– A NEW ZEALAND GUIDE TO –

GROWING ALTERNATIVE EXOTIC FOREST SPECIES

2023

AN INTRODUCTION TO SELECTING THE RIGHT SPECIES FOR YOUR SITE

Ministry for Primary Industries
Manatū Ahu Matua

scion

THE PURPOSE OF THIS GUIDE

This booklet provides a guide to commercially available exotic alternatives to radiata pine. It explains the suitability of these species for growers - farmers, other private landowners, councils, iwi and investors. It is designed to support both experienced growers who are looking to diversify the exotic timber species they are managing, and new growers who need information on the range of commercial species available for establishing plantations and woodlots. The management conditions for each species are described briefly, and their potential for timber (solid wood or engineered wood markets) or biomass (biofuel and other traditional and novel bio-products).

PLANTING FORESTS AND WOODLOTS FOR CARBON BENEFITS

All species featured in this guide can be registered under the Emissions Trading Scheme (ETS) if planted on eligible land and planting designs comply with ETS rules. 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.

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Karanga atu rā tēnei ki ngā momo rāwhao i te wao nui a Tāne, tēnei te atua o te ngahere me ngā mea katoa kei roto, e whakatau nei i a koutou katoa.

Haere mai koutou ki te tautāwhi i te āhuatanga o te ao tawhito, me ngā rākau rangatira ki roto i te marae a Tāne.

Whakatau mai, whakatau mai, whakatau mai!

This is the welcome call to all exotic species within the domain of Tāne Mahuta, the god of the forest and all that is within, welcome to you all.

Your purpose being to support native regeneration of high value native species, and long-term conversion of native forests.

Welcome, welcome, welcome!

Introduction

Te Ara Whakahou – Ahumahi Ngahere - the Forestry and Wood Processing Industry Transformation Plan[1] was launched In November 2022 by Te Uru Rākau – New Zealand Forest Service. The Aotearoa New Zealand forest industry currently relies largely on a single species – radiata pine – and around 60% of all pine grown here is exported as unprocessed logs[2]. The plan envisages an industry that is growing a more diverse range of commercial species, has increased demand for New Zealand-grown wood products, and increased regional processing. New markets such as biomass and engineered wood are developing, partly supplied by diverse species. The plan has a stated goal that alternative species (non-radiata) will increase to 20% of all planting by 2030.

New Zealand is committed to reducing its net greenhouse gas emissions as the climate emergency comes increasingly into focus. A national strategy is being developed to support efforts by growers to diversify the plantation estate. Planting more forests, whether these be native or exotic species, will help offset greenhouse gas emissions in the short-to-medium term, thanks to trees' ability to remove carbon from the atmosphere and convert it into wood.

Developing a national strategy for ready-to-plant exotic species other than radiata pine

Growers considering investment in alternative commercial exotic species will be supported by Te Ara Whakahou – Ahumahi Ngahere - the Forest and Wood Processing Industry Transformation Plan - which will develop an industry based on alternatives to radiata pine in New Zealand.

- Growers will be supported by necessary infrastructure to support the successful growing and regional onshore processing of new product streams using logs for regional, national, and international markets.

- These plantings would best be established in planned regional wood supply catchments[3].

- Each catchment would be centred on a future well-connected processing operation or hub, ensuring a short transport distance between the forests and the processing hub.

- This will generally be at a smaller scale and produce different products to radiata pine processing, so new small-to-medium-scale mills will be needed.

- New jobs would be created, and regional wealth generated.

To be economically viable, a small-to-medium scale processing operation needs an estimated sustainable annual input of 50,000 cubic metres of logs. To ensure this supply, a total of 5,000 hectares of forests need to be planted in each wood supply catchment over around 30 years. This equates to around only 170 hectares per year of new forests for 30 years. The new forests would best be of the same or compatible species, to generate a sustainable annual log supply that will attract investment in regional processing and marketing.

The species included in this guide

The species featured in this booklet are commercial exotic species, and their wood can be used in product lines that radiata pine is generally not suitable for. The species featured are both hardwoods and softwoods and are considered by industry experts to be ready to plant at commercial scale. They are proven in a range of New Zealand environments and have known potential to produce commercially accepted timbers for a variety of uses. Some are proven biomass producers; others have been trialled in engineered wood products such as laminated veneer lumber (LVL). They can be planted as alternatives to, or complementary to, mainstream plantation species such as radiata pine and Douglas-fir.

The species featured are:

- Cypresses
- Eucalypts
- Redwood
- Japanese cedar
- Poplars

Cypresses are well-known softwoods growing in New Zealand, especially *Cupressus macrocarpa* ('macrocarpa') but increasingly other species including *Cupressus lusitanica* (Mexican cypress) and some cypress hybrids. Cypress timber has long been a Kiwi favourite because of its versatility for indoor and outdoor uses, attractive appearance, natural durability above ground and ease of working.

Eucalypts – over 600 eucalypt species grow naturally in Australia, a handful of which have a proven track record in New Zealand either as hardwood timber and/or biomass producers. The species selected for this guide are divided into two groups: (i) naturally durable timber producers and (ii) non-durable timber producers.

Redwood – also known as 'Coast' or 'Californian redwood' (*Sequioa sempervirens*) – is a softwood well-suited to growing conditions in parts of New Zealand, evidenced by the redwood forests around Rotorua (established in 1901) and other early plantings. Commercial plantings have increased markedly in the 21st century, especially in the North Island, where growers see scope to supply international markets as the North American supply runs out.

Japanese cedar – often called 'cryptomeria' or sometimes 'sugi' (*Cryptomeria japonica*) – is a softwood with similar properties to redwood but will grow well on more challenging sites. It is best known as a shelter-belt tree in Taranaki and Bay of Plenty, but where it has been grown as a timber tree it has proved to be productive and easy to grow.

Poplars have been planted by New Zealand's hill-country farmers for many decades, primarily for soil conservation but also for livestock shade, shelter, fodder and for amenity. They are a hardwood, and a wide range of cultivars are available to suit different site types. Some have denser wood and good form and are therefore also suited to timber production.

There are many other species that grow well in New Zealand and have potential to produce quality timber and biomass, but that are not yet considered ready to be planted at scale (see Appendix 2).

Markets and products for the selected species

Market opportunities for alternative commercial species, estimated to be worth up to $2 billion per year[4] include:

- **sawn timber** – domestic substitution of copper chrome arsenate (CCA)-treated timber for outdoor uses
- **posts and poles** – substitution of CCA-treated timber for vineyards, agriculture and horticulture
- **hardwood and softwood imports** – substitution of high-value sawn timber imports including decking, flooring, joinery timbers, sleepers and other products worth over $400 million in 2021

- **exports** – potential to replace Australian and tropical hardwoods and other timbers that are becoming scarce (e.g. North American redwood)
- **engineered wood products** – as a component of high-strength engineered wood products – e.g. glulam, laminated veneer lumber (LVL) and cross-laminated timber (CLT). This includes as a component of radiata LVL or plywood, to increase stiffness and hence value
- **biomass** – serving pulp markets and with potential to replace solid or liquid fossil fuels and in new biochemicals and biomaterials as technologies and markets develop.

How regional processing could develop

The New Zealand timber processing industry already utilises several timber species for sawn timber and specialist product uses. Processors tend to be smaller scale mills, with the capacity to handle short runs, and experience in managing and marketing a range of species. These mills are generally located near sources of supply.

Developing this capacity over time (through the growth of existing operations and the establishment of new mills and further processors) will depend on:

- the projected increase in available regional supply (e.g., the maturing cypress resource in the South Island)
- expanding the existing product range and market for these timbers (both local and overseas)
- establishing sustainable supply chains that feed into wider domestic and export markets (in terms of the volume, grade and quality of timber)
- having access to larger population centres.

There is significant regional diversity across New Zealand: much of the North Island is suited to growing a range of both softwoods and hardwoods whereas the South Island is more constrained, with environmental conditions limiting some species and fewer large population centres.

There are already existing and emerging examples of alternative species being grown at scale in some regions. Redwoods are increasingly being planted in areas of Waikato and Taranaki with good summer rainfall: investment in regional processing is a distinct future possibility due to the scale of the resource. Drought-tolerant durable eucalypts are being planted

in dryland parts of Marlborough, Wairarapa, Hawke's Bay and Northland, with a view to supplying naturally durable timber products to regional markets such as vineyards and orchards. Cold-tolerant eucalypt biomass crops are grown on land with gentle topography for industrial markets in the central North Island, Canterbury, Otago and Southland.

The existing small-scale sawmilling industry

New Zealand already has over 70,000 hectares of alternative species growing, planted from the early days of the NZ Forest Service (1920s) onwards[5]. A number of small-scale sawmills operate throughout New Zealand, processing and marketing alternative timbers. These businesses are found both in permanent locations and operating as mobile or 'portable' mills which travel to site. Some sawmills specialise in only one species (most commonly cypresses), while others handle a range of species. Products include flooring and decking timbers, farm timbers, garden landscaping timbers, and high-end joinery timbers.

In the short-to-medium term, while new alternative species forests planted from now on grow and become ready for harvest, there is potential for the small-scale sawmilling sector to expand to make the most of the resource that is already growing.

Growing alternative species – key considerations

Growing exotic (non-native) alternatives to radiata pine has the potential to be financially rewarding once sustainable supply chains are sufficiently developed. Growers need to consider market development as well as growing requirements and the regional scale for their crop, and take advice, before launching into planting.

Key aspects to consider are:

- **matching species to site** - alternative species can be quite exacting in their site requirements, so it is important to understand what species will suit your soils and climate. Sources of advice could include those who have planted and managed these species locally – from nursery staff to farm and forest managers, New Zealand Farm Forestry Association field days and workshops
- **potential regional markets and choice of growing regime** – awareness of existing or emerging local markets may influence species choice and the way the trees are grown
- **scale** – to enable market development and attract investment in centralised processing, alternative species need to be planted at

scale within any given region or supply catchment. Connect with other growers in your region to find out what species are being grown so you can add to the overall scale

- **secondary benefits** – alternative species have the potential to provide other benefits as well as timber or biomass – for example, soil conservation, shade and shelter, pollen and nectar, wildlife habit, and amenity and recreation benefits. Consider these at the planning stage.

Growing timber or growing a biomass crop

A range of exotic species can be grown for sawn timber and high-value wood products. Biomass can be a by-product of harvesting a timber crop, a waste product of wood processing operations; or trees can be grown for biomass exclusively.

Crops grown exclusively for biomass are currently found in the central North Island and Southland, where the whole tree crops are chipped for pulp markets. Biomass market opportunities will increase as biofuels replace fossil fuels and new biomaterials are developed.

The key differences between growing trees for timber and for biomass are:

- **rotation length** – biomass crops are generally short rotation (less than 20 years); timber rotations will likely range from 25-45 years
- **silviculture requirements** – while timber crops may need pruning and thinning, biomass crops require little intervention following establishment (other than possibly pest and weed control)
- **harvesting** – biomass harvesting involves harvesting and utilising the whole crop, which may be transported to a centralised location for chipping or chipped on-site. Gentle topography and good access are essential.

Harvesting a short-rotation eucalypt crop for biomass, Southland.

Planning a new planting

Anyone considering planting alternative species at a reasonable scale, with the aim of producing a commercial timber or biomass crop, should be aware that a lead-in time of at least two years is not unusual.

Your investment will be significant, so good planning is essential. Those without experience are advised to seek professional advice early on. Aim to select advisors with some experience of alternative species. This includes any forest management company or contractors employed to plan, manage and execute operations on the ground.

Plans should include:

- careful consideration of objectives (including desired end products)
- site, species and planting stock selection; regime selection
- budgeting – to include anticipated pruning and thinning costs
- applying for any available planting grants in advance – check with your regional council and Te Uru Rākau – NZ Forest Service
- checking your site's eligibility for the Emissions Trading Scheme (ETS)
- complying with statutory requirements – e.g., notifying your regional council
- ordering trees well in advance – ideally 12-24 months ahead of planting
- site preparation – planning access (including future harvest access), drainage, fencing, pest and weed control, pre-planting spraying
- organising planting contractors, plant delivery and possibly cold storage of seedlings.

Once the trees are in the ground, plans need to be in place for:

- maintenance of the young trees – release spraying, replacing any significant early losses, on-going pest control
- claiming planting grants (may require one or more inspections)
- depending on the chosen regime, form pruning, clearwood pruning, production thinning, thinning to waste
- registering for the ETS if eligible.

Establishment costs

Costs associated with forest establishment will be different for every site[6]. Major expenditure items include:

- pre-planting mapping, fencing, roading and other site preparation e.g. weed spraying, pest control
- plants and plant delivery
- planting by contractors
- release spraying and other post-planting maintenance including blanking (replacing losses)
- management and supervision costs.

Any grant payments for planting may take some time to materialise, so cash-flow planning should allow for this. Income from carbon credits will take several years to come on-stream.

Timing and costs of pruning and thinning operations will depend on species, regime and tree growth rates. Costs also vary between contractors; management and supervision charges will be extra. See Appendix 4 for some indicative establishment costs.

Financial returns from alternative species

The standard technique for assessing the potential profitability of a forestry investment is discounted cashflow analysis, which includes all costs and returns over a rotation and allows for the time value of money. This type of analysis is relatively easy when assessing a radiata pine investment, because there is no shortage of regional data, including long-run log market data. But until more alternative species are being grown, harvested and marketed; investment analysis is difficult as the lack of good data means some significant assumptions have to be made.

Key variables affecting forestry financial outcomes include:

- roading and earthwork costs
- crop establishment and maintenance costs
- crop productivity, quality and rotation length
- harvesting, marketing and transport costs
- availability of regional markets; prices paid by domestic and export markets for logs and products
- ETS eligibility and carbon values
- rates, insurance, management and administration costs.

CYPRESSES

Cypress species are Northern Hemisphere conifers belonging to the Cupressaceae family. Their versatile timber is decorative, durable and strong. Some cypresses such as 'macrocarpa' have been widely grown and utilised in New Zealand for many decades.

Four species and two groups of hybrids are considered to have most potential in New Zealand.
The four species are: *Cupressus macrocarpa* ('macrocarpa'), *C. lusitanica*, (Mexican cypress), *Chamaecyparis lawsoniana* (Lawson cypress) and *C. torulosa* (Himalayan cypress).
Promising hybrids have been produced from crossing (i) *C. macrocarpa x Chamaecyparis nootkatensis* and (ii) *C. lusitanica x Ch. nootkatensis* – this group includes the *Ovensii* hybrid (Ovens cypress)[a].

Cypresses provide growers with a versatile timber that can be used in a range of situations (from decorative uses to those requiring durable and strong timber). Scion, with industry partners, has invested in breeding trials over several decades to identify species with the most potential in New Zealand, and which have greater resistance to cypress canker.

New selections are being trialled and will support the next generation of plantings. Growers should always source stock, in particular *C. macrocarpa*, from canker-resistant selections.

About this species group

Optimal soil type	Prefer moderately fertile, well-drained soils
Optimal annual rainfall	Perform best where rainfall >1000 mm per year
Drought tolerance	Good
Periodic waterlogging tolerance	Low – can survive periodic waterlogging but poorly drained soils should be avoided

[a] *Chamaecyparis nootkatensis* (Alaskan yellow cedar) has very durable heartwood. Ovens cypress was the original *C. lusitanica x Ch. nootkatensis* hybrid, which is now being out-performed by new hybrids becoming available. *C. macrocarpa x Ch. nootkatensis* hybrids are also known as Leylandii.

Frost tolerance	Good
Exposure tolerance (Almost all trees grow better in sheltered conditions)	Good – but only on free-draining soils
Shade tolerance	Good
Coastal site tolerance	*Cupressus macrocarpa* and some macrocarpa hybrids can withstand severe coastal conditions: other species and hybrids less so
Fire resilience	Low
Altitude tolerance	Will succeed at altitudes of up to 800 m in the North Island and 700 m in the South Island. Species other than macrocarpa are snow tolerant
Coppicing species	No
Growth model status	Growth models and a cypress calculator[7] are available

Obtaining the right planting material

New Zealand has had *C. lusitanica* and *C. macrocarpa* breeding programmes going back many decades. The NZ Farm Forestry Association Cypress Development Group (CDG) has recently partnered with Scion to produce improved germplasm or seedlots of cypresses as well as hybrid clones. *Cupressus macrocarpa* selections should be limited to germplasm selected for canker resistance.

Growing regimes for cypresses

Highest returns will be achieved from pruned sawlogs grown on to 40+ years to produce a range of premium products from clear heartwood. Production thinning on accessible sites has potential to be profitable as the wood from young trees can be used for framing or appearance grade applications.

Silvicultural requirements

For sawlog crops, plant at 800-1100 stems per hectare (stems/ha). Prune to

6 metres. If production thinning is an option, thin to 400-500 stems/ha for *C. macrocarpa* and *C. lusitanica* and 600 stems/ha for *Ch. lawsoniana* or the hybrids. Then production thin as trees reach marketable size.
Thin directly to a lower final crop stocking (200-300 stems/ha) if production thinning is not possible and on poorer sites.

Pest and disease threats

Cypress canker (*Seiridium cardinale*) is a fungal disease mainly affecting macrocarpa and the *C. macrocarpa* hybrids. *Ch. lawsoniana* is also vulnerable. Canker is widespread and a serious problem on warm sites where dieback, stem malformation and tree death can occur, with drought-stressed trees most susceptible. *Cupressus lusitanica* is less susceptible to canker, as are *C. lusitanica* hybrids. *Cupressus torulosa* appears to be very tolerant. Breeding programmes to identify canker-resistant macrocarpa genotypes are underway.

Timber properties, products and markets

All cypresses grown in New Zealand produce a similar decorative pale yellow to golden timber that is light and strong. Heartwood is durable above ground and is suited to a wide range of indoor and outdoor joinery and structural applications (see Table 2, Appendix 1). Thermal modification (heating the wood to high temperatures) significantly increases both sapwood and heartwood durability. There are well-established markets and a small-scale sawmilling industry based on macrocarpa in New Zealand. Demand from China and other Asian countries is strong, where cypress is regarded as a premium timber. Very few high-quality logs are currently available for export but what is available commands high prices.

More information

Cypress has a zero rating for wilding spread.
The Cypress Strategy 2022-2042[8] produced by the NZFFA Cypress Development Group and the Specialty Wood Products Research Partnership will help to inform further opportunities for this species.

Air-drying cypress timber.

Above: 10-year-old Ovens cypress, Wairarapa
Below: Macrocarpa-clad home, Kapiti coast

DURABLE EUCALYPTS

Eucalyptus bosistoana - coast grey box

Eucalyptus bosistoana (coast grey box) originates in mixed coastal forests of south-east Australia. It is a species that grows best on fertile soils and sheltered sites including river flats prone to periodic flooding. Timber is hard, heavy and naturally durable (in-ground life expectancy of over 25 years): one emerging market is vineyard and fence posts.

About this species

Optimal soil type	Prefers fertile, free-draining soils. Not recommended for infertile soils
Optimal annual rainfall	600-2500 mm/yr
Drought tolerance	Moderate - not recommended for very dry sites (<600 mm/yr)
Periodic waterlogging tolerance	Good
Frost tolerance	Moderate - frost tolerant to minus 6ºC
Exposure tolerance	Low - E. bosistoana needs a sheltered growing environment to produce trees of good form
Shade tolerance	Moderate
Coastal site tolerance	Low - not recommended for exposed coastal sites if timber production is an objective
Fire resilience	Good - will produce vigorous epicormic growth following fire
Altitude tolerance	Best suited to sheltered lowland sites, including river flats. Its natural habitat is 0-500 m above sea level
Coppicing species	Yes
Growth model status	A growth model is under development

Obtaining the right planting material

The NZ Dryland Forests Innovation (NZDFI) tree breeding programme includes *E. bosistoana*[9] and first generation *E. bosistoana* nursery stock bred by NZDFI with improved growth, form and heartwood features is available. Future generations of improved material will be released over time. *Eucalyptus bosistoana* was selected by NZDFI because of its high natural durability and ability to thrive across a range of environmental zones.

Growing regimes

Growers may wish to consider:

i. short-rotation 'peeler pole' regimes (approx. 15-20-year rotation), that can produce both veneer and posts for vineyards/other primary production. Short rotation regimes are most suited to gentle topography with good access, and where a local market for products is likely to develop in future. Fast growth, high wood density and ability to coppice means *E. bosistoana* has potential as a short-rotation biomass crop
ii. peeler log/sawlog regimes (approx. 30 - 40-year rotation), producing logs suitable for sawing to produce durable timber products; also peeling to produce veneer for engineered wood products. On sites with good access, production thinning could be considered.

Silvicultural requirements

Form pruning in years 1-2 and sometimes beyond is recommended to ensure a single dominant leading stem develops. Little clearwood pruning is likely to be needed for post and pole crops, but sawlog crops will need two to three clearwood pruning lifts.

Thinning is required for long-term regimes. On sites with good access, production thinning could produce material suitable for pole production, leaving a widely spaced sawlog crop.

Pest and disease threats

Eucalyptus bosistoana is susceptible to two pests currently found in New Zealand, eucalyptus tortoise beetle (*Paropsis charybdis*) and eucalyptus variegated beetle or EVB (*Paropsisterna cloelia*). These pests can defoliate trees in summer on some sites, but this is variable with healthy trees able to tolerate this browsing. NZDFI research has shown some families are more tolerant to pests than others; breeding selections will include pest tolerance in future. Scion is conducting research into biocontrol agents for the eucalyptus tortoise beetle.

Timber properties, products/applications and markets

Eucalyptus bosistoana is a very durable species with an in-ground life expectancy of over 25 years, and an above-ground life expectancy of over 40 years (see Table 2, Appendix 1). The extremely dense, strong heartwood timber is suited to in-ground applications e.g., posts and poles for vineyards and other agricultural/horticultural uses, heavy engineering, structural uses, crossarms, decking and flooring. *Eucalyptus bosistoana* has a wide sapwood band. It peels well and veneers have potential for laminated veneer lumber (LVL).

Other information

Eucalyptus bosistoana is a site-demanding species so care is needed with siting. Form (straightness) can be excellent but is generally variable. *Eucalyptus bosistoana* flowers in late January to February producing nectar attractive to bees.

The University of Canterbury School of Forestry has undertaken significant recent research into *E. bosistoana's* timber properties and growth potential as well as its potential for essential oil production.

10-year-old E. bosistoana on river flats, Marlborough.

Above: Eucalyptus bosistoana seedlings, grown by Morgans Road Nursery, Blenheim.

Left: Peeled E. bosistoana veneer – produced as part of NZDFI's wood quality research.
Right: Eucalyptus bosistoana log prepared for sawing. Note the thick bark and wide sapwood band.

Eucalyptus cladocalyx - sugar gum

Eucalyptus cladocalyx (sugar gum) is a versatile species that originates in dry parts of South Australia. Its main advantage is that it can produce naturally durable timber on some of New Zealand's driest, toughest east coast sites as long as they are largely frost-free.

About this species

Optimal soil type	Tolerates dry, skeletal and stony soils; *E cladocalyx* will thrive on a range of soil types except wet and poorly drained soils.
Optimal annual rainfall	500-1000 mm/year
Drought tolerance	Good - tolerates very low rainfall. Prefers dry conditions; not recommended on sites with high rainfall and humidity
Periodic waterlogging tolerance	Low - intolerant of wet sites in general
Frost tolerance	Low – not frost tolerant
Exposure tolerance	Good - the most wind-tolerant durable eucalypt (all eucalypts grow better on sheltered sites)
Shade tolerance	Low
Coastal site tolerance	Good - tolerant of coastal exposure (and saline soils in Australia)
Fire resilience	Will produce epicormics vigorously following fire
Altitude tolerance	Not frost tolerant but will tolerate a range of sites
Coppicing species	Yes
Growth model status	No growth model available

Obtaining the right planting material

Growers are recommended to plant seedlings sourced from improved Australian seedlots. *Eucalyptus cladocalyx* is included in many of the NZ Dryland Forests Innovation (NZDFI) trial sites[10], but no *E. cladocalyx* breeding populations have been established in New Zealand to date.

Growing regimes

Growers may wish to consider:

i. short-rotation 'peeler pole' regimes (approx. 15-20-year rotation or possibly longer on tougher sites). These can be processed into both veneer and posts for vineyards/other primary industries. Short rotation regimes are most suited to gentle topography with good access, and where a local market for products is likely to develop in future
ii. peeler log/sawlog regimes (approx. 30 - 40-year rotation, possibly longer on tougher sites), producing logs suitable for sawing to produce durable timber products; also peeling to produce veneer for engineered wood products. On sites with good access, production thinning could produce material suitable for pole production, leaving a widely spaced sawlog crop
iii. permanent forests on more challenging sites.

Silvicultural requirements

Form pruning in years 1-2 and sometimes beyond is recommended to ensure a single dominant leading stem develops. Little clearwood pruning is likely to be needed for post and pole crops, but sawlog crops will need one or more clearwood pruning lifts. Thinning is required for long-term regimes.

Pest and disease threats

Eucalyptus cladocalyx has proved to be relatively tolerant of browsing pests such as *Paropsis* larvae and beetles in NZDFI's trials to date.

Timber properties, products/applications and markets

Eucalyptus cladocalyx is a very durable species. Heartwood is pale brown with a fine uniform texture; *E. cladocalyx* has a narrow sapwood band. The extremely dense heartwood is suited to in-ground applications e.g., posts and poles for vineyards and other agricultural/horticultural uses, also heavy engineering, structural uses, crossarms, decking and flooring.

Other information

This species has a very useful role to play on drier sites that aren't too cold, including stony or skeletal soils, and where exposure will challenge other durable eucalypt species[11]. It is native to South Australia where its natural site conditions are extremely dry (250-500 mm of rain per year). Stem form is variable on exposed sites.

Eucalyptus cladocalyx flowers in January-February. Its large white flowers produce nectar for bees.

Above: Eight-year-old E. cladocalyx growing in North Canterbury.
Below left: A honey bee feeding on E. cladocalyx flowers. Below right: Eucalyptus cladocalyx vineyard posts, Wairarapa.

Eucalyptus globoidea - white stringybark

Eucalyptus globoidea (white stringybark) is a versatile species originating from coastal New South Wales and eastern Victoria. It grows consistently well across a range of New Zealand sites and produces naturally durable timber with many potential uses. *Eucalyptus globoidea* has good natural form and self-pruning ability and is tolerant of insect pests. It is a reliable, naturally durable species for New Zealand growers.

About this species

Optimal soil type	Suited to a wide range of soils except skeletal and sandy soils. Requires well drained sites
Optimal annual rainfall	800 - 2500 mm/year
Drought tolerance	Moderate - not recommended for very dry sites (< 600 mm/yr)
Periodic waterlogging tolerance	Low
Frost tolerance	Moderate - minimum temperature minus 5°C
Exposure tolerance	Moderate - severe exposure will deform the main stem
Shade tolerance	Moderate
Coastal site tolerance	Moderate
Fire resilience	Good - will produce epicormics vigorously following fire
Altitude tolerance	A versatile species with good growth rates across a range of site types (natural range 0-1100 m a.s.l)
Coppicing species	Yes
Growth model status	A growth model has been developed

Obtaining the right planting material

The NZDFI breeding programme includes *E. globoidea*[12]. First generation *E. globoidea* nursery stock with improved growth, form and heartwood features developed by NZDFI is available. Future generations of improved material will be released over time.

Growing regimes

Growers may wish to consider:

i. short rotation 'peeler pole' regimes (approx. 15-20-year rotation), that can produce both veneer for engineered wood products and posts for vineyards/other primary industries. It could also be considered as a short-rotation biomass crop due to its fast growth, high wood density and ability to coppice
ii. peeler log/sawlog regimes (approx. 30-40-year rotation), producing logs suitable for sawing to produce durable timber products; also peeling to produce veneer for engineered wood products. Thinning will be required for longer rotations.

Silvicultural requirements

Form pruning is recommended in years 1-2 and sometimes beyond to ensure a single dominant leading stem develops. Little clearwood pruning is likely to be needed for post and pole crops. Because this species is self-pruning, highly stocked regimes (1600+ stems/ha) with only thinning interventions produce high quality sawlogs.

On sites with good access, production thinning could produce material suitable for peeler pole production, leaving a sawlog crop to grow on to maturity.

Seven-year-old E. globoidea, Hawke's Bay.

Pest and disease threats

Eucalyptus globoidea is generally tolerant of insect pests that feed on the foliage of some eucalypt species in New Zealand.

Timber properties, products/applications and markets

Eucalyptus globoidea heartwood is durable above ground and is approved for various exterior above-ground building components exposed to weather – e.g., exterior decking (see Table 2, Appendix 1). Heartwood is medium brown; timber is typically straight grained with moderately fine texture. It has a narrow sapwood band. The dense timber is suited to structural uses as well as poles and posts. It has potential for flooring and outdoor furniture. It peels well and veneers have potential in LVL.

Other information

Recent research at the University of Canterbury School of Forestry into *E. globoidea* has produced a growth and heartwood volume model, as well as good knowledge of *E. globoidea's* timber properties and uses.

Eucalyptus globoidea has a wide range of flowering timing from mid-winter through to early summer. It produces nectar and pollen for bees and native birds.

Above left: Nine-year-old E. globoidea planted on a cut-over site, Wairarapa.
Above right: 27-year-old E. globoidea, Bay of Plenty.

Above: An NZDFI peeling trial using mixed species of durable eucalypts to produce naturally durable posts.
Below: Cattle yards constructed with locally grown E. globoidea, Gisborne.

Eucalyptus microcorys - tallowwood

Eucalyptus microcorys, or tallowwood, is a highly durable eucalypt species considered one of Australia's finest hardwoods. Widely grown in Northland and Bay of Plenty, where large mature trees demonstrate its adaptability to milder climates, this species tends to be restricted to coastal North Island sites free from heavy frost. *Eucalyptus microcorys* timber has excellent in-ground durability, along with high strength and hardness, and has been prized historically for dance floors.

About this species

Optimal soil type	Grows well on most soil types from heavy clays to sands and can cope with limited drainage. Requires adequate soil depth and shelter so not suitable for upper slopes
Optimal annual rainfall	750-2000 mm/year
Drought tolerance	Moderate
Periodic waterlogging tolerance	Moderate
Frost tolerance	Low
Exposure tolerance	Low - prefers reasonably sheltered sites. Can be subject to limb breakages if exposed to high winds
Shade tolerance	Very high
Coastal site tolerance	Moderate - salt spray from direct coastal exposure can cause leaf burn
Fire resilience	Good - will produce epicormics vigorously following fire
Altitude tolerance	Requires warm sites
Coppicing species	Yes
Growth model status	No growth model available

Obtaining the right planting material
Tends to be a reliable performer from Australian imported seed from northern New South Wales. Trees should only be planted from seed of known provenance or originating from selected trees. Growers should discuss seed sources with nurseries. There has been no *E. microcorys* breeding programme in New Zealand to date.

Growing regimes
Moderately fast growing, suitable for sawlog production with a rotation of 25+ years.
Well suited to continuous cover regimes due to its shade tolerance. It grows very large, so a continuous cover regime where trees are harvested over time and large trees harvested at 100+ years old has potential.

Silvicultural requirements
A clearfell regime should target harvest in 25-35 years. A high initial stocking of trees is recommended (1600-2000 stems/ha) that is progressively thinned to leave a final crop stocking of 300-500 stems/ha. Pruning is recommended.

Pest and disease threats
Eucalyptus microcorys is a healthy species with no pest or disease issues of any consequence. Susceptible to possum browsing when young.

Timber properties, products/applications and markets
The light brown heartwood is very durable, dense, hard, very strong and very stiff (see Table 2, Appendix 1). Despite its density, tallowwood saws and machines well. Sawn timber is suitable for appearance products such as flooring, laminated benchtops and both interior and exterior joinery. The timber has considerable potential for use as high-value appearance structural products such as exposed beams, rafters and glulam where the natural lustre of this timber is on display. What is not suitable for timber can be used for firewood - *Eucalyptus microcorys* is also an excellent fuelwood because it burns slowly and gives off great heat.

Top: 25-year-old E. microcorys, Northland. Bottom: Green-sawn E. microcorys timber.

Eucalyptus muelleriana - yellow stringybark

Eucalyptus muelleriana is a forest tree of good form, generally growing with a straight trunk to half or more of the tree height. It is naturally found south of Woollongong in southern New South Wales to southern Victoria. In New Zealand, it can be grown on warm microsites at least as far south as Canterbury. *Eucalyptus muelleriana* is a tall tree, growing up to 50m tall and to 3m diameter at maturity (>40 years).

About this species

Optimal soil type	Clay soils are tolerated as long as reasonably free draining. Can grow well in low-fertility sandy soils with early fertiliser
Optimal annual rainfall	700-1200 mm/year
Drought tolerance	Good drought tolerance - better than some other eucalypts
Periodic waterlogging tolerance	Low - will not tolerate waterlogged soil
Frost tolerance	Low - in colder districts plant only on north facing slopes
Exposure tolerance	Good
Shade tolerance	Moderate
Coastal site tolerance	Good
Fire resilience	Good - will produce epicormics vigorously following fire
Altitude tolerance	Not frost tolerant
Coppicing species	Yes
Growth model status	No growth model available

Obtaining the right planting material

Trees should only be planted from seed of known provenance or originating

from selected trees. Growers should discuss seed sources with nurseries. There has been no *E. muelleriana* breeding programme in New Zealand, but selection of good local provenances has produced high quality progeny.

Growing regimes

Most suited to sawlog production with a rotation of 30-40 years. On sites with good access, production thinning could produce material suitable for post and pole production, leaving a sawlog crop to grow on to maturity. Good shade tolerance means *E. muelleriana* could be used in continuous cover forestry. It could also be considered as a short-rotation biomass crop due to its fast growth, high wood density and ability to coppice.

Silvicultural requirements

Unimproved seed can produce multiple trunks, so a high initial stocked (1000-2000 stems/ha) is recommended, progressively thinned to a final stocking somewhere between 100 and 250 stems/ha.
Clearwood pruning will be necessary especially at lower stockings.

Pest and disease threats

Eucalyptus muelleriana is generally a healthy tree with no pest or disease issues of any consequence.

Timber properties, products/applications and markets

Eucalyptus muelleriana heartwood is durable above ground (See Table 2, Appendix 1). Recommended uses include general purpose construction, flooring, furniture, outdoor structures like pergolas, steps and handrails and posts and poles. What is not suitable for timber can be used for firewood.

Other information

An attractive, healthy, clean tree, (does not shed messy bark) that has been used as a landscape tree in parks. It is regarded as a medium producer of both nectar and pollen for bees, and birds visit the flowers for nectar.

20-year-old E. muelleriana, Marlborough Sounds.

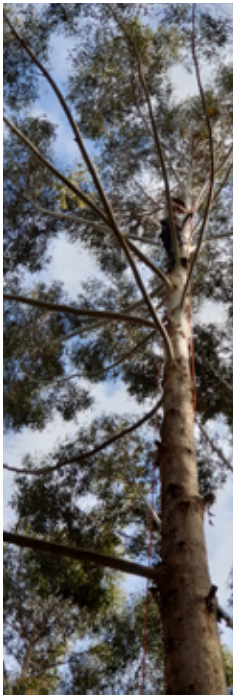
Eucalyptus muelleriana table made from home-grown timber, Hawke's Bay.

Eucalyptus pilularis - blackbutt

Eucalyptus pilularis, or blackbutt, is a durable hardwood species prized in its native New South Wales. Widely planted in Northland and Bay of Plenty, where considerable volumes of mature trees have been milled and marketed over the past thirty years. *Eucalyptus pilularis* produces a valuable hardwood timber, durable above ground, and used mostly for flooring and exterior decking. It is fast growing, but frost tender when young and requires free draining soils.

About this species

Optimal soil type	Tolerates poor quality soils from compact clays to sandy loams, requires free drainage and does not tolerate a high water table
Optimal annual rainfall	1000-1500 mm/year
Drought tolerance	Moderate drought tolerance
Periodic waterlogging tolerance	Low
Frost tolerance	Low when young
Exposure tolerance	Good
Shade tolerance	Moderate
Coastal site tolerance	Good
Fire resilience	Good - will produce epicormics vigorously following fire
Altitude tolerance	Prefers low altitude (<200m a.s.l)
Coppicing species	Yes
Growth model status	No growth model available



Obtaining the right planting material

Seed is available from good stands and well-proven local seedlines in Northland. Trees should only be planted from seed originating from selected trees;

growers should discuss seed sources with nurseries. There has been no *E. pilularis* breeding programme in New Zealand to date.

Growing regimes

Fast growing and suitable for harvesting and sawmilling into solid timber products from twenty years old. *Eucalyptus pilularis* produces high sawn timber recoveries for a eucalypt. This means large diameter logs are unnecessary and a clearfell regime should target harvest in 25+ years at a final stocking of 300-500 stems per hectare. Because the species grows very large, a continuous cover regime is suitable, where trees are harvested over time and individual trees could be harvested at 100+ years old. It could also be considered as a short-rotation biomass crop due to its fast growth, high wood density and ability to coppice.

Silvicultural requirements

An initial stocking of 2000 stems/ha will allow the trees to self-prune and provide a high selection ratio at thinning. Trees from selected seedlines can be planted at 600-1000 stems/ha but will require clearwood pruning.

Pest and disease threats

Eucalyptus pilularis is a healthy species with no pest or disease issues of consequence.

Timber properties, products/applications and markets

The honey-coloured heartwood is durable above ground and the wood is very strong and very stiff (see Table 2, Appendix 1). Despite its density, *E. pilularis* saws and machines well. Slight interlocking of the grain can produce an attractive fiddleback figure. Sawn timber is suitable for both interior and exterior joinery, flooring, decking, laminated benchtops and structural applications such as glulam where the natural lustre of this timber is on display. What is not suitable for timber can be used for firewood – *E. pilularis* is also an excellent fuelwood because it burns slowly and gives off great heat.

Above: 23-year-old E. pilularis, Northland.

Right: Eucalyptus pilularis floor, Wairarapa.

Corymbia maculata - spotted gum

Spotted gums are one of the most important commercial hardwood species of eastern Australia and interest in planting the species for timber is increasing. The spotted gums are very attractive trees between 20 m and 50 m tall in cultivation, but up to 70 m tall in the wild. The most well-known species in New Zealand is *Corymbia maculata*, and there are some excellent examples growing here.

N.B. In 1995 about 100 species of eucalyptus were taken out of the genus *Eucalyptus* and put into new genus called *Corymbia*.

About this species

Optimal soil type	Can grow in a wide range of soils ranging infertile, light-textured soil to clays. Remarkably tolerant of climates and soil types that differ from those of its natural distribution
Optimal annual rainfall	500-2000 mm/year
Drought tolerance	Very good drought tolerance
Periodic waterlogging tolerance	Moderate - tolerant of some waterlogging
Frost tolerance	Low frost tolerance when young
Exposure tolerance	High
Shade tolerance	Moderate
Coastal site tolerance	High
Fire resilience	Good - can survive fire better than most other plantation eucalypts, and considered to be fire retarders in Australia where they have been planted to act as fire breaks
Altitude tolerance	Avoid sites with potential for out-of-season frosts
Coppicing species	Yes
Growth model status	No growth model available

Obtaining the right planting material

Trees should only be planted from seed of known provenance or originating from selected trees. Growers should discuss seed sources with nurseries. Australian breeding programmes are producing improved seed. There has been no *Corymbia* breeding programme to date in New Zealand.

Growing regimes

Most suited to sawlog production: growers can expect a 30–40-year rotation depending on site.

Corymbia maculata is drought tolerant thanks to a very deep root system; trees do not compete strongly for moisture with plants growing underneath if widely spaced. Their bark is reputedly more resistant to animal damage than some species, so the species has potential for agroforestry.

Silvicultural requirements

An initial stocking of 1600-2000 stems/ha will allow the trees to self-prune and provide a high selection ratio at thinning. If there is a risk of frost, ripping and mounding - especially on heavy clay soil - is generally recommended.

Weed control at establishment is critical, as *C. maculata* seedlings have a weak competitive ability.

Sawlog crops will require pruning and thinning, similar to other eucalypts.

Pest and disease threats

Corymbia maculata is a healthy tree with no disease or pest issues of consequence.

Timber properties and products

Corymbia maculata is one of Australia's premium timber species, yielding a strong, heavy, hard heartwood, classed as durable above ground (see Table 2, Appendix 1). It has a large variety of uses including in mines and for heavy construction, high strength trusses and beams, flooring, boat building, furniture and bent work, plywood, veneer, decking, garden landscaping, fence posts, and joinery. It is one of the best timbers for high-impact tool handles as it absorbs shock well. *C. maculata* has a wide sapwood band.

Young plantation-grown trees are suitable for high quality fuelwood with an extremely high calorific value. They are also suited to production of fine papers.

Other information

Corymbia maculata are valuable pollen producers and support honey production in Australia. The flowers are also attractive to nectar-eating birds. Sawdust is used for smoking and curing meat. Essential oils are another potential by-product.

Above: 25-year-old Corymbia maculata, Northland.
Below left: Band-sawn C. maculata. Below right: Corymbia maculata lining boards.

NON-DURABLE EUCALYPTS

Eucalyptus fastigata – brown barrel

Eucalyptus fastigata originates from parts of New South Wales and was first planted in New Zealand in the 1880s and 1890s. Substantial plantings were established from the late 1970s in the Waikato, associated with the Kinleith paper mill. The species is a reliable performer and grows fast on good sites. Timber is suitable for solid wood or veneer, or it can be grown for short fibre pulp. *Eucalyptus fastigata* is considered one of the healthier and more adaptable eucalypts in New Zealand.

About this species

Optimal soil type	Prefer loamy soils with a moist but well-drained subsoil
Optimal annual rainfall	750-2000 mm/yr
Drought tolerance	Low
Periodic waterlogging tolerance	Low
Frost tolerance	Frost tolerant to at least minus 10ºC
Exposure tolerance	Moderate
Shade tolerance	Low
Coastal site tolerance	Low tolerance of salt-laden winds
Fire resilience	Good - will produce vigorous epicormic growth following fire
Altitude tolerance	Up to 1400 m (50 - 500 m optimum)
Coppicing species	Yes
Growth model status	A growth model and calculator[13] are available

Obtaining the right planting material

New Zealand has an *E. fastigata* breeding programme, and improved seed is available from Proseed New Zealand. Seedlings produced from this seed should be first choice for intending growers. Provenance testing undertaken since the mid-1970s has identified some seed sources with poor form which need to be avoided.

Growing regimes

Eucalyptus fastigata is a versatile species so growers can consider, for example:

i. sawlog or veneer production under a 'traditional' full rotation of 25-30 years
ii. short-rotation for fibre to chip, or to produce biomass for bioenergy. Expect a 15-year rotation, mechanically harvested.

Silvicultural requirements

For sawlog crops, plant 1100 stems/ha, prune as required to 6 metres, and thin twice to achieve a final crop stocking of 200-300 stems/ha. Expect a rotation of 25-30 years. For very large trees, thin to 100 stems/ha and expect a rotation of 40-50 years.

For short-rotation crops, plant at 1100 stems/ha. No pruning or thinning required. Harvest will be fully mechanised.

Pest and disease threats

Eucalyptus fastigata currently has no significant pest or disease issues in New Zealand. It may suffer localised infections of leaf spot fungi in sustained warm and humid conditions.

Timber properties, products/applications and markets

Eucalyptus fastigata heartwood is non-durable. The timber colour ranges between blonde and yellow. One of the easier eucalypts to work with, although it may suffer from growth-stresses, reducing yield for solid wood processing and causing splitting of veneers. It is suitable for indoor joinery and furniture; also potentially for veneers in engineered wood products. Limited volumes are currently produced and traded in New Zealand. Most trees grown here go into pulp and paper. Given its fast growth, *E. fastigata* has a role in future biomass forests.

Other information

Two NZ Forest Research Institute Bulletins (No.s 119 and 124 (#18)) have plenty of further information about *E. fastigata*[14,15].

Right: Eucalyptus fastigata, age 10, Wairarapa.

Above: Freshly milled E. fastigata.

Below: A staircase made using E. fastigata.

Eucalyptus nitens – shining gum

Eucalyptus nitens is a tall fast-growing species, native to the mainland of south-east Australia, first introduced to New Zealand around 1920. Early trials showed its promise, but the arrival of the eucalypt tortoise beetle (*Paropsis charybdis*) in North Island sites initially curtailed deployment. *Eucalyptus nitens* is grown successfully at scale in cooler New Zealand climates. Currently, the majority of stands are unpruned and destined for the fibre/chip market. *Eucalyptus nitens* has the potential to be grown on short rotations for bioenergy.

About this species

Optimal soil type	Moderately fertile moist loams, over a clay subsoil, also grows well on soils derived from basalt, granite, shist, shale and sandstone
Optimal annual rainfall	750-1750 mm/yr
Drought tolerance	Low
Periodic waterlogging tolerance	Low - not suited to wet sites
Frost tolerance	Good - handles temperatures as low as minus 12ºC Grown on sites encountering between 50-150 frosts per year
Exposure tolerance	Good
Shade tolerance	Low
Coastal site tolerance	Low - prefers cooler high-altitude sites
Fire resilience	Low - very sensitive to fire, often killed
Altitude tolerance	800-1300 m a.s.l, but stands have been found to 1600 m in New South Wales
Coppicing species	Yes
Growth model status	A growth model and calculator have been developed

Obtaining the right planting material

New Zealand has an *E. nitens* breeding programme and seed orchard seed is available from several sources including Proseed NZ, Olsen Seed and Southwood Export Limited. If seed orchard seed cannot be sourced, the best provenances are from central Victoria or northern New South Wales.

Growing regimes

Eucalyptus nitens typically grows fast with straight, clean stems. It is generally easy to mill but challenging to dry. Most plantings are destined for the short-rotation pulp chip market. Growers can consider:

i. short-rotation for fibre to chip, or to produce biomass for bioenergy. Expect a 15-year rotation and mechanical harvesting
ii. sawlog or veneer production under a 'traditional' full rotation of 25-30 years.

Silvicultural requirements

For short rotations, plant at 1100 stems/ha. No thinning or pruning required. Harvest will be fully mechanised.

For sawlog crops, plant 1100 stems/ha, prune to 6 metres and thin twice to achieve a final crop stocking of 200-300 stems/ha. Expect a rotation of 25-30 years. For very large trees, thin to 100 stems/ha and expect a rotation of 40-50 years.

Pest and disease threats

An ongoing pest management strategy to monitor against *Paropsis* is required – this pest is controlled by spraying before populations build up. Adult leaves are susceptible to *Paropsis* browsing, which leads to reduced growth or death. Integrated pest management programmes covering monitoring and insecticide spraying are essential. There are ongoing attempts to establish biological controls for *Paropsis* and other leaf chewing insects. There are several leafspot fungi (*Septoria pulcherrima, Mycospharella spp*), which can infect juvenile leaves on warm high summer rainfall sites, causing growth loss. *Eucalyptus nitens* from New South Wales is less susceptible and therefore better matched to such sites.

Timber properties, products/applications and markets

Eucalyptus nitens timber is non-durable (see Table 2, Appendix 1), with creamy coloured sapwood and light brown heartwood. It is suitable for furniture, flooring, veneers and engineered wood products. Producing sawn timber is difficult due to degrade in drying, but recent studies using best-practice methods suggest these problems can be reduced.

The current main market for *E. nitens* in New Zealand is for short-fibre chip production. In Australia it is used in CLT (cross-laminated timber). Future markets are likely to include biomass, given its high growth rates.

Other information

Eucalyptus nitens has been the subject of significant research in New Zealand over the years[17].

North Canterbury company Specialty Timber Solutions has developed a range of flooring products from *E. nitens*[18].

28-year-old E. nitens, North Canterbury.

Above: Eucalyptus nitens being converted into flooring products, Specialty Timber Solutions, North Canterbury.
Below: Eucalyptus nitens can be used to produce attractive furniture.

Eucalyptus regnans – mountain ash

Eucalyptus regnans grows naturally in Victoria and Tasmania. It was first introduced to New Zealand around 1856. Since the 1970s it has been planted for short fibre production and sawn timber: most plantings have been concentrated in the central North Island associated with the Kinleith paper mill. Provenance testing began in the1970s and identified large provenance variations for growth, tree form and frost tolerance. Given its fast growth, *E. regnans* has potential to be grown on short rotations for bioenergy uses.

About this species

Optimal soil type	Deep friable clay loams, good drainage
Optimal annual rainfall	1100 mm+ gives best growth
Drought tolerance	Low - native climate does not have a severe dry period
Periodic waterlogging tolerance	Low – *E. regnans* has zero tolerance of water-logging
Frost tolerance	Good – at higher elevations can tolerate light to moderate snowfalls and frequent frosts (over 80 per annum). Can tolerate minus 9ºC, but some variation depending on provenance
Exposure tolerance	Good
Shade tolerance	Low - *E. regnans* usually grows in pure stands as a tall open-forest formation
Coastal site tolerance	Low
Fire resilience	Good - will produce epicormics vigorously following fire
Altitude tolerance	Sea level to 600 m in Tasmania, and around 150 m - 1100 m in Victoria
Coppicing species	No
Growth model status	A growth model has been developed

Obtaining the right planting material

New Zealand has an *E. regnans* breeding programme going back several decades. Improved seed is available from Proseed NZ and seedlings grown from this seed should be first choice for growers.

Growing regimes

Eucalyptus regnans is a versatile species, and growers can consider:

i. sawlog or veneer production under a 'traditional' full rotation of 25-30 years
ii. short-rotation for fibre to chip, or to produce biomass for bioenergy. Expect a 15-year rotation.

Silvicultural requirements

For sawlog crops, plant 1100 stems/ha, prune as required to 6 metres, and thin twice to achieve a final crop stocking of 200-300 stems/ha. Expect a rotation of 25-30 years. For very large trees, thin to 100 stems/ha and expect a rotation of 40-50 years.

For short-rotation crops – plant at 1100 stems/ha. No thinning or pruning required. Harvest will be fully mechanised.

Pest and disease threats

Barron Road Syndrome (BRS), a fungal complex disease, can affect new foliage in higher rainfall areas. There has been some success in breeding trials selecting against BRS, so seed orchard seed should be used. Keeping stocking at a level to allow reasonable airflow is helpful to prevent fungal diseases.

Timber properties, products/applications and markets

Heartwood is non-durable (see Table 2, Appendix 1), medium yellow to light brown. Producing sawn timber is difficult due to growth stresses and degrade in drying. However, once seasoned it is easily worked with hand and machine tools. Suitable for furniture, joinery, and flooring. Also for slicing/veneers. Markets are currently limited and only small volumes are traded. *Eucalyptus regnans* grown in New Zealand is most commonly chipped for use in pulp and paper.

Other information

Two NZ Forest Research Institute Bulletins (No.s 119 and 124 (#11)) have significant further information about *E. regnans*[19,20].

Left: 38-year-old E. regans, Marlborough Sounds.

56-year-old E. regnans, Rotorua.

A farmhouse kitchen with E. regnans benchtops and cypress joinery.

REDWOOD

Sequoia sempervirens - Redwood

Sequoia sempervirens (Coast redwood) is a long-lived, evergreen tree that is endemic to a narrow coastal strip from central California to southern Oregon. It was first introduced to New Zealand between 1860 and 1870, with more extensive plantings in the 1920s and 1930s. The 2000s have seen a substantial increase in plantings as redwood's productivity and market potential have been recognised.

Sequoia sempervirens performs best in areas with good summer rainfall including Northland, Waikato, Bay of Plenty and Taranaki in the North Island, and Nelson, Tasman and in well-drained soils of the West Coast in the South Island.

About this species

Optimal soil type	Prefers well-drained, fertile soils
Optimal annual rainfall	750-1250 mm/yr
Drought tolerance	Low - growth is severely reduced in areas with seasonal water deficits and low humidity
Periodic waterlogging tolerance	Low/moderate - can withstand periodic flooding once established but not when young
Frost tolerance	Moderate - vulnerable to unseasonal frosts but can withstand snow cover
Exposure tolerance	Good - wind-firm and resistant to breakage, but sheltered sites produce the best form trees
Shade tolerance	Good
Coastal site tolerance	Low
Fire resilience	Good - noted for its fire resistance due to thick bark of mature trees and lack of flammable resin
Altitude tolerance	Grows successfully at up to 500 m a.s.l. in the North Island & 300-400 m a.s.l. in the South Island

Coppicing species	Yes
Growth model status	Growth models and a redwood calculator[21] are available

Obtaining the right planting material

Both seedlings and clones are available. Seedlings grown from seed imported from the northern and central parts of *S. sempervirens*' natural range are more productive than material originating from southern parts. Seedlings grown from seed collected from selected New Zealand trees are also available and show increased resistance to *Botrytis* infection. Clonal material, selected for superior growth and form, superior heartwood durability and improved basic density, is now available from some nurseries.

Growing regimes

Manage on a pruned sawlog regime to maximise production of clear grades of timber. Expect a rotation of 35-40 years on productive sites to produce sawlogs. *Sequoia sempervirens* can carry high stockings over long rotations, making it a good choice for regimes targeting both timber and carbon.

Silvicultural requirements

Planting clonal material at 500-600 stems/ha produces a crop at final stocking with no need for thinning. Seedlings should be established at higher stockings (800 stems/ha minimum), with thinning of inferior stems. Pruning, potentially up to 6-8 metres, is needed to produce clearwood; early pruning lifts may well result in epicormic growth - small side shoots - which need to be removed. *Sequoia sempervirens* is suitable for management under mixed-age, continuous cover systems.

Pest and disease threats

There are currently no significant pest and disease threats to *S. sempervirens* in New Zealand.

Timber properties, products/applications and markets

Sequoia sempervirens timber is lightweight and the heartwood is moderately durable, deep reddish-brown changing to nut brown when exposed to light. Sapwood is almost white and is non-durable. Wood is soft and straight-grained, easy to work, odour free, non-resinous and free of oily materials.

In New Zealand, *S. sempervirens* timber complies with the NZ Building Code[22] as acceptable for exterior cladding but not decking or framing. It

may be used as weatherboards and as decorative interior panelling, but its low density, low strength and low hardness restrict its applications.

Other information

Sequoia sempervirens is a coppicing species, which is unusual for a conifer. The species has a zero rating for wilding spread. Some further recommended reading is suggested[23, 24].

Above: Pruning S. sempervirens at Lake Tutira, Hawke's Bay.

Right: 38-year-old S. sempervirens, King Country.

Left: Sequoia sempervirens coppice shoots growing from the stump of a harvested tree.

Above left: Sequoia sempervirens cladding, Eastbourne.
Above right and below: Sequoia sempervirens interior panelling and sarking in a Hawke's Bay house.

JAPANESE CEDAR

Cryptomeria japonica - Japanese cedar

Cryptomeria japonica (Japanese cedar) is widely distributed in Japan, where it has been cultivated and utilised for centuries. Small stands were planted in various parts of New Zealand during the 1860s-1870s, with further forest plantings between 1937-1955, often for 'enrichment' of logged indigenous forest. However, most plantings have been for horticultural shelterbelts, due to *Cryptomeria's* high wind tolerance.

Sometimes referred to as 'Japanese redwood' or 'Sugi', *Cryptomeria* grows well in parts of New Zealand where redwood also performs best, i.e., in areas of Northland, Waikato, Bay of Plenty, Taranaki, Nelson, Tasman and in well-drained soils of the South Island West Coast.

About this species

Optimal soil type	Performs well on a range of soils of moderate to high fertility, including clays, but not on light sandy soils, or on poorly drained soils
Optimal annual rainfall	1000-2000 mm+
Drought tolerance	Moderate
Periodic waterlogging tolerance	Good - will tolerate periodic waterlogging
Frost tolerance	Moderate - intolerant of out-of-season frosts, but tolerant of cool temperatures
Exposure tolerance	Good - significantly more wind tolerant than redwood
Shade tolerance	Moderate - persists under heavy shade and will respond when released, hence its use for 'enrichment' plantings in logged indigenous forests of south Westland
Coastal site tolerance	Moderate
Fire resilience	Low – unlike redwood

Altitude tolerance	Successful at altitudes up to 760 m in the North Island and 600 m in the South Island
Coppicing species	No
Growth model status	No growth model available

Obtaining the right planting material

There is no breeding programme or seed orchard for *Cryptomeria japonica* in New Zealand and there have been no recent importations of seed from Japan. Proseed NZ sources seed from local Canterbury stands, and this performs well, but is mainly grown by nurseries producing tree-stocks for shelterbelts rather than timber production. Clonal propagation from cuttings is possible, and one nursery in New Plymouth produces an excellent clone – 'Egmont' – which has performed very well in Taranaki woodlots.

Growing regimes

Cryptomeria is best managed on a pruned sawlog regime, and growers should anticipate a minimum rotation length of 40 years. *Cryptomeria* can carry high stockings over long rotations, making it a good choice for regimes targeting both timber and carbon. Small coupe harvesting from an early age is feasible if the stand is to be transitioned to a mixed-age, continuous cover system.

Silvicultural requirements

Target final crop stockings should around 400 – 500 stems/ha from an initial planting of 1000-1100 stems/ha. Clearwood pruning and thinning are required for quality timber production.

Pest and disease threats

Cryptomeria is generally healthy in New Zealand. The bark is more palatable than redwood, and at risk of being browsed by goats and deer.

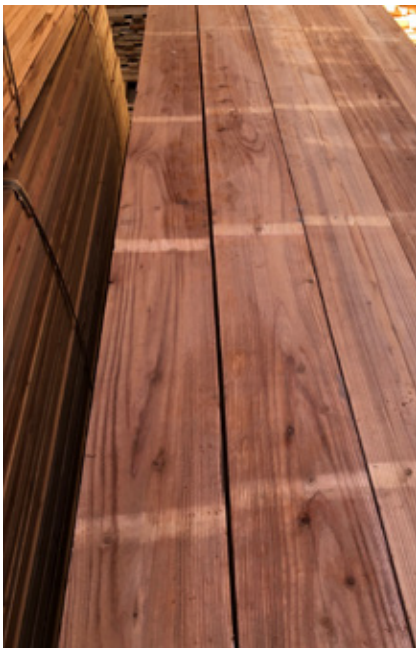
Timber properties, products/applications and markets

In Japan, *Cryptomeria* is widely used for decorative panelling and cladding, joinery, gates, doors, beams, arches and even wine barrels and wooden sandals. The sapwood is yellowish and the heartwood is red brown with yellowish streaks. Heartwood is moderately durable, similar to redwood. The timber is fragrant and has excellent working properties.

Most *Cryptomeria* timber sold domestically is imported from Japan. It is a cheaper alternative to imported western red cedar for exterior cladding.

Future domestic markets would substitute home-grown timber for this imported timber. Future export markets include Japan, other Asian countries and Australia where demand for high-value clear grades is high.

Above left: 25-year-old Cryptomeria japonica, Wairarapa.



Above left: Cryptomeria japonica at the Holt arboretum, Hawke's Bay.
Above right: Cryptomeria japonica timber. Below: Cabin with C. japonica shiplap cladding.

POPLARS

Poplars originate through most of the temperate and colder zones of all Northern Hemisphere continents and are a major plantation and agroforestry species around the world. They are deciduous hardwoods and are a versatile group of species or cultivars grown in New Zealand for erosion control, shelter, fodder, and timber. They are easily planted and propagated as clones, often hybrid cultivars. Clones with a range of traits are available to suit the diversity of sites where poplars are planted for soil conservation.

About this species group

Optimal soil type	Typically a valley floor species, it is remarkably adaptable to grow on thinner hill soils
Optimal annual rainfall	750-2000 mm+ (depending on clone)
Drought tolerance	Drought tolerant clones can be selected such as Crowsnest, Veronese, Selwyn and Fraser
Periodic waterlogging tolerance	Good – generally tolerant of water-logged soils
Frost tolerance	Good - colder climate zone origin clones show good frost tolerance
Exposure tolerance	Good – some clones will tolerate exposed and windy sites; aim for less brittle clones
Shade tolerance	Low – poplar thrives in open paddocks and full sunlight
Coastal site tolerance	Moderate - some clones are more salt tolerant
Fire resilience	One species, *P. trichocarpa*, is resistant to fire and will resprout after major scorching
Altitude tolerance	Many clones have been bred to succeed in steeper hill country
Coppicing species	Yes
Growth model status	No growth model available

Obtaining the right planting material

Poplar breeding programmes, ongoing for many years, have produced a range of selections suitable for erosion control on hill farms. Some selections have been made for quality timber production. Breeding is led by the Poplar and Willow Research Trust[25], in conjunction with regional councils.

Growing regimes

Poplars grown for timber production can be grown at up to 400 stems/ha final crop spacings, with an expected rotation of 25-30 years.
Most poplar plantings are traditionally at wide spacing for erosion control, often combined with livestock grazing, with perhaps no more than 100 stems/ha. Livestock shade, shelter and sometimes fodder are important secondary benefits.

Silvicultural requirements

If combined with livestock grazing, poplar is best established as 3-metre poles protected by a Dynex sleeve. Poles will need form pruning to select a leading stem. Without livestock, poplar can be established as stakes or as one-year rooted cuttings. Clearwood pruning will be needed to produce quality timber if trees are widely spaced. Poplar is very palatable to deer, so if planting without the protection of a 3-metre sleeve or deer fence, deer must be tightly controlled.

Pest and disease threats

New Zealand commercial selections have been screened for rust resistance and there is a low incidence of most diseases in open spaced plantings. Many hybrid clones are very susceptible to possum browsing; where there is high possum browsing pressure, balsam hybrids with their bitter leaves – e.g., Kawa, Rotorangi, Kaimai, Shinsei, and Pecam - are a good choice.

Timber properties, products/applications and markets

Poplar timber is light, relatively strong for its density, and non-durable. The timber can be treated with preservative to improve durability, although preservative penetration into poplar timber can be variable. Uses include as furniture, flooring, decking, farm pallets, fence posts, battens and railing. Higher density cultivars such as Kawa can be used for structural applications. There is an international market for poplar logs, and for use as a face veneer on plywood. Poplar chip is used in producing high quality paper.

Other information

The Poplar and Willow Research Trust has an excellent selection of information leaflets and videos for growers all freely available[26].

Right: Poplar being grown for timber while providing shade and shelter for grazing livestock.

Below: A cabin made from home-grown poplar timber, Bay of Plenty.

Above and top: Poplar battens (poplar is generally preservative- treated for fencing applications).

Left: Poplar cladding timber.

APPENDICES

Appendix 1. A note on timber durability

A key characteristic of many of the alternative species featured in this guide is that their heartwood has some degree of natural durability. Natural durability is defined as 'the inherent resistance of a specific timber to decay and to insect attack'. Naturally durable timber contains natural biochemicals that prevent wood rot, and therefore does not need preservative treatment. The most durable timbers can last for many decades both in the ground and above ground.

An Australian Standard[27] is widely used to describe timber durability. Durability classifications are based on the average life expectancy of heartwood, either in contact with the ground and/or above the ground, outdoors.

Table 1: Durability classification (Australian Timber Natural Durability Ratings)

Durability class	Description	Examples of applications	Probable in-ground life expectancy (years)	Probable above-ground life expectancy (years)
1	Very durable	Piles, sleepers, wharves, bridge timbers electricity cross-arms, posts and poles. Plus exterior above-ground and interior uses.	> 25	> 40
2	Durable	In-ground: posts and horticultural/vineyard poles, Above-ground: decking, cladding, exterior joinery Plus interior uses e.g. flooring, joinery	15 - 25	15 - 40
3	Moderately durable	Exterior above-ground – e.g. cladding, fencing rails, decking. Plus interior uses.	5 - 15	7 - 15
4	Non-durable	Interior use only unless treated.	0 - 5	0 - 7

New Zealand researchers have tested many New Zealand-grown species for in-ground durability[28], and use the Australian system to describe their findings. In some cases the New Zealand classification differs from the Australian classification. Neither the Australian nor the New Zealand data cover all the species featured in this booklet.

Note that durability classifications are only a guide. Each class covers a multi-year timespan, and some species are towards the high end of the time-span (i.e. more durable), others towards the lower end. Wood properties vary within and between species (for example, some cypresses have more durable heartwood than others), and actual timber life will depend on the ground conditions, the age of the tree from which the timber is cut, and the piece size.

Table 2 shows the durability of alternative species featured in this booklet. The New Zealand data relate only to in-ground durability; above-ground durability will generally be better than in-ground durability. Note that in New Zealand, above ground classification is not provided, as in-ground is the more conservative figure and above ground performance will be higher. The Australian data are indication but not a guarantee of New Zealand performance.

Table 2: Alternative species durability (Australian Standard and New Zealand-grown timber)

Species	Australian Standard Classification[27]		New Zealand-Grown Timber[28]
	In-Ground	Above Ground	In-Ground
Cypresses			3[1,2]
E. bosistoana	1	1	1
E. cladocalyx	1	1	1
E. globoidea	2		2
E. microcorys	1	1	
E. muelleriana	3	2	2
E. pilularis	2	1	2
C. maculata	2	1	2
E. fastigata	4	3	3[1]
E. nitens	4	3	
E. regnans	4	3	3[1]
Redwood	2	1	3[2]
Japanese Cedar			3[2]
Poplar	4		4

[1] Species with durability towards the lower end of the range
[2] Species with durability towards the upper end of the range
No data available

Cross sections of (left) Cupressus macrocarpa and (right) Eucalyptus bosistoana showing the darker, durable heartwood in the centre, and the lighter sapwood band around the outside. C. macrocarpa is moderately durable; E. bosistoana is very durable. Species with a narrow sapwood band yield a greater proportion of heartwood when milled, so this is a desirable trait.

Appendix 2. Species excluded from this guide

This guide focuses on non-native, or 'exotic' alternatives to radiata pine, selected because they have most immediate potential to be grown at scale for timber.

There are many other species with potential in New Zealand, and as the industry becomes more diverse, investment in breeding to improve these species may become worthwhile. The most well-known species and species groups excluded from this booklet are listed in the table below.

Species		Current status
Acacias – blackwood, silver wattle	Acacia spp.	No NZ breeding programmes. Could be considered in future.
Douglas-fir	Pseudotsuga menziesii	An important NZ plantation species. New planting in the South Island constrained by wilding risk; new planting in the North Island constrained by risk of Swiss Needle Cast.
Eucalypts – many other species	Eucalyptus spp.	Many other species, mainly durable species, which could be considered in future with more investment in genetic improvement. Others have low potential due to poor insect tolerance or poor timber properties.

Species excluded from this guide cont.

Species		Current status
Grand fir and other firs	Abies spp.	Limited provenance information: no tree breeding programme; no significant seed available.
Larches	Larix spp.	Limited provenance information: no tree breeding programme; no significant seed available; wilding risk.
Oaks	Quercus spp.	NZ breeding programmes in early stages. Could be considered in future.
Pine species or hybrids	Pinus spp.	Other pine species or hybrids could be considered in future with more investment in seed supply at scale. Currently excluded as considered similar to radiata pine.

Appendix 3. Example growing regimes

Some example regimes for featured species are shown below.

Species	Rotation length (years)	Stems per hectare at planting	Form Pruning	Clearwood Pruning	Thinning	Summary
Cypress	35-45	800-1100	N/A	3-4 times to reach at least 6 metres, Years 4-10	Twice, years 11-15. Production thinning possible on right sites.	… are a genuine option, with many applications and existing domestic and export markets. A new NZ resource is urgently needed to replace dwindling macrocarpa supplies.
Eucalypts – short rotation biomass regime	12-15	1100	N/A	N/A	N/A	… have exciting potential for biofuel and biomaterials. Markets emerging rapidly. Gentle topography essential for fully mechanised operations.
Eucalypts – short rotation solid wood	15-20	1100-1600	1-2 times	Not necessary except perhaps edge trees.	0-1 time depending on planting density and species	… have a ready market as vineyard and orchard posts and poles, and exciting potential as a component of engineered wood. Planting at scale starting to happen.

Species	Rotation length (years)	Stems per hectare at planting	Form Pruning	Clearwood Pruning	Thinning	Summary
Eucalypts - sawlogs	25-40	600-2000 (depending on species & genetics).	2-4 depending on species.	0-3 times to reach 6 m, depending on species and planting density.	2-3 times, years 6-12. Production thinning possible on right sites.	… have great potential in a wide range of markets, domestic and export. Specialist sawing and drying skills needed. Market development plus planting at scale needed.
Redwood	35-45	500-800 depending whether clones or seedlings	N/A	3 times, years 6-12 to reach 6-8 metres (plus some epicormic management)	Once (only if planted at higher density), year 12-14.	… have excellent potential in domestic markets which need to be developed; also known export markets. Planting at scale already happening in parts of the North Island.
Japanese cedar	40-50	1000 - 1100	N/A	3 times, years 6-12 to reach 6-8 metres	1-2 times	… have good potential but need to build a reputation as a substitute for redwood & some imported softwood timbers.
Poplar	25-35	100-400 depending on objectives	Poles need form pruning to select a leading shoot.	2-3 times to 6 metres	N/A	… are an excellent multi-purpose option, with a widespread resource already growing and suitable for small-scale mobile sawmilling. Timber and biomass markets need to be developed.

Appendix 4. Indicative establishment costs

The following table is intended to provide growers with some ball-park guidance around likely costs of establishment operations, based on examples from 2022-23. Growers are advised to do their own research and seek advice for their own circumstances.

Cost item	Cost estimates (2022-23) excl.GST and excl. management/ supervision costs	Other considerations
Fencing	**$/metre** Post and batten 18-25	Farm livestock and horses must be excluded from new plantings for several years, if not permanently. Other pests e.g. goats, deer, possums, rabbits and hares must be controlled pre-planting and kept at low levels.
Trees	**$/000 plants** Cypress 1,500-3,000 Eucalypts 1,500-3,100 Redwood - seedlings 1,500-2,250 Redwood clonal material 3,000-4,300 Japanese cedar 1,500-2,250 Poplar Rooted cuttings 2,000-2,500 3-metre poles per pole inc. sleeve and planting $25-$32/pole	Prices will vary depending on the genetics of the stock, whether seedlings or clones, the number ordered, whether bare-root or containerised, and the plant size. Freight charges and cold storage, if needed, will be extra. Some regional councils offer subsidised poles and planting.
Planting	**$/tree** 65 cents - $1.80/tree	Costs vary with species, size and type of planting stock (bigger seedlings and containerised plants cost more to plant), and planting terrain/difficulty.
Chemical weed control (pre and post-planting)	Spot-spraying (including chemical) 35-50 cents/tree Helicopter blanket spraying (including chemical) $250 - $400/ha	Some species require only one weed control application; others may need at least two, depending on early growth rate and level of competition from surrounding vegetation. Helicopter spraying costs vary according to the total area sprayed: larger areas cost less per hectare.
Form pruning	Lopper pruning (age 1-2) Approx. $1/tree Older trees (combined with first clearwood lift) $2.50-$4.00/tree	Durable eucalypts and poplars only

Cost item	Cost estimates (2022-23) excl.GST and excl. management/ supervision costs	Other considerations
Clearwood pruning	$2.50-$4.00/tree	Cost will depend on species and pruning height. Some species (e.g. cypress) cost more to prune due to large number of branches. Aim to keep diameter over stubs (DOS) to no more than 15-18 cm.
Production thinning	N/A	This should be at least break-even if not a profitable operation.
Thinning to waste	$850-$1200/ha	
Management/ supervision of operations	Can be significant – e.g. an additional 10-20% on top of other costs	

Appendix 5. Glossary

Bioenergy/biofuel Bioenergy (often used interchangeably with biofuel) is, in the case of forestry, energy derived from woody biomass.

Biomass Biomass is plant-based material used to produce biofuel and a wide range of other biomaterials. In the case of forestry, biomass can be produced form short-rotation crops harvested in their entirety, or from harvesting or sawmilling residues.

CCA Copper Chrome Arsenate – a toxic substance used to treat timber to increase its durability.

Clearwood pruning Removal of all branches from the stem of a tree to promote the growth of clearwood (knot-free wood).

Coppice Coppice/coppicing is the growth of new shoots from a cut tree stump. Tree species which coppice retain live root systems after harvest and can be harvested many times without needing to be replanted.

Cross-laminated timber (CLT)	A wood panel product made from gluing together layers of solid sawn lumber. Each layer of boards is usually oriented perpendicular to adjacent layers – hence 'cross-laminated'. Used for walls or floors in building construction.
Emissions Trading Scheme (ETS)	A key tool for meeting NZ's domestic and international climate change targets. Forest growers with eligible land can earn carbon credits by establishing new plantings or allowing trees to regenerate on the land.
Engineered wood	Engineered wood includes a range of wood products manufactured by using an adhesive to glue together smaller wood particles (lumber, veneer, strands, chips or fibres) to make homogenous, wood products of larger size. Glulam, LVL, Plywood and CLT are engineered wood products.
Epicormics	Shoots growing out from a bare tree stem which can become branches if not pruned.
Form pruning	Involves selecting a single leading stem in a young tree, and removing competing stems (usually done with secateurs or loppers).
Glulam	Glued laminated timber - a type of structural engineered wood where layers of wood are glued together, usually in the same dimension.
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.

Laminated veneer lumber (LVL)	Sheets of veneer glued together parallel to the grain to create a strong, homogenous structural product. Used as beams in building construction.
Production thinning	Removal of a proportion of trees from a mid-aged crop to reduce competition between stems. Felled trees are extracted and utilised – e.g. for posts and poles, some joinery applications.
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.
Softwood	Softwoods are gymnosperms (conifers). Their wood is structurally distinct from angiosperms (hardwoods) and may or may not be physically softer.
Thinning to waste	Removal of a proportion of trees from a mid-aged crop to reduce competition between stems. Felled trees are left to decompose in the forest.
Veneer	Thin sheets of wood produced either by slicing or rotary peeling logs. Can be used as decorative faces on cheaper products or as a component of engineered wood products.

Appendix 6. Bibliography and sources of further information

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Sources of further information about alternative species

- The NZ Farm Forestry Association (NZFFA) is the best source of information and expertise about alternative species. Members of regional branches throughout New Zealand have many decades of experience of growing alternative species. There are also special interest groups for cypresses, eucalypts, redwoods, and poplar ***(https://www.nzffa.org.nz/)***.
- A NZFFA species selection tool is available at ***https://www.nzffa.org.nz/farm-forestry-model/species-selection-tool/***
- Some tree nurseries can also provide very good information about alternative species.
- Two organisations actively involved in breeding and promoting alternative species are:
  > NZ Dryland Forests Innovation – durable eucalypts ***(https://nzdfi.org.nz)***
  > NZ Poplar and Willow Research Trust – poplars ***(https://poplarandwillow.org.nz/)***
- Te Uru Rākau – NZ Forest Service ***(mpi.govt.nz/forestry/)***, including the Canopy website for practical advice ***(canopy.govt.nz)***, is developing alternative species resources and expertise.
- Forestry consultants/forest management companies – some forestry consultants have knowledge and practical experience of alternative species but many don't. Ask for evidence of experience when selecting your professional advisors.
- Species calculators and a decision support system to assist with species selection are available at on the Forest Growers Research website ***https://fgr.nz/***
- Scion or search on-line for FRI bulletin series 199 and 124. ***(https://www.scionresearch.com/)***

- Technical reports produced by the Specialty Wood Products Research Partnership can be found at ***https://fgr.nz/documents/*** All documents prefixed with SWP, dates from 2018-2022. Over 150 reports available.
- Two useful books written by experienced farm foresters (some information now superseded):
  > Neil Barr (1996) Growing eucalypt trees for milling on New Zealand farms. 140 pp. Available from the NZ Farm Forestry Association
  > John Mortimer (2003) A selection of alternative timbers. 72 pp. Taitua Books, Hamilton, NZ.

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GROWING ALTERNATIVE EXOTIC FOREST SPECIES — N 20 23 Z

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Te Uru Rākau New Zealand Forest Service

FOREST GROWERS RESEARCH

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NZDFI NEW ZEALAND DRYLAND FORESTS INNOVATION