga argyrophylla (Chun & Kuang) Greguss 259
Pseudotsuga brevifolia W. C. Cheng & L. K. Fu 965

Pseudotsuga davidiana Bertrand 490
Pseudotsuga flahaultii Flous 963
Pseudotsuga forrestii Craib 965
Pseudotsuga gausseni Flous 966
Pseudotsuga japonica (Shiras.) Beissn. 86, 286, 541, **960**, *993*, 1055
Pseudotsuga macrocarpa (Vasey) Mayr 254, 959, **961**
Pseudotsuga menziesii (Mirb.) Franco 27, 52, 63, 70, 91, 102, 117, 254, 284, 300, 304, 313, 322, 510, 581, 584, 617, 690, 697, 701, 719, 727, 737, 772, 959, **962**, 980, 982, *993*, 1005, 1026, 1033, 1052
Pseudotsuga menziesii (Mirb.) Franco var. *flahaultii* (Flous) Silba 963
Pseudotsuga menziesii (Mirb.) Franco subsp. *glauca* (Beissn.) E. Murray 963
Pseudotsuga menziesii (Mirb.) Franco var. ***glauca*** (Beissn.) Franco 76, 80, 81, 120, 129, 317, 582, 611, **963**, 1026
Pseudotsuga menziesii (Mirb.) Franco subsp. *macrocarpa* (Vasey) E. Murray 961
Pseudotsuga menziesii (Mirb.) Franco var. ***menziesii*** **963**, *993*
Pseudotsuga menziesii (Mirb.) Franco var. *oaxacana* Debreczy & Rácz 963
Pseudotsuga shaanxiensis S. Z. Qu & K. Y. Wang 965
Pseudotsuga sinensis Dode 98, 182, 255, 258, 277, 295, 492, 537, 541, 604, 885, **964**, 986, 1008, 1050, 1068
Pseudotsuga sinensis Dode var. ***brevifolia*** (W. C. Cheng & L. K. Fu) Farjon & Silba **965**
Pseudotsuga sinensis Dode var. *forrestii* (Craib) Silba 965
Pseudotsuga sinensis Dode var. ***gaussenii*** (Flous) Silba 959, **966**
Pseudotsuga sinensis Dode var. ***sinensis*** 959, **965**, *993*
Pseudotsuga sinensis Dode var. *wilsoniana* (Hayata) L. K. Fu & Nan Li 965
Pseudotsuga wilsoniana Hayata 965
Pseudotsuga xichangensis C. T. Kuan & L. J. Zhou 965

R

Retinispora Siebold & Zucc. 281
Retinispora formosensis (Matsum.) A. V. Bobrov & Melikyan 281
Retinispora lawsoniana (A. Murray bis) A. V. Bobrov & Melikyan 283
Retinispora obtusa Siebold & Zucc. 281, 286
Retinispora pisifera Siebold & Zucc. 288
Retinispora taiwanensis (Masam. & S. Suzuki) A. V. Bobrov & Melikyan 286
Retrophyllum C. N. Page 42, 53, 54, **967**
Retrophyllum comptonii (J. T. Buchholz) C. N. Page 166, **967**, 968, *994*
Retrophyllum minus (Carrière) C. N. Page 20, 350, 353, 361, 967, **969**, 970, *994*
Retrophyllum piresii (Silba) C. N. Page 967, **970**
Retrophyllum rospigliosii (Pilg.) C. N. Page 967, **971**, 972
Retrophyllum vitiense (Seem.) C. N. Page 835, 967, **972**, 973, 974

S

Sabina Mill. 393
Sabina ashei (J. T. Buchholz) A. V. Bobrov & Melikyan 400
Sabina convallium (Rehd. & E. H. Wilson) W. C. Cheng & L. K. Fu var. *microsperma* W. C. Cheng & L. K. Fu 418
Sabina microsperma (W. C. Cheng & L. K. Fu) W. C. Cheng & L. K. Fu 418
Sabina pingii (W. C. Cheng) W. C. Cheng & W. T. Wang var. *wilsonii* (Rehd.) W. C. Cheng & L. K. Fu 452, 453
Sabina silicicola Small 486
Sabina vulgaris Antoine 393
Sabina vulgaris Antoine var. *erectopatens* W. C. Cheng & L. K. Fu 409
Sabina vulgaris Antoine var. *yulinensis* T. C. Chang & C. G. Chen 463
Sabinella Nakai 393
Sabinella phoenicea (L.) Nakai 393
Salisburyodendron A. V. Bobrov & Melikyan 148
Salisburyodendron australis (D. Don) A. V. Bobrov & Melikyan 148, 151
Salisburyodendron corbassonii (de Laub.) A. V. Bobrov & Melikyan 166
Salisburyodendron lanceolata (Warb.) A. V. Bobrov & Melikyan 161
Salisburyodendron montana (de Laub.) A. V. Bobrov & Melikyan 166
Salisburyodendron moorei (Lindl.) A. V. Bobrov & Melikyan 166

Salisburyodendron ovata (Vieill.) A. V. Bobrov & Melikyan 169
Salisburyodendron ovata (Vieill.) A. V. Bobrov & Melikyan subsp. *hypoleuca* (C. Moore *ex* Henkel & W. Hochst.) A. V. Bobrov & Melikyan 169
Saxegothaea Lindl. 41, 53, 54, **975**
Saxegothaea conspicua Lindl. 382, 900, **975**, 976, *994*
Schubertia Mirb. 988
Schubertia disticha (L.) Mirb. 988
Sciadopityaceae Luerss. 21, 24, 43, 45, **54**, 977, 978, 1074
Sciadopitys Siebold & Zucc. 18, 43, 48, 54, 317, **393**, 436, 452, 464, 624, **977**, 978
Sciadopitys verticillata (Thunb.) Siebold & Zucc. 21, 86, 286, **977**, *994*, 1030, 1039, 1055
Sequoia Endl. 21, 24, 36, 48, 49, 238, 530, **979**
Sequoia sempervirens (D. Don) Endl. 21, 48, 284, **979**, 980, *995*, 1005, 1026, 1033, 1077
Sequoiadendron J. T. Buchholz 24, 36, 48, 49, 238, 282, **981**
Sequoiadendron giganteum (Lindl.) J. T. Buchholz 21, 25, 254, *546*, 711, 719, 981, 982, *995*
Squamataxus J. Nelson 975
Squamataxus albertiana J. Nelson 975
Stachycarpus Tiegh. 943
Stachycarpus amarus (Blume) Gaussen 983
Stachycarpus andinus (Poepp. *ex* Endl.) Tiegh. 943
Stegocedrus Doweld 521
Stegocedrus austrocaledonica (Brongn. & Gris) Doweld 521, 522
Stegocedrus chevalieri (J. T. Buchholz) Doweld 524
Stegocedrus yateensis (Guillaumin) Doweld 526
Steinhauera Presl 981
Steinhauera gigantea (Lindl.) Kuntze *ex* Voss 981
Strobus Opiz 626
Strobus weymouthiana Opiz 626
Sundacarpus (J. T. Buchholz & N. E. Gray) C. N. Page 43, 53, 54, 378, **983**
Sundacarpus amarus (Blume) C. N. Page 155, 331, 352, 360, 377, 378, 542, 878, 950, **983**, 984, *995*

T

Taiwania Hayata 36, 48, 49, **985**, 986
Taiwania cryptomerioides Hayata 255, 282, 286, 295, **985**, 986, *995*, *996*
Taiwania flousiana Gaussen 985
Taiwania yunnanensis Koidz. 985
Tassilicyparis A. V. Bobrov & Melikyan 298
Tassilicyparis dupreziana (A. Camus) A. V. Bobrov & Melikyan 298, 310
Taxaceae Gray 18, 21, 22, 24, 26, 35, 43, 45, 47, **55**, 174, 228, 229, 258, 555, 957, 1001, 1032, 1094, 1096, 1099, 1100, 1102
Taxodium Rich. 17, 21, 37, 48, 49, 388, 953, **988**
Taxodium ascendens Brongn. 990
Taxodium distichum (L.) Rich. 290, 322, 531, 691, 700, 782, 979, **988**, 989, 990, 991, *996*
Taxodium distichum (L.) Rich. var. *ascendens* (Brongn.) Mast. 990
Taxodium distichum (L.) Rich. var. ***distichum*** **990**
Taxodium distichum (L.) Rich. var. ***imbricarium*** (Nutt.) Sarg. **990**
Taxodium distichum (L.) Rich. var. *mucronatum* (Ten.) A. Henry 990
Taxodium distichum (L.) Rich. subsp. *nutans* (Aiton) E. Murray 990
Taxodium mucronatum Ten. 988, **990**, 991, *996*
Taxodium sempervirens D. Don 979
Taxus L. 22, 28, 44, 55, 174, 175, 268, 380, 481, 511, 555, 562, 975, 978, **1001**, 1009, 1013, 1014, 1016, 1017, 1040
Taxus baccata L. 74, 111, 113, 263, 610, 620, 757, *996*, *997*, 1001, **1002**, 1003, 1004, 1005, 1007, 1011, 1017, 1018
Taxus baccata L. subsp. *brevifolia* (Nutt.) Pilg. 1004
Taxus baccata L. subsp. *canadensis* (Marshall) Pilg. 1005
Taxus baccata L. subsp. *cuspidata* (Siebold & Zucc.) Pilg. 1011
Taxus baccata L. subsp. *cuspidata* (Siebold & Zucc.) Pilg. var. *chinensis* Pilg. 1007
Taxus baccata L. subsp. *cuspidata* (Siebold & Zucc.) Pilg. var. *latifolia* Pilg. 1011
Taxus baccata L. subsp. *floridana* (Nutt. *ex* Chapm.) Pilg. 1012
Taxus baccata L. var. *microcarpa* Trautv. 1011
Taxus baccata L. var. *minor* Michx. 1005
Taxus baccata L. subsp. *wallichiana* (Zucc.) Pilg. 1016, 1017
Taxus biternata Spjut 1011
Taxus brevifolia Nutt. 284, 737, 982, *997*, 1002, **1004**, 1005, 1026
Taxus brevifolia Nutt. var. *polychaeta* Spjut 1004

Taxus brevifolia Nutt. var. *reptaneta* Spjut 1004, 1005
Taxus caespitosa Nakai 1011
Taxus caespitosa Nakai var. *angustifolia* Spjut 1011
Taxus caespitosa Nakai var. *latifolia* (Pilg.) Spjut 1011
Taxus canadensis Marshall 65, 1002, 1004, **1005**, 1006
Taxus canadensis Marshall var. *floridana* (Nutt. *ex* Chapm.) Silba 1012
Taxus canadensis Marshall var. *minor* (Michx.) Spjut 1006
Taxus celebica (Warb.) H. L. Li 1016, 1017
Taxus chienii W. C. Cheng 957
Taxus chinensis (Pilg.) Rehd. 66, 84, 175, 182, 270, 277, 297, 492, 541, 885, **1007**, 1014, 1016, 1017, 1068
Taxus chinensis (Pilg.) Rehd. var. *mairei* (Lemée & Lév.) W. C. Cheng & L. K. Fu 1014
Taxus chinensis (Pilg.) Rehd. var. *yunnanensis* (W. C. Cheng & L. K. Fu) L. K. Fu 1016
Taxus communis J. Nelson 1001
Taxus contorta Griff. 1002, **1008**, 1009, 1017, 1018
Taxus contorta Griff. var. *mucronata* Spjut 1016
Taxus cuspidata Siebold & Zucc. 100, 590, 1002, 1007, **1009**, 1010, 1011, 1039
Taxus cuspidata Siebold & Zucc. var. *caespitosa* (Nakai) Q. L. Wang 1011
Taxus cuspidata Siebold & Zucc. var. *chinensis* (Pilg.) C. K. Schneid. 1007
Taxus cuspidata Siebold & Zucc. var. ***cuspidata*** *997*, **1011**
Taxus cuspidata Siebold & Zucc. var. *latifolia* (Pilg.) Nakai 1011
Taxus cuspidata Siebold & Zucc. var. *microcarpa* (Trautv.) Kolesn. 1011
Taxus cuspidata Siebold & Zucc. var. ***nana*** *hort. ex* Rehd. **1011**
Taxus elongata Aiton 819, 860
Taxus falcata Thunb. 140, 142
Taxus floridana Nutt. *ex* Chapm. 1002, **1012**, 1013, 1040, 1041
Taxus florinii Spjut 1016
Taxus fuana Nan Li & R. R. Mill 1008, 1009, 1017
Taxus globosa Schltdl. 601, 1002, 1012, **1013**, 1014
Taxus globosa Schltdl. var. *floridana* (Nutt. *ex* Chapm.) Spjut 1012
Taxus harringtonii Knight *ex* J. Forbes 268, 272, 273
Taxus kingstonii Spjut 1014
Taxus latifolia Thunb. 876
Taxus macrophylla Thunb. 819, 886
Taxus mairei (Lemée & Lév.) S. Y. Hu *ex* T. S. Liu 1002, **1014**, 1015, 1017
Taxus mairei (Lemée & Lév.) S. Y. Hu *ex* T. S. Liu var. *speciosa* (Florin) Spjut 1014
Taxus ×media Rehd. 1011
Taxus minor (Michx.) Britton *ex* Small & Vail 1005
Taxus montana Humb. & Bonpl. *ex* Willd. 950
Taxus nucifera L. 1032, 1038
Taxus obscura Spjut 1016
Taxus phytonii Spjut 1016
Taxus speciosa Florin 1014, 1015
Taxus spinulosa Sm. 928
Taxus suffnessii Spjut 1016
Taxus sumatrana (Miq.) de Laub. 1016, 1017
Taxus umbraculifera (Siebold *ex* Endl.) Lawson var. *microcarpa* (Trautv.) Spjut 1011
Taxus umbraculifera (Siebold *ex* Endl.) Lawson var. *nana* (Rehd.) Spjut 1011
Taxus verticillata Thunb. 977
Taxus wallichiana Zucc. 277, 579, 620, 986, 1002, 1007, 1009, 1015, **1016**, 1017, 1018
Taxus wallichiana Zucc. var. *chinensis* (Pilg.) Florin 1007
Taxus wallichiana Zucc. var. *mairei* (Lemée & Lév.) L. K. Fu & Nan Li 1014
Taxus wallichiana Zucc. var. *yunnanensis* (W. C. Cheng & L. K. Fu) C. T. Kuan 1016
Taxus yunnanensis W. C. Cheng & L. K. Fu 1009, 1016, 1036, 1050
Tetraclinis Mast. 38, 48, 49, 532, **1019**, 1021
Tetraclinis articulata (Vahl) Mast. 28, 289, 310, *997*, **1019**, *1020*
Thalamia Spreng. 560
Thalamia aspleniifolia (Labill.) Spreng. 560
Thuja L. 37, 48, 50, 226, 532, 817, 963, **1022**, 1030
Thuja articulata Vahl 1019
Thuja chengii 817
Thuja chilensis D. Don 226
Thuja cupressoides L. 1056, 1058
Thuja dolabrata Thunb. *ex* L. f. 1030, 1031
Thuja koraiensis Nakai *997, 998*, **1022**, 1023
Thuja lineata Poir. 387
Thuja occidentalis L. 804, 1022, **1024**, 1026
Thuja orientalis L. 817
Thuja pensilis Staunton *ex* D. Don 387

Thuja plicata Donn *ex* D. Don 63, 91, 117, 254, 510, 617, 719, 737, *998*, 1005, 1022, **1025**, 1026, 1066
Thuja sphaeroidea Spreng. 281
Thuja standishii (Gordon) Carrière 97, 128, 1022, **1027**, 1030
Thuja sutchuenensis Franch. *998*, 1022, **1028**
Thujopsis Siebold & Zucc. *ex* Endl. 37, 48, 49, **1030**
Thujopsis dolabrata (Thunb. *ex* L. f.) Siebold & Zucc. 1027, **1030**
Thujopsis dolabrata (Thunb. *ex* L. f.) Siebold & Zucc. var. ***dolabrata*** *998*, **1031**
Thujopsis dolabrata (Thunb. *ex* L. f.) Siebold & Zucc. var. ***hondae*** Makino **1031**
Thujopsis standishii Gordon 1027
Titanodendron A. V. Bobrov & Melikyan 191
Titanodendron hunsteinii (K. Schum.) A. V. Bobrov & Melikyan 191, 208
Titanodendron klinkii (Lauterb.) A. V. Bobrov & Melikyan 208
Titanodendron schumanniana (Warb.) A. V. Bobrov & Melikyan 208
Torreya Arn. 22, 44, 55, **1032**, 1040
Torreya ascendens Nakai *ex* Uyeki 1038
Torreya californica Torr. *998*, 1032, **1033**
Torreya fargesii Franch. 1032, **1034**
Torreya fargesii Franch. var. ***fargesii*** 1034, **1035**
Torreya fargesii Franch. var. ***yunnanensis*** (W. C. Cheng & L. K. Fu) N. Kang 1034, **1035**
Torreya grandis Fortune *ex* Lindl. 297, 489, 1032, 1034, **1035**, 1036
Torreya grandis Fortune *ex* Lindl. var. *fargesii* (Franch.) Silba 1035
Torreya grandis Fortune *ex* Lindl. var. ***grandis*** 1036, **1037**
Torreya grandis Fortune *ex* Lindl. var. ***jiulongshanensis*** Z. Y. Li, Z. C. Tang & N. Kang 1034, **1037**
Torreya grandis Fortune *ex* Lindl. var. *yunnanensis* (W. C. Cheng & L. K. Fu) Silba 986
Torreya jackii Chun 1032, **1037**, 1038
Torreya nucifera (L.) Siebold & Zucc. 86, 293, 960, *999*, 1032, **1038**, 1039
Torreya nucifera (L.) Siebold & Zucc. var. *grandis* (Fortune *ex* Lindl.) Pilg. 1037
Torreya parvifolia T. P. Yi, L. Yang & T. L. Long 1037
Torreya taxifolia Arn. 1013, 1032, **1040**, 1093, 1101
Torreya yunnanensis W. C. Cheng & L. K. Fu 1035
Tsuga (Endl.) Carrière 19, 41, 52, 273, 274, 432, 459, 549, 551, 573, 595, 954, 959, 963, 1031, **1042**
Tsuga argyrophylla (Chun & Kuang) de Laub. & Silba 259
Tsuga blaringhemii Flous 1047
Tsuga canadensis (L.) Carriere 64, 615, 775, 804, 1006, 1024, 1042, **1043**, 1044, 1046
Tsuga caroliniana Engelm. 90, 1042, 1043, **1044**, 1045, 1046
Tsuga chinensis (Franch.) E. Pritz. 66, 72, 77, 82, 83, 84, 118, 131, 180, 182, 258, 260, 282, 511, 551, 578, 604, 605, 612, 614, 885, 965, 986, 1008, 1042, **1045**, 1046, 1050
Tsuga chinensis (Franch.) E. Pritz. var. ***chinensis*** 98, *999*, **1046**
Tsuga chinensis (Franch.) E. Pritz. var. *daibuensis* S. S. Ying 1047
Tsuga chinensis (Franch.) E. Pritz. var. *formosana* (Hayata) H. L. Li & H. Keng 1046
Tsuga chinensis (Franch.) E. Pritz. var. *forrestii* (Downie) Silba 1050
Tsuga chinensis (Franch.) E. Pritz. var. ***oblongisquamata*** W. C. Cheng & L. K. Fu **1047**
Tsuga chinensis (Franch.) E. Pritz. subsp. *patens* (Downie) E. Murray 1046
Tsuga chinensis (Franch.) E. Pritz. var. *patens* (Downie) L. K. Fu & Nan Li 1046
Tsuga chinensis (Franch.) E. Pritz. var. ***robusta*** W. C. Cheng & L. K. Fu **1047**
Tsuga chinensis (Franch.) E. Pritz. var. *tchekiangensis* (Flous) W. C. Cheng & L. K. Fu 1046
Tsuga chinensis (Franch.) E. Pritz. subsp. *wardii* (Downie) E. Murray 1049
Tsuga diversifolia (Maxim.) Mast. 97, 105, 128, 506, 573, 591, 1027, 1030, 1042, 1043, **1047**, 1048
Tsuga diversifolia (Maxim.) Mast. subsp. *blaringhemii* (Flous) E. Murray 1047
Tsuga douglasii (Sabine *ex* D. Don) Lindl. var. *glauca* Beissn. 963
Tsuga dumosa (D. Don) Eichler 77, 78, 79, 87, 114, 125, 305, 504, 511, 579, 586, 618, 620, 805, 965, 986, 1043, **1048**, 1049, 1050
Tsuga dumosa (D. Don) Eichler subsp. *leptophylla* (Hand.-Mazz.) E. Murray 1049

Tsuga dumosa (D. Don) Eichler var. *yunnanensis* (Franch.) Silba 1048
Tsuga dura Downie 1048
Tsuga formosana Hayata 1046
Tsuga forrestii Downie 126, *999*, 1042, 1043, **1050**, 1051
Tsuga heterophylla (Raf.) Sarg. 63, 91, 117, 254, 284, 510, 598, 617, 719, 737, 980, *999*, 1005, 1026, 1042, 1043, **1051**, 1052, 1053, 1054, 1066
Tsuga japonica Shiras. 960
Tsuga ×jeffreyi (A. Henry) A. Henry 1042, 1054
Tsuga leptophylla Hand.-Mazz. 1049
Tsuga longibracteata W. C. Cheng 549, 1042
Tsuga mairei Lemée & Lév. 1014
Tsuga mertensiana (Bong.) Carrière 63, 101, 117, 443, 508, 510, 581, 598, 617, 637, 674, 737, 1026, 1042, **1052**, 1053, 1054, 1066
Tsuga mertensiana (Bong.) Carrière subsp. ***grandicona*** Farjon 102, 1043, **1054**
Tsuga mertensiana (Bong.) Carrière subsp. ***mertensiana*** 1043, **1053**
Tsuga mertensiana (Bong.) Carrière subsp. ***mertensiana*** var. ***jeffreyi*** (A. Henry) C. K. Schneid. 1042, **1054**
Tsuga mertensiana (Bong.) Carrière subsp. ***mertensiana*** var. ***mertensiana*** *999*, **1053**
Tsuga oblongisquamata (W. C. Cheng & L. K. Fu) L. K. Fu & Nan Li 1047
Tsuga patens Downie 1046
Tsuga pattoniana (Balf.) Senecl. var. *jeffreyi* A. Henry 1042, 1054
Tsuga sieboldii Carrière 86, 286, 293, 541, 960, 978, 1039, 1042, 1043, **1054**, 1055
Tsuga tchekiangensis Flous 1046
Tsuga wardii Downie 1048
Tsuga yunnanensis (Franch.) E. Pritz. 1048
Tsuga yunnanensis (Franch.) E. Pritz. subsp. *dura* (Downie) E. Murray 1048
Tumion Raf. *ex* Greene 1032
Tumion taxifolium (Arn.) Greene 1032

V

Veitchia Lindl. 567
Veitchia japonica Lindl. 567
Verataxus J. Nelson 1001

W

Washingtonia Winslow 981, 982
Washingtonia californica Winslow 981
Wellingtonia Lindl. 981, 982
Wellingtonia gigantea Lindl. 981, 982
Widdringtonia Endl. 24, 39, 48, 50, **1056**
Widdringtonia cedarbergensis J. A. Marsh *999*, **1056**, 1100
Widdringtonia cupressoides (L.) Endl. 1058
Widdringtonia dracomontana Stapf 1058
Widdringtonia nodiflora (L.) Powrie *1000*, 1056, **1058**, 1061
Widdringtonia nodiflora (L.) Powrie var. *dracomontana* (Stapf) Silba 1058
Widdringtonia nodiflora (L.) Powrie var. *whytei* (Rendle) Silba 1060
Widdringtonia schwarzii (Marloth) Mast. 1056, **1059**, 1060
Widdringtonia whytei Rendle *1000*, 1056, **1060**, 1061
Wollemia W. G. Jones *et al.* 18, 21, 35, 46, **1062**, 1063
Wollemia nobilis W. G. Jones *et al.* 18, *1000*, **1062**, 1097

X

Xanthocyparis Farjon & Hiep 38, 48, 49, 298, 299, **1064**, 1065, 1068
Xanthocyparis nootkatensis (D. Don) Farjon & Harder 617, *1000*, 1026, 1053, **1065**, 1066
Xanthocyparis vietnamensis Farjon & Hiep 180, 182, 258, *1000*, 1008, 1064, 1065, **1066**, *1067*, 1093, 1096

End notes

* The following new combination has been published in this book:

Pinus taiwanensis Hayata var. *fragilissima* (Businský) Farjon

* Many names of species and infraspecific taxa have been typified in this book.