Te Uru Rākau New Zealand Forest Service

A New Zealand guide to growing our native tall tree species

An introduction to selecting the right native species for your site

Te Kāwanatanga o Aotearoa
New Zealand Government

The purpose of this guide

This booklet provides a guide to common native tall tree species. It explains the suitability of these species for growers – farmers, other private landowners, councils, iwi and investors. The management conditions for each species are described, along with both timber and non-timber uses and environmental services.

Planting forests and woodlots for carbon benefits

Forests need to meet certain requirements to register them in the Emissions Trading Scheme (ETS). Carbon and the ETS are not covered in this guide. Growers should seek early professional advice on the ETS, and how to maximise its benefits.

Tāne's Tree Trust
NATIVE FORESTS FOR OUR FUTURE
Herehere a te Wao-nui-a-Tāne

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Introduction

There are multiple benefits associated with native forests: improved biodiversity, water quality, landscape, shade and shelter, climate resilience, cultural identity, and social and economic opportunities.

The beauty of native forests is that they can provide many, even all, of these benefits at the same time and on the same area of land.

This booklet aims to stimulate interest in establishing new native forests and protecting and enhancing forest remnants. It features 15 well-known native tall trees and provides initial guidance on species choice for different site-types and objectives; also, how to establish and manage planted or naturally regenerating forests to ensure trees survive and thrive.

Establishing and managing native forests requires considerable investment in time and money. New growers are well-advised to do further research and seek advice related to their own site and objectives before embarking on native forest projects.

History

New Zealand's native forests have had a long genesis. The tectonic plates on which New Zealand rides carried the country away from other significant land masses 80-100 million years ago, and the native flora and fauna have developed largely in isolation since. Consequently, many species are unique to New Zealand, or at most only distantly related to others in the world.

Most land below the treeline was once clothed in tall forest with many different tree species with varying site tolerances, ecological niches and wood properties. Since humans arrived in New Zealand, barely 800 years ago, the natural environment has been substantially modified. Up to 98 percent of some forest types have been lost. Although around one-third of New Zealand's land area is now legally protected, this is mainly in montane and alpine regions. Lowland native forests and other natural ecosystems continue to face threats from agriculture, plantation forestry, mining, urban development, and destruction by introduced mammals and invasive non-native plant species.

If we regard the last 80 to 100 million years during which New Zealand's forests developed in relative isolation from the rest of the world as one year, then the period during which humankind and our fellow travellers have been free to extract such a toll on those same forests is no more than the last five minutes.

Cultural considerations – Ngā taonga o te Wao Nui a Tāne

Māori colonised New Zealand about 800 years ago and developed a close affinity with the natural environment. Connection to the forest, Te Wao Nui a Tāne, is one

of the foundations of the Māori world. Māori see themselves as descended from Tāne Nui a Rangi, as well as everything else living in the forest, the trees and plants, the birds and insects. The interconnectedness of this world is essential to the health and survival of all that are part of it. For Māori themselves to be well, they need the forest to be well.

Ka ora te whenua, ka ora te tangata
When the land is well, the people are well.

The primary purpose of the forest, therefore, is not to provide timber, to store carbon, or provide other services that benefit the human race but to cover Papatūānuku, the Earth Mother, and keep her well. The karakia (prayers) and other tikanga (customary law) that guide how Māori relate to the forest are to ensure that this order of priorities is upheld and that the forest itself can continue its primary role of caring for Papatūānuku and all the life that she encompasses.

The forest trees that are greatly valued – tōtara, kauri, rimu and others – were and continue to be used and treasured by Māori. But many of the species most used, particularly for rongoā (traditional medicine) and for kai (food), weaving materials, and many other uses, are found in the regenerating fringe of the forest and in the sub-canopy. These are also critical to sustaining manu (birds) and the many other species that are part of the network that enables the mauri (life force) of the forest to thrive, and to be self-sustaining.

Restoring indigenous forest is about restoring the whole forest whanau (family); they all need each other to thrive. If this is done successfully, the wellbeing of the trees that are most valued for their timber and their ability to store carbon will be maximised.

The many values associated with native forests

Most remaining native forest is protected within the conservation estate, but there are still considerable areas of native forest in private and Māori ownership. There are also substantial opportunities to plant and regenerate new native forests within agricultural and horticultural landscapes, as well as within urban environments. Integrating native forest back into our working lands and urban areas will enhance existing land uses rather than compete with or replace them.

Thriving native trees and forests contribute to the biosphere and are critical to people's well-being. Well-managed native forests can provide environmental benefits, cultural and spiritual values, and timber and non-timber forest products, all on the same site.

Native forests provide resilience in a time of climate change. They improve land stability in erodible steeplands, moderate peak flows in floods, provide shade and shelter for people and animals, and, as coastal buffers, protect shorelines and inland resources.

Industries based on native forest species have been important in the past. There is a resurgence of interest not only in establishing and protecting native forests, but also in exploring options for sustainable production of a range of products and services associated with these forests.

Newly established and regenerated native forests can be enhanced to provide future generations with a sustainable resource of high-quality specialty timbers. Once native forest is established, continuous cover forestry practices (where harvesting is undertaken as single tree or small group felling) will maintain the multiple benefits of the forest, including biodiversity, soil and water quality values and landscape aesthetics.

Left to right – tōwai, tawa, pukatea, rewarewa, rātā, rimu

Left to right – maire, tōtara, taraire, tawhai, kauri, pūriri.

Native species timbers are attractive and have high-value end-uses.

New native forests – successful establishment

In New Zealand, some land requires rehabilitation following severe erosion and/or the need to improve water quality; and some hill and upland areas are gradually becoming naturally revegetated as livestock numbers diminish. Many lowland farms include steep gullies, areas that are difficult to farm, or riparian zones that could support native forest. Some farms have native forest remnants that could be enhanced with additional management. Land on the urban fringe, in parks and green spaces within towns and cities, and in coastal areas, all has potential to support native trees.

Establishing native forests

Planting nursery-raised seedlings is the most common method for establishing native trees. Growers can choose the species they want and control the density and pattern of the growing stand. Planting, however, can be a high-risk activity and expensive and demanding to carry out, especially on a large scale.

Direct seeding is an option that is of interest but is likely to be site-specific.

Encouraging natural regeneration so that the land reverts to forest is often a cheaper and more resilient option. Its success depends on whether local seed sources exist, and the intensity of weed competition.

Planting: the usual method of establishing native species is to use plants raised from seed in containers (pots, planter bags, or root-trainers) in plant nurseries. Most native conifer and hardwood tree species can be grown from seed using standard nursery techniques.

All planting programmes require careful pre-planning. Site preparation, matching species to site, planting methods, and quality of planting stock contribute to the survival, growth, and eventual form of mature trees. Just as important is to ensure post-planting maintenance is well resourced and timely.

Livestock must be excluded, and grazing/browsing pests controlled before planting begins and for as long as possible following establishment.

Reversion: native vegetation regenerates naturally in many cleared or partially logged areas throughout the country. The pace at which this process occurs, and the species composition of resulting communities is influenced by many factors, including original forest characteristics, site history (for example, intensity of logging, burning, and clearance), environmental conditions such as soil-type and rainfall, and current land use. Nearby seed sources of desired species are needed, as are seed-dispersing birds, skinks and other animals.

Browsing pests such as deer, goats and possums, will inhibit natural regeneration, and weed species can out-compete and smother the slower-growing native species. Encouraging natural regeneration by reducing or eliminating things that inhibit it, like pests and weeds, may be a more practical and cost-effective strategy than planting.

Seed sourcing and ecosourcing

Obtaining quality seed from healthy parent trees is vital if new planting or forest restoration programmes are to succeed. Recommended best practice seed collection is to collect seed within a locality from a minimum of 10 different trees, ideally spaced over several hundreds of metres, to obtain seed from a diverse genetic mix. Seed of the same species collected from the same area should be mixed together before sowing.

Ecosourcing is defined as "sourcing seed from nearby natural populations to propagate native planting stock for planting in the same locality". There is ongoing debate on the role of ecosourcing and defining the boundaries for local provenances. Some regard ecosourcing as important for ecological restoration projects. Others contend that for other types of plantings – such as for amenity, arboreta, or when selecting plants for particular traits, for example, when establishing a timber resource – it may be less relevant.

Strict adherence to using only local seed raises difficulties where the definition of boundaries for seed-collecting zones is not clear, or the supply of local seed is inadequate. A pragmatic approach is required, so that people are not discouraged from planting native species. Planters should ask nurseries about their ecosourcing policies.

Creating a forest environment – a successional process

Mature indigenous forest develops in multiple steps, with each step providing the conditions that will suit the next group of plants. The process of recolonising a bare patch of land (either naturally or via human intervention) is called "succession". It takes many decades for the succession process to transform an area from bare land to a maturing forest.

The first step in the succession process is when early colonising (or "pioneer") species – often shrub hardwoods such as kānuka and mānuka – create conditions suitable for other later successional species to establish.

Colonising species grow on open sites as they can cope with the extremes of local climate during the establishment phase. These species can quickly form a canopy cover, creating a shady, sheltered environment and enabling inter-planting or regeneration of later successional species. The canopy also suppresses weed growth and reduces early maintenance of later successional species.

These colonising species can be planted as a "nurse" species, either a year or two before or at the same time as the desired later successional species. These species can be interplanted amongst the nurse, benefitting from the environment they provide.

Establishing native plantations without nurse species

Where the objective is to establish native trees for timber, planting without a nurse cover can optimise growth and reduce maintenance of overtopping nurse species.

Several light-demanding conifer species including tōtara and kauri, and hardwood species rewarewa and beeches, have been successfully planted or can naturally regenerate on open sites without a nurse species. Matching tree species to site is critical, so growers should seek advice before embarking on planting a single species without a nurse cover.

There are pros and cons of planting without a nurse species, with success dependent on the species in question, planting density, commitment and resources available for management and longer-term objectives.

A major consideration is planting density – high-density planting (for example, at 1.5 metre spacing, equivalent to 4444 stems/hectare) is expensive but the forest should become established and canopy closure will be relatively rapid. However, if there is high survival and good early growth, many trees will need to be thinned to waste within a decade to maintain growth of residual trees.

Lower-density planting (for example, two metre or three metre spacing, 2500 and 1100 stems/hectare respectively) may not achieve canopy cover for at least two decades, depending on species planted and growth rate. This leaves sites vulnerable to weed invasion, meaning a prolonged maintenance period.

Some species such as kahikatea, tānekaha and kauri form mostly single, straight leaders irrespective of planting conditions. Others like tōtara and many of the

hardwoods form rounded multi-stemmed crowns, often with multiple leaders, especially when planted at wider spacing. Where timber is an objective, form-pruning will be needed to improve tree form and wood quality. Thinning down to recommended final crop stockings allows the best-quality trees to be selected and grown on for timber.

Shrub hardwood species are usually cheaper than native tree species and provide a compromise for those considering open planting of timber species. They can "bulk-out" a planting site to give early canopy cover and reduce the period of weed control to about five to ten years for widely spaced stands, and about two to three years for dense plantings.

Working with nature – benefits of natural regeneration

Given the high cost of planting natives, strategies that encourage natural regeneration are often more practical than wide-scale planting to achieve permanent forest. This is relevant for restoring native forest over large areas of low-productivity pastoral land.

The rate of natural regeneration on all site-types is variable, depending on region, site, seed sources, grazing stock and pest animals, and weed species. Some of these factors may slow natural regeneration for many decades. In some situations, additional planting can complement natural regeneration, especially re-introducing a seed source for species that have been lost from the area or have become locally scarce.

Seed islands

Establishing "seed islands" across landscapes is a method of targeting small areas for planting to assist nature to establish diverse native forests at scale through natural regeneration. It is a pragmatic and cost-effective option, given the high cost of blanket planting natives and the impracticality of intensive blanket planting, especially on a large scale. Colonising species will begin producing seed in as little as three years after planting; later successional species can begin producing seed from about age 12-15, depending on species.

Seed islands will become like stepping stones, attracting birds to roost, feed and fly between groves and assist in spreading seed across the wider regenerating or planted landscape. Following livestock removal and control of pest animals, large areas of marginal pastureland should revert to native forest if there are existing seed banks or nearby seed sources. Additional predator control would enable more birds to survive and disperse seed.

Direct seeding

There is interest in using high-tech methods such as drones for direct seeding natives across degraded landscapes to establish native forest. These tools may offer an alternative although success is likely to be site- and species-specific. Large quantities of seed are required to be collected which is expensive and trials to date indicate competition from exotic weeds and grasses reduce establishment

of natives. Further work is required to determine if direct seeding can be a cost-effective method especially for large scale reversion of natives.

Maintenance and monitoring

Native plantings fail most often because of lack of post-planting maintenance, particularly releasing natives from regrowth of weeds, grasses, ground ferns, and exotic brush weeds. Regular manual and/or chemical releasing for up to five years after planting is required on most sites. Where vigorous blackberry and woody weeds are present, and depending on density and early performance of the planted trees, releasing may need to be extended for up to 10 years until canopy closure. Ongoing control of deer, goats and possums is also essential.

Most native planting projects are focused on just planting, and few follow up with monitoring, other than a cursory glance hoping that most trees have survived and beaten the weeds. Planting trees is only the first step towards establishing new areas of native forest. Monitoring early survival and growth of plantings will provide valuable insights into what is working or what isn't and enables timely scheduling of weed and pest animal control.

Estimating costs of establishment and other planning tools

A Native Forest Toolkit, which comprises four interactive calculators to help with all aspects of planning a new planting, including cost estimates and a carbon calculator, is freely available on the Tāne's Tree Trust website: **tanestrees.org.nz/resources/native-forest-toolkit/**

These calculators enable growers to explore the economic and practical implications of different establishment and management scenarios, specific to their own site and objectives.

Silviculture – pruning and thinning

Pruning: where timber production is an objective, pruning to improve stem or "butt log" form may be an effective intervention. Competing leaders or forks, steeply angled and heavy branches, should all be removed to encourage a single straight main stem to develop. Sometimes pruning away branches from competing neighbouring trees or ferns is also beneficial.

There is only a limited time in a tree's development when pruning is useful. Branches should be pruned before they exceed 45 millimetres in diameter and before the diameter of the trunk at that point exceeds 15-20 centimetres. It is better to prune early and often, removing no more than one-third of the green crown or foliage. Only prune selected potential final crop trees, which may range in number from as few as several dozen trees per hectare to a maximum of around 400. Use good pruning equipment and techniques to minimise damage such as tearing bark and creating entry points for disease. Large pruning wounds may cause long-term damage to the tree.

Pruning is labour-intensive and costly. The economic case for pruning is not proven. Managing an effective nurse to minimise or avoid the need for pruning may be a better strategy for some species. Some species will grow straight and tall with the help of a nurse species, but others, such as tōtara, still require substantial form and lower stem pruning to achieve a straight, branch-free butt log.

Thinning: once potential crop trees have formed clear boles, clearing competing trees around them can improve growth rates. The aim is to enable the selected crop trees to develop thick trunks and for that they need space and light to develop large green crowns. Timing is important, and thinning is better done gently in several stages to reduce the risk of windthrow. There is a balance to find between having high stocking rates to suppress branch development and reduce the need for pruning versus maintaining good growth rates.

Harvesting

Landowners plant native trees for many reasons: some have possible future timber production in mind. Such plantations should be registered with Te Uru Rākau – New Zealand Forest Service as "Planted Indigenous Forests" to help avoid regulatory difficulties when it comes to harvesting. Registering planted indigenous forests is a simple and cost-free process. It means those forest areas can then be treated like an exotic woodlot, under Part 3A of the Forests Act 1949, preserving a range of harvesting options – including clear-felling.

Native forests typically have multiple values. When it comes to harvest time, alternatives to clear-felling may be of interest. Fortunately, converting to selective harvesting and various forms of continuous cover forestry are likely to suit most native plantations. These systems can retain the environmental, ecological and amenity values of the forest while sustainably providing timber. Remnant existing forests and naturally regenerated native forests can only be legally harvested in this way under the provisions of the Forests Act. Good examples exist to demonstrate that it can be done.

The regulatory environment

When it comes to indigenous forestry, several sets of regulations often apply. These regulations can and do change. Landowners and forest managers are advised to frequently update themselves or get advice regarding the regulations that might apply.

Part 3A of the Forests Act 1949

Part 3A of the Forests Act differentiates between planted indigenous forests and naturally established existing forests. Naturally established forests comprise land wholly or predominantly covered in indigenous vegetation, which includes naturally reverting or regenerating forest cover.

The distinction becomes important for harvesting, especially if interplanting into existing or regenerating forest areas, such as enrichment planting. Harvesting from naturally established forest land is subject to the provisions of Part 3A of the Forests Act – this generally means harvesting can only be done on a sustainable basis, so no clear felling.

In contrast, planting a native forest on non-indigenous forest land is exempt from these requirements. The forest could be harvested like an exotic woodlot. (A reminder: landowners are advised to register their "Planted Indigenous Forests" with Te Uru Rākau – New Zealand Forest Service, to avoid regulatory barriers in the future.)

The Resource Management Act 1991 and National Policy Statements

The Resource Management Act (RMA) and National Policy Statements are mostly given effect through regional and district plans, which may change every 10 years or so. These plans have policies and rules to protect significant natural areas (SNAs) and outstanding landscapes/features, and natural character values. These often include rules on indigenous vegetation clearance, although they may not contain any explicit provision for harvesting indigenous forests, planted or natural. In some districts, harvesting, even with an approved sustainable forest management permit or plan under the Forests Act, may also require a resource consent process.

The New Zealand Emissions Trading Scheme

Potential for planted and/or naturally established native forest areas to earn income from carbon credits depends largely on whether they are eligible to enter the New Zealand Emissions Trading Scheme (ETS). The date of establishment is likely to be a critical point, particularly if it pre-dates 1990. Landowners interested in entering the ETS can get more information from Te Uru Rākau – New Zealand Forest Service: **forestryets@mpi.govt.nz**

Native forests registered in the Permanent Forest Category of the ETS may earn carbon credits and low-intensity harvesting may also be allowed.

Taxation

There are some unique tax liabilities relevant to forestry including indigenous forestry. It is recommended professional advice is sought on this matter.

Summary – the regulatory environment

In summary, there are different pieces of legislation, policies and rules that landowners and forest managers need to follow when considering indigenous forestry. The regulatory environment is also subject to change. That said, people should not be dissuaded from embarking on native forest projects. Native forests are long-term, enduring features, and the case for establishing them is strong.

Those considering indigenous forestry can contact Te Uru Rākau – New Zealand Forest Service for more information: **indigenous.forestry@mpi.govt.nz**

Beeches

The New Zealand beeches are amongst our best-known native trees. Two-thirds of the remaining native forest in New Zealand is beech forest. Because of their wide distribution, beech species grow with a range of other native trees, both native conifers and other hardwoods. However, many natural beech forests are dominated by just one or two beech species with characteristically open understories. Along with some native conifers, the beeches have been historically the most significant native timber species.

There are five beech species recognised in New Zealand: the three with most potential for growers are silver beech (*Lophozonia menziesii*), red beech (*Fuscospora fusca*) and black beech (*Fuscospora solandri*). (The beeches were formerly known as *Nothofagus*.)

About these species

Optimal soil type	**Silver beech** – tolerates a wide range of soil types. **Red beech** – prefers deep, well drained, fertile soils of lower slopes and river terraces. **Black beech** – tolerates poor and droughty soils.
Optimal annual rainfall	**Silver beech** – prefers generally higher rainfall (1500-6000 mm/year). **Red beech** – prefers average rainfall (> 1000 mm/year). **Black beech** – tolerates very low rainfall (750 mm/year).
Drought tolerance	**Silver and red beech** – moderate drought tolerance. **Black beech** – high drought tolerance. Drought can kill individual trees and even stands of all beech species. Drought stress may be a precursor to insect and fungal attack.
Periodic waterlogging tolerance	**Red beech** – moderate, tolerant of occasional waterlogging. **Silver beech** – low, prefers well drained soils. **Black beech** – low, intolerant of periodic waterlogging.
Frost tolerance	**Silver and black beech** – high. **Red beech** – moderate. Unseasonal (spring) frost is a major threat to open-planted beech seedlings.
Exposure tolerance	**Moderate** – young beeches planted on exposed sites without a nurse species can result in high mortality.

Shade tolerance	**Silver beech** – moderate/high. **Red beech** – moderate. **Black beech** – low. Cover is required for all the beeches in the first 2 years on exposed sites; best growth on open sites once established.
Coastal site tolerance	Low – all species have low tolerance to salt spray.
Fire resistance, flammability rating	Low fire resistance, low/moderate flammability.
Altitude tolerance	**Silver beech** – grows at high altitudes. North Island typically 750 m to timberline, isolated stands below 750 m; South Island sea-level to timberline. **Red beech** – prefers lower- to mid-slopes. North Island typically 300-1000 m; South Island sea-level to 1000 m. **Black beech** – tolerates lowland to mid altitudes.
Place in succession	Late successional species but can colonise bare surfaces.

Successful establishment

Beech seedlings are supplied by nurseries in containers but can be raised as bare-rooted stock. Red and black beech take up to two years from sowing to reach a 40-60 centimetre seedling; silver beech may take up to three years. Seedlings should be inoculated with mycorrhizae in the nursery – usually achieved by mixing beech forest duff into the potting mix or nursery bed.

Beech are amongst the fastest growing of all planted native trees. In open sheltered sites, seedlings can be planted at between 1000-2500 stems/hectare (between three metres and two metres apart). More stems/hectare means higher planting costs but earlier canopy closure, lower weed control costs, and potentially better stem form. In general, young beech need regular weed control for up to five years after planting.

On exposed harsh sites, survival and growth will be enhanced by use of a fast-growing nurse of hardy local pioneer shrub species, or interplanting in canopy gaps within existing shrubland. Nurse species

14-year-old silver beech in Southland, planted at 1800 stems/hectare and pruned to produce a single branch-free stem.

at two to three metres spacing help control weeds and provide shelter for later inter-planting of beech. Maintenance may be needed to ensure the nurse trees don't smother the beech over time.

If planting beech within a forest, large gaps in the canopy or light overhead shade are optimal. Planting within mānuka shrubland is also a good option, as beneficial mycorrhizae may be present.

Silvicultural requirements

Form pruning to remove double leaders and large branches may be needed at low planting densities. Higher density stands will need to be thinned to 800 stems/hectare or less, probably by age 20 depending on site and growth rate.

Growth rates vary widely with site conditions and stocking rates. In general, red beech is the fastest growing, then black beech, and silver beech is the slowest. Annual height increment over 80 years averages 34 centimetres in red and black beech and 23 centimetres in silver beech. Good growth rates are usually confined to fertile soils in mild climates and fairly open stands.

Beech regenerates readily in many situations within or close to natural forests providing a much cheaper alternative to planting. Dense "pole stands" commonly develop after major disturbance. Thinning naturally regenerated stands down to 800 stems/hectare or less (around 3.5 to 4 metres spacing) should be done in several light operations, beginning by age 15 years.

Pest and disease threats

Pinhole borer is widespread in beech forest and is a major factor affecting timber quality. The borer produce a network of fine tunnels within the wood. Base populations live in dead and dying trees. Living trees are not often attacked until their diameter exceeds about 15 centimetres, or are under stress. Pole stands thinned before the trees reach 15 centimetres diameter could help reduce pinhole borer invasion. However, natural, old beech stands often have wood defects because of historical invasions of pinhole borer – particularly in high disturbance forests. Planted and tended stands should have lower risk of defects as a result of silviculture.

Pūriri/ghost moth is another threat: larvae bore much larger tunnels

High quality clear wood from red beech.

than pinhole borer in live wood and may severely limit high-quality beech timber production in the North Island. As with pinhole borer, attack by pūriri moth larvae is often associated with fungi which further damage wood.

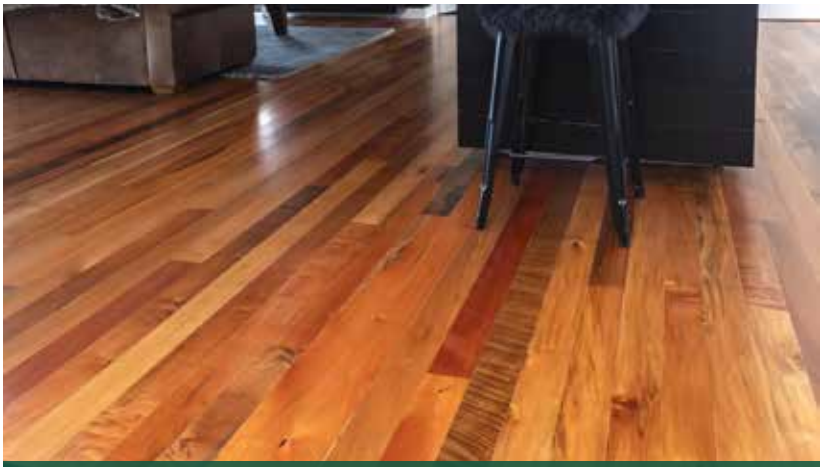
Beeches are relatively unpalatable to browsing animals.

Silver beech from Southland provides superb interior joinery in the Supreme Court in Wellington.

Timber properties, products and markets

New Zealand beeches are medium-density hardwoods with a straight grain and a fine, even texture. They have excellent sawing, machining, turning and nailing properties. They also stain, glue, and finish well. Beech wood performs well where strength, stability and appearance are required and is especially good for turnery, joinery, and cabinetry.

Heartwood colour varies with species from reddish to pinkish brown although black beech often has blackish streaks, which can be a decorative feature in panelling. Sapwood is lighter coloured whitish brown, pinkish or amber. Drying has been an important issue with beeches, with heartwood slow to dry and prone to warping, checking and collapse.



Red beech flooring.

Silver beech is an attractive furniture timber and when French-polished, it can resemble mahogany. Pinhole borer holes can be used as a feature grade in "antique" furniture, flooring and picture frames.

Red beech heartwood, when dry, is extremely stable and suitable for furniture, flooring, stair treads and decorative interior finishing. Its fine even texture makes it highly suitable for turning. It can be used in exterior exposed situations, such as pergolas and outdoor decking, without chemical treatment.

Black beech timber is strong and stable, but durability is variable. It is suitable for tool handles, furniture, exposed floors, and interior joinery.

Non-timber products and environmental services

Beech forests are highly valued for recreation, hunting, sphagnum moss harvesting, and beekeeping, and provide the backdrop for much tourism.

A distinct type of honey is derived from beech honeydew. The honey is used to make mead.

Cultural services and Mātauranga Māori

Historical evidence of Māori using beech wood is limited. Bark was used for dyes and the wood for small items like fishing lures due to its hardness. There is limited evidence for foraging in beech forest, particularly in the South Island, with suggestions this may be due to a lack of fruit that attracts native birds. Beech forests are relatively barren in terms of food and plant resources compared with other native forest types.

Other information

There are several small private operations sustainably managing old growth and regenerating beech forest operating within the requirements of the Forests Act (for example, silver beech in Southland, red beech in Westland, black beech in North Canterbury).

There is scope to manage plantations for timber using continuous cover techniques. Gaps created by harvesting would need to be large enough to allow natural regeneration and/or planted seedlings to thrive.

Kahikatea

Kahikatea *(Dacrycarpus dacrydioides)* is our tallest native tree. Kahikatea-dominated forest was once widespread and highly valued by Māori. Because it was commonly found on fertile lowlands, kahikatea was vulnerable to clearance for agriculture, with about 98 percent loss of the original forest. Now common only in south Westland, kahikatea forest is otherwise largely restricted to small remnants, often unfenced and degenerating. Its potential is becoming recognised as a relatively easy-to-grow species with high environmental and cultural values, and unique timber properties.

About this species

Optimal soil type	Grows on a wide range of soils. Frequently dominant on fertile swampy sites but grows faster on better-drained soils.
Optimal annual rainfall	Most abundant where there is moderate to high rainfall.
Drought tolerance	Low until well established.
Periodic waterlogging tolerance	Tolerates waterlogged soils and periodic inundation, but this slows growth. Dieback has been observed after rapid, major changes in water table.
Frost tolerance	Good – generally frost hardy, but nursery-raised seedlings can be frost tender.
Exposure tolerance	Moderate – can be grown in the open but seedlings are not wind tolerant if grown on exposed sites.
Shade tolerance	Low – tolerates some partial shade but young kahikatea requires full light for maximum growth.
Coastal site tolerance	Good – often naturally present in coastal and estuarine areas.
Fire resilience, flammability rating	Foliage is moderately flammable; but the forests' generally wet habitat makes for good fire resistance.
Altitude tolerance	Sea level to 750 m in North Island. Upper altitude limit steadily decreases southwards.
Place in succession	A long-lived (600+ years), light demanding, pioneer tree species. Needs disturbance and open sites to regenerate naturally.

Successful establishment

Kahikatea seeds most years, with heavy crops usually every three to five years. Seedlings are easily raised in nurseries as bare-root or in containers; containerised stock is most commonly available. Expect high survival and moderate growth rates on most sites but avoid dry sites. Plant at a minimum of 2500 stems/hectare (two metre spacing) on open sheltered sites. If planting in canopy gaps within a nurse species, such as mānuka, plant 2500 stems/hectare (two metre spacing). Release seedlings regularly to ensure they are not overtopped by competing vegetation as they require full overhead light.

Young kahikatea seedlings propagated in a commercial nursery.

Kahikatea will naturally regenerate (often prolifically) if there is sufficient light, plus local seed sources and vectors (tūī, bellbirds and kererū). Whether stands are planted or naturally regenerating, grazing livestock need to be excluded and other potential pests such as deer, hares and rabbits, need to be controlled.

Silvicultural requirements

Kahikatea naturally forms a conical shape with a single leader and small lower branches. Pruning may not be required unless open grown. Thin planted pole stands down to 400-600 stems/hectare once the canopy has closed and before the trees get too tall (at about eight to nine metres in height, around age 25-30).

Kahikatea can reach 10 metres high and 15 centimetres diameter at breast height in 30 years on average sites and ultimately grows to over 60 metres high with a trunk that is two metres in diameter.

Naturally regenerating stands can be dense with high timber volumes per hectare.

Pruned kahikatea stand planted on ex-quarry site with a mānuka nurse crop that has largely died out, Bay of Plenty.

These stands will benefit from progressive thinning to 400-600 stems/hectare.

Pest and disease threats

Kahikatea is relatively disease- and pest-free. Cicadas can damage saplings. Major changes in the water table, particularly cycles of flooding and drought, are thought to cause poor tree health with trees dying in some cases.

Timber properties, products and markets

Sawn timber is easily dried but prone to sapstain (discolouration caused by fungi) if not dried soon after sawing or treated with an anti-sapstain product.

The creamy-white sapwood is light, straight-grained with a fine, even texture. It is easily worked but non-durable and prone to borer. The white to yellow heartwood is reasonably durable, but slow to form, though it is more prominent in kahikatea from hilly sites.

Kahikatea was historically used for butter boxes, cheese crates and dairy machinery as it does not taint food products. Other historic uses included weatherboards (if treated), and interior uses including framing, panels, flooring and joinery.

A kahikatea ceiling.

Potential markets for non-tainting uses include domestic woodware, chopping boards, cake containers and specialty food packaging. Kahikatea is suitable for boat building if preservative-treated.

Non-timber products and environmental services

Kahikatea has a pivotal ecological role in swamp forests and riparian zones – habitats that support a wide range of indigenous plants and animals. Prolific production of fruit (swollen seed receptacles) provides an important food source for native species. Kahikatea swamp forest ecosystems also provide flood protection, protect water quality, and provide shade and shelter – which are all the more critical in an era of climate change.

There are potential markets for products derived from the fruit.

Kahikatea fruits prolifically, enhancing its biodiversity value. The fruit was a prized food for Māori. There are potential markets for products derived from the fruit.

Cultural services and Mātauranga Māori

Māori used kahikatea sapwood for carving and canoes. The hard heartwood was used to make tools and weapons. The burnt soot was used as a tattooing pigment, and leaves and bark were used for rongoā (traditional Māori medicine). Kahikatea forest ecosystems supported mahinga kai – traditional food sources. Kahikatea often fruits prolifically, and this was collected for feasts – with competition amongst young men who took great risks to climb high and collect the most fruit.

The extensive loss of kahikatea forest had a major impact on Māori wellbeing.

Other information

Through much of New Zealand, scattered (mostly small) kahikatea remnants are the sole reservoirs of a once rich lowland indigenous biodiversity. These remnants provide important "stepping stone" habitats for wildlife. While many remnants are unfenced, grazed, unhealthy and degenerating, there now are numerous local kahikatea restoration projects involving restoration of existing stands, and new plantings.

There is limited research on growing kahikatea, with more information needed on silviculture and potential markets for timber and non-timber products.

Planted kahikatea stand approximately 40+ years, Whitehall, Waikato.

Kauri

Kauri (*Agathis australis*) is New Zealand's highest profile native tree, dominant in the natural rainforests of northern New Zealand. It can live 1000 years or more: massive individuals are regarded as taonga (national treasures). During early European settlement most kauri forest was logged, cleared for farming or destroyed by fires. The small remaining areas of mature kauri forest are now in reserves, with regeneration occurring in some areas.

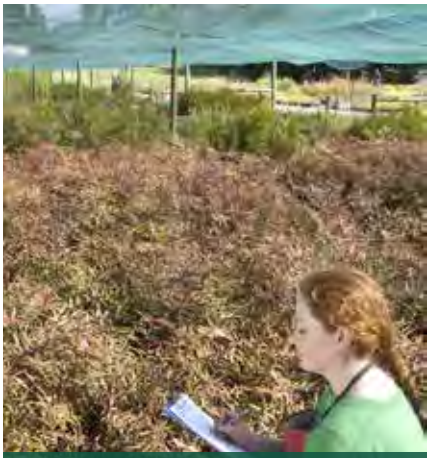
Kauri has natural good form and sought-after timber properties so is a major species to consider for planting on suitable sites as a future wood resource. Kauri dieback disease is a threat which potential growers must consider.

About this species

Optimal soil type	Tolerates a wide range of soil types. Grows best on fertile well-drained soils but slow-growing groves do establish on drought-prone, infertile ridgetops and upper slopes where there is less competition.
Optimal annual rainfall	Moderate/high – can tolerate a wide range of soil moisture conditions.
Drought tolerance	Mature trees tolerant; young seedlings are vulnerable to drought.
Periodic waterlogging tolerance	Low/moderate.
Frost tolerance	Low – seedlings are very frost sensitive. Frosts are the major determinant of kauri's natural distribution; planted trees can grow well in frost-free sites outside kauri's natural range.
Exposure tolerance	Moderate/high – grows in open warmer sites; benefits from light shelter on harder sites.
Shade tolerance	Low/moderate – young trees require light wells in shrubland or sheltered open sites.
Coastal site tolerance	Moderate/high.
Fire resistance, flammability rating	Low fire resistance, moderate flammability.
Altitude tolerance	Predominantly a lowland species from sea level to 300 m; tolerates higher elevations in the north.
Place in succession	Mid to late, long-lived successional species that can be replaced by broadleaf species long term; can colonise bare surfaces where competition is limited.

Successful establishment

Kauri is generally sold as containerised stock. In nurseries, seedlings grow to approximately 30 centimetres height in one year, 60 centimetres in two years. Growers must source seedlings from nurseries free from kauri dieback disease.



Kauri seedlings in a commercial nursery, where plants are normally raised in containers.

On exposed or difficult sites, kauri is best planted within an existing or planted nurse (for example, mānuka or kānuka). Restrict planting without a nurse to sheltered, warm sites. Planting at relatively low density (for example, 1000 stems/hectare or less; three to five metres spacing) reduces establishment cost but time to canopy closure will be slow and some pruning may be needed. Planting at higher density (for example, 2500 stems/hectare, two metres spacing) promotes earlier canopy closure, reduces the need for extended weed control and pruning, but more thinning will be needed later on.

On good sites kauri does not compete well with faster-growing broad-leaved trees, shrubs and ferns, so regular releasing may be needed.

Silvicultural requirements

Kauri sheds its small lower branches naturally without leaving knots. Young kauri generally grow a single leader; remove occasional double leaders or persistent large lower branches by pruning. Thin pole stands to a final spacing of about 500 stems/hectare (four to five metres spacing) or less in several light operations, beginning around age 20-30 depending on planting density and growth. Production thinning using continuous cover techniques is an option from about age 60.

Kauri grows fast – average annual growth rates are around

Young kauri plantation – trees are more than six metres high six years after planting on this fertile lowland site within a kiwifruit orchard where the kauri has had exceptional management.

seven millimetres trunk diameter and 35 centimetres height growth. Volumes of 600-800 cubic metres/hectare for planted kauri at age 60 can be achieved on good sites. Heartwood development is slow – usable quantities are not likely to occur until trunk diameters reach at least 60 centimetres.

Naturally regenerating kauri can be managed for timber, as a cheaper alternative to planting. Dense regenerated pole stands need to be gradually thinned to a target of 500 stems/hectare or less.

A 49-year-old kauri plantation, Hawke's Bay.

Pest and disease threats

Kauri dieback is a fatal disease, caused by a soil-borne root-rot pathogen *Phytophthora agathidicida*, which kills trees and seedlings of all ages. Measures are in place to prevent further spread of kauri dieback into disease-free areas. This includes restricted access to infected kauri forest and prohibiting removal of kauri plant material, soil or goods from infected areas. Growers need to source kauri seedlings from disease-free nurseries; contractors and visitors to nurseries and plantations must follow cleaning protocols for equipment, tyres and footwear.

There are few other pathogens and pests affecting kauri. Possums, goats and deer can all potentially damage planted kauri seedlings and saplings.

Timber properties, products and markets

Mature kauri heartwood is one of the finest softwoods in the world. It has been widely used for construction, furniture, joinery and turning. Heartwood has excellent working qualities with straight, fine, even grain allowing a high-quality finish. It is moderately durable

Kauri wood has excellent working properties, the straight fine even grain giving a high-quality finish.

in-ground and very durable when continuously wet. Wood recovered from ancient logs preserved in swamps is highly valued for craft work. Sapwood has many similar properties to heartwood but is less durable and susceptible to borer. Kauri sapwood logs from plantations could be a valuable future solid wood resource for internal uses.

Non-timber products and environmental services

Kauri forest harbours unique biodiversity. The limited areas of remaining old growth kauri forests are major tourist attractions.

Kauri gum has been significantly important for Māori and European settlers for multiple uses.

Cultural services and Mātauranga Māori

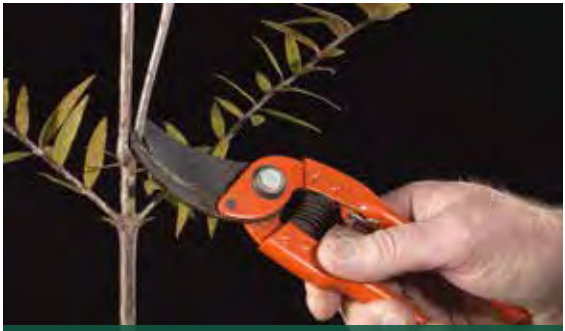
Kauri forest has special cultural significance for Māori. Trees were used for making waka taua (seagoing canoes), carving and construction of whare (buildings). Kauri gum was valued for chewing as well as a fire kindler, torch fuel, tattooing pigment, and as a pest deterrent in kūmara plantations.

Some Māori associate kauri with Tāne, the god of the forest.

Other information

Continuous cover forestry is an option for kauri: large canopy gaps will be needed to stimulate natural regeneration of replacement kauri.

A cure for kauri dieback has yet to be found. Only strict adherence to hygiene protocols will ensure *Phytophthora agathidicida* does not spread to new areas. Long-term seed storage and planting outside the natural range have been proposed to conserve kauri germplasm.



Form-pruning to remove double leaders can start from the sapling stage.

Kōwhai

New Zealand has eight *Sophora* species, commonly called kōwhai. They are shrubs and small-to-medium sized trees that readily interbreed creating many intermediate hybrid forms. They have attractive, distinctive yellow flowers that are important food sources for native birds. However, all parts of the plant (especially the seeds) are poisonous to livestock.

The two largest kōwhai species are *S. tetraptera* (large-leaved kōwhai) and *S. microphylla* (small-leaved kōwhai), and these are profiled here. *S. microphylla* is the most widespread, found naturally throughout both the North and South Island. *S. tetraptera* is naturally found in central and eastern regions of the North Island, and is more of a lowland species, but has been extensively planted outside its natural range.

They have excellent wood properties, but there are major knowledge gaps in growing and using kōwhai for timber and non-timber products.

About these species

Optimal soil type	Well-drained, sandy loam, slightly acidic, moderately fertile sites. Kōwhai are legumes (nitrogen-fixers) and can tolerate a range of site-types.
Optimal annual rainfall	Tolerate drylands, but moderate rainfall is optimal.
Drought tolerance	Moderate.
Periodic waterlogging tolerance	Low – intolerant of waterlogged soils.
Frost tolerance	Moderate – *S microphylla* is hardier than *S. tetraptera*.
Exposure tolerance	Moderate – grow well in the open but need protection from strong winds.
Shade tolerance	Low – tolerate partial shade but require full light for maximum growth.
Coastal site tolerance	High – both species are naturally present in coastal areas.
Fire resilience/flammability rating	Low flammability. Moderate to good fire resilience.
Altitude tolerance	*S. microphylla* – sea level to 800 m altitude over most of New Zealand. *S. tetraptera* – sea level to 450 m altitude in the North Island.
Place in succession	Light demanding, pioneer species.

Successful establishment

Kōwhai are regular seeders and easy to grow from seed, provided the hard seed shell is nicked or abraded. Take care when ordering kōwhai planting stock for conservation plantings – ask the nursery whether seedlings have been raised from seed collected from local, natural populations. Because kōwhai are popular native trees for gardens, there are cultivars including kōwhai hybrids and even an exotic relative sold in nurseries.

Kōwhai prefer dry, sunny sites and can tolerate wind, drought, and cooler climates. They naturally grow on river terraces, flood plains, hill slopes and rocky ground, and beside waterways and forest edges. Being nitrogen fixers, they can establish on nutrient-poor sites and improve soil fertility. However, they grow best on moderately fertile, free-draining soils.

Kōwhai will naturally regenerate if there is sufficient light, plus local seed sources.

Flowers and foliage (left) and seed pods (right) of kōwhai.

Whether stands are planted or naturally regenerating, livestock need to be excluded and pests such as deer, hares and rabbits need to be controlled. Exotic weeds and grasses will compete with kōwhai until the seedlings are large and vigorous enough to overtop them. Spot-spraying planting sites well before planting is advised. Follow-up spraying may be needed – take care as kōwhai can easily be damaged or killed by herbicide. Grass-selective herbicides are better than broad-spectrum herbicides.

Both species are semi-deciduous and can be leafless while flowering.

Silvicultural requirements

S. microphylla grows up to 25 metres tall, with a trunk of up to 60 centimetres diameter. *S. tetraptera* grows up to 15 metres tall, with a short trunk up to one metre in diameter.

Both species have moderate growth rates of about 45 centimetres per year in height, and eight millimetres per year in diameter for trees up to 20 years old.

There is a lack of information on growing kōwhai for timber. It is not known which species might be more useful for timber production, or whether they may play a role in continuous cover forestry.

Pest and disease threats

Kōwhai are relatively disease- and pest-free, but are attacked by the kōwhai moth caterpillar, which can defoliate trees. However, kōwhai can tolerate partial defoliation. The native drywood termite can attack sawn timber.

Timber properties, products and markets

The wood is heavy, dense, strong, elastic, and durable. It is one of our strongest native hardwoods. The wood is lustrous and finishes well. It was used by European settlers for tools, machinery, fences, and cabinet work. However, the wood should not be used for domestic ware as it can be toxic.

Kōwhai are typically found on dryland country as seen here along the shores of Lake Hāwea, Central Otago.

Non-timber products and environmental services

Kōwhai have extensive root systems that help minimise erosion. They stabilise riverbanks in riparian plantings. Because they are nitrogen fixers, they can colonise rocky, poor-quality sites and improve soil fertility.

The leaves and flowers are an important food source for native birds.

Cultural services and Mātauranga Māori

Māori highly valued kōwhai for their timber and medicinal properties. The wood was used for fences and whare construction, tools, domestic implements and weapons. A solution obtained from boiling the bark or leaves was used on cuts, wounds, skin rashes and infections. Poultices were used for sprains, tumours, and bruises. Kōwhai were also used to make dyes.

Kōwhai are important in protecting waterways and supporting mahinga kai (traditional food sources).

Other information

The main threat for kōwhai comes from planting hybrids, horticultural cultivars, foreign species (for example, Chilean Pelu, *S. cassioides*) and also kōwhai species outside of their natural range. Because kōwhai readily hybridise, this undermines the unique characteristics of the natural species and ecotypes.

All parts of the plant are poisonous to humans and livestock, particularly the seed.

Kōwhai provide food for native birds, particularly in spring.

Matai and Miro

Matai (*Prumnopitys taxifolia*) and miro (*Prumnopitys ferrugineus*) are temperate softwood trees, common in natural rainforests throughout New Zealand. Both species are relatively slow growing, with the largest trees found in the central North Island and the West Coast region of the South Island. Matai can live for 1000 years, and miro for 600 years. Timber was valued by early settlers for interior uses such as beams and flooring.

Slow growth and demanding site and management requirements mean that matai and miro are less likely to be popular for new planting than other native species. Where they are already established in secondary forest, they remain species to protect, as apart from their timber they have significant cultural and ecological importance.

About these species

Optimal soil type	Prefer friable, free-draining soils of moderate fertility. Matai is generally found in areas of higher fertility but lower rainfall than miro.
Optimal annual rainfall	Prefer regular year-round rainfall. Matai prefer around 650-700 mm/year; miro prefer a minimum of 800 mm/year. Both species can tolerate much higher rainfall (perhaps up to 6000 mm/year, similar to rimu).
Drought tolerance	Low – but can tolerate a range of soil moisture conditions once well-established.
Periodic waterlogging tolerance	Low/moderate.
Frost tolerance	Low – seedlings are frost sensitive and early growth is best under a canopy.
Exposure tolerance	Moderate – grow best with some shelter either where trees are growing together or with other species in a closed canopy.
Shade tolerance	Good – will quietly develop under a canopy until well established then respond to light when canopy openings arise. More shade tolerant than species such as tōtara, kauri and kahikatea.
Coastal site tolerance	Low – not coastal species.
Fire resistance, flammability rating	Low fire resistance, moderate flammability.
Altitude tolerance	Predominantly a lowland species from sea level to 800 m in the north and 300 m in the south.
Place in succession	Mostly a secondary species or “follower” in established forest. Miro tend to be late-successional (very shade tolerant) whereas matai will regenerate and establish earlier after a large disturbance.

Growing regimes

Mataī and miro seedlings are sometimes available raised in containers and even naturally regenerated seedlings can be potted up and will develop to a plantable size in around two years (30-50 centimetres).

Planted mataī and miro seedlings will most likely only thrive if planted with a nurse species or under an existing shrub cover, such as kānuka, mānuka, or fast-growing broad-leaved species. Where planting bare land a 3:1 mix of shrubs to trees with a combined stocking of 2000-2500 stems/hectare (two metres spacing) is recommended.

Potted two-year-old mataī seedlings.

Planting sites should be fenced to exclude stock; other browsing/grazing pests should be controlled. Young trees require releasing from weeds, ground ferns, and woody shrubs for up to four to five years after planting. Early growth is similar to rimu but slower than several other softwood species, so these species require a prolonged period of early care.

Both mataī and miro will germinate on cleared sites which are allowed to revert to forest naturally, so there is scope to manage natural regeneration rather than planting a new forest.

Silvicultural requirements

Little information is available about silviculture: it seems certain that gradual releasing from overhead cover, care with spacing and possibly some form of pruning will all contribute to an improved stand. Data on growth is also sparse but plantings in the northern Waikato have reached around 12 metres tall and 15 centimetres in trunk diameter after 45 years. Ultimately mataī and miro can reach 25 metres high and 1.0-1.3 metres in trunk diameter, with broad crowns held up by large branches.

Pest and disease threats

Mataī and miro are generally robust trees, able to withstand strong winds. The trees have little in the way of pest or disease problems; however, possums, deer and goats will damage seedlings and saplings.

Both species appear reasonably resilient to human activities such as soil disturbance and alterations to drainage.

Timber properties, products and markets

Mataī and miro timber is heavier and denser but also a little more brittle than some other softwoods. Overall miro timber is generally inferior to mataī, being wetter, less stable and more brittle; however, it shares qualities of high strength and excellent machining and finishing properties with straight, fine, even grain.

Miro flooring.

Mataī often has excellent colour and attractive grain, and is remarkable for its silken finish. Both species have low durability when in ground contact but are very durable under cover: recycled flooring cut more than 100 years ago is often in "mint" condition and in big demand.

Non-timber products and environmental services

Māori used oil extracts from the fruit as an insect repellent, gum was used for ulcers and wounds and a concoction of leaf and bark material of miro was useful for relieving stomach pains. A liquor extracted from fissures in the wood of mataī (mataī beer) was also drunk to ease consumption and used as an antiseptic, and later European bushmen drilled the trees and used the liquid for the same purposes.

In conjunction with other trees in our native forests, mataī and miro help control soil erosion, provide landscape aesthetic and amenity areas and other cultural and environmental values.

Miro berries, drupe-like and up to two centimetres long.

Cultural services and Mātauranga Māori

These species have cultural significance for Māori, as both trees were important for medicinal values and their fruit. Where the trees existed they were taonga: this spiritual dimension will undoubtedly continue to be a rationale for growing and maintaining them in our forests. Both species produce large drupe-like fruit favoured by wildlife, particularly kererū.

Miro is the more prolific seeding tree and accordingly was often the site of bird snares. Mataī is dioecious with separate male and female trees and bears relatively fewer drupes. Where tōtara was rare, Māori would prefer mataī as an alternative, where it was also used for canoes, bailers, handles and so on. Miro wood was used less.

Other information

The two species can be quickly distinguished by their bark – mataī bark is dark greyish and has a hammered appearance, flaking off in ovoid chunks to reveal an orange-red underbark. Miro bark is much more finely scaled and has a dotted indentation.

Miro foliage, mature tree.

Pūriri

Pūriri (*Vitex lucens*) is related to tropical and subtropical hardwood timber species and grows naturally in coastal and lowland forests in the top half of the North Island. It prefers warm, moist, and fertile sites and can be one of the quickest growing native timber species. Its timber is potentially very high value. It is renowned for its durability even in wet ground contact, and is hard, heavy, and strong, with interlocking grain and attractive colours. Pūriri is a large, long-lived species with very high ecological values, providing almost year-round food for some native birds.

About this species

Optimal soil type	Prefers moist, fertile, free-draining soils, especially volcanic soils, but can also be found on fertile, yellow clay loams.
Optimal annual rainfall	Performs best where rainfall exceeds 1250 mm/year.
Drought tolerance	Good resistance to droughts once established.
Periodic waterlogging tolerance	Tolerant of periodic flooding on free-draining soils, but intolerant of prolonged waterlogged conditions.
Frost tolerance	Low – prone to damage by frosts.
Exposure tolerance	Moderate – grows better on more sheltered sites. Crowns contract with stress (for example, wind burn), but resprout. Prone to toppling in extreme winds.
Shade tolerance	Moderate – shade tolerant but grows fastest with overhead light through a gap in the canopy. Mature crowns enjoy full light conditions.
Coastal site tolerance	Good – often naturally present in coastal and estuarine forests.
Fire resilience/flammability rating	Low-moderate flammability.
Altitude tolerance	Mostly found from lowland to around 400 m in the upper North Island.
Place in succession	A long-lived mid-late successional tree species preferring to establish within a forest environment and becoming part of an old-growth forest.

Successful establishment

Where local seed sources and kererū are present, pūriri can naturally regenerate within forests as long as livestock are excluded.

Pūriri seed is easily germinated so seedlings are commonly available at nurseries. It can also be propagated by cuttings. On favourable sites the species is usually easy to establish. Planted seedlings can grow quite fast – often over 50 centimetres in height per year in sheltered conditions and annual increases in trunk diameter of one centimetre once established. Some releasing to prevent smothering in the early establishment phase is important. Toppled trees can coppice and sprout from fallen trunks and branches.

Healthy young pūriri seedling.

Silvicultural requirements

Pūriri saplings growing in open, full-light conditions, or planted with a nurse species, are prone to branching heavily and developing multiple leaders. For timber production as pure stands in open conditions, pūriri would need to be established at high stocking rates (at least 4,400 stems/hectare) and severely thinned. More cost-effectively, pūriri can be established as part of a mixed-species forest (at up to 625 stems/hectare) within an effective nurse cover – preferably under a light overhead canopy, or into gaps within a forest canopy. Eventually pūriri develop massive spreading crowns, so final crop stocking may be well less than 120 stems/hectare. Underplanting within an existing forest, and/or managing natural regeneration, are both practical options.

Pūriri can grow tall and straight through gaps in the surrounding tree canopy.

For best growth rates and stem form, creating and/or maintaining overhead light gaps and pruning is

recommended for the selected crop trees (30-120 stems/hectare). In suitable microsites, pūriri can develop tall, straight, branch-free trunks up to about nine metres. However, do not expect any sawlogs above the main trunk. Coppicing and epicormic regrowth may occur after pruning or thinning.

The high value of the timber means production thinning should be an option. Pūriri is well-suited to sustainable harvesting as part of mixed-species, near-natural, continuous cover forestry regimes.

Pest and disease threats

Pūriri is generally a resilient species. Specimens in open, exposed conditions (such as farmed river flats) often appear to have declining health, especially their crown foliage. This may be from stresses caused by soil compaction, stem damage, and exposure rather than insect or disease problems. If protected, many will resprout with epicormic growths from the stems.

The grub of the pūriri moth (*Hepialis virescens*) is the only significant insect pest. It tunnels into the growing wood leaving L-shaped holes about one centimetre in diameter and up to 15 centimetres long. Although these do not affect the durability, they create defects that can significantly affect the timber's value and use.

A pūriri māripi laying on a rough sawn pūriri board and showing moth grub holes to the left (carving by Mark Howard).

Timber properties, products and markets

Pūriri timber is scarce and highly prized. It commands very high prices – even with pūriri moth grub holes. Its strength, hardness, and durability make it suitable for exterior uses; however its high value and beauty mean it is desirable for interior applications, such as furniture, stair treads, and artworks. It machines and carves well and finishes easily. Colours range from smoky grey-browns to dark chocolate browns – almost ebony black. Sapwood is often light grey; sometimes it is difficult to distinguish between sapwood and heartwood.

Pūriri carving (carving by Mark Howard).

Non-timber products and environmental services

Large, old pūriri trees have outstanding ecological values. They are an important food source for tūī and kererū, with almost year-round flowers and fruit from February to September. Their spreading crowns often host a range of epiphytes, while their leaf litter creates rich dark humus.

Cultural services and Mātauranga Māori

Pūriri timber is suitable for many traditional Māori artefacts, especially weapons (for example patu, tewhatewha, and taiaha). Other uses where strength is important include palisades, tools, digging implements, hair combs and paddles. Pūriri is also used in rongoā (traditional medicines).

Other information

Settlers used the timber extensively for house piles, bridge beams, and fence posts, but also to improvise when needed, for things such as axle bearings and knitting needles.

Pūriri has been identified as a species warranting more trials and research into its potential use for timber production.

Old pūriri have outstanding ecological values.

Rewarewa

Rewarewa (*Knightia excelsa*) is a distinctive evergreen broadleaved tree with narrow, columnar crowns that often emerge above regenerating forest. It is medium-sized, growing up to 30 metres high and one metre in diameter, with coarsely toothed, long leathery leaves. Scattered trees or small stands occur in lowland and hill-country forest in the North Island and in the Marlborough Sounds in the South Island.

Rewarewa is well known for its distinctive timber with an attractive flecked appearance. It has the potential to be a fast-growing timber tree which, on the right site, can produce good-quality timber for specialist uses including veneer. Its common name "New Zealand honeysuckle" refers to the timber's decorative properties and abundant nectar production.

About this species

Optimal soil type	Free draining soils. Often associated with poor or disturbed soils such as on roadside berms and cuttings.
Optimal annual rainfall	Prefers moderate rainfall of around 1000 mm/year. Favours regions with warm to hot summers.
Drought tolerance	Moderate.
Periodic waterlogging tolerance	Poor.
Frost tolerance	Moderate – tolerates frost to -10°C but damaged by out-of-season frosts. Frost-tender when young.
Exposure tolerance	High – readily establishes on open disturbed sites and tolerates strong winds.
Shade tolerance	Low – often establishes on open sites with distinctive columnar crowns visible above young secondary forest.
Coastal site tolerance	Moderate.
Fire resistance, flammability rating	Moderate fire resistance. Low/moderate flammability.
Altitude tolerance	Sea level to 750 m in North Island, 200 m in South Island.
Place in succession	Early successional, long-lived pioneer species. Often visible as emergent scattered trees or as small stands in regenerating forest.

Successful establishment

Annual seed crops of rewarewa are variable. The velvet red seed capsules must be collected before they split and release windblown seed. Rewarewa is easy to grow from seed; expect moderate germination rates. Seedlings are best raised in containers, as root development can be poor if raised as bare-rooted stock. Young seedlings grow quickly to over 50 centimetres within two years in the nursery with protection from frosts.

Rewarewa seedling in a PB3 planter bag ready to plant out.

Rewarewa is not commonly grown by nurseries in large numbers: there is limited demand and few plantations have been established. Rewarewa is however being planted on open, lowland sites – for example as street trees, in amenity areas and occasionally in pasture. Rewarewa often naturally regenerates with a range of early successional shrub and small tree species, indicating it is likely to establish when interplanted in gaps within a nurse cover. Maintaining overhead light will ensure fast growth of this light-demanding species, enabling crowns to emerge through the nurse canopy.

Silvicultural requirements

Rewarewa are generally known for their symmetrical columnar shape (similar to young kauri). Height growth averages 30-40 centimetres per annum and annual diameter increment five to eight millimetres. A survey of the performance of native plantations indicates that average height and diameter for planted rewarewa will be up to 19 metres high and 36 centimetres in diameter by age 60 years.

Rewarewa have upright crowns with erect branches. Multiple leaders can occur irrespective of stand density in natural or planted stands.

There has been no research into rewarewa silviculture.

Older rewarewa seedlings approximately two metres tall planted in open grassland as amenity trees, Te Miro, Waikato.

Pest and disease threats

Rewarewa is a hardy species, mostly free of fungal disease. Seedlings can be badly damaged by thrips in warmer parts of the country. Planted seedlings and saplings can sometimes have a rust-like appearance on their leaves, especially in shady conditions.

The sapwood of rewarewa is prone to attack by borer species *Anobium* and *Lyctus*.

Sawn rewarewa wood showing its dark-coloured fleck.

Timber properties, products and markets

Rewarewa wood is instantly recognisable by its pale to dark reddish colour and attractive flecked appearance. The dry sapwood is silvery pinkish brown and the heartwood dark red to purple-brown with very prominent medullary rays (distinctive lines radiating from the centre of the log to the bark). The timber is not durable, but the borer-susceptible sapwood is treatable with boron salts.

Rewarewa timber takes a long time to dry. Once dry, it machines well. The timber is tough, stiff, and hard wearing, with non-skid properties. When sawn in a certain way, the figure (grain pattern) resembles oak. It can also be peeled for veneer.

Early uses included bush tramways, brake blocks, non-skid floor strips and fence battens. Inlay and decorative work continues, particularly for small wood products such as rulers made of inlaid native timbers for the tourism market.

Non-timber products and environmental services

In spring, the dense spikes of reddish flowers produce abundant nectar, attracting tūī and bellbirds. Rewarewa also produces distinctive dark-coloured honey.

Rewarewa is commonly planted as a specimen tree in gardens and parks as it can tolerate poor soils, light frosts, and strong winds when planted on open sites, and has an attractive, symmetrical appearance.

Cultural services and Mātauranga Māori

There has been no evidence found of Māori making significant use of rewarewa timber. The flowering of rewarewa was a seasonal marker, indicating the sixth month of the Māori calendar (October-November). Nectar was collected and eaten by Māori who picked the flowers in late spring and tapped them onto the inside of a gourd vessel. The inner bark was used to bandage over wounds to stop bleeding and speed healing.

A traditional Māori story says the distinctive, curved shape of the seed pods inspired the shape of the waka.

Other information

Rewarewa was called the "Bucket of Water" tree by early settlers as it is useless for firewood.

A widely spaced plantation of rewarewa established in an urban park with low intensity grazing among the trees.

Rimu

Rimu (*Dacrydium cupressinum*) is the most widely occurring native conifer, prominent in many forest types throughout New Zealand. It is often seen emerging above other trees in mixed conifer/hardwood forest, with its distinctive graceful weeping foliage and flaky bark.

Historically, rimu was the most important native timber tree due to its abundance and wide distribution, high-quality wood and multiple uses. There is scope to increase planting of rimu as a timber resource on suitable sheltered sites where growers provide timely weed control.

About this species

Optimal soil type	Found on a wide range of soils including well and poorly drained; slightly acidic soil with good organic matter content is ideal. Regenerates on disturbed sites where mineral soil is exposed and competition reduced.
Optimal annual rainfall	Moderate (1000 mm) to high (> 6000 mm) – does not grow well in hot dry areas.
Drought tolerance	Low/moderate.
Periodic waterlogging tolerance	Moderate/high – tolerates poorly drained soils (but grows better on well-drained sites).
Frost tolerance	Moderate – tolerates temperatures down to -5°C when established.
Exposure tolerance	Low – seedlings and saplings need shelter from wind.
Shade tolerance	High – one of the most shade tolerant native conifers. Persists in full or partial shade but very slow growth. Best growth is in well-lit forest gaps.
Coastal site tolerance	Low for seedlings, high as mature trees.
Fire resistance, flammability rating	Moderate fire resistance. Moderate/high flammability.
Altitude tolerance	Common in lowland and montane forest; occasionally found in lower subalpine forest (up to 750 m in North Island, 600 m in South Island).
Place in succession	Early to mid-successional, long lived canopy tree, often emergent above the canopy.

Successful establishment

Rimu has infrequent and irregular mast seeding so seed collection is erratic and costly. Seedlings can be raised as bare-root or in containers, although achieving a vigorous fibrous root system can be difficult. Supply from nurseries is limited due to inconsistent seed supply and limited demand.

Rimu seedlings planted within the shelter of regrowth and logging slash, Papamoa Hills Regional Park, Bay of Plenty.

On open sites, rimu is best planted in combination with nurse shrub species. A 3:1 mix of shrubs to trees with a combined stocking of at least 2500 stems/hectare (two metres spacing) is recommended. For existing nurse shrubland, plant rimu as single seedlings or in small groups of three to five within canopy gaps or along cut lines. Regular releasing, including keeping canopy gaps open, is essential until the trees have outgrown competing vegetation. Planting rimu on open, exposed sites is not recommended.

Rimu can be planted as a single species but only on sheltered lowland sites. Plant at least 2500 stems/hectare and ensure any competing vegetation is controlled. Natural regeneration is likely to be slow and scattered within regenerating shrubland. Occasionally dense pole stands can develop where there is a ready seed source and birds to spread seed.

Rimu has slow initial growth. Seedlings growing without overhead shade can grow 15-25 centimetres/year over the first five years, and up to 40 centimetres/year on good sites once established. The latest rimu growth model indicates trees can reach 20 metres in height and 40 centimetres trunk diameter at age 60, at 1000 stems/hectare. Rotations of 80 years or more are required to obtain stem diameters of at least 50 centimetres. Heartwood formation is slow.

Planted rimu stand, 63 years old, before thinning.

Silvicultural requirements

Dense pole stands where trees have trunk diameters around 10-20 centimetres should be thinned to a final spacing of about 500 stems/hectare (four to five metres spacing) or less. This should be undertaken in one or more operations from about age 30 depending on density and growth-rate.

After the first thinning-to-waste at Holts Forest Ecosanctuary, northern Hawke's Bay.

Removing multiple leaders and pruning steeply angled lower branches can start from the established sapling stage which, depending on growth rate, can be from age 10. Thinning densely planted stands provides opportunities to remove poor-form trees. More pruning is likely required for lower-density planted and open-grown rimu.

There is scope to manage planted or naturally regenerating rimu under a continuous cover forest system by selectively harvesting small groups of trees.

Pest and disease threats

Rimu is largely resistant to insect attack or disease. Cicada damage can deform planted seedlings. Sapwood is susceptible to *Anobium* (house borer). Rimu is the least palatable of the native conifers, but deer can ringbark saplings, and hares can nip tops off seedlings. Kākā can ringbark pole trees.

Highly decorative rimu heartwood is favoured as furniture and interior joinery.

Timber properties, products and markets

Rimu wood is known for its beautiful reddish-brown hue and fine grain. The heartwood is highly decorative, even-textured, hard and even-wearing. It is durable above ground, paints well, and is excellent for machining and finishing. Dry heartwood needs drilling before nailing. Sapwood does not sapstain easily, seasons readily and machines and finishes well.

High grades of rimu heartwood are used for flooring, weatherboards, interior joinery, veneer and high-quality furniture. Lower grades are used for framing.

Fruiting rimu, Whirinaki Forest, central North Island.

Non-timber products and environmental services

Rimu trees play a vital role in the New Zealand ecosystem. As long-lived, tall, emergent trees with massive crowns, they often harbour a diverse canopy ecosystem of epiphytes and lianes with associated fauna. Their mast fruiting cycle produces a bounty of small, fleshy fruits every few years providing feasts for native birds including the endangered kākāpō.

As rimu is so widely distributed in many forest types and is a long-lived species, it is a significant contributor to controlling soil erosion, and providing landscape aesthetic, amenity and other cultural and environmental values.

Cultural services and Mātauranga Māori

Rimu holds cultural significance for Māori. It was used for buildings and, where tōtara and kauri were not available, for canoes. Like tōtara, it was easily worked with stone tools, wooden wedges and mallets. Māori fashioned war spears, patu, and toki from rimu. Grubs found near the roots of rimu trees were used as pigment for moko (facial tattoos). Rimu bark and leaves were used to treat various ailments and injuries.

Adventure tourism integrated within a remnant rimu forest allows people to experience the tall cathedral like trees as they walk along a raised walkway, West Coast Tree Top Walk and Tower Zipline, near Hokitika, West Coast.

Tānekaha

Tānekaha (*Phyllocladus trichomanoides*, also known as celery pine) is a warm-temperate softwood tree, common in natural rainforests of northern New Zealand – the southern boundary is roughly a line between Whanganui and Waipukurau in the North Island. It is also found in northern Marlborough and western Nelson in the South Island. In Northland, secondary forest developing under kānuka often includes tānekaha and kauri together, especially on the drier ridges where there is plenty of light. It grows to become a moderately tall (20-25 metres) straight-stemmed tree, generally 80 centimetres to one metre in diameter.

Tānekaha's natural good form and strong, versatile timber make it a species to consider for planting on suitable sites as a future wood resource. Growth rate is likely to be slower than kauri, but management is straightforward, and it has no particular pest or disease issues.

About this species

Optimal soil type	Tolerates a wide range of soils and soil moisture conditions; best growth on fertile well-drained sites.
Optimal annual rainfall	Moderate/high.
Drought tolerance	High – often well represented on drier ridges especially where there is plenty of light.
Periodic waterlogging tolerance	Low/moderate.
Frost tolerance	Low – seedlings are frost sensitive and early growth is best under a light canopy.
Exposure tolerance	Moderate/high – grows in open warmer sites including hard clay ridges in Northland; benefits from light shelter on harder sites.
Shade tolerance	Low/moderate – requires light wells in shrubland or sheltered open sites and grows best under an open canopy such as tall kānuka.
Coastal site tolerance	Moderate/high.
Fire resistance, flammability rating	Low fire resistance, moderate flammability.
Altitude tolerance	Predominantly a lowland species from sea level to 300 m; higher elevations in the north.
Place in succession	In secondary forest where there is a seed source, it is a reasonable early coloniser.

Growing regimes

Tānekaha seedlings are usually available in containers: naturally regenerated seedlings can be potted up and will develop to a plantable size in 18-24 months (30-50 centimetres).

Fence planting sites to exclude stock. A pre-planting spot-spray is recommended where there is vigorous exotic grass. For best results, interplant tānekaha at 625-1100 stems/hectare (three to four metres spacing) within an existing or planted nurse shrubland such as mānuka or kānuka.

Tānekaha seedlings ready for planting. Seedlings usually reach this size after two years in the nursery.

Release regularly, for up to four to five years, to prevent competition from weeds, grasses, ground ferns, and woody shrubs. Tānekaha does not tolerate competition from faster-growing broadleaved trees, shrubs and ferns on good sites. Fertiliser may boost establishment on more nutrient-deficient soils. Early growth is slower than kauri but similar to tōtara.

Tānekaha can be quite abundant on some sites reverting from pasture to forest, indicating that there is scope to manage natural regenerating tānekaha as a future timber resource.

Tānekaha planted on retired farmland, Te Miro, Waikato.

Silvicultural requirements

Tānekaha has slender, horizontal branches in whorls on the lower stem, so pruning is relatively straightforward. Natural apical dominance promotes a single straight leader; form pruning may be required for occasional double leaders or large lower branches, especially around stand edges. Where there is dense regeneration, sapling and pole stands will need thinning over several operations to about 500 stems/hectare or less. Young natural stands often include a mix of tree sizes and ages and will require frequent intervention to get the best results.

Trees that have regenerated naturally in the forest can reach 15-20 metres tall and with trunks of 30 centimetres diameter at around age 40 on average sites. This is significantly less than kauri, but similar or better than other native conifer species.

A continuous cover forestry approach will promote development of multi-species, multi-aged forest while retaining the benefits of mature forest. Large canopy gaps will be needed to allow sufficient light to stimulate early growth of replacement tānekaha. Ultimately, tānekaha is likely to be replaced by more shade-tolerant and faster-growing broadleaf species.

Pest and disease threats

Tānekaha is generally regarded as a resilient, wind-firm species. Pests and diseases are of low or only local importance. Possum, deer and goats will damage seedlings and saplings. Grazing livestock should be fenced out of plantations or naturally regenerating stands.

Timber properties, products and markets

Overall tānekaha is the strongest of our native softwoods. Heartwood is dark yellow to light brown. Timber has excellent working qualities with straight, fine, even grain allowing a high-quality finish. It is moderately durable for ground contact, similar to cypress species such as macrocarpa.

Tānekaha sapwood is likely to be useful for internal applications, although limited information is available.

Tānekaha laminated beam over tōtara.

Non-timber products and environmental services

Tānekaha is an important component of northern forest ecosystems, often found in mixtures with other tree species. In conjunction with other native tree species, it helps control soil erosion, provides landscape aesthetic and amenity areas and other cultural and environmental values.

Cultural services and Mātauranga Māori

For some Māori tānekaha has cultural significance as the timber was used for making weapons and as components in traditional whare and other construction. Tānekaha bark was used to produce a red dye; and it was also used medicinally

as a liver tonic and for treatment of dysentery and vomiting. Its many uses meant tānekaha was considered a taonga: this spiritual dimension will undoubtedly continue to be a rationale for growing and maintaining tānekaha in our forests.

Other information

Tānekaha earns the name celery pine from the appearance of its leaves, which are in fact flattened petioles or "phylloclades" (leaf-like branches). Trees bear both male and female cones which ripen at different times. The male cones are notable for appearing quite purple at first, then becoming bright red as they ripen.

There is limited recorded information or experience of growing and using tānekaha; it is a species warranting more trials and research into its potential use for timber production.

Mature tānekaha.

Taraire

Taraire (*Beilschmiedia tarairi*) is related to tawa (*Beilschmiedia tawa*) which it replaces as a dominant hardwood species in forests from Auckland northwards. Its natural southern range extends to Raglan in the west and Mt Hikurangi (Gisborne District) in the east. Like tawa, taraire often forms part of the mixed broadleaf canopy beneath the emergent crowns of kauri and old-growth podocarps such as rimu and tōtara. It is shade-tolerant, preferring sheltered, warm, moist, and fertile sites. Although not a main target species when forests were cleared, taraire was incidentally taken and used, particularly in Northland where it gained a reputation as good flooring timber.

Taraire is an important food source for kererū, and in turn, its regeneration is largely reliant on kererū distributing its seeds.

About this species

Optimal soil type	Prefers moist, fertile, free-draining soils, especially volcanic soils. Intolerant of poorly drained soils.
Optimal annual rainfall	Performs best where rainfall exceeds 1350 mm/year.
Drought tolerance	Low – droughts often cause crown dieback or death.
Periodic waterlogging tolerance	Moderate – tolerates periodic flooding on free-draining soils, but intolerant of prolonged waterlogged conditions.
Frost tolerance	Low – prone to damage by frosts.
Exposure tolerance	Low – requires sheltered sites to establish well. Crowns contract with stress (for example, wind burn). Prone to toppling in extreme wind events.
Shade tolerance	High – shade tolerant but grows fastest with overhead light through a gap in the canopy. Mature crowns can withstand full light conditions.
Coastal site tolerance	Good – often naturally present in coastal and estuarine forests.
Fire resilience/flammability rating	Moderate flammability. Low-moderate resilience to fire damage.
Altitude tolerance	Mostly found from lowland to around 450-600 m in Northland; prefers below 350 m south of Auckland. Gives way to tawa at higher altitudes.
Place in succession	A successional tree species preferring to establish within a forest environment and becoming part of the canopy beneath emergent old-growth podocarps.

Successful establishment

Taraire seed is easily germinated, and seedlings are commonly available at nurseries. Seedlings and saplings are shade tolerant and exposure sensitive. Good site selection is critical – taraire require sheltered, warm sites without extreme wet or dry soil conditions.

Established taraire seedling.

Taraire are more appropriately planted as part of a diverse mix of native forest species and with associated nurse species (such as mānuka, kānuka or fast-growing broadleaves) rather than as pure single-species stands. Seedlings should be planted with a total stocking of 2500 stems/hectare. Expect moderately high growth rates on good sites. Underplanting within an existing forest or regenerating shrub cover are also practical options.

Where local seed sources and kererū are present, taraire can naturally regenerate within forests provided grazing is excluded.

Silvicultural requirements

Little is known about how taraire respond to pruning. Managing the form of developing saplings is probably better done by managing the environment around them, such as by planting them in gaps within an existing forest canopy, or under a light nurse cover. To maximise growth rates and minimise the risk of failure, ensure the saplings have a light well, or gap in the canopy above them, but retain sufficient side shelter.

Deep, crunchy leaf-litter forms under taraire trees.

Eventually taraire take their place in the tree canopy and can have 7-12 metres long branch-free boles before developing large spreading crowns, and trunks up to around 90 centimetres in

diameter. Large trees are often "piped" (hollow in the centre), so targeting trees with diameters of less than about 60 centimetres would be recommended for harvesting.

Being a shade-tolerant hardwood, taraire may be suited to sustainable harvesting as part of a mixed-species, near-natural, continuous cover forestry regime, rather than as a single-species plantation.

Pest and disease threats

Taraire has no known serious species-specific diseases or pest threats.

Crowns of trees often appear in poor health in exposed situations, especially following droughts or windy conditions. Severe drought can cause crown die-back and even death. Branches interlocked with other trees are easily broken and damaged in storm events.

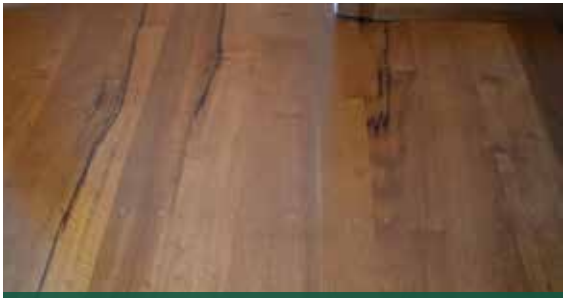
Fallen trees are highly susceptible to attack by wood-boring beetles (*Lyctus* and *Anobium*) and prone to sap-stain. Fallen logs need to be extracted and milled as quickly as possible if any usable timber is to be salvaged.

Browsing animals will eat the regenerating seedlings and prevent natural regeneration.

Timber properties, products and markets

Taraire timber is heavier and stronger and has more colour than tawa. The dry heartwood is light brown, with slight pinkish tinges. The paler sapwood provides contrast. Occasionally, scribbly line patterns of blackish discoloration create an attractive feature. In the past taraire was sometimes referred to as New Zealand oak because the flat sawn boards resembled some true oaks (*Quercus* species). The timber was used for mouldings, interior finishes, and furniture.

Taraire is suitable for many interior applications. It has moderately high strength, stiffness and attractive colouration. It machines well, and due to its hardness, it is suitable for flooring, for which it is still in demand – when available. It is not suitable for exterior use.



In North Auckland, where it is locally abundant, taraire has a reputation as a very good flooring timber. A small proportion of taraire timber has dark lineal discolouration which can be a sought-after feature.

Non-timber products and environmental services

Taraire trees are valuable for species diversity in northern forests. Their large purple fruit is an important food for kererū. They may provide resilience to a warming climate, being tolerant of warm temperatures. Their shade tolerance means they could be important for succession through non-native species' canopies (such as radiata pine and weed species such as tree privet). Their large, leathery leaves create heavy shade and a thick leaf litter, resulting in distinct understorey conditions. Fallen trees are quickly broken down by fungi and insects adding to the nutrient recycling of the forest.

Cultural services and Mātauranga Māori

Although taraire fruit, when cooked or roasted, were a staple food for some Māori, no evidence has been found to suggest that its timber had specific traditional use.

Diverse native broadleaf forest dominated by taraire and kohekohe.

Tawa

Tawa (*Beilschmiedia tawa*) is a broadleaved canopy tree often dominant in lowland and upland forests of the North Island, and lowland forests of the upper South Island. It is a medium-sized to tall evergreen tree forming a rounded crown when mature, generally reaching 20-30 metres high with trunk diameters up to one metre but usually less. Tawa is shade tolerant – often found in all tiers of high forest – but slow growing.

Tawa has been highly sought after for a few specialty uses such as flooring and turning, but supplies from old-growth forest are now very limited. There has been no significant planting of tawa – it requires sheltered sites, is slow to establish and very slow growing.

About this species

Optimal soil type	Tolerates a wide range of soils; does not thrive on poorly drained or dry soils.
Optimal annual rainfall	Medium to high rainfall, ideally > 1200 mm well-distributed during the year.
Drought tolerance	Low – intolerant of dry and low humidity conditions. Seedlings susceptible to drought. Established trees can be killed or suffer dieback in severe droughts.
Periodic waterlogging tolerance	Low.
Frost tolerance	Moderate – withstands frost down to -8°C but readily damaged by out-of-season frosts. Seedlings susceptible to frost. Exposed trees can suffer crown dieback or be killed by severe frosts.
Exposure tolerance	Moderate – seedlings susceptible to wind on exposed sites.
Shade tolerance	High – prefers shady sheltered sites during establishment.
Coastal site tolerance	Moderate.
Fire resistance, flammability rating	Low fire resistance, moderate flammability.
Altitude tolerance	Sea-level to 750 m in the North Island, below 300 m in the South Island.
Place in succession	Late successional shade-tolerant species. Does not establish on open sites. Found mostly at all ages and sizes beneath high-forest canopies.

Successful establishment

Tawa fruits during summer months, producing large fleshy drupes dispersed mainly by gravity and kererū. Seed crops are annual but very variable in abundance.

Tawa is easily propagated from freshly fallen, fully developed fruits when sown immediately in partly shaded nursery conditions. Germination is improved if the flesh surrounding the seed is removed.

Naturally regenerating tawa.

Only small numbers of tawa are raised in nurseries, achieving plantable size of at least 50 centimetres in a minimum of two years. Tawa's specific site requirements and slow growth after planting means there is little demand for planting stock. There is no data on growth rates of planted tawa.

Silvicultural requirements

Because tawa is not widely planted, there are few examples of it being managed for timber in indigenous plantations. Tawa is the predominant canopy tree species in extensive tracts of old-growth forest across much of the North Island, and it could be made available from privately-owned and sustainably managed old-growth forests. Harvest rates are currently low due to weak customer demand.

Tawa regenerates well in shade or small canopy gaps, but it is sensitive to exposure, tending to deteriorate in intensively disturbed forests. It will coppice readily from blown-over saplings or trees. It grows slowly in natural stands, averaging 1.8 millimetres/year in trunk diameter in the central North Island. Attaining harvestable size for tawa will take at least 100 years, maybe longer. Trees also often have poor form unless drawn up in gaps in mature forest.

A fenced stand of native forest dominated by tawa.

Remnant scattered tawa within a dairy farm in the central North Island, near Rotorua.

There has been no work on pruning and thinning.

Tawa growth rates in forests will likely increase with more light. Try low-intensity small-gap harvesting to create gaps in the forest canopy. Growth will slow again if canopy gaps close over.

Pest and disease threats

Anobium and *Lyctus* borers may attack the sapwood of tawa. A fungal disease can cause the centre of some trees to decay. However, neither issue is considered a serious threat.

Seedlings and small saplings can be browsed by deer and goats where pest numbers are high. In winter, possums may eat seed from the ground after the pulp has rotted. Pigs and rats also eat the fruit.

Timber properties, products and markets

Heartwood is bright creamy brown except for contrasting dark brown to black heartwood in large logs, due to the fungal disease mentioned above. Heartwood is not durable. White outer sapwood is susceptible to borer but can be treated with boron salts to enhance durability.

Early uses included dairy and other utensils, furniture, turned handles, rollers, clothes pegs, interior finish and weatherboards. High grades of tawa were widely used for attractive, hard-wearing flooring, including squash court floors. It is a favoured species for turning across the grain and often used for drawer knobs. It dresses well and can be readily stained and polished.

Tawa flooring, note the pale timber colour.

A significant use up to the 1990s was as short-fibred pulp for fine writing and printing papers. The wood is sought after for firewood as it burns green due to a low moisture content when freshly cut. Tawa has a reputation for being dangerous where trees partly cut through have sometimes split suddenly from the stump to the top of the tree, termed by tree-fallers as "barber-chairing".

Tawa is mainly used in small quantities for flooring and veneers.

Non-timber products and environmental services

Both kererū and (where present) kōkako contribute to dispersal of tawa seeds. These are the only birds remaining from New Zealand's original biota large enough to disperse tawa effectively. As with other canopy species in old-growth native forest, large tawa trees support abundant epiphytes which are sanctuaries for native fauna such as wētā, skinks and geckos.

Cultural services and Mātauranga Māori

Some Māori prized tawa highly for long bird spears. The kernels of the fruit were eaten. Berries were steamed in a hāngī for two days, then washed to remove the turpentine-flavoured pulp. The dried kernels were stored and when required, soaked in hot water and pounded, sometimes flavouring being added to the mashed meal.

Tawa forest with dense understorey of shrub hardwoods, Te Miro, Waikato.

Tōtara

Tōtara (lowland tōtara, *Podocarpus tōtara*) is one of New Zealand's best known and most culturally significant trees. It was naturally distributed throughout the country on fertile, free-draining, lowland forest sites. Its timber was revered by Māori and early settlers for its durability and workability. Tōtara has been identified as one of the most promising native tree species for timber production – it is easy to establish with many characteristics suitable for forestry purposes. Extensive areas of naturally regenerating tōtara forest already exist on farms in many regions.

About this species

Optimal soil type	Tolerates a wide range of soils, from sandy and alluvial soils to heavy yellow clays, but prefers reasonable fertility.
Optimal annual rainfall	Survives in dry climates but performs best where rainfall is > 800 mm/year.
Drought tolerance	Good, the most drought resistant of the native conifers but can be killed by extreme drought.
Periodic waterlogging tolerance	Tolerant of periodic flooding on free draining soils, but intolerant of prolonged waterlogged conditions.
Frost tolerance	Good on lowland sites. Planted seedlings in frost hollows at higher altitudes can be killed by heavy frost.
Exposure tolerance	Good but grows better on more sheltered sites.
Shade tolerance	Low-moderate. Tolerant of open, high light conditions.
Coastal site tolerance	Moderate. Often naturally present in coastal and estuarine forests.
Fire resilience/flammability rating	Low tolerance of fire. Moderate-high flammability.
Altitude tolerance	Naturally found at altitudes of up to 600 m in the North Island and 500 m in the South Island. However, grows best in lower altitudes.
Place in succession	A pioneer tree species regenerating readily on open sites with other colonisers such as kānuka, but typically succeeding kānuka and forming long-lived old-growth forest.

Successful establishment

Naturally regenerating tōtara on pastoral hill-country – the species is resistant to livestock browsing and some herbicides.

Tōtara is the most widely planted native tree in New Zealand as it is hardy and tolerates a wide range of sites. Seedlings are readily available from most nurseries each year. Planted seedlings will require weed control for at least the first 12 months after planting particularly from vigorous grass growth, and longer where exotic brush weeds are invading. There is no single recommended planting prescription. On mild sites, tōtara can be planted without a nurse cover at a rate of anywhere between 1250-4500 stems/hectare. Otherwise, interplant a minimum of 625 tōtara stems/hectare (approximately four metres apart) with a nurse species (for example, kānuka) or within gaps in existing vegetation. Nurse crops need to provide light overhead cover to effectively influence form as the trees grow. Heavy shade is detrimental to growth and form.

Tōtara do regenerate naturally on many sites but planting is the best way to ensure an area gets established within a given timeframe.

Silvicultural requirements

Tōtara are notorious for forking and heavy branching, even at moderately high planted densities (2500-4000 stems/hectare). Early and frequent form-pruning is essential for all planted regimes if producing straight stems for timber is an objective. Prune up to 400 stems/hectare and progressively thin down to these 400 stems/hectare as they reach a mean trunk diameter at breast height (DBH) of 40 centimetres. Harvest pruned trees from 45-60+ centimetres DBH. Expect a rotation of 85+ years on good sites. Rather than clear-felling, progressive selective harvesting of the biggest trees is an option from about 50 years old.

A thinned stand of naturally regenerated tōtara showing the many straight stems with timber potential.

Selectively harvesting a tōtara tree from a stand.

Pest and disease threats

Tōtara is a robust species with few health concerns. It can be affected by pests and diseases including various fungi, insects, and tōtara die-back. However, no pests, except perhaps possums, have caused significant widespread ill-health or threat. It is relatively unpalatable to most browsing animals.

Timber properties, products and markets

Tōtara timber is an excellent softwood suitable for a wide range of applications. The heartwood is very durable, and suitable for structural and exterior applications. The sapwood is resistant to borer and suitable for interior use including furniture and linings. With a mean wood density of around 480 kilogrammes/cubic metre, tōtara is a fairly soft, lightweight but stable timber.

Non-timber products and environmental services

Tōtara has a useful role in regenerating native forest cover, especially on farms and previously cleared land. It provides food for birds and bees and creates a forest environment for many other species to inhabit. It has unique potential for agroforestry and integration within pastoral systems. Extractives, for example totarol, are used in natural health products and cosmetics.

A freshly sawn tōtara beam being milled into planks, showing attractive heartwood.

Cultural services and Mātauranga Māori

Tōtara has had significant roles and values in Māori and Pakeha cultural histories. It is renowned as a carving timber (for whare, waka, and smaller artefacts), also for building uses where durability and stability were essential attributes (for example, piles, window joinery, framing and fence posts). The bark and berries were commonly utilised, and even the smoke was used as rongoā for certain conditions – such was the mana and value of the tree.

Other information

Natural tōtara forests on private land can be managed for sustainable timber yields under Part 3A of the Forests Act. Practical guidance on managing tōtara, including videos, freely downloadable material, and online calculators are available from the Tāne's Tree Trust website (**tanestrees.org.nz**).

Tōtara cladding on a farm shed with a tōtara gate.

Appendix 1: Species excluded from this guide

The 15 species featured in this guide are included because they are the most well-known and commonly planted. More is therefore known about them than others, both in terms of their establishment and management, and the values and uses of their timber and non-timber products.

There are many other native tree species which are part of different forest-types in New Zealand – some examples are listed below. Most are available from nurseries and can be added to planting mixtures on suitable sites.

Species		Distinctive characteristics
Black maire	*Nestigis cunninghamii*	Now only found in patches throughout the North Island, medium-sized tree once favoured for firewood. Very popular for turning – dark, dense wood.
Kānuka	*Kunzea ericoides*	Common throughout New Zealand, dense timber with pinkish colour and smooth finish.
Kawaka/ Pāhautea	*Libocedrus plumosa/L. bidwillii*	Pāhautea or New Zealand cedar is found in wet, mountainous areas of both islands. Kawaka is found in the upper half of the North Island and upper South Island in coastal to lowland mixed hardwood forest. Both have reddish straight grained wood, are relatively soft and only used for appearance purposes.
Mangeao	*Litsea calicaris*	Small-medium sized tree found over much of the northern half of the North Island, strong tough timber with good durability.
Pōhutukawa	*Metrosideros excelsus*	Large tree recognised for flowering through Christmas period, red-brown timber, hard and heavy but cuts and finishes well.
Pukatea	*Laurelia novae-zelandiae*	Common large tree in swampy areas, pale timber easily sawn, low density and durability.
Rātā (Northern and Southern)	*Metrosideros robusta and M. umbellata*	Large (N) to medium (S) sized tree with dense, heavy timber that is hard to saw and turn but is hard-wearing. Notable for flowering.
Silver pine	*Manoao colensoi*	Modest-sized tree found in damper areas in Northland, central North Island and the West Coast. Pale timber darkens over time, extremely durable.
Tītoki	*Alectryon excelsus*	Medium-sized tree found over the North Island and northern half of the South Island, tough springy wood which is hard to finish.

Appendix 2: Glossary

Apical dominance	A trait which varies by tree species. Species with strong apical dominance produce a single leading stem which grows upwards. Species with low apical dominance produce multiple leading stems which tend to grow outwards (unless they are form-pruned).
Butt log	The first log cut above the stump usually of a pruned tree felled for timber.
Clear-felling	Harvesting a large area of forest in one operation.
Clearwood pruning	Removal of lower branches from the stem of a tree to promote the growth of clearwood (knot-free wood).
Columnar	Tall, narrow tree crowns.
Continuous cover forestry (CCF)	Continuous cover forestry is a management system which uses ecological principles and follows natural processes. The forest canopy is always maintained at one or more levels and the forest largely self-regenerates. Harvesting involves taking single trees or small groups (also called 'coupes') of trees so that biodiversity and other values are not compromised.
Coppice	Coppice/coppicing is the growth of new shoots from a cut tree stump or fallen tree. Tree species which coppice retain live root systems after harvest and can be harvested many times without needing to be replanted.
Deciduous	Tree species which lose all their leaves and then replace them, usually in response to seasonal changes.
Diameter at breast height (DBH)	The standard measurement height of tree stem diameter (1.4 metres from the ground – on the high side of the tree if on a slope).
Drupe	Large fleshy fruit with a stone containing a seed.
Emissions Trading Scheme (ETS)	A tool for meeting New Zealand's domestic and international climate change targets by encouraging afforestation. Forest growers with eligible land can earn carbon credits by establishing new plantings or allowing trees to regenerate on the land.
Epicormics	Shoots growing out from a bare tree stem which can become branches if not pruned (sometimes induced by increased light after thinning depending on the species).
Epiphytes	A plant that grows on another plant, using it for support.
Form pruning	Involves selecting a single leading stem in a young tree, and removing competing stems (usually done with secateurs or loppers).
Hardwood	Hardwoods are angiosperms (flowering trees). Their wood is structurally distinct from softwoods, but is not always especially hard.

Heartwood	The inner wood (inside the sapwood) in a tree stem, usually yielding the densest and most durable timber.
Leader	The dominant or 'leading' growing stem of a tree.
Lianes	A woody vine or creeper.
Mahinga kai	Māori food sources or gathering.
Mast seeding	Irregular, synchronised seeding. Most species seed regularly, while mast seeders only produce large quantities of seed in mast years.
Mātauranga Māori	Traditional Māori knowledge, skill or understanding.
Mycorrhizae	Fungi that have a symbiotic relationship with the roots of many plants, including trees. Different tree species have different mycorrhizal associations. Mycorrhizae are essential to trees' well-being, delivering nutrients in return for carbon photosynthesized by the tree.
Natural regeneration	Where trees grow from seed which is dispersed naturally – either directly from the parent tree or via birds and other wildlife.
Nurse species	Trees and shrubs which protect the target species while they are young by providing shelter and shade. Nurse species can be planted or be present naturally.
Pole crops/trees	Forest stands where trees are relatively young, straight trees with branch-free trunks that have grown up in close proximity to one another. They may require thinning to develop both height and diameter.
Podocarps	Podocarps are a family of evergreen coniferous trees. Many of New Zealand's best-known native trees are podocarps, such as rimu, kahikatea, miro, matai and tōtara.
Production thinning	Removal of a proportion of trees from a mid-aged crop to reduce competition between stems. Felled trees are extracted and used – for example, for posts and poles, some joinery applications.
Pruning	Removal of lower branches to create a clear stem, with knot-free timber.
Releasing	Removal of competing vegetation from around young trees, usually either by spot-spraying with a herbicide or hand-weeding.
Reversion	The process of land reverting to forest through a series of successional stages. Sometimes also referred to as natural regeneration.
Ringbark	Removal of a complete ring of bark from the trunk of a tree. The tree will usually die as a result of being 'ringbarked'.
Semi-deciduous	Tree species which can lose some leaves – for example in response to seasonal changes or stressors like pests and drought – and then regrow their leaves and recover.
Sapling	A young, still slender but established tree.

Sapwood	The outer, usually softer and lighter-coloured wood between the heartwood and the bark. Sapwood is not durable.
Sawlog	A log that has a large enough diameter to be sawn (commercially) into timber products.
Seedling	A young tree originating from a seed. Most native trees are available from nurseries as ready-to-plant seedlings.
Shrubland	Areas dominated by natural shrubs (also known as scrub or bush).
Silviculture	The practice of managing forests, usually for timber production.
Softwood	Softwoods are gymnosperms (conifers). Their wood is structurally distinct from angiosperms (hardwoods) and may or may not be physically softer.
Thinning	Removal of a proportion of trees from a mid-aged crop to reduce competition between stems. Felled trees are usually left to decompose in the forest ("thinning to waste").
Windthrow	Trees being toppled or snapped by wind, sometimes exacerbated as a result of stand thinning.

Appendix 3: Sources of further information

Organisations providing advice and information

- **Tāne's Tree Trust** is New Zealand's largest organisation devoted to promoting the planting, management and sustainable use of native trees for all the values that these forests provide. The Tāne's Tree Trust website (**tanestrees.org.nz**) has comprehensive resources related to native trees and their management including:
  - a Native Forest Toolkit, which comprises four calculators to help with all aspects of planning a new planting, including cost estimates;
  - a Plant Monitoring Toolkit;
  - species profiles;
  - publications;
  - videos;
  - research project updates and results.
- **Te Uru Rākau – New Zealand Forest Service** offers a free forestry advisory service for landowners interested in planting trees: **mpi.govt.nz/forestry-advisory-service**
- **Trees That Count** promotes and supports native afforestation projects by using donations from businesses and individuals to provide trees for planting projects – for example by community groups and schools: **treesthatcount.co.nz**
- The **New Zealand Farm Forestry Association** has a network of regional branches that organise field days for landowners interested in small-scale native and exotic species planting and management: **nzffa.org.nz**
- There are many local groups and initiatives actively involved in planting native trees or maintaining areas of native forest. These groups, along with native plant nurseries, are often excellent sources of local knowledge and advice.

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- Substantial resources produced by the Northern Tōtara Working Group (NTWG), Tāne's Tree Trust and others are available on the Tāne's Tree Trust website: **tanestrees.org.nz/about-us/northland-totara-working-group-ntwg/ntwg-publications-resources/**

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Find out more

Canopy website

For more information about planting trees, visit **canopy.govt.nz**

Or scan the QR code using your phone's camera.

Tāne's Tree Trust website

To find out more about the role and work of the Tāne's Tree Trust, visit **tanestrees.org.nz**

Or scan the QR code using your phone's camera.

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