

The Red List of Nothofagus

Harry Baldwin, Megan Barstow & Malin Rivers





BOTANIC GARDENS CONSERVATION INTERNATIONAL (BGCI) is the world's largest plant conservation network, comprising more than 500 botanic gardens in over 100 countries, and provides the secretariat to the IUCN/SSC Global Tree Specialist Group. BGCI was established in 1987 and is a registered charity with offices in the UK, US, China and Kenya.



IUCN/SSC GLOBAL TREE SPECIALIST GROUP (GTSG) forms part of the Species Survival Commission's network of over 7,000 volunteers working to stop the loss of plants, animals and their habitats. SSC is the largest of the six Commissions of IUCN – The International Union for Conservation of Nature. It serves as the main source of advice to the Union and its members on the technical aspects of species conservation. The aims of the IUCN/SSC Global Tree Specialist Group are to promote and implement global red listing for trees through the Global Tree Assessment and to act in an advisory capacity to the Global Trees Campaign.



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Back cover: *Nothofagus glauca* (Martin Gardner)

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Nothofagus

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Nothofagus alpina (Cristian Echeverria)

FOREWORD



Nothofagus antarctica (Arboretum Wespelaar)

A lack of conservation assessments for trees can limit the extent of conservation efforts directed to species most in need, causing trees to be missed out of important conservation legislation and forgotten in terms of funding opportunities. The Global Tree Assessment aims to produce conservation assessments for all the world's 60,065 tree species by 2020, providing essential information for the protection of tree species. *The Red List of Nothofagus*, along with 15 other Red List publications contributes to the completion of this ambitious initiative.

Nothofagaceae is a relatively small family containing 37 species of tree (and occasionally shrub), all in the genus *Nothofagus*. Despite the limited number of species in the Southern Hemisphere the group is ecologically significant. Across parts of South America and Oceania, *Nothofagus* have made up large tracts of forests, across various altitudes for centuries. However, many of these forests are now in decline due to anthropogenic threats; thus many species of *Nothofagus*

have become threatened with extinction in the wild. *Nothofagus* is a particularly good group for highlighting the variety of threats faced by tree species across the globe. It illustrates how threats to trees can evolve with time. For Nothofagaceae threats have changed over time from historical over exploitation for timber, to current pressures from land use conversion and into the future, the impacts of climate change.

One of the largest areas of *Nothofagus* forests is found in Chile. Here, *Nothofagus* species occur across a wide range of latitudes (32° to 56° S) and altitudes (0 to 2,500 m a.s.l). Since the Spanish conquest in the 16th century, *Nothofagus* forests have been cleared and over exploited. The only three *Nothofagus* species endemic to Chile are at risk of extinction due to historical expansion of agricultural land and, more recently, conversion to forest plantations of exotic species and recurrent forest fires in dry seasons. This risk of extinction suddenly increased for *N. alessandrii*, whose area of occupancy declined by 45% in only one event of forest fire in 2017.

The Red List of Nothofagus provides a unique opportunity to look at conservation efforts already in place for the group. Luckily, many *Nothofagus* species are found in protected areas. The *ex situ* survey of *Nothofagus*, finds twenty species of *Nothofagus* are held in botanic gardens, arboreta or seed bank collections but this does not include all threatened taxa. This will now become a conservation priority for the group, offering the most at risk species a lifeline into the future.

Due to the family's dominance in landscapes it is well understood in comparison to many other tree families. Having this knowledge helps us identify variation in threats which in turn informs the variety of vital conservation action needed to protect *Nothofagus* in the wild. The majority of *Nothofagus* were assessed as Least Concern only experiencing minor threats and no species were identified as Data Deficient. However, synergetic effects between stochastic (e.g. climate change and natural disasters) and deterministic (e.g. human-induced land change) factors can lead to an irreversible change in the threat status of many of them. Therefore, for *Nothofagus*, and in fact for all trees, every assessment counts, even for those that are not assessed as threatened. Where possible regional and taxonomic experts are encouraged to contribute this information and support the Global Tree Assessment, to improve our understanding of global tree species conservation.

Cristian Echeverría
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IUCN RED LIST CATEGORIES

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

LIST OF ACRONYMS

- BGCI** Botanic Gardens Conservation International
- CBD** Convention on Biological Diversity
- FFI** Fauna & Flora International
- GSPC** Global Strategy for Plant Conservation
- GTA** Global Tree Assessment
- GTC** Global Trees Campaign
- GTSG** Global Tree Specialist Group
- IUCN** International Union for Conservation of Nature
- SSC** Species Survival Commission



Collecting *Nothofagus cunninghamii*, Australia (Daniel Luscombe)

EXECUTIVE SUMMARY



Nothofagus alpina (Arboretum Wespelaar)

All *Nothofagus* species are native to the Southern Hemisphere, often forming the major component of forests in parts of Chile, Argentina, New Zealand, New Caledonia and Australia. Outside of these countries, species are also present in Papua New Guinea and Indonesia. Stands of *Nothofagus* trees can be several centuries old. Many species were historically important sources of timber and there is still some minor harvest for this purpose. *Nothofagus* are used for fuel wood and certain trees are popular in horticulture.

The *Red List of Nothofagus* contains IUCN Red List Assessments for all 37 species of *Nothofagus*, including 11 species (30%) threatened with extinction.

The island of New Guinea holds the greatest diversity of *Nothofagus* species. Species on this island are threatened by

restricted geographic range and population decline caused by deforestation. Australia is home to three species of *Nothofagus* and has the highest proportion of threatened taxa. This is due to the impact of climate change on all species and in particular, the increased mortality of *Nothofagus cunninghamii* due to Myrtle Wilt infection. In Chile, whilst non-native plantations have reduced the logging of *Nothofagus* forests, this has in turn increased threats such as natural fire and disturbance, resulting in further decline. Similarly, in New Caledonia, human land use change is threatening 40% of native *Nothofagus*.

An increase in both *in situ* and *ex situ* conservation is needed to protect all threatened *Nothofagus* and maintain the health of currently lower risk taxa. Currently 20 species of *Nothofagus* are held in *ex situ* collections, including 90 collections of

threatened taxa, representing six out of the 11 threatened species. However, none of the most threatened, Critically Endangered, species are reported from botanical collections. The species most frequently found in *ex situ* collections are those that are at less risk of extinction. It is essential that collections of threatened *Nothofagus* are made and that these collections are diverse and as genetically representative of the species in the wild as possible. Due to this, the family currently falls short of The Global Strategy for Plant Conservation Target 8 as fewer than 75% of threatened Nothofagaceae are in *ex situ* collections.

The *Red List of Nothofagus* identifies those *Nothofagus* species most at risk of extinction in the wild, highlighting the need to target conservation action to some 11 threatened taxa. A diverse array of conservation will be required to protect the species from the number of threats affecting them.



Nothofagus obliqua (Arboretum Wespelaar)

PART 1

BACKGROUND

Nothofagaceae is a family of deciduous and evergreen forest trees. The family is made up of 37 species, all in the genus *Nothofagus*. The genus has a disjunct Southern Hemisphere distribution. Species occur in South America (south-western Argentina and Chile), Australia (south-eastern Australia and Tasmania), New Zealand, Indonesia, Papua New Guinea and New Caledonia.

The group has an abundant fossil record. Both pollen and macrofossil records indicate that *Nothofagus* occurred throughout much of southern Gondwana before the breakup of the supercontinent. Since this time the change in climate and continental shift has led to pre-historic extinction of some *Nothofagus* species and has resulted in the reduction of the genus in comparison to a rich fossil history (Zamaloa and Berreda, 1992). The widespread distribution and excellent fossil record of *Nothofagus* has resulted in it being a key focus of Southern Hemisphere biogeographic research (Hill, 2001; Heenan and Smissen, 2013).

The genus is found in an array of different environments at varying altitudes; from sea level to 4,000 m dominating lowland, montane or subalpine forests, both in temperate and tropical habitats. Many *Nothofagus* (especially those from the tropics) can live for well over 500 years (Marshall and Beehler, 2011) and play an integral role in supporting the ecology and biodiversity of these forests. However, *Nothofagus* species and forests are at increasing threat from anthropogenic activities which are exacerbating natural decline in *Nothofagus* forests (See Case Study 1). Pressures from timber harvesting, plantations, pests and diseases, fire, grazing, perennial and non-timber crops and climate change are the current and immediate threats that are changing the dynamics of *Nothofagus* forest ecology and affecting the future of these species.



Nothofagus fusca (Arboretum Wespelaar)

Red List	Year published
The Red List of Endemic Trees and Shrubs of Ethiopia and Eritrea	2005
The Red List of Trees of Guatemala	2006
The Red List of Magnoliaceae	2007
The Red List of Oaks	2007
The Red List of Maples	2009
The Red List of Trees of Central Asia	2009
The Red List of Mexican Cloud Forest Trees	2011
The Red List of Rhododendrons	2011
A Regional Red List of Montane Tree Species of the Tropical Andes	2014
The Red List of Betulaceae	2014
The Red List of Magnoliaceae – revised and extended	2016
The Red List of US Oaks	2017
The Red List of Theaceae	2017
The Red List of <i>Fraxinus</i>	2018
The Red List of <i>Zelkova</i>	2018
The Red List of <i>Nothofagus</i>	2018

Table 1. Tree Red List reports produced by Botanic Gardens Conservation International in partnership with Fauna & Flora International, the Global Tree Specialist Group and others.

The *Red List of Nothofagus* addresses the need to evaluate the conservation status of *Nothofagus* trees and to contribute towards both Target 2 of the Global Strategy for Plant Conservation and the Global Tree Assessment (Box 1). It identifies those species most at risk of extinction in the wild and enables the direction of conservation effort towards these species. Prioritising the most at risk tree species is the first step in safeguarding threatened trees species as part of the Global Trees Campaign. This programme is a partnership between BGCI and Fauna & Flora International and over the last thirteen years 15 tree Red List publications (Table 1) have been produced which have guided the conservation of many at risk species. The *Red List of Nothofagus* will now inform these efforts for the genus.



Mixed Papua New Guinea forest including *Nothofagus pullei* (Timothy Utteridge)

Box 1: Global Tree Assessment (GTA)

There are about 60,000 tree species globally, but many of them have not had their conservation status assessed.

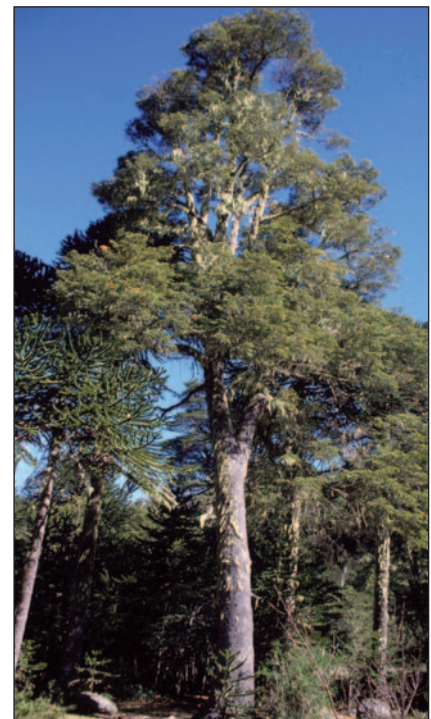


The Global Tree Assessment aims to provide conservation assessments of all the world's tree species by 2020.

Despite the importance of trees, many are threatened by over-exploitation and habitat destruction, as well as by pests, diseases, drought and their interaction with global climate change. In order to estimate the impact of such threats to trees there is an urgent need to conduct a complete assessment of the conservation status of the world's tree species – the Global Tree Assessment.

The Global Tree Assessment, led by BGCI and the IUCN SSC Global Tree Specialist Group, prioritises the tree species at greatest risk of extinction. The Global Tree Assessment provides information to ensure that conservation efforts are directed at the right species so that no tree species becomes extinct.

www.globaltreeassessment.org



Nothofagus dombeyi (Arboretum Wespelaar)

METHOD



Nothofagus obliqua, *N. alpina* and *N. domeyi* trees in Araucania region, Andes (Cristian Echeverría)

TAXONOMIC SCOPE AND CONCEPTS

This publication includes IUCN Red List assessments for all species in the genus *Nothofagus* s.l. and hence the family Nothofagaceae.

Nothofagus were originally classified in the genus *Fagus*; they were transferred to their own genus in 1850 and into their own family, Nothofagaceae, in 1962. Many authors and botanists have disagreed over the taxonomy and relationships of the group. A recent paper proposed that *Nothofagus* should be split into four genera (*Lophozonia*, *Fuscospora*, *Nothofagus* and *Trisyngene*). This proposal would create substantial taxonomic complications for fossil *Nothofagus* as well as difficulties in the use of the extensive current literature on

the genus. Therefore, it has not yet been widely adopted and is not followed here, but synonyms are given for threatened species in this report.

For this publication the taxonomic concepts followed are those reflected in The World Checklist of Selected Plant Families (WCSP, 2018), with the exception of *Nothofagus rutila*, where there is not sufficient information to establish if this is a species (C. Echeverría pers com. 2018). The genus consists of 37 species. Intraspecific taxa were not included, as the IUCN Red List of Threatened Species only accepts these conservation assessments if a species has also been assessed. Plant authority names follow those from The International Plant Names Index (IPNI, 2018).

CONSERVATION ASSESSMENT METHOD

For each species, information was collected on geographic distribution, population data, population trends, habitat and ecology, use and trade, threats, and conservation measures (in place and required). Information for the assessments was collated from published and unpublished sources including national and regional floras, scientific papers, published and unpublished reports, herbarium records, and expert knowledge. National red lists were consulted when available. For a full list of references used for each species, see the individual species Red List assessment available online at the IUCN Red List website (www.iucnredlist.org). A Red List category was then assigned to each species,

using all the available information and the 2001 IUCN Red List Categories and Criteria Version 3.1 (IUCN, 2012).

Species are assigned one of eight categories (Figure 1): Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) and Data Deficient (DD). Critically Endangered, Endangered and Vulnerable are the three threatened categories. Taxa that do not qualify for a threatened category, but are close to qualifying for or are likely to qualify for a threatened category in the near future, can be assigned to the category Near Threatened. Least Concern is used for species that are assessed but are not considered threatened including widespread species and rare but stable species. The use of the category Data Deficient may be assigned to poorly known taxa. In this report NT and LC are grouped as “Not Threatened”.

In order to assess whether a species belongs to a threatened category (CR, EN, VU) the species are evaluated in relation to five criteria: A) Population reduction; B) Geographic range; C) Small population size and decline; D) Very small or restricted population; and E) Quantitative analysis. The criteria are based on a set of thresholds and subcriteria. Extensive guidelines are available to facilitate the process for the conservation assessors (IUCN Standards and Petitions Subcommittee, 2017). Assessors evaluate taxa using all five criteria, but a taxon only needs to fulfil one of the five criteria to qualify for a threatened category. When several criteria are met resulting in different status assessments, the precautionary principle is applied and the most threatened category should be assigned (IUCN, 2012). It is recommended that species on the list are reevaluated at least once every 5-10 years (IUCN, 2012). Once completed and reviewed the

assessments are sent to the IUCN Red List for publication on the IUCN Red List of Threatened Species (IUCN, 2018).

All assessments in this report are completed to a global scale.

REVIEW AND EVALUATION

Wherever possible, expert opinions were sought for all species assessed. Sometimes experts carried out the conservation assessment for their own species (assessors), and sometimes they contributed data for the conservation assessment to be carried out (contributors). In accordance with IUCN Red List regulations, all assessments were also reviewed by a member of the Global Tree Specialist Group (reviewer).

For full details of the assessors, contributors and reviewers see the IUCN Red List of Threatened Species website (www.iucnredlist.org).

RED LIST REPORT FORMAT

This report lists all species with their authors, country distribution and the conservation assessment ratings. The threatened species are also listed with the rationale for the conservation assessment. All other information (including synonyms, full distribution information, habitat, ecology, conservation measures, threats and uses) are listed on the website for the IUCN Red List of Threatened Species 2018 (IUCN, 2018, www.iucnredlist.org).

The threatened (Critically Endangered, Endangered and Vulnerable) species are listed alphabetically in Part 2A.

The Near Threatened species are listed alphabetically in Part 2B.

The Least Concern species are listed alphabetically in Part 2C.

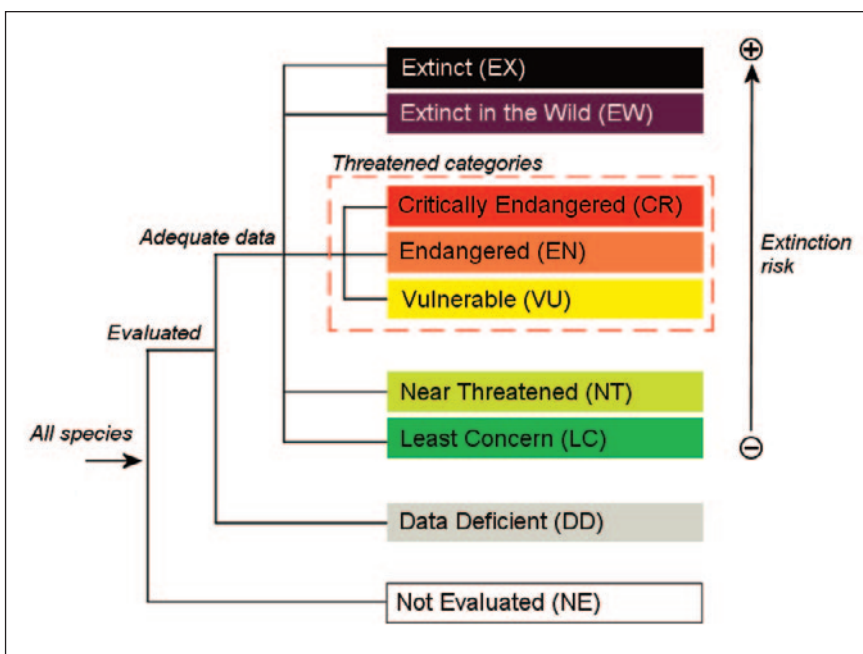


Figure 1. Structure of the IUCN Categories (version 3.1) (Credit: IUCN)

RED LIST RESULTS

THREAT STATUS OF *NOTHOFAGUS*

All 37 species of *Nothofagus* were assessed during this project. Globally, 11 species are listed as threatened (Critically Endangered, Endangered or Vulnerable) and 26 species are not threatened (Near Threatened or Least Concern) (Figure and Table 2). The percentage of threatened species is 30%.

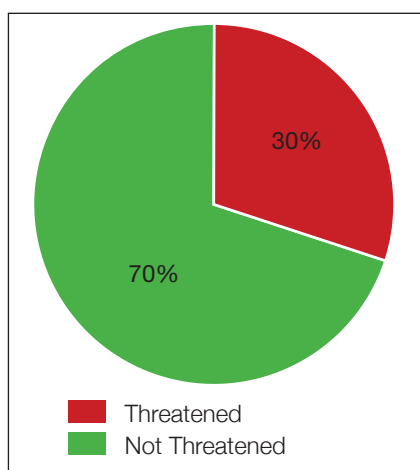


Figure 2. Summary of threat status of *Nothofagus*

CRITERIA USED

The majority of threatened *Nothofagus* are assessed using criterion B (Table 3), indicating these species are threatened due to their restricted range. The remaining threatened species were listed under criterion A, threatened by population declines. No species were assessed using criteria C or D, indicating that population size is difficult to estimate as this information is lacking for many tree species and also that *Nothofagus* are often abundant in their habitat. No species were assessed under criterion E.

COUNTRY ANALYSIS

Nothofagus species are distributed across seven countries in both temperate and tropical biomes. The centres of diversity are Papua New Guinea and Indonesia (14 species) and Chile and Argentina (10 species) (Figure 3). Twenty-two species (59%) of *Nothofagus* are single country endemics. The threatened species of *Nothofagus* are found in Australia, New Caledonia, Chile, Indonesia and Papua New Guinea (Figure 4).



Nothofagus pumilio (Arboretum Wespelaar)

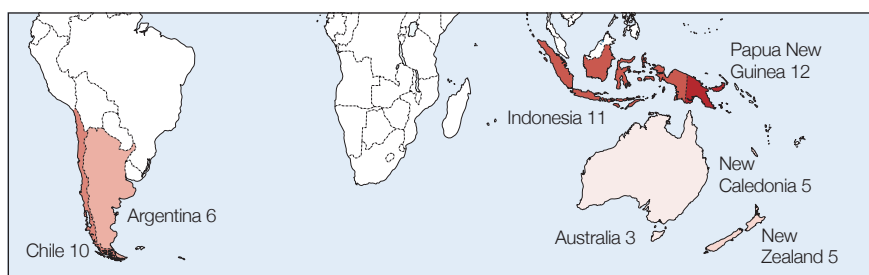


Figure 3. *Nothofagus* species richness per country

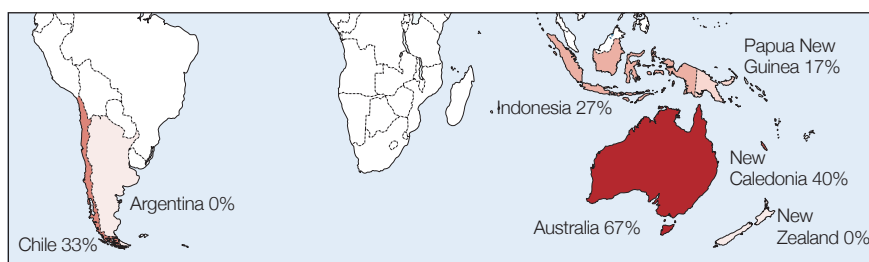


Figure 4. The percentage of threatened *Nothofagus* per country

IUCN Red List category	Number of species
Extinct	0
Extinct in the Wild	0
Critically Endangered	3
Endangered	3
Vulnerable	5
Near Threatened	4
Least Concern	22
Data Deficient	0
TOTAL	37

Table 2. The number of *Nothofagus* species in each IUCN Red List category

IUCN Red List category	Number of species
Criterion A	3
Criterion B	8
Criterion C	0
Criterion D	0
Criterion E	0

Table 3. The number of threatened *Nothofagus* conservation assessments using the five different Red List criteria.

MAJOR THREATS TO NOTHOFAGUS

The primary threat to *Nothofagus*, affecting two-thirds of all species, is deforestation and wood harvesting (Figure 5). This threat not only clears the habitat of many species, but directly removes *Nothofagus* trees from their environment. Historically this threat was much greater for species in New Zealand and Australia, pressure has eased in these countries but logging remains a threat to *Nothofagus* on New Guinea as well as, in other localities.

The second greatest threat to the group is modification of natural systems, such as an increase and alteration of fire regimes. This is a particular threat to the species in Chile, Australia and on New Guinea. It can be driven by climate change, development of plantations and habitat fragmentation. There is further unnatural disturbance from pollution and conversion of habitats to agriculture, road networks and other infrastructure developments. These activities fragment the habitat of the species and can reduce the ability for *Nothofagus* to regenerate as germination conditions deteriorate and land available for growth is reduced. Deforestation for agriculture is a major threat impacting both threatened and not threatened *Nothofagus*.

A growing threat to *Nothofagus* is climate change, where both habitat shifting, droughts and temperature extremes have been mentioned as major threats. This is of particular concern as *Nothofagus* exhibit poor dispersal ability and may not be able to adapt and migrate in response to a warming climate. Those species already at high elevations such as *Nothofagus baumanniae* are greatest at risk.



Nothofagus glauca (Martin Gardner)

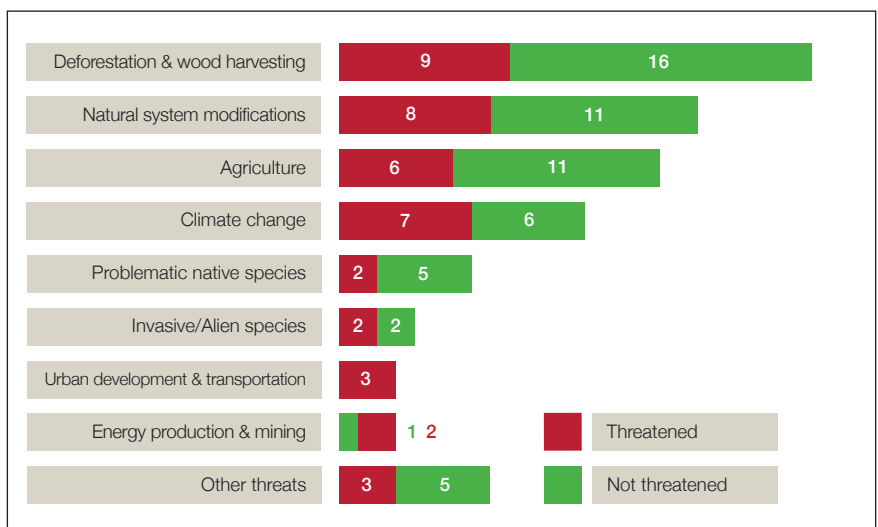


Figure 5. Threats to threatened and not threatened *Nothofagus* species

For more information on country specific threats see Case Study 1. For threats to individual species, see full species accounts on the IUCN Red List (www.iucnredlist.org).

POPULATION TRENDS

One third of *Nothofagus* species (12 species) are experiencing population decline, whilst only 16% of species (6 species) are considered to have a stable population. For more than half of the species (19 species), population trend is unknown (Figure 6).

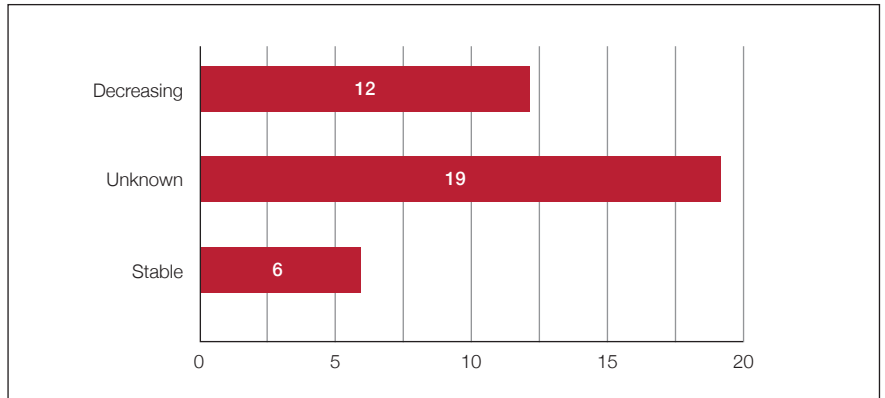


Figure 6: Population trends of *Nothofagus* species

USES

Two thirds of *Nothofagus* have an identified use. Seven uses of *Nothofagus* are recorded, including use for timber, which can be used in construction and the manufacture of household goods and handicrafts (Figure 7). The species can be further utilised for fibre and fuelwood. The genus also has some ornamental value, being used in horticulture. For more information on *Nothofagus* in cultivation see Case Study 2.

Twelve species (32%) have no recorded uses.

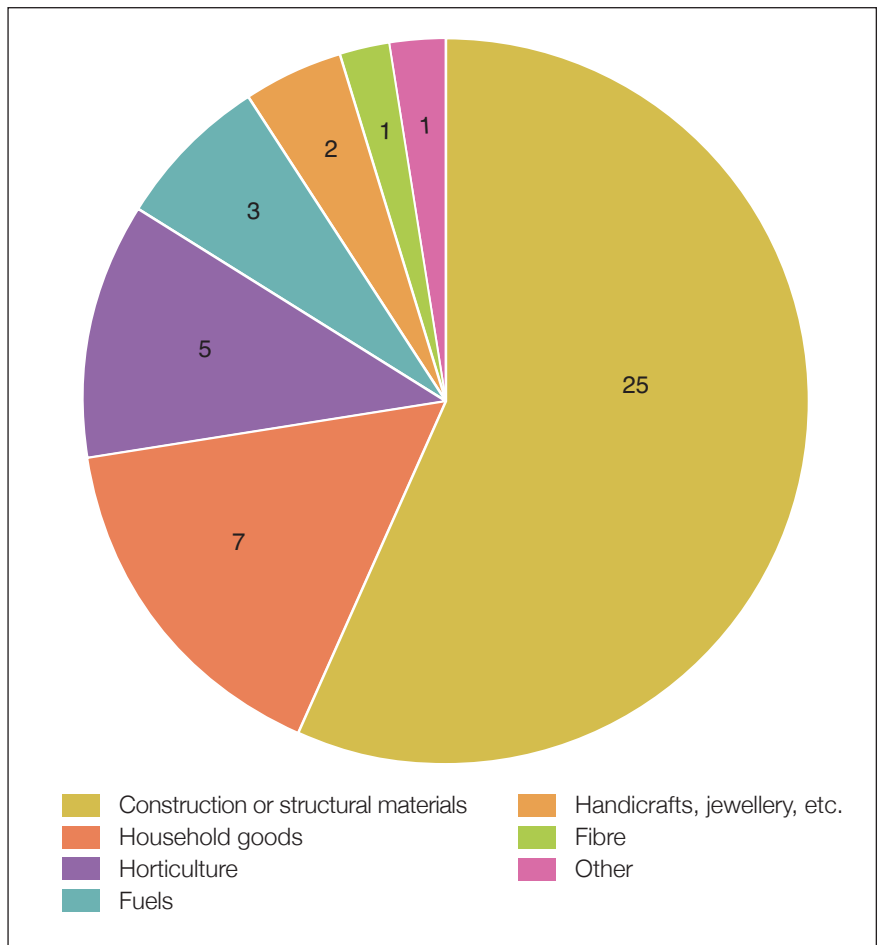


Figure 7: The recorded uses of *Nothofagus* species



Nothofagus pullei (Timothy Utteridge)

CASE STUDY 1: THREATS TO *NOTHOFAGUS*

NEW GUINEA

The island of New Guinea is home to 14 species of *Nothofagus* across Indonesia and Papua New Guinea. Despite the island's high floral diversity, there has been a paucity of botanical exploration in each country, leading to a limited understanding of both ecology and the specific threats to the flora.

Fire

One of the most significant threats to forests in Papua New Guinea is fire. Repeated burning eventually leads to dieback which allows invasion of common grasses such as *Imperata cylindrica*. Once grasses have established, this reduces the fertility of the soils, depletes the soil seed bank and changes the microclimate and ecology; therefore preventing further regeneration.

Logging and Agriculture

Traditionally *Nothofagus* have been harvested at low, subsistence volumes for both non-timber and timber products owing to the use of hand tools such as

stone axes. Locally, harvested wood is utilised for fuel and construction purposes. Since the 1950's, where greater mechanisation was brought onto the island, there has been a rapid increase in logging and commercial activities. An equally large threat to *Nothofagus* is the expansion of subsistence farming, with traditional agricultural activities occupying 20% of Papua New Guinean land surface. New clearings are left fallow and invasive grasses appear. For Papua New Guinea, a combination of these activities has meant that between 1972 and 2002, 15% of tropical forests have been cleared and 8.8% were degraded through logging. These threats are likely to continue into the future as much land is allocated for logging concessions as the island's human population continues to grow.

NEW CALEDONIA

Five species of *Nothofagus* are native to New Caledonia. They occur in the rainforest and upper montane regions of the island from 160 to 1,350 m. Here some species exhibit very narrow geographic

ranges (*N. baumanniae*), while others are present across the length of the island (*N. aequilateralis*). Currently there are over 50 nature reserves across New Caledonia, covering over 10% of the land area.

Logging and Agriculture

Rainforests in New Caledonia previously occupied a much larger range, decreasing from 70% of land area to 21.5% today. Remaining forest is fragmented and surrounded by agriculture and grasslands. With clearing of land, comes the greater occurrence of fire which invades the perimeter of *Nothofagus* forests. This increases the fragmentations of forests potentially increasing the inbreeding of *Nothofagus* and leading to a loss of genetic diversity. This is a particular threat to those species which already have a restricted range and small population size.

Climate Change

New Caledonian *Nothofagus* have a long history of persistence through periods of considerable climatic fluctuation which has been mirrored in changes and movements of many species geographical ranges.

Global warming coupled with anthropogenic threats may again displace these ranges. For *Nothofagus baumanniae*, already confined to the uppermost altitudes of New Caledonia, there is limited opportunity for migration.

Mining

The main economic income for the country is nickel which is heavily mined throughout New Caledonia, causing huge environmental impact to forests which are exposed to mining and mine spoils. New Caledonia produces half of the world's nickel, the development of these mines causes terrible soil erosion and has destroyed thousands of hectares of forest.



Threats from land clearing and grazing, Chile (Cristian Echeverría)

AUSTRALIA AND NEW ZEALAND

Nothofagus is the dominant genus of cool temperate rainforest trees in parts of Australia; in the states of Victoria, New South Wales and Tasmania. Three *Nothofagus* species are native to Australia and five species are native to New Zealand.

Logging

Nothofagus timber is used to make furniture, flooring and panelling. The greatest threat from logging occurred during the period of European colonisation in the 18th and 19th century. Historically *N. menziesii* was threatened by overexploitation and this activity led to the isolation of some stands, leading to its now patchy distribution in New Zealand. This pressure has now eased. Commercial logging of *Nothofagus* is now limited in Australia and New Zealand, but there is still harvesting of trees in Tasmania and from private estates. There is also some commercial cultivation and harvest of *N. cunninghamii*.

Fire

Fire remains the greatest threat to the survival of *Nothofagus* species in Victoria, New South Wales and Tasmania. Evidence suggests that many fires do not penetrate far into undisturbed rainforest, but repeated burning can lead to the establishment of more flammable vegetation. Fire is facilitated by disturbance to the *Nothofagus* canopy from pathogens, road construction and logging. Historically, both *N. cunninghamii* and *N. moorei* have suffered from fire but can regenerate and maintain populations albeit with loss of genetic diversity. Large areas of Tasmanian montane forest and woodland has been burnt in the last 50 years, and *N. gunnii* shows very little regeneration in these sites. This is partly due to the absence of surviving seed



Burned *Nothofagus alessandrii* trees, Chile (Cristian Echeverría)

trees and poor dispersability. New Zealand species are susceptible to fire which is occurring in greater frequency due to a warming climate.

Pests and Pathogens

Myrtle Wilt is a fungal disease which attacks, Australian endemic, *N. cunninghamii* caused by the hyphomycete pathogenic fungus *Chalara australis*. The disease is considered native to Australia, and *N. cunninghamii* is the only known naturally infected host. Following infection, the trees become susceptible to the tiny pin hole borer *Platypus subgranosus* which spreads the diseases further; risk to *N. cunninghamii* is greatest on sites of forest disturbance. In New Zealand, *Platypus* species can also affect native *Nothofagus* at times of stress. This is of growing concern due to the potential stress that increasing global temperatures is having on *Nothofagus*; resulting in a potential combined affect on mortality.

Introduced fauna particularly browsing animals (such as red deer, pigs and goats), alters *Nothofagus* forest structure and composition, all of which has an adverse impact on the regeneration of *Nothofagus* forests.

Climate Change

Climate change is likely to put *Nothofagus* forests under new stresses such as drought. In general, trees in the genus exhibit poor dispersal ability and therefore migration is likely to be slow, especially if species are intolerant of climatic stresses. Species such as *N. gunnii* and *N. moorei* which are already restricted to the coolest, most humid sites are both likely to become more fragmented as the climate changes, therefore making migration more difficult. In North Island, New Zealand, stands of *N. cliffortioides* have experienced dieback due to drier conditions. Climate change is having a compound affect making the



Border between Pine plantation and native *Nothofagus alessandrii* forest, Chile

(Cristian Echeverría)

species more susceptible to pests, as well as increasing mortality from fires and extreme cold events. Changing temperatures can reduce the viability of seed and make germination conditions unviable. This will further extend the time needed for these species to regenerate.

CHILE AND ARGENTINA

Chile and Argentina collectively encompass 11 species of *Nothofagus*, with five species endemic to Chile. In Chile and Argentina, all *Nothofagus* species are poorly represented in national parks and reserves. There is a need to develop larger sized reserves which encourage natural disturbances and the natural regeneration of the species.

Introduced Species

The introduction of deer to South America has impeded regeneration of *Nothofagus* species through browsing.

This has also been seen with the introduction of the European hare (*Lepus capensis*) and wild boars (*Sus scrofa*).

Logging and Deforestation

All *Nothofagus* species in South America are an important economic and ethnobotanical resource. Timber is used for a wide variety of purposes, including construction, structural materials, fuel, handicrafts, furniture and jewellery, all of which show an ongoing threat. However, the *Nothofagus* forests of Chile and Argentina have been subject to large destructive exploitation for timber and for non-native plantations. Beginning in the 1950's, areas planted with *Pinus radiata* in Chile have grown exponentially until recent years. Increased coverage by plantations also increases the occurrence of fire, as well as destroying *Nothofagus* forest. The remaining mosaic of plantations and forests, limits genetic exchange between *Nothofagus* stands and alters

the habitat so that germination is less favourable. It is hoped that the current scale of plantations is adequate to support paper and timber demand, so the threat to *Nothofagus* forests will be relieved.

By Harry Baldwin

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EX SITU SURVEY OF *NOTHOFAGUS*



Nothofagus pumilio (Arboretum Wespelaar)

An *ex situ* survey allows us to assess the coverage of species within botanic gardens, arboreta and seed banks. *Ex situ* collections provide an important back up to protect species from extinction. Using BGCI's PlantSearch database (Box 2), we analysed the presence of Nothofagaceae collections in botanic gardens, arboreta and seed banks across the world. *Nothofagus* trees are found in many European gardens and institutions in the Southern Hemisphere.

For this *ex situ* survey to inform conservation action, cultivar and hybrid records (downloaded 22.10. 2018) were excluded; infraspecific records were included and assigned to their appropriate

PlantSearch

BGCI's PlantSearch database is the only global database of plants in cultivation in botanic gardens and related institutions. It is available online and is free to access. Data included in PlantSearch is provided by *ex situ* collection holders and this data provides the basis for broader *ex situ* assessments, such as this survey. By uploading a taxa list to PlantSearch, collection holders not only contribute data to the global botanical community, but they can also assess the conservation value of their own collections, including the threat status and number of other *ex situ* collections each taxon is known from. BGCI encourages collection holders to upload up-to-date taxa lists on an annual basis to ensure accuracy and enhance usability of the data provided through PlantSearch.



www.bgci.org/plant_search.php

species. Collections held under synonyms were also included in the analysis. In total there are 449 records of Nothofagaceae species in collections, from 132 institutions in 29 countries (Table 4) (see Appendix 2 for a full list of institutions).

SPECIES FOUND IN EX SITU COLLECTIONS

Fifty-four percent (20 species) of *Nothofagus* are in *ex situ* collections. Of the threatened taxa, 45% (5 species) are in *ex situ* collections. Currently there are no Critically Endangered *Nothofagus* species recorded from *ex situ* collections (Figure 8). The seven threatened species currently not in *ex situ* collections should be brought into collections as a priority

(Table 5). Those species not in collections are found in Chile, New Caledonia, Papua New Guinea and Indonesia.

Target 8 of the Global Strategy for Plant Conservation calls for 75% of threatened plants to be held in *ex situ* collections (CBD, 2012), therefore *Nothofagus* (with 42%) falls short of this target. However, *Nothofagus* does perform better than trees on average, where a study in 2015 (Rivers *et al.* 2015) show that only a quarter of threatened trees are found in *ex situ* collections.

	2018 <i>ex situ</i> survey
Number of records	449
Number of institutions	132
Number of countries	29

Table 4. Summary statistics for *Nothofagus ex situ* survey.



Nothofagus macrocarpa (Martin Gardner)



Nothofagus nervosa (Arboretum Wespelaar)

Species	Red List Category
<i>Nothofagus baumanniae</i>	EN
<i>Nothofagus crenata</i>	VU
<i>Nothofagus discoidea</i>	EN
<i>Nothofagus glauca</i>	VU
<i>Nothofagus nuda</i>	CR
<i>Nothofagus stylosa</i>	CR
<i>Nothofagus womersleyi</i>	CR

Table 5. Threatened *Nothofagus* species not in *ex situ* collections

NUMBER OF EX SITU COLLECTIONS

Some *Nothofagus* are well represented in *ex situ* collections (Table 6). Others are found in fewer than ten collections, for example *Nothofagus grandis* is found in just one collection. Small numbers of *ex situ* collections are unlikely to capture the full genetic diversity of a wild population and therefore do not provide adequate material for restoration and reintroduction. Furthermore, the occurrence of a species in a single collection, at one institution does not give protection for threatened taxa against stochastic events. *Ex situ* collections for *Nothofagus* should be diverse and held at multiple institutions, for greatest conservation impact.

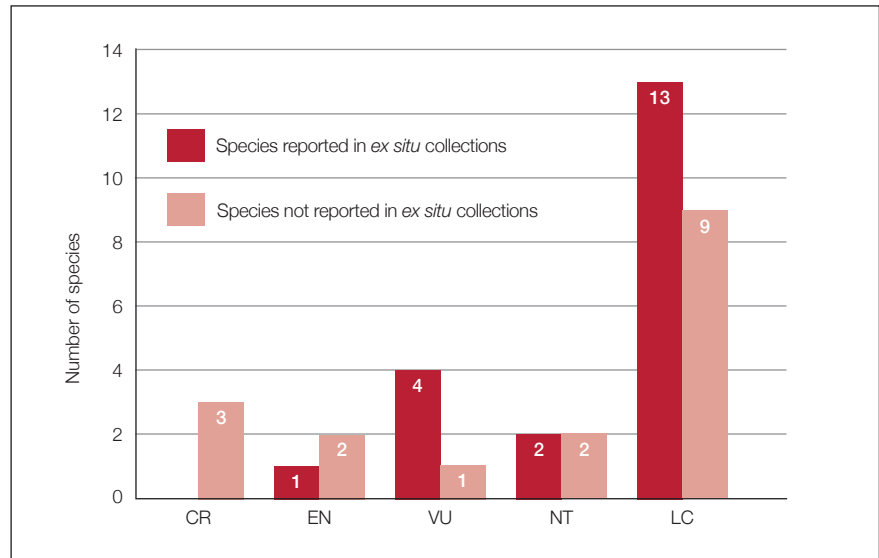
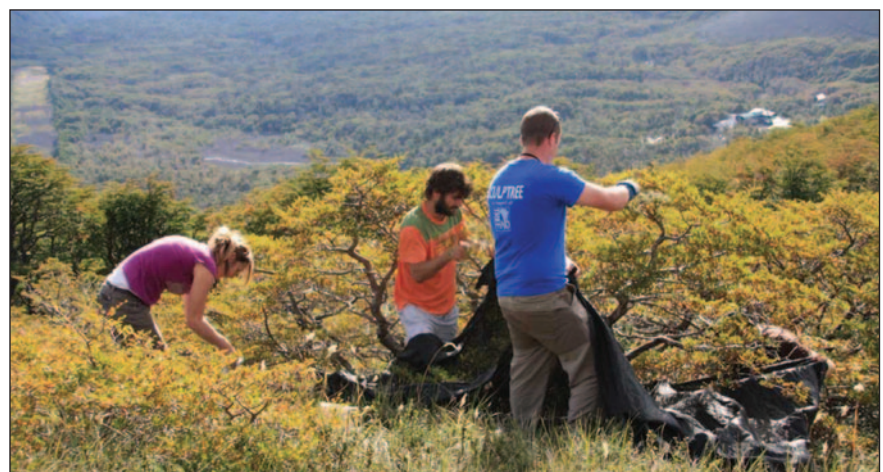


Figure 8. Presence and absence of *Nothofagus* species in *ex situ* collections per IUCN Red List Category.

Species	Number of <i>ex situ</i> collections	Red List Category
<i>Nothofagus antarctica</i>	86	LC
<i>Nothofagus obliqua</i>	66	LC
<i>Nothofagus alpina</i>	42	LC
<i>Nothofagus dombeyi</i>	35	LC
<i>Nothofagus cunninghamii</i>	28	VU

Table 6. *Nothofagus* species with the largest numbers of *ex situ* collections.



Nothofagus antarctica collecting, Chile (Daniel Luscombe)

CASE STUDY 2: *NOTHOFAGUS ALESSANDRII* IN CONSERVATION



Nothofagus alessandrii (Cristian Echeverría)

The Royal Botanic Garden Edinburgh's network of 'safe sites' established by the International Conifer Conservation Programme (ICCP), is also used to distribute known provenance plant material of threatened Chilean plant species. Included in this programme is one of the most threatened tree species of continental Chile - *Nothofagus alessandrii*. This very distinctive species was probably first introduced to cultivation in the British Isles in 1976 by

Lord Bradford and since this date cultivation has been restricted to a few specialist collections. Notable trees include one at Hergest Croft Arboretum (Herefordshire) which measured 22 m in 2013 and three closely planted trees at Plas Newydd Gardens (Anglesey) which are of a similar height.

Since this initial introduction, little new plant material has come from Chile, except those accessioned by the Royal

Botanic Gardens, Kew, Wakehurst and the Royal Botanic Garden Edinburgh. The ICCP plants originate from just two of the 15 known locations of *N. alessandrii* one of these sites, Piedra del Montaña, was severely affected by forest fires in 2017. To date, the ICCP, together with the help of Bedgebury Pinetum and The National Trust Conservation unit in Devon, has distributed 140 plants to 42 'safe sites'.

The establishment and cultivation of *N. alessandrii* in the British Isles is not entirely straight forward as trees can be susceptible to low winter temperatures - the warm temperate coastal forests of Chile, from where this species hails, has a minimum winter temperature of 6°C. The establishment in cultivation of trees in areas with sub-zero winter temperatures requires careful siting in locations with plenty of protection from cold winds but open to full sun. Freely drained, south-facing slopes are preferred sites.

Regular monitoring of planted trees within the ICCP's network of sites has given the first detailed recorded observations of growth rates in the formative years of *N. alessandrii* in cultivation. For example, a tree planted in 2008 at Bowood House in Wiltshire, is now just over 10 m tall. While a tree planted in Murthly Estate (Perthshire) in 2009 is now 5.3 m tall and one at the nearby Cluny Garden (Perthshire) planted in 2008 measures 4.2 m. The latter trees are very healthy but not surprisingly, the slower growth rates reflect the cooler weather conditions of Perthshire in Scotland. The intention is to continue to broaden the genetic base of *N. alessandrii* in cultivation by adding more material collected from across its natural range.

By Martin Gardner



Nothofagus alessandrii (Martin Gardner)



CONCLUSIONS AND RECOMMENDATIONS



Nothofagus antarctica (Cristian Echeverria)

POLICY RELEVANCE

The Red List of Nothofagus aims to inspire and encourage conservation action by prioritising those species most at risk of extinction. This publication also directly contributes to the Global Strategy for Plant Conservation Target 2, which calls for “an assessment of the conservation status of all known plant species, as far as possible, to guide conservation action” by 2020 (CBD, 2012). This Red List also contributes to the Global Tree Assessment, an initiative to assess the conservation status of all the world’s tree species by 2020 (Box 1). The Global Tree Assessment, led by BGCI and the IUCN SSC Global Tree Specialist Group, provides information to ensure that conservation efforts are directed at the right species so that no tree species becomes extinct.

Nothofagus are keystone species in many parts of their range, therefore the protection of these species is essential to the functioning of different forest habitats in the Southern Hemisphere. The genus has strong historical value as a preferential timber tree and is significant in understanding prehistoric environments and ecology due to its occurrence in the fossil record. It is therefore vital that *Nothofagus* are conserved.

RECOMMENDATIONS

Ensure threatened species of *Nothofagus* are protected both *in situ* and *ex situ*

- The threatened species that are not currently found in *ex situ* collections should be brought into collections as a priority.
- Genetic diversity should be considered when curating *ex situ* collections, particularly developing multiple collections of one species, which are diverse and held in different institutions.



Nothofagus pullei (Timothy Utteridge)

- Assess the extent to which *Nothofagus* species are contained within protected areas and the potential to expand these sites to include more species where possible.
- Develop integrated conservation action plans for the most threatened species.

Increase understanding of *Nothofagus* species in a changing world

- It would be valuable to further survey populations of *Nothofagus* across New Guinea, in particular those species, which are assessed as threatened to better understand population size and ecology.
- It is essential to monitor the species of *Nothofagus* assessed as Least Concern and Near Threatened as they may be experiencing slow decline. It should be ensured that this rate does not change and these populations are maintained.
- More research into the genus and its adaptability to climate change should be undertaken.

Raise awareness, build local capacity and mobilise action

- Use local nurseries to produce material for both conservation action and to ease the pressure on local wild populations.
- Build capacity in horticulture, propagation and conservation techniques to empower local partners and communities.

The Red List of Nothofagus provides a baseline for the status of *Nothofagus* species worldwide. It aims to provide information to prioritise conservation action to protect threatened *Nothofagus* species from extinction. Equally, it aims to inspire action to improve the conservation status of these species and promote the importance of this unique and interesting group of trees.

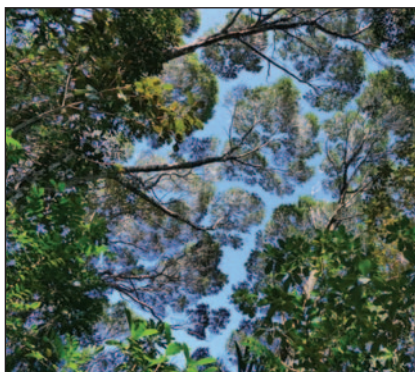
CASE STUDY 3: *NOTHOFAGUS* IN NEW CALEDONIA



Aenetus cohici female (Thierry Salesne)

A small island in the South Pacific, New Caledonia has been recognised as a global biodiversity hotspot for conservation priorities for over thirty years. It is home to almost 3,400 vascular plant species, of which ca. 75% are endemic with many cases of micro-endemism. New Caledonian *Nothofagus* are no exception, as all five species are endemic, and some, like *Nothofagus baumanniae* and *N. discoidea* are restricted to very small areas. Another microendemic and a sixth species of *Nothofagus* may even be present on the Tchingou massif, following further taxonomic observation and clarification.

Tall *Nothofagus* trees grow up to 20 m in height and occur in dense humid forest at low and medium altitudes. They have adapted well to serpentine soil, but can also be found on ferrallitic volcano-



Nothofagus aequilateralis (Benoît Henry)

sedimentary substrate. Thus, all New Caledonian *Nothofagus* are somewhat impacted by mining activities, one of three major threats to the territory's flora. Bushfires, another threat, can also have huge effects on *Nothofagus* as these trees usually form gregarious monospecific groups, stimulating their own regeneration and impeding other species' development. Animal invasive species are also a threat in New Caledonia but seem to have minimal impact on *Nothofagus*. Of more concern is climate change which is predicted to impact those *Nothofagus* species found at high altitudes across the territory such as *N. baumanniae*.

Two out of five New Caledonian *Nothofagus* are assessed as threatened. This is in line with the assessment results of the New Caledonia Plants Red List Authority, which found that 42% of 1,040 native species are threatened in the wild. *Nothofagus* species provide important habitat for wildlife on New Caledonia. These trees are the preferred host plants for New Caledonia's largest moth, *Aenetus cohici*, an endemic species and the only representative of the Hepialidae family. The larvae bore a tunnel into the wood, where they can remain for several years. Unfortunately this insect species is as threatened as its host on the ultramafic massifs of New Caledonia.



Nothofagus codonandra (Benoît Henry)

By Laure Barrabé, Jérémy Girardi, Thierry Salesne and Hervé Vandrot

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Nothofagus balansae (Gildas Gâteblé)

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PART 2

A. NOTHOFAGUS SPECIES EVALUATED AS THREATENED

Nothofagus alessandrii Espinosa
Syn. *Fuscospora alessandrii* (Espinosa)
Heenan & Smissen

EN B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)

Chile

Nothofagus alessandrii is a large tree endemic to Chile in the Coastal Cordillera of Region VII. It has a restricted area of occupancy (AOO) of 116 km² and an extent of occurrence (EOO) of 755 km². The population is thought to be fragmented, small and remnant of a much larger population. The species has experienced historical population decline due to habitat loss and over exploitation. These still threaten the species but to a lesser degree. The main threat to the species at present are forest fires, which have resulted in recent decline in species AOO and caused fluctuation in the number of mature individuals. The species is globally assessed as Endangered.

Nothofagus baumanniae (Baum.-
Bod.) Steenis

Syn. *Trisyngyne baumanniae* (Baum,-Bod)

EN B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)

New Caledonia

This species is endemic to New Caledonia where it is found in just three sites. In these sites it is a keystone species of stunted cloud forest habitat which many understory plants, invertebrates, mammals and birds rely on. It is restricted to altitudes above 900 m with an extent of occurrence (EOO) of 558.7 km² and an area of occupancy (AOO) that is not anticipated to be much greater than 24 km². It is suggested that this species never extended far beyond its current geographical range, but there has been some decline due to the impact of fire. This threat causes continuing decline to habitat, population size and both, AOO and EOO. The species is found in the protected reserves of Botanique du Mount Mou and Mount Kouakoué. It also experiences disturbance from anthropogenic pressures such as



Nothofagus cunninghamii (Jan De Langhe / Arboretum Wespelaar)

agriculture and nickel mining. Considering the species has three locations and is impacted regularly by fire, it has been globally assessed as Endangered.

Nothofagus crenata Steenis

Syn. *Trisyngyne crenata* (Steenis) Heenan & Smissen

VU B1ab(iii,v)

Indonesia; Papua New Guinea

This large tree species is native to New Guinea. It has a restricted range with an estimated extent of occurrence (EOO) of 5,341 km² and is known from only four locations. Being a large tree it is likely used as a timber species, yet there is no literature to support this. Between 1972 and 2002, 13% of Papua New Guinea's rainforests have been logged which is a continuing threat to the species. Considering the species fractured population and continuing decline due to timber and deforestation, it has been globally assessed as Vulnerable.

Nothofagus cunninghamii (Hook.) Oerst.

Syn. *Fagus cunninghamii* Hook;
Lophozonia cunninghamii (Hook.)

Heenan & Smissen

VU A4bce

Australia

Nothofagus cunninghamii is a large tree species. It is native to Australia (Victoria) and Tasmania where it experiences threats from fire, habitat loss, poor regeneration, timber harvest and Myrtle Wilt infection. All of these factors have caused major historical population decline. Threats to the species remain, although pressure from logging has eased and therefore there is continuing population decline into the future. In Victoria, the species is more severely affected by these threats than in Tasmania. The species is also predicted to experience a greater decline as a result of climate change and its adverse impact on regeneration. Overall population is predicted to decline between 30 and 50% over three generations (past and future). The species is globally assessed as Vulnerable.

Nothofagus discoidea (Baum.-Bod.)

Steenis

Syn. *Trisyngyne discoidea* Baum.-Bod.**EN B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)**

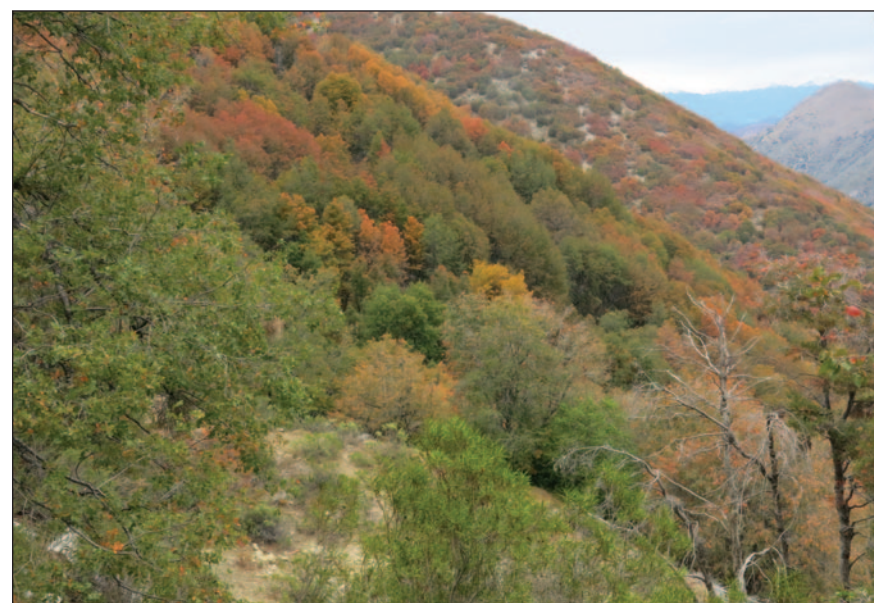
New Caledonia

Nothofagus discoidea is endemic to New Caledonia. It is restricted to ultramafic soils and is found in just five locations. This species was thought to be more widespread but now has a restricted extent of occurrence (EOO) of 2,598 km². The species has experienced natural historical population decline due to climate change but this has been exacerbated by nickel mining and fire. These activities still threaten the species and are suspected to be causing a decline in the species habitat quality, EOO and area of occupancy (AOO). This shows a decline in the species native habitat range and there is also anticipated decline in mature individuals. Current threats to the species reduce the chance of regeneration as they do not encourage, and even limit, the large-scale disturbance needed to promote regeneration. The species is globally assessed as Endangered.

Nothofagus glauca (Phil.) KrasserSyn. *Fagus glauca* Phil.; *Lophozonia glauca* (Phil.) Heenan & Smissen**VU A2c**

Chile

Nothofagus glauca is a large tree species. It is endemic to south-central Chile and is dominant over much of its native range. The species was historically threatened due to its use as a timber, leading to over exploitation. More recently, the expansion of *Pinus radiata* and other non-native species plantations, although reducing the harvest pressure on *N. glauca*, have caused significant habitat loss across the range of the species. Due to the use of the species for timber and deforestation of the native habitat, population is estimated to have declined by at least 30% over the last three generations. The population has become fragmented putting it at greater risk from anthropogenic forest fires. The species is found in both *ex situ* collections and protected areas, and has been globally assessed as Vulnerable.

*Nothofagus glauca* (Martin Gardner)*Nothofagus macrocarpa* (Martin Gardner)**Nothofagus macrocarpa** (A.DC.)

F.M.Vázquez & R.A.Rodr.

Syn. *Lophozonia macrocarpa* (A.DC.)

Heenan & Smissen

VU B1ab(iii)

Chile

The species is endemic to Chile and confined to three localities in the area of Santiago. It grows in a mountain range between 500–2,000 m with an area of occupancy (AOO) of 2,372 km² and an extent of occurrence (EOO) of 12,625 km². It is known to be harvested for wood and coal purposes. It is likely the species had a wider EOO in the past, but due to logging and conversion of land use, the species is now confined to a very small area. The species reproduces vegetatively which may cause genetic problems in the future. The species has been globally assessed as Vulnerable.



Nothofagus moorei
(Jan De Langhe / Arboretum Westpelaar)

Nothofagus moorei (F.Muell.) Krasser
Syn. *Fagus moorei* F.Muell.; *Lophozonia moorei* (F.Muell.) Heenan & Smitsen

VU A2cd
Australia

This species is native to south-eastern Queensland and north-eastern New South Wales, Australia. It has an estimated extent of occurrence (EOO) of 58,000 km². It grows to a large tree of 40 m and is typically a component of cool temperate rainforests. This habitat is predicted to be at risk from climate change. Southeast Australia is responding to climate change by becoming warmer and drier, which puts pressure on this rainforest species. In addition, fires are becoming more prevalent with a drier, warmer climate which is likely to be the cause for its patchy distribution. Fire will continue to threaten the species in the future. The species was historically coppiced and used for timber, but this is no longer a major use or threat to the species. Clonal regeneration has been reported to be

common, while sexual regeneration is believed to be rare, potentially reducing the genetic diversity of the species. Overall, the species is probably in slow decline due to climate change and fires, while human practices are exacerbating this. Historically the species has been dramatically reduced in extent and abundance through forestry and clearing for agriculture. This is estimated to have caused at least a 30% reduction over three generations. The species is globally assessed as Vulnerable.

Nothofagus nuda Steenis
Syn. *Trisyngyne nuda* (Steenis) Heenan & Smitsen

CR B1ab(iii)
Papua New Guinea

This species is only known from a single collection near the Tauri River in the Gulf province of Papua New Guinea which was made in 1966. Considering the species' particularly small range and very few individuals, dispersal and regeneration of the species is limited. There may have also been historical population decline due to habitat loss or over exploitation. From the research undertaken, it is known that logging of rainforest and montane forest has occurred historically and has reduced *Nothofagus* forest dramatically. The most prominent threats to the species are currently fire, logging and conversion of land use which has resulted in recent decline in many mature individuals. This species is globally assessed as Critically Endangered.

Nothofagus stylosa Steenis
Syn. *Trisyngyne stylosa* (Steenis) Heenan & Smitsen

CR B2ab(iii)
Indonesia
This species is confined to one population found in central New Guinea within the mountain range of West Papua, Indonesia. It has an area of occupancy (AOO) of

4 km². The species is known to grow alongside other species of *Nothofagus* which are more widespread and used for timber. The species may be used similarly and therefore logging is a potential risk. It is known that logging of rainforest and montane forest has been undertaken historically and has reduced *Nothofagus* forest dramatically. The main threats to this species are logging, fire and conversion of land use. These threats are causing a decline in habitat area. The species has been globally assessed as Critically Endangered.

Nothofagus womersleyi Steenis
Syn. *Trisyngyne womersleyi* (Steenis) Heenan & Smitsen

CR B1ab(i,ii,v)+2ab(i,ii,v)
Indonesia

The species is restricted to one location in West Papua, Indonesia, presenting an extent of occurrence (EOO) and area of occupancy (AOO) of 4 km². It is known to occur at 1,200 m alongside *Nothofagus flaviramea* which is a much more widespread species. There is no record of any specific threats to this species, yet considering it grows alongside a more abundant and highly sourced timber species, it is likely that *N. womersleyi* could be lost due to logging. It is known that logging of rain forest and montane forest has been undertaken historically and has reduced *Nothofagus* forest dramatically. The main threats to this species are logging, fire and conversion of land use. In conclusion, the species small EOO, severely fragmented population and the continued threat of logging leads to the assessment of this species as Critically Endangered.

B. NOTHOFAGUS SPECIES EVALUATED AS NEAR THREATENED

Nothofagus aequilateralis (Baum.-Bod.)
Steenis
New Caledonia

Nothofagus codonandra (Baill.) Steenis
New Caledonia

Nothofagus gunnii (Hook.f.) Oerst.
Australia

Nothofagus pseudoresinosa Steenis
Papua New Guinea



Landscape including *Nothofagus gunnii*, Tasmania (Joanna Wenham)

C. NOTHOFAGUS SPECIES EVALUATED AS LEAST CONCERN



Nothofagus alpina (Jan De Langhe / Arboretum Wespelaar)

Nothofagus alpina (Poepp. & Endl.)
Oerst.
Argentina; Chile

Nothofagus antarctica (G.Forst.) Oerst.
Argentina; Chile

Nothofagus balansae (Baill.) Steenis
New Caledonia

Nothofagus betuloides (Mirb.) Oerst.
Argentina; Chile

Nothofagus brassii Steenis
Papua New Guinea; Indonesia

Nothofagus carrii Steenis
Papua New Guinea; Indonesia

Nothofagus cliffortioides (Hook.f.)
Oerst.
New Zealand

Nothofagus dombeyi (Mirb.) Oerst.
Argentina; Chile

Nothofagus flaviramea Steenis
Papua New Guinea; Indonesia

Nothofagus fusca (Hook.f.) Oerst.
New Zealand

Nothofagus grandis Steenis
Papua New Guinea; Indonesia

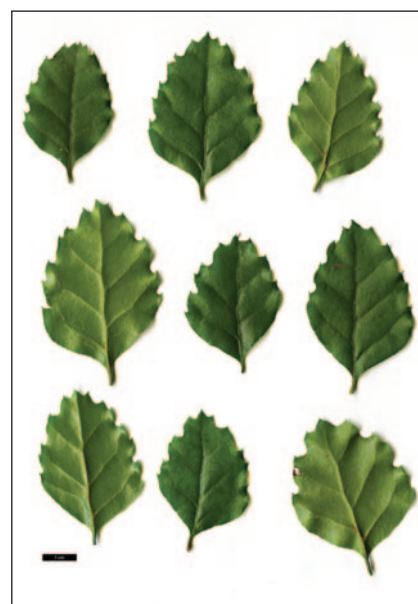
Nothofagus menziesii (Hook.f.) Oerst.
New Zealand



Nothofagus antarctica
(Jan De Langhe / Arboretum Wespelaar)



Nothofagus betuloides
(Jan De Langhe / Arboretum Wespelaar)



Nothofagus fusca
(Jan De Langhe / Arboretum Wespelaar)



Above: *Nothofagus dombeyi*, Above right: *Nothofagus obliqua* (Jan De Langhe / Arboretum Wespelaar)

Nothofagus nitida (Phil.) Krasser
Chile

Nothofagus obliqua (Mirb.) Oerst.
Argentina; Chile

Nothofagus perryi Steenis
Papua New Guinea

Nothofagus pullei Steenis
Papua New Guinea; Indonesia

Nothofagus pumilio (Poepp. & Endl.)
Krasser
Argentina; Chile

Nothofagus resinosa Steenis
Papua New Guinea; Indonesia

Nothofagus rubra Steenis
Papua New Guinea; Indonesia

Nothofagus solandri (Hook.f.) Oerst.
New Zealand

Nothofagus starkenborghiorum
Steenis
Papua New Guinea; Indonesia

Nothofagus truncata (Colenso)
Cockayne
New Zealand



Nothofagus pumilio
(Jan De Langhe / Arboretum Wespelaar)

Nothofagus menziesii
(Jan De Langhe / Arboretum Wespelaar)

Nothofagus nitida
(Jan De Langhe / Arboretum Wespelaar)

APPENDIX 1

Full list of evaluated *Nothofagus* species and the number of *ex situ* collections

Taxon name	Red List Category	Red List Criteria	<i>Ex situ</i> Collections
<i>Nothofagus aequilateralis</i> (Baum.-Bod.) Steenis	NT		0
<i>Nothofagus alessandrii</i> Espinosa	EN	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)	17
<i>Nothofagus alpina</i> (Poepp. & Endl.) Oerst.	LC		42
<i>Nothofagus antarctica</i> (G.Forst.) Oerst.	LC		86
<i>Nothofagus balansae</i> (Baill.) Steenis	LC		0
<i>Nothofagus baumanniae</i> (Baum.-Bod.) Steenis	EN	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	0
<i>Nothofagus betuloides</i> (Mirb.) Oerst.	LC		17
<i>Nothofagus brassii</i> Steenis	LC		0
<i>Nothofagus carrii</i> Steenis	LC		0
<i>Nothofagus cliffortioides</i> (Hook.f.) Oerst.	LC		14
<i>Nothofagus codonandra</i> (Baill.) Steenis	NT		2
<i>Nothofagus crenata</i> Steenis	VU	B1ab(iii,v)	0
<i>Nothofagus cunninghamii</i> (Hook.) Oerst.	VU	A4bce	28
<i>Nothofagus discoidea</i> (Baum.-Bod.) Steenis	EN	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	0
<i>Nothofagus dombeyi</i> (Mirb.) Oerst.	LC		35
<i>Nothofagus flaviramea</i> Steenis	LC		0
<i>Nothofagus fusca</i> (Hook.f.) Oerst.	LC		21
<i>Nothofagus glauca</i> (Phil.) Krasser	VU	A2c	18
<i>Nothofagus grandis</i> Steenis	LC		1
<i>Nothofagus gunnii</i> (Hook.f.) Oerst.	NT		10
<i>Nothofagus macrocarpa</i> (A.DC.) F.M.Vázquez & R.A.Rodr.	VU	B1ab(iii)	5
<i>Nothofagus menziesii</i> (Hook.f.) Oerst.	LC		21
<i>Nothofagus moorei</i> (F.Muell.) Krasser	VU	A2cd	22
<i>Nothofagus nitida</i> (Phil.) Krasser	LC		7
<i>Nothofagus nuda</i> Steenis	CR	B1ab(iii)	0
<i>Nothofagus obliqua</i> (Mirb.) Oerst.	LC		66
<i>Nothofagus perryi</i> Steenis	LC		0
<i>Nothofagus pseudoresinosa</i> Steenis	NT		0
<i>Nothofagus pullei</i> Steenis	LC		0
<i>Nothofagus pumilio</i> (Poepp. & Endl.) Krasser	LC		20
<i>Nothofagus resinosa</i> Steenis	LC		0
<i>Nothofagus rubra</i> Steenis	LC		0
<i>Nothofagus solandri</i> (Hook.f.) Oerst.	LC		13
<i>Nothofagus starkenborghiorum</i> Steenis	LC		0
<i>Nothofagus stylosa</i> Steenis	CR	B2ab(iii)	0
<i>Nothofagus truncata</i> (Colenso) Cockayne	LC		4
<i>Nothofagus womersleyi</i> Steenis	CR	B1ab(i,ii,v)+2ab(i,ii,v)	0

APPENDIX 2

Participating institutions

Alpengarten auf dem Schachen
 Arboretum (Institute of Silviculture, Forestry Faculty)
 Arboretum at the University of California, Santa Cruz
 Arboretum des Grands-Murcins
 Arboretum Freiburg-Günterstal
 Arboretum Groenendaal - Flemish Forest Department - Houtvesterij Groenendaal
 Arboretum National des Barres (et Fruticetum Vilmorinianum)
 Arboretum Oudenbosch
 Arboretum Wespelaar
 Auckland Botanic Gardens
 Australian National Botanic Gardens
 Australian PlantBank - Mount Annan Botanic Garden
 Bedgebury National Pinetum & Forest
 Belmonte Arboretum
 Benmore Botanic Garden
 Birmingham Botanical Gardens and Glasshouses
 Blue Mountains Botanic Garden, Mount Tomah
 Bokrijk Arboretum
 Booderee Botanic Gardens
 Botanic Garden Meise
 Botanic Garden of Rostock University
 Botanic Garden, Delft University of Technology
 Botanic Gardens of South Australia
 Botanical Garden of Moscow Palace of Pioneers
 Botanical Garden of Tartu University
 Botanical Garden of the University of Bern
 Botanical Garden of Vilnius University
 Botanical Garden University of Duesseldorf
 Botanical Garden, Natural History Museum of Denmark
 Botanical Garden-Institute, Ufa Research Center
 Botanische Gärten der Universität Bonn
 Botanischer Garten der Carl von Ossietzky-Universität Oldenburg
 Botanischer Garten der Justus-Liebig Universität Giessen
 Botanischer Garten der Ruhr-Universität Bochum
 Botanischer Garten der Technischen Universität Darmstadt
 Botanischer Garten der Technischen Universität Dresden
 Botanischer Garten der Universität des Saarlandes
 Botanischer Garten der Universität Freiburg
 Botanischer Garten der Universität Kiel
 Botanischer Garten der Universität Osnabrück
 Botanischer Garten der Universität Ulm
 Botanischer Garten Frankfurt am Main
 Brooklyn Botanic Garden
 Burrendong Botanic Garden & Arboretum
 Cambridge University Botanic Garden
 Conservatoire Botanique National du Brest
 Conservatoire et Jardin botaniques de la Ville de Genève
 Dawyck Botanic Garden
 Dendrological garden of the Silva Tarouca Research Institute for Landscape and Ornamental Gardening
 Denver Botanic Gardens
 Eden Project, The
 EEB Biodiversity Education and Research Greenhouses
 Elisabeth C. Miller Botanic Garden
 Finnish Museum of Natural History / Helsinki University Botanic Garden
 Forstbotanischer Garten der Technischen Universität Dresden
 Forstbotanischer Garten und Arboretum
 Fundacion Jardín Botánico Nacional Viña del Mar
 Ghent University Botanic Garden
 Glasgow Botanic Gardens
 Gothenburg Botanical Garden
 High Beeches Gardens Conservation Trust
 Hof ter Saksen Arboretum
 Hortus Botanicus Amsterdam
 Hortus Botanicus Reykjavikensis
 Hoyt Arboretum
 Jardí Botanic de Barcelona

Jardin Botánico (Instituto de Botanica)
 Jardín Botánico Cascada Escondida"
 Jardín Botánico de Bahía Blanca
 Jardin Botanique de la Ville de Caen
 Jardin Botanique de la Ville de Lyon
 Jardin Botanique de Marnay sur Seine
 Jardin botanique de Paris
 Jardin des Plantes
 Jardins botaniques du Grand Nancy et de l'Université de Lorraine
 JC Raulston Arboretum
 Jerusalem Botanical Gardens
 Kalmthout Arboretum
 Karwarra Australian Native Botanic Garden (Yarra Ranges Council)
 Kirstenbosch National Botanical Garden
 Kunming Botanical Garden
 Kurpark Bad Bellingen
 Les Jardins Suspendus
 Leuven Botanic Garden
 Lipizauga Botanical Sanctuary
 Logan Botanic Garden
 Maribor University Botanic Garden
 Millennium Seed Bank
 Montreal Botanical Garden / Jardin botanique de Montréal
 Mount Usher Gardens
 National Arboretum Canberra
 National Botanic Garden of Wales
 National Rhododendron Garden
 Neuer Botanischer Garten der Universität Göttingen
 Oekologisch-Botanischer Garten Universität Bayreuth
 Oxford University Botanic Garden & Arboretum
 Paignton Zoo Environmental Park
 Pukekura Park
 Rhododendron Species Foundation and Botanical Garden
 Rogów Arboretum of Warsaw University of Life Sciences
 Royal Botanic Garden Edinburgh
 Royal Botanic Gardens Kew (Wakehurst)
 Royal Botanic Gardens Sydney
 Royal Botanic Gardens, Kew
 Royal Botanic Gardens, Victoria - Melbourne Gardens
 Royal Horticultural Society's Garden, Harlow Carr
 Royal Horticultural Society's Garden, Hyde Hall
 Royal Horticultural Society's Garden, Rosemoor
 Royal Horticultural Society's Garden, Wisley
 Royal Roads University Botanical Gardens
 Royal Tasmanian Botanical Gardens
 Royal Veterinary and Agricultural University Arboretum
 San Francisco Botanical Garden
 Sentier de Decouverte
 Sheffield Botanical Gardens
 St. Andrews Botanic Garden
 Stavanger Botanic Garden
 Tasmanian Arboretum Inc
 Tatton Garden Society/Quinta Arboretum
 The Australian Botanic Garden, Mount Annan
 The Sir Harold Hillier Gardens
 The Tree Register of the British Isles
 Timaru Botanic Garden
 Tregothnan Estate
 University of British Columbia Botanical Garden
 University of California Botanical Garden at Berkeley
 University of Dundee Botanic Garden
 University of Melbourne Grounds and Gardens
 University of Washington Botanic Gardens
 Utrecht University Botanic Gardens
 VanDusen Botanical Garden
 Von Gimborn Arboretum
 Westonbirt, The National Arboretum

APPENDIX 3

IUCN Red List Categories and Criteria

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time-frame appropriate to the taxon's life cycle and life form.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time-frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

NEAR THREATENED (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

THE CRITERIA FOR CRITICALLY ENDANGERED, ENDANGERED AND VULNERABLE

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk of extinction in the wild:

- A. Reduction in population size based on any of the following:
 1. An observed, estimated, inferred or suspected population size reduction of $\geq 90\%$ over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
 - (a) direct observation
 - (b) an index of abundance appropriate to the taxon
 - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
 - (d) actual or potential levels of exploitation
 - (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
 2. An observed, estimated, inferred or suspected population size reduction of $\geq 80\%$ over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may

not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of $\geq 80\%$, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
 4. An observed, estimated, inferred, projected or suspected population size reduction of $\geq 80\%$ over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
1. Extent of occurrence estimated to be less than 100 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at only a single location.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 2. Area of occupancy estimated to be less than 10 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at only a single location.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
- C. Population size estimated to number fewer than 250 mature individuals and either:
1. An estimated continuing decline of at least 25% within three years or one generation, whichever is longer, (up to a maximum of 100 years in the future) OR
 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
 - (a) Population structure in the form of one of the following:
 - (i) no subpopulation estimated to contain more than 50 mature individuals, OR
 - (ii) at least 90% of mature individuals in one subpopulation.
 - (b) Extreme fluctuations in number of mature individuals.
- D. Population size estimated to number fewer than 50 mature individuals.
- E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).
- ENDANGERED (EN)**
- A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:
- A. Reduction in population size based on any of the following:
1. An observed, estimated, inferred or suspected population size reduction of $\geq 70\%$ over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
 - (a) direct observation
 - (b) an index of abundance appropriate to the taxon
 - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
 - (d) actual or potential levels of exploitation
 - (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of $\geq 50\%$ over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 3. A population size reduction of $\geq 50\%$, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 4. An observed, estimated, inferred, projected or suspected population size reduction of $\geq 50\%$ over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
1. Extent of occurrence estimated to be less than 5000 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than five locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 2. Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than five locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
- C. Population size estimated to number fewer than 2500 mature individuals and either:
1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR
 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
 - (a) Population structure in the form of one of the following:
 - (i) no subpopulation estimated to contain more than 250 mature individuals, OR
 - (ii) at least 95% of mature individuals in one subpopulation.
 - (b) Extreme fluctuations in number of mature individuals.
- D. Population size estimated to number fewer than 250 mature individuals.
- E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).
- VULNERABLE (VU)**
- A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:
- A. Reduction in population size based on any of the following:
1. An observed, estimated, inferred or suspected population size reduction of $\geq 50\%$ over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
 - (a) direct observation
 - (b) an index of abundance appropriate to the taxon
 - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

- (d) actual or potential levels of exploitation
 - (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
2. An observed, estimated, inferred or suspected population size reduction of $\geq 30\%$ over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
 3. A population size reduction of $\geq 30\%$, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
 4. An observed, estimated, inferred, projected or suspected population size reduction of $\geq 30\%$ over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
1. Extent of occurrence estimated to be less than 20,000 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than 10 locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 2. Area of occupancy estimated to be less than 2000 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than 10 locations.
- b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
- C. Population size estimated to number fewer than 10,000 mature individuals and either:
1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR
 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
 - (a) Population structure in the form of one of the following:
 - (i) no subpopulation estimated to contain more than 1000 mature individuals, OR
 - (ii) all mature individuals are in one subpopulation.
 - (b) Extreme fluctuations in number of mature individuals.
- D. Population very small or restricted in the form of either of the following:
1. Population size estimated to number fewer than 1000 mature individuals.
 2. Population with a very restricted area of occupancy (typically less than 20 km²) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.
- E. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.



The Red List of Nothofagus

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