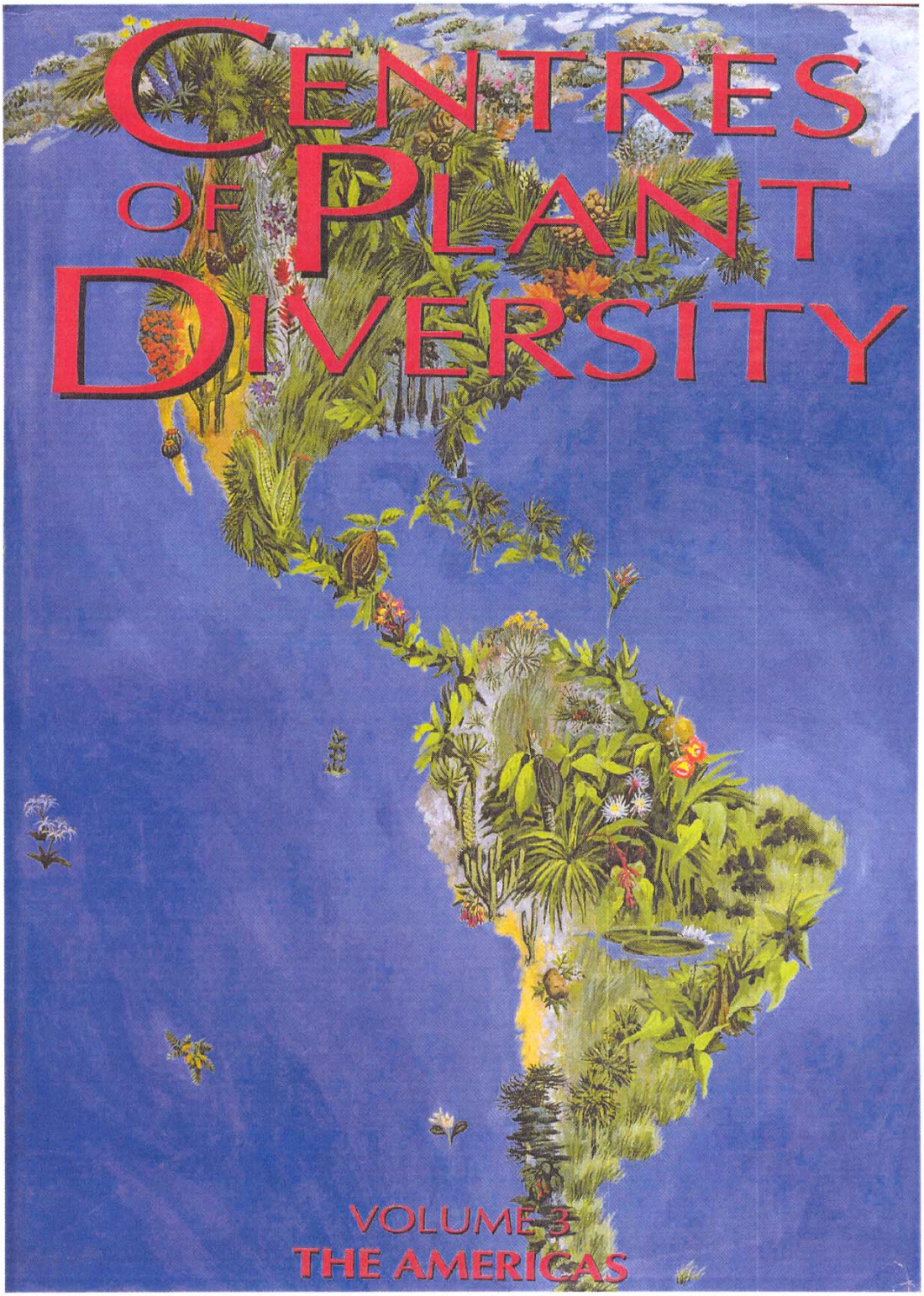

CENTRES
OF PLANT
DIVERSITY
VOLUME 3
THE AMERICAS

CENTRES OF PLANT DIVERSITY

A Guide and Strategy for their Conservation

Project Director: V.H. HEYWOOD
Project Coordinator: S.D. DAVIS

VOLUME 3
THE AMERICAS

edited by

S.D. DAVIS, V.H. HEYWOOD, O. HERRERA-MACBRYDE, J. VILLA-LOBOS AND A.C. HAMILTON

published by
The World Wide Fund For Nature (WWF)
and IUCN – The World Conservation Union

with financial support from the
European Commission (EC) and the
U.K. Overseas Development Administration (ODA)

WWF IUCN The World Conservation Union NATIONAL MUSEUM of NATURAL HISTORY ODA

1997

Citation: WWF and IUCN (1994–1997). Centres of plant diversity. A guide and strategy for their conservation. 3 volumes. IUCN Publications Unit, Cambridge, U.K.

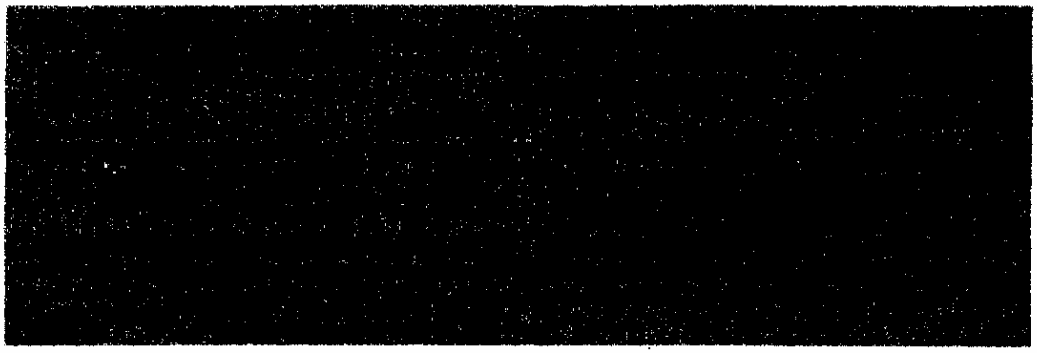
British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.
ISBN 2-8317-0199-6

Designed and produced by the Nature Conservation Bureau Limited, Newbury, Berkshire, U.K.

Printed by Information Press, Oxford, U.K.

SOUTHERN CONE: CPD SITE SA45

TEMPERATE RAIN FOREST of Chile



Geography

The western margin of southern South America has cool-temperate rain forest on a narrow landmass extending over c. 17.5° of latitude. The rain-forest zone constitutes a remarkable ecological island of wet forest, which is isolated by c. 1500–2000 km from other wet closed-canopy forests on the South American continent (Arroyo *et al.* 1996).

The rain forest occurs predominantly in Chile along the Andean and Coastal cordilleras, with small extensions across the Andes into neighbouring Argentina. The Andean Cordillera reaches c. 2000 m in height whereas the Coastal Cordillera rarely exceeds 1000 m. The Andean Cordillera is heavily glaciated, steep volcanic terrain which is highly prone to avalanches, with many of the glacial surfaces now covered by andesitic deposits (Veblen and Ashton 1978; Veblen, Schlegel and Oltremari 1983). In the far south the dominant physiographic features are deep fjords, the coastal archipelago, the North and South Patagonian Icefields, and tidewater glaciers (Alaback 1991). The Coastal Cordillera of central Chile consists predominantly of Late Palaeozoic and Mesozoic metamorphic and plutonic rocks, intruded by Mesozoic plutons and dikes (Irwin 1989). Unlike the Andes, there is no evidence of glaciation (Villagrán 1990).

Conditions for rain forest in southern South America are provided by the Andean Cordillera intercepting strong westerly winds along the Pacific coast during winter and summer months and the cool northward-flowing oceanic Humboldt Current maintaining humid and foggy conditions in coastal locations. Throughout south-western South America, as a result of the low land/ocean ratio of southern South America and strong oceanic influences, the climate is highly equable, there being no latitudinal increase in annual temperature range (Arroyo *et al.* 1996). Delimited climatically according to criteria developed by Alaback (1991), the rain-forest region has its northern limit close to treeline in the Andes at c. 38°30'S and close to the coast at 38°54'S, with its southern limit around the Cape Horn Islands off the mainland at 55°30'S. The rain forest extends from sea-level to the tree limit except in the Central Valley north of 41°S (Map 79), where conditions are too warm for the general forest to be considered cool-temperate rain forest.

The eastern limit at c. 39°S is on the western side of the Andes close to the treeline (1500 m) and then extends across the Andes into Argentina to 42°–43°S. Southward, the eastern limit again lies on the Chilean side of the Andes initially below the tree limit, to extend again to the treeline (c. 600 m) on the western margins of the North and South Patagonian icefields and the mountains of Tierra del Fuego. The region so delimited has a January isotherm of less than 16°C and annual precipitation from 1400–4900 mm (Veblen, Schlegel and Oltremari 1983), with more than 9–10% received over the summer months (Alaback 1991; Arroyo *et al.* 1996).

Based on floristic criteria (e.g. Oberdorfer 1960), the northern limit of the rain-forest zone is at 37°30'S and the south-eastern limit in south-eastern Tierra del Fuego. Relict stands of rain forest occur intermittently on steep south-facing slopes along the Chilean coast in the Mediterranean-type climate region (CPD Site SA44). Disjunct stands may be found as far north as 30°S, where they persist on fog-bound summits (Pérez and Villagrán 1985).

The rain forest, whether defined climatically or floristically, gradually intergrades to the north into Mediterranean-climate forests, and to the east to drier areas of *Austrocedrus chilensis* and deciduous *Nothofagus* forests. The ecotone between rain forest and Mediterranean climate in south-central Chile is broad and uneven, with many rain-forest elements extending far north of the climatic rain-forest boundary (Arroyo *et al.* 1996). Along the south-western margin of the continent where precipitation may exceed 4000 mm, rain forest gives

way to Magellanic moorland containing patches with rain-forest elements (Pisano 1977). Higher elevations on the island of Chiloé (Ruthsatz and Villagrán 1991) and the Coastal Cordillera farther north (Ramírez 1968) may also bear Magellanic moorland.

Geographic Information System (GIS) and other estimates suggest that cool-temperate rain forest originally covered from 70,000 km² to less than 110,000 km² (Kellogg 1993) – the larger GIS-derived figure is an over-estimate since alpine and moorland areas were not excluded. The actual area of native forest is estimated at 76,000 km² by INFOR (1991), which probably includes all the rain forests and Mediterranean forests with *Nothofagus* (but probably not sclerophyllous Mediterranean formations).

Vegetation

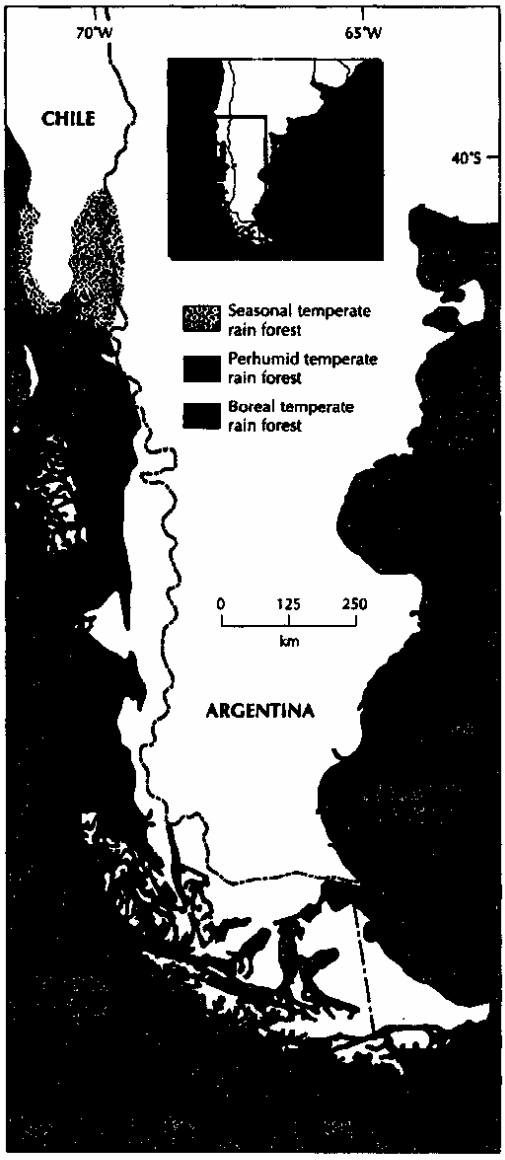
In this account the climatic definition of rain forest is followed; the rain-forest region as so defined includes both evergreen (Valdivian, North Patagonian, and Magellanic or Sub-Antarctic) and deciduous rain-forest types. Kellogg (1993) has suggested further division into seasonal and non-seasonal types, with the latter having perhumid and boreal sections (Map 79). On floristic criteria, only the predominantly evergreen Valdivian, North Patagonian and Magellanic rain-forest areas are classified as rain forest.

Much early vegetation study in the southern South American rain forest emphasized the phytosociological approach, with many plant associations described (Oberdorfer 1960). More recent work has emphasized physiognomic characteristics in combination with key dominants (Veblen and Schlegel 1982; Veblen, Schlegel and Oltremari 1983). The cool-temperate rain forest is most appropriately considered a mosaic of floristic types responding locally to key environmental gradients and soil conditions, reflected in gradual shifts in dominance and species richness. An outstanding feature is structural complexity, expressed in an unusually high representation for temperate forest of woody vines (lianas), climbing shrubs and hemi-parasites (Arroyo *et al.* 1996). In the Valdivian rain-forest zone, the key environmental variables are steep altitudinal temperature gradients in the Andean and Coastal cordilleras, east-west trending valleys with contrasting microclimates, and in the Andes heavy avalanching and volcanism (Veblen and Schlegel 1982; Veblen, Schlegel and Oltremari 1983).

In the Coastal Cordillera and the Andean range (western flank), succession with increasing altitude is from high-diversity, evergreen closed-canopy rain forest to mixed angiosperm-conifer rain forest and then evergreen conifer forest. In the Andes at high elevations, the conifer forest is eventually succeeded by deciduous forest, which occurs to the treeline (c. 900–1200 m).

Low- to mid-elevation closed-canopy rain forest contains many species of vines, vining shrubs and woody epiphytes, e.g. *Asteranthera ovata, Mitraria coccinea, Sarmienta repens* (Gesneriaceae); *Campsidium valdivicum* (Bignoniaceae); *Hydrangea integerrima* (Hydrangeaceae); *Luzuriaga* spp. (Philesiaceae); and *Griselinia racemosa* (Cornaceae); hemi-parasites; and epiphytic ferns, especially Hymenophyllaceae. On well-drained sites the dominant angiosperm trees are *Aextoxicon punctatum, Laurelia sempervirens, Nothofagus obliqua, Eucryphia cordifolia* and *Laureliopsis philippiana*, with Proteaceae (*Gevuina avellana, Embothrium coccineum, Lomatia* spp.), Myrtaceae (such as *Amomyrtus luma, Myrceugenia* spp., *Luma* spp.), *Dasyphyllum diacanthoides* (Asteraceae) and *Rhaphithamnus spinosus* (Verbenaceae) well represented throughout. *Nothofagus* is lacking in low-elevation forests on Chiloé Island (Donoso, Escobar and Urrutia 1985). Important tree species in structurally simpler, well-drained mid-elevation rain forest include *Nothofagus dombeyi, Laureliopsis philippiana, Weinmannia trichosperma, Caldcluvia paniculata, Saxegothaea conspicua,*

MAP 79. ORIGINAL DISTRIBUTION OF COOL-TEMPERATE RAIN FOREST IN SOUTHERN SOUTH AMERICA
(after Kellogg 1993)



Nothofagus alpina, *Drimys winteri* and *Podocarpus nubigena*. The understorey is dark, with few herbaceous species (e.g. *Nertera grandensis*) and low shrub cover (Arroyo *et al.* 1996). *Chusquea* spp. are conspicuous in forest gaps and along the edges.

On poorly drained low- and mid-elevation sites *Tepualia stipularis* and *Pilgerodendron uviferum* become prominent, forming extensive inundated forests (Martínez 1981; Veblen and Schlegel 1982). In the Central Valley other inundated areas ("fiadis" and "hualves") occurring over an iron hardpan and drying in the summer months under higher temperatures are typically dominated by species of Myrtaceae and *Drimys winteri* (Winteraceae) (Ramírez *et al.* 1991).

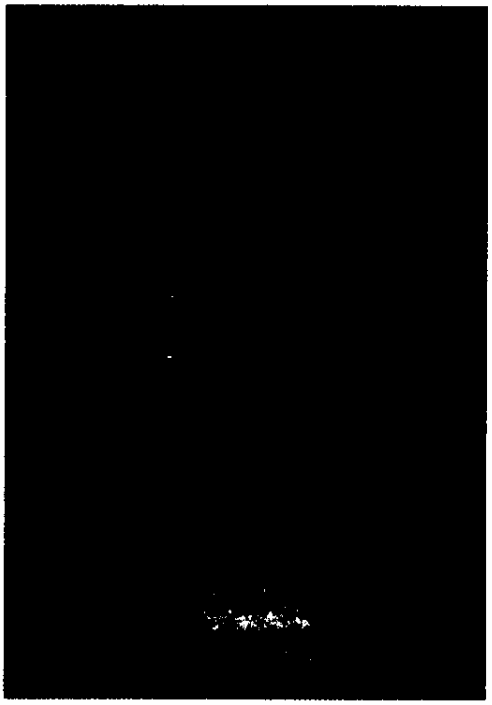
Gymnosperm-dominated forests in the Valdivian rain-forest zone principally contain *Fitz-roya cupressoides* (Cupressaceae), which occurs discontinuously on the Coastal Cordillera from 39°50'S to 43°30'S and in the Andes from 40°S to 43°30'S. *Araucaria araucana* (Araucariaceae) forests appear only at the northern end of the rain-forest zone in the Andean Cordillera, whereas *Pilgerodendron* sometimes becomes dominant on swampy sites. Important variants of *Fitz-roya* forest include *Fitz-roya–Nothofagus betuloides* forest on upland slopes with winter snow; *Fitz-roya–Nothofagus nitida* forest on gentle slopes with over 4500 mm annual precipitation; *Fitz-roya–Pilgerodendron* forest on saturated soil on level marine terraces; marginal mixed forests at lower elevations in the Coastal Cordillera with such species as *Weinmannia trichosperma*, *Drimys winteri* and *Nothofagus nitida*; and upland forest in the Coastal Cordillera with strong dominance of *Fitz-roya* (Donoso *et al.* 1993).

In the Andes, the evergreen angiosperm and mixed angiosperm-gymnosperm forests are eventually succeeded by predominantly deciduous forests comprised of *Nothofagus pumilio* and *N. antarctica*. A dense understorey of *Chusquea* spp. and typical shrub species (e.g. *Drimys andina*) usually prevails to treeline.

In the northern portion of the evergreen rain-forest zone, *Nothofagus betuloides*, more characteristic of the Magellanic rain forest, may also occur at treeline. East of the Andes below the deciduous forest belt, the rain forest is floristically impoverished; important species include *Nothofagus dombeyi*, *Saxegothaea conspicua*, *Laureliopsis philippiana* and *Podocarpus nubigena* (Dimitri and Correa 1966–1967). The *Podocarpus* intergrades into a band of *N. dombeyi* dominated forest subtended by drier *Austrocedrus chilensis* forest, which eventually intergrades with Patagonian steppe (see CPD Site SA46). Small areas of *Fitz-roya* and *Pilgerodendron* forest continue to appear on the eastern side of the Andes.

North Patagonian (43°20'S–47°30'S) and Magellanic (47°30'S–55°30'S) rain forests represent successively floristically impoverished and structurally simpler versions of the Valdivian rain forest. The North Patagonian rain forest occurs principally in heavily glaciated fjords and on numerous coastal islands on very thin glacial soils and exposed rock surfaces. The tree species typical of low-elevation Valdivian rain forest such as *Eucryphia cordifolia*, *Aextoxicon punctatum*, *Nothofagus*

CPD Site SA45: Temperate rain forest of Chile. Valdivian cool-temperate rain forest along the coast, in the Los Lagos (X) Region of Chile. Photo: Adriana Hoffmann.



CPD Site SA45: Evergreen cool-temperate rain forest ("tipo chilote"); dominant species are *Nothofagus nitida*, *N. betuloides*, *Weinmannia trichosperma* and *Fitz-roya cupressoides*. Photo: Adriana Hoffmann.

alpina, *Dasyphyllum diacanthoides* and *Laureliasempervirens* are reduced in importance or absent, leaving such dominants as *Notbofagus dombeyi*, *Weinmannia trichosperma* and *Saxegothaea*, with abundant *Maytenus magellanica*, *Podocarpus nubigena* and *Drimys winteri*. Epiphytic ferns and frondose lichens are especially abundant, as are *Chusquea* spp. in the understorey. The Magellanic rain forest develops on thin podzolized soils of fluvioglacial origin. The northern *Notbofagus dombeyi* is replaced by the vicariant *N. betuloides*; *Pseudopanax laetevirens*, *Maytenus magellanica* and *Podocarpus nubigena* become very abundant and *Chusquea* disappears. A plentiful herbaceous and shrubby understorey appears under the shorter and more open crowns (Arroyo *et al.* 1996).

On poorly drained coastal sites throughout the North Patagonian and Magellanic rain-forest zones, swamp forests with *Tepualia* and *Pilgerodendron* continue to occur. In spite of its high-latitude position, six species of vines/climbing shrubs may be found in Magellanic rain forest, constituting some of the world's highest latitudinal records for climbing plants: *Campsidium valdivicum*, *Griselinia ruscifolia*, *Lebetanthus myrsinites*, *Luzuriaga polyphylla*, *Philesia magellanica* and *Mitraria coccinea*.

Flora

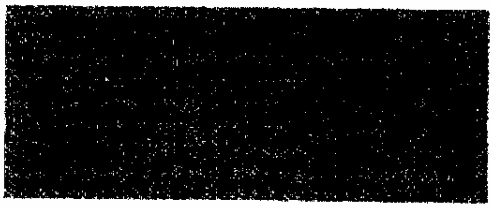
Southern South American cool-temperate rain forest has a rich flora with a predominance of angiosperms and diverse life forms. Factors that have influenced its present taxonomic composition include: (1) a long-standing Gondwanan connection, which involved South America, Antarctica and other southern continents throughout the Cretaceous and Early to Mid Tertiary; (2) direct vegetational continuity between southern South America and tropical latitudes of South America in the Tertiary; (3) the present-day high climatic equability; and (4) relatively recent differentiation of a Mediterranean-type climate to the north of the rain-forest region. These features together have resulted in a rain-forest flora with unusually high generic richness and a high degree of relictual regional endemism.

Arroyo *et al.* (1996) estimated that the true rain-forest flora – those taxa occurring in or under the rain-forest canopy or within its immediate influence – comprises some 205 genera in 96 families, which includes 82 genera of woody plants in 50 families. At least one-third of the woody genera are of southern Gondwanan origin, with their nearest extant or fossil relatives in the general region of Australia, New Zealand, New Caledonia and New Guinea – such as *Aristotelia* (Elaeocarpaceae); *Caldcluvia* (Cunoniaceae); *Discaria* (Rhamnaceae); *Eucryphia* (Eucryphiaceae); *Gevuina*, *Lomatia* (Proteaceae); *Notbofagus* (Fagaceae); and *Pseudopanax* (Araliaceae). One-quarter of the woody genera have neotropical affinities, with their nearest congeners in the northern Andes or in south-eastern Brazil/north-eastern Argentina-Uruguay – such as *Antidaphne* (Eremolepidaceae), *Azara* (Placourtiaceae), *Crinodendron* (Elaeocarpaceae), *Dasyphyllum* (Asteraceae), *Myrceugenia* (Myrtaceae), *Rhaphithamnus* (Verbenaceae) and *Tristerix* (Loranthaceae).

Most outstandingly, a third of the woody genera and one family (Aextoxicaceae) are endemic to the southern temperate area of Chile and Argentina (including Mediterranean-climate scrublands). Important monotypic regionally endemic genera occurring in the rain forest include *Fitz-roya*, *Pilgerodendron* (Cupressaceae); *Saxegothaea* (Podocarpaceae); *Laureliopsis* (Monimiaceae); *Lebetanthus* (Epacridaceae); *Embothrium* (Proteaceae); *Tepualia* (Myrtaceae); *Desmaria*, *Notanthera* (Loranthaceae); *Aextoxicon* (Aextoxicaceae); *Latua* (Solanaceae); *Asteranthera*, *Sarmienta*, *Mitraria* (Gesneriaceae); *Campsidium* (Bignoniaceae); and *Lapageria*, *Philesia* (Philesiaceae). Close to 80% of the regionally endemic genera are monotypic (Arroyo *et al.* 1996). Such monotypic genera, by in large, represent ancient relictual taxa that were more widely distributed over southern South America in the Tertiary and have survived in the cool and equable coastal climatic conditions present today. The high concentration of relict endemic genera in this rain forest is analogous to the many palaeoendemic genera on some islands (Axelrod, Arroyo and Raven 1991).

Only two woody endemic genera (*Fitz-roya* and *Pilgerodendron*) are totally restricted to the rain-forest habitat. The majority of the regional endemics also occur farther north in the sclerophyllous forest in the Mediterranean-climate region, which together with the rain forest forms the more natural biogeographic province.

Although the flora of the general rain-forest area is fairly well known (Dimitri 1972), knowledge has only been recent on the total species richness for the rain-forest habitat (species in or under the forest canopy or within its immediate influence). South of 40°S, the vascular plant flora in Chile is estimated to total c. 1300 species (Arroyo, unpublished). A conservative estimate suggests that close to 450 vascular plant species may be found in the cool-temperate rain forest (Arroyo *et al.* 1996).



Probably close to one-third of all the species of vascular plants in southern Chile thus depend to some extent on the rain-forest habitat. The woody rain-forest flora comprises c. 160 species; 44 are mostly evergreen trees, 81 shrubs and 35 vines. Herbaceous species number close to 300, of which 31 are epiphytes – mainly hymenophyllaceous ferns. Nonetheless, many herbaceous species are only occasional in the rain forest. Estimates of species richness are unavailable for the lichen and moss floras which are poorly known, but the region is very rich in lichens (Galloway 1992).

Strong reductions in species richness are seen in comparing the succession of rain-forest types along the latitudinal gradient (Arroyo *et al.* 1996). Maximum tree-species richness is at 40°–41°S, where degradation of the forest is most intense. Around 45°S, an area under imminent threat due to recent construction of penetration routes, the rain forest has some 20 species of trees and a rich vine flora. The largest woody family is Myrtaceae (15 spp.); the largest tree genus is *Notbofagus* (Fagaceae) (7 spp.); followed by *Lomatia* (Proteaceae) (3 spp.); and then *Podocarpus* (Podocarpaceae), *Amomyrtus* and *Myrceugenia* (Myrtaceae) and *Maytenus* (Celastraceae) (2 spp. each).

Total species richness in the Chilean cool-temperate rain forest far exceeds that reported in the much smaller area of such rain forest in Tasmania (Jarman, Kantvilas and Brown 1991). However since the sizes are very distinct for the regions compared, it cannot as yet be ascertained whether South American cool-temperate rain forest is intrinsically richer. Greater richness, however, is evident in comparison with the cool-temperate rain forest of the Pacific Northwest of the U.S.A., where there are far fewer species present in an area of about twice the size (Alaback, pers. comm.).

A very large proportion of the woody species occurring in southern South American rain forest, and many of the herbaceous species, are endemic to southern South America. Relatively few species in the rain forest are entirely restricted to the rain-forest habitat, as defined climatically. The low rain-forest endemism reflects the very gradual ecotone between the Mediterranean sclerophyllous forest and the rain forest, with many species being in both vegetation types. The following trees may be considered restricted to the rain forest: *Nothofagus nitida*, *Fitz-roya*, *Crinodendron bookerianum* and *Pilgerodendron*, and *Podocarpus nubigena* is almost restricted to it. Among shrubs, *Baccharis elaeoides* (Asteraceae) and *Latua pubiflora* are endemic to the rain-forest zone, although they also are found in non-forest habitats. Other virtually endemic rain-forest species occurring in the rain forest and/or adjacent vegetation types in the rain-forest zone include *Blechnum corralense* (Blechnaceae); *Megalastrum spectabile* var. *philippianum* (Dryopteridaceae); *Gleichenia litoralis* (Gleicheniaceae); *Hymenophyllum quetribuense*, *H. umbratile* (Hymenophyllaceae); *Anemone bepaticifolia* (Ranunculaceae); *Viola corralensis* (Violaceae); *Loasa acerifolia* (Loasaceae); *Valdivia gayana* (Saxifragaceae); *Misodendrum macrolepis* (Misodendraceae); *Erctila syncarpellata* (Apocynaceae); *Cynanchum lancifolium* (Asclepiadaceae); *Lobelia bridgesii* (Campanulaceae); *Uncinia negeri* (Cyperaceae); *Dioscorea cissophylla* (Dioscoreaceae); and *Arachnitis quetribuensis* (Corsiaceae). Although *Gaultheria antarctica* (Ericaceae) and *Tapeinia pumila* (Iridaceae) are endemic to the general region and occur in rain forest, they are more typical of alpine or moorland habitats.

To these species can be added many more that occur only marginally outside the rain-forest area, such as *Philesia magellanica*, *Hymenophyllum nabuelbuapense*, *Griselinia racemosa*, *Lebetanthus myrsinites* and *Gunnera lobata*, and a number of species virtually restricted to the rain forest that appear again on the Juan Fernández Islands – *Hymenophyllum cuneatum*, *Trichomanes exsectum*, *Serpyllopsis caespitosa* (Hymenophyllaceae); and *Peperomia nummularioides* (Piperaceae). The above-mentioned endemics have their greatest concentration in the Coastal Cordillera around latitudes 40°–42°S, which on palynological grounds is considered to have provided an important refugium for rain-forest species in the Pleistocene (Villagrán 1990). This area undoubtedly should be an important focus for conservation efforts.

There are no records of plant species extinct within historic times. The most threatened species are *Araucaria araucana* and *Fitz-roya cupressoides*. They are the largest trees in Chile and the most valued for their wood. *Araucaria araucana* (Chilean population), *Fitz-roya* and *Pilgerodendron* are in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and *Fitz-roya* is listed as threatened (i.e. IUCN Vulnerable) under the U.S. Endangered Species Act (which additionally controls import of its wood into U.S.A.).

Other species in the rain forest are considered to be variously threatened: among the endangered are *Pitavia punctata*, *Berberidopsis corallina* and *Valdivia gayana*; those vulnerable include *Austrocedrus chilensis*, *Persea lingue*, *Laurelia philippiana* and *Nothofagus alpina*; and those rare include *Citronella mucronata*, *Corynabutilon ochsenii*, *Eucryphia glutinosa*, *Hebe salicifolia*, *Lobelia bridgesii*, *Maytenus chubutensis*, *Myrceugenia colchaquensis*, *M. leptospermoides*, *M. pinifolia*, *Orites myrtoidea*, *Prumnopitys andina*, *Ribes integrifolium*, *Satureja multiflora*, *Schinus marchandii* and *Scutellaria valdiviana*.

Useful plants

Fitz-roya cupressoides ("alerce") is used for construction of various kinds. Because the wood is unaffected by heat and humidity, it has been the most valued Chilean native timber. The wood is used for musical instruments, shingles and light carpentry; the inner bark for ship caulking; and the resin is burned as incense (Bernath 1937). The wood of *Araucaria araucana* is used in construction of ceilings, floorings, furniture and pulp. *Nothofagus* species are all-purpose timbers used for furniture components, cabinet work, flooring and millwork.

Social and environmental values

The region supports one of the oldest and largest tree species in the world, *Fitz-roya cupressoides* – documented at living more than 3600 years (Lara and Villalba 1993). These temperate rain forests have high generic richness, an outstanding percentage of regionally endemic genera (Arroyo *et al.* 1996), and a preponderance of biotic interactions for pollination and dispersal (Riveros 1991; Riveros, Humaña and Lanfranco 1991; Armesto and Rozzi 1989).

In addition to being home to a high diversity of important plant species, the temperate rain forest provides essential habitat for numerous bird species and more than 35 mammal species (other than bats and marine mammals), including the puma and other cats, as well as two species of endangered deer, the huemul (*Hippocamelus bisulcus*) and the pudú (*Pudu pudu*) – one of the smallest deer in the world (Gilroy 1992). The endangered river otter (*Lutra provocax*) has been reduced to remnant populations in Andean streams of the Valdivian rain-forest zone. In addition, habitat destruction in the Valdivian forest is threatening the poorly known marsupials *Dromiciops* and *Rhyncholestes* (Veblen, Schlegel and Oltremari 1983).

Scientific botanical exploration was begun in 1782 by naturalist Juan Ignacio Molina, who published the first works on the Chilean flora to include species from the northern portion of the rain forests. Presently the Universidad de Concepción, Universidad Austral de Chile in Valdivia and Corporación Nacional Forestal (CONAF) are involved in scientific research on this region.

Threats

Historically, exploitation was not prevalent until the mid 16th century when the Spanish arrived. Forests were destroyed as the land was cleared for settlements and agriculture, and trees were cut for construction materials and fuelwood. Severe destruction did not take place until the 19th century – considered one of the most massive deforestations recorded in Latin America (Veblen, Delmastro and Schlatter 1976) – when colonists began occupying the lower slopes and progressively moved higher. Only 25% of Chile's original area of native forests may be intact (Armesto and Smith-Ramírez 1994).

Present threats are logging, clearing, afforestation, fire, agriculture and grazing. The average rate of deforestation in Chile in the 1980s was 500 km² per year, c. 0.7% of the remaining total annually (Ormazábal 1993).

Although fire was at one time the most destructive force, that has lessened considerably. Regeneration of *Fitz-roya* is helped by light burning, but extensive cutting and burning like that which occurred during the colonization of southern Chile inhibits or prevents regeneration. At one time Alerce National Monument preserved more burned and logged forest than primary forest.

Over the past 15 years many of Chile's rain forests have been clear-cut to satisfy foreign demands for timber and woodchips. Today logging of the Valdivian forest for woodchips and fuelwood for industrial and home uses is without doubt the major threat to the integrity of these temperate rain forests. In 1990 native species produced 52% of the woodchips exported and 20% came from natural old-growth forests (Barnett 1992). Wood of short fibres is used to produce the chips, such as from species of *Nothofagus*, *Eucryphia*, *Aextoxicon*, *Weinmannia* and *Laurelia*.

Considered the most valued timber in Chile, *Fitz-roya* has been exploited commercially since the late 16th century (Veblen and Ashton 1982). Due to its durability and resistance to fungal and insect attacks, it has played an important role in Chile's economy. In 1976, the species itself was declared a National Monument, a decree that prohibits the cutting of live trees. Although some logging has stopped, illegal extraction persists (cf. Veblen and Ashton 1982).

Clear-cutting is destructive to the rain forest, and another devastating factor is its replacement with vast monocultural plantations of the exotic *Pinus radiata*. Areas of extensive exploitation are in the provinces Valdivia, Cautín and Malleco, where 60% of the country's timber is produced. To some extent this has relieved pressure on harvesting primary forest; however, the risk of epidemic diseases and soil changes due to rotation of the plantations pose real threats.

The most recent threat to Chilean rain forest is in the southernmost forests, including areas as far south as Tierra del Fuego. Timber companies from Canada (British Columbia) and a joint Chilean-Japanese firm have purchased several large tracts to set up logging operations for woodchips production (Gilroy 1992).

Although 40 national areas are protected legally, many undergo illegal logging and grazing.

Conservation

There are 25 National Parks, 14 National Reserves and one National Monument in the region (WCMC 1992). Several National Parks are quite extensive, such as Laguna San Rafael NP with 17,420 km². One of the important parks is Alerce Andino NP (established in 1982), which protects *Fitz-roya* (alerce) and other important rain-forest species, such as *Nothofagus* spp. The amount of forest included in protected areas throughout Chile is estimated to be less than 15,000 km² (Ormazábal 1992) and possibly as low as just over 10,000 km² (Armesto and Smith-Ramírez 1994).

References

Alaback, P.B. (1991). Comparison of temperate rainforests of the Americas. *Rev. Chilena Hist. Nat.* 64: 399–412.

Armesto, J.J. and Rozzi, R. (1989). Seed dispersal syndromes in the rainforest of Chiloé: evidence for the importance of biotic dispersal in a temperate rainforest. *J. Biogeography* 16: 219–226.

Armesto, J.J. and Smith-Ramírez, C. (eds) (1994). Propuesta de la Sociedad de Ecología de Chile respecto al Proyecto de Ley: "Recuperación del Bosque Nativo y de Fomento Forestal". *Noticiero Biol.* 2(1): 2–8.

Arroyo, M.T. Kalin, Riveros, M., Peñaloza, A., Cavieres, L. and Faggi, A.M. (1996). Phytogeographic relationships and regional richness patterns of the cool temperate rainforest of southern South America. In Lawford, R.G., Alaback, P.B. and Fuentes, E.R. (eds), *High latitude rainforests and associated ecosystems of the west coast of the Americas: climate, hydrology, ecology and conservation*. Springer-Verlag, Heidelberg, Germany. Pp. 134–172.

Axelrod, D.I., Arroyo, M.T. Kalin and Raven, P.H. (1991). Historical development of temperate vegetation in the Americas. *Rev. Chilena Hist. Nat.* 64: 413–446.

Barnett, A. (1992). Vanishing worlds of temperate forests. *New Scientist* 1846: 10.

Bernath, E.L. (1937). Coniferous forest trees of Chile. *Tropical Woods* 52: 19–26.

Dimitri, M.J.L. (ed.) (1972). *La región de los bosques andino-patagónicos: sinópsis general.* Instituto Nacional de Tecnología Agropecuaria (INTA), Col. Científ. 10. Buenos Aires. 381 pp.

Dimitri, M.J.L. and Correa, H. (1966–1967). La flora andino-patagónica. Estudio filosociológico de una comunidad edáfica entre Puerto Blest y Laguna Frías, del Parque Nacional Nahuelhuapi. *Anales Parques Nacionales* 11: 5–39.

Donoso, C., Escobar, B. and Urrutia, J. (1985). Estructura y estrategias regenerativas de un bosque virgen de Ulmo (*Eucryphia cordifolia* Cav.) – Tepa (*Laurelia philippiana* (Phil.) Looser) en Chiloé, Chile. *Rev. Chilena Hist. Nat.* 58: 171–186.

Donoso, C., Sandoval, V., Grez, R. and Rodríguez, J. (1993). Dynamics of *Fitzroya cupressoides* forests in southern Chile. *J. Vegetation Sci.* 4: 303–312.

Galloway, D.J. (1992). Lichens of Laguna San Rafael, Parque Nacional "Laguna San Rafael", southern Chile: indicators of environmental change. *Global Ecol. Biogeogr. Letters* 2: 37–45.

Gilroy, S. (1992). Disturbing the ancients. *Buzzworm* 4(1): 38–43.

INFOR (1991). *Estadísticas forestales 1990.* Bol. Estadística No. 21. Instituto Forestal (INFOR), Santiago.

Irwin, J.J. (1989). A note on Jurassic and early Cretaceous alkaline magmatism in the Coastal Cordillera of central Chile (30°30'–34°S). *J. South Amer. Earth Sciences* 2: 305–309.

Jarman, S.J., Kantvilas, G. and Brown, M.J. (1991). *Floristic and ecological studies in Tasmanian rainforest.* Tasmanian NRCP Report No. 3. 67 pp.

Kellogg, E. (ed.) (1993). *Coastal temperate rain forests: ecological characteristics, status and distribution worldwide.* A working manuscript, July 1993. Ecotrust and Conservation International, Occasional Paper Series No. 1. Portland, Oregon and Washington, D.C. 64 pp.

Lara, A. and Villalba, R. (1993). A 3620-year temperature record from *Fitzroya cupressoides* tree rings in southern South America. *Science* 260: 1104–1106.

Martínez, O. (1981). Flora and phytosociological description of a relict of *Pilgerodendron uvifera* (D. Don) Florin in the San Pablo de Tregua farm (Valdivia-Chile). *Bosque (Valdivia)* 4: 3–11.

Oberdorfer, E. (1960). *Pflanzensoziologische Studien in Chile.* Tüxen, R. (ed.), Flora et Vegetatio Mundi II. Verlag J. Cramer, Weinheim, Germany. 208 pp.

Ormazábal, C.S. (1992). Bosques naturales en Chile: ¿Cuánto privado? ¿Cuánto estatal? *Ambiente y Desarrollo (Chile)* 8: 38–41.

Ormazábal, C.S. (1993). The conservation of biodiversity in Chile. *Rev. Chilena Hist. Nat.* 66: 383–402.

Pérez, C. and Villagrán, C. (1985). Distribución de abundancias de especies de bosques relictos de la zona mediterránea de Chile. *Rev. Chilena Hist. Nat.* 58: 157–170.

Pisano, E. (1977). Fitogeografía de Fuego-Patagonia chilena. I. Comunidades vegetales entre las latitudes 52° y 56°S. *Anales Instituto Patagonia (Chile)* 8: 121–250.

Ramírez, C. (1968). Die Vegetation del Moore del Cordillera Pelada, Chile. *Bericht Oberhess. Gesellschaft für Natur- und Heilkunde zu Gieben, Neue Folge, Naturwissenschaftliche Abteilung* 36: 95–101.

Ramírez, C., San Martín, C., Figueroa, H., MacDonald, R. and Ferrada, V. (1991). Estudios ecosociológicos en la vegetación de los ñadis de la Décima Región de Chile. *Agro Sur* 19: 34–47.

Riveros, M. (1991). *Biología reproductiva en especies vegetales de dos comunidades de la zona templada del sur de Chile, (40°S).* Ph.D. thesis, Universidad de Chile, Santiago. 301 pp.

Riveros, M., Humaña, A.M. and Lanfranco, D. (1991). Actividad de los polinizadores en el Parque Nacional Puyehue, X Región, Chile. *Medio Ambiente* 11(2): 5–12.

Ruthsatz, B. and Villagrán, C. (1991). Vegetation pattern and soil nutrients of a Magellanic moorland on the Cordillera de Piuchué, Chiloé Island, Chile. *Rev. Chilena Hist. Nat.* 64: 461–478.

Veblen, T.T. and Ashton, D.H. (1978). Catastrophic influences on the vegetation of the Valdivian Andes, Chile. *Vegetatio* 36: 149–167.

Veblen, T.T. and Ashton, D.H. (1982). The regeneration status of *Fitzroya cupressoides* in the Cordillera Pelada, Chile. *Biol. Conserv.* 23: 141–161.

Veblen, T.T. and Schlegel, F.M. (1982). Ecological review of the southern forests of Chile. *Bosque (Valdivia)* 4: 73–116.

Veblen, T.T., Delmastro, R.J. and Schlatter, J.E. (1976). The conservation of *Fitzroya cupressoides* and its environment in southern Chile. *Environm. Conserv.* 3: 291–301.

Veblen, T.T., Schlegel, F.M. and Oltremari, J.V. (1983). Temperate broad-leaved evergreen forests of South America. In Ovington, J.D. (ed.), *Temperate broad-leaved evergreen forests.* Ecosystems of the World Vol. 10. Elsevier, Amsterdam. Pp. 5–31.

Villagrán, C. (1990). Glacial climates and their effects on the history of the vegetation of Chile: a synthesis based on palynological evidence from Isla de Chiloé. *Rev. Palaeobot. Palynol.* 65: 17–24.

WCMC (World Conservation Monitoring Centre) (1992). *Protected areas of the world: a review of national systems.* Vol. 4: *Nearctic and Neotropical.* IUCN, Gland, Switzerland and Cambridge, U.K. 459 pp.

Authors

This Data Sheet was written by Dra. Mary T. Kalin Arroyo (Universidad de Chile, Facultad de Ciencias, Departamento de Biología, Casilla 653, Santiago, Chile) and Adriana E. Hoffmann-J. (Fundación Claudio Gay, Alvaro Casanova 613 - Peñalolén, Santiago, Chile).