Specialty Wood Products

Research Partnership




FOREST GROWERS RESEARCH

Programme Description

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Specialty Wood Products Research Partnership

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INTRODUCTION

The Specialty Wood Products Research Partnership (SWP) is a partnership between Government and industry which aims to develop a high-value specialty wood products industry based on alternatives to radiata pine, namely Douglas-fir, eucalypts and cypresses.

Forestry is New Zealand's third largest primary export earner, but it relies heavily on a single species, radiata pine. This leaves the industry vulnerable to fluctuations in demand, unable to capitalise on some market opportunities, and, with such large areas of a single species, at risk from a potentially devastating pest or disease outbreak. Limited areas of alternative or 'specialty' species have been planted over the years to diversify the forest resource; processing challenges, lack of scale and infrastructure, and geographically dispersed resources have restricted market development and the areas planted to date.

By generating a broader range of higher-value, better-performing timber products matched to specialty markets, the SWP will increase the competitiveness of the existing forest industry. Key global market trends identified include demand for high-stiffness timbers, naturally durable timbers, dark and rich-coloured timbers, and a strong sustainability brand. Specialty species have the potential to supply these markets, and also have the potential to complement the mainstream radiata pine industry through improving the performance of engineered wood products.

The SWP is also concerned with regional development. A sustainable harvest of sufficient volume from existing specialty species forests, or new forests of high-performing genotypes, planted within economic range of processing plants and export ports, is necessary to ensure the viability of this new industry. Advances in processing and market development will lead to new value chains being established in conjunction with our key investors; investors who operate in the regions and have existing routes to market through their international parent companies.

PROGRAMME VISION

The SWP programme will catalyse the development of a new industry based on species other than radiata pine, delivering higher value products, providing diversification, and mitigating the risks of growing a single species while supporting regional development. Crucially, the programme is driven by key industry players.

- New Zealand will substantially increase its area of specialty species forests and high-value-based manufacturing industries – and the underpinning science and industry capability to catalyse further growth.
- Benefits to New Zealand include $350million of exports by 2030, driven by commercial forest diversification, regional growth, and Māori economic growth.

PROGRAMME FUNDING

The SWP is a seven-year programme which began on July 1st 2015, with a total budget approaching $14 million. Annual contributions from partners are as follows:

- Industry contributions	$710,000 p.a.
- Ministry for Business, Innovation & Employment	$710,000 p.a.
- Scion aligned core funding	$550,000 p.a.
- Total SWP programme funding	**$1.97million p.a.**

OPPORTUNITIES

There is a real opportunity to add value to the maturing resource of specialty species already growing in New Zealand, as well as to encourage new plantings of these potentially high-value species.

However, gains are needed in genetics, site matching, forest health, timber drying and improved wood performance if these species are to reach their potential.

1. Optimise the potential of existing plantings

There are over 138,000 ha of Douglas-fir, eucalypts and cypresses already in the ground, distributed throughout New Zealand (Figures 1 and 2).

Current annual estimated total harvest volumes for these groups are (MPI data 2015):

- Douglas-fir 1,028,000m³
- Eucalypts (non durable) 475,000m³
- Cypresses 21,000m³

At present, Douglas-fir is primarily destined for structural lumber markets or exported as logs, non-durable eucalypts are predominantly grown for pulp and paper markets, and cypresses are used to produce a range of interior and exterior timber products. Naturally durable eucalypts are an emerging species.

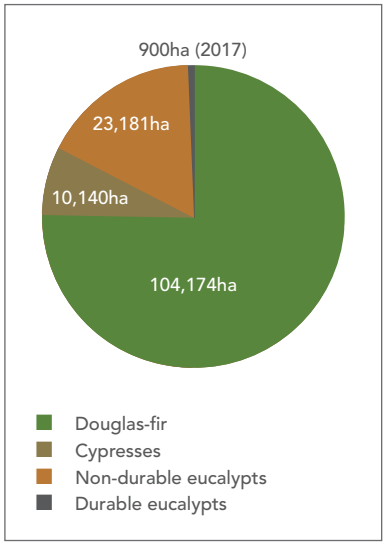


Figure 1: Area breakdown by specialty wood species

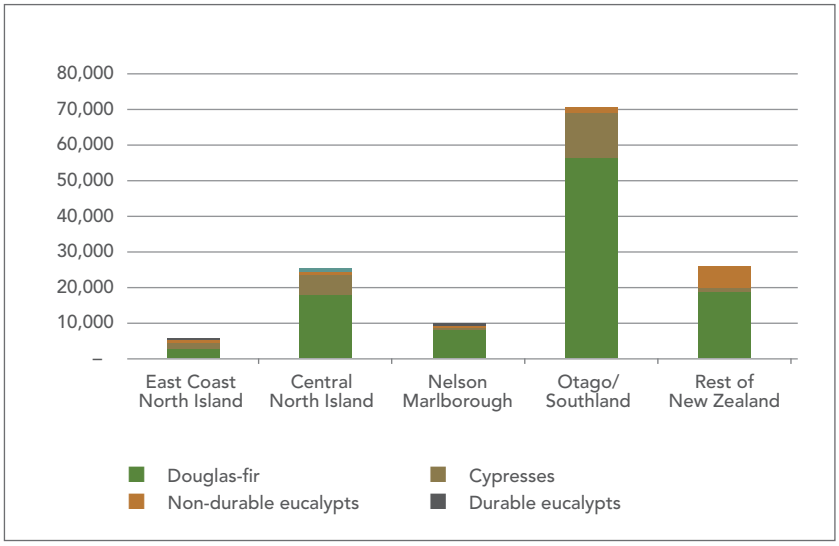


Figure 2: Regional distribution of specialty species (MPI NEFD 2016)

2. Create a step change in quality of new plantings

The SWP aims to promote new planting of both existing and new species for future high-value export products. To make significant progress in planting new areas of specialty species, the programme has to address growth strain and other timber quality problems, improve drying and wood performance, and gain grower confidence in the species.

3. Generate scale by focusing on four regions

The SWP has identified four target regions where efforts will be focused (Figure 3): the North Island east coast, central North Island, Marlborough/Nelson, and Otago/Southland. The SWP sees opportunities to generate scale through clustering planted areas, building new value chains and stimulating regional development. The current localised distribution of the species within New Zealand reinforces the need for a regional approach in the SWP programme; the regions identified are also all well-served by ports via which products can be exported.

Figure 3: SWP target regions and port locations

MARKET DEMANDS DRIVING THE OPPORTUNITY

Significant market opportunities for specialty timbers have already been identified by the SWP. These opportunities have driven both species choices and research rationale, and give great confidence in the potential of the programme. Markets identified include:

- high strength structural timber (MGP 10 and greater - i.e. stronger than average radiata pine)
- high stiffness engineered wood products, e.g. laminated veneer lumber (LVL), including as a component of engineered pine products
- naturally durable coloured hardwoods for a range of uses (Class 1 and Class 2, Australian Standard AS5604-2005)
- naturally durable coloured softwood for a range of uses (Class 1 to Class 3 AS5604-2005)
- high value indoor and outdoor furniture
- interior joinery, panelling and flooring
- naturally produced fine chemicals.

BENEFITS TO NEW ZEALAND

The SWP will develop a high-value specialty wood products industry from current and new plantings of Douglas-fir, eucalypts, and cypresses. Exports of $350million per annum by 2030 are predicted, with products going into global markets demanding chemical-free, stiff and attractive timbers. We anticipate the value of these exports will rise to $3.6billion p.a. by 2050. In addition there will be significant spill-over benefits from regional employment and a strong domestic market.

End users of SWP's research already have routes to market to ensure the Ministry for Business, Innovation and Employment (MBIE) priorities under the programme '*Biological Industries for Emerging Industries and Minor Forestry Species*' are achieved.

RESEARCH AIMS AND TIMING

SWP research will deliver future harvests with predictable quality and high value, delivered to specialty markets, through focussing on four key areas:

1. **processing options** for Douglas-fir, non-durable eucalypts, and cypresses will be transformed enabling the production of high-value specialty wood products
2. **improved breeding stock** will be developed that will overcome the current problems of growth strain, checking and collapse in lumber
3. **a new, naturally durable eucalypt resource** will be developed
4. **forest health** will be an ongoing priority in all selected species.

DELIVERING RESEARCH OUTCOMES

Regional strategies will be developed by the SWP together with key investors who recognise the commercial potential of these species. Through seamless engagement of scientists, engineers, seedling producers and foresters, the SWP will enable New Zealand to become a recognised supplier of superior high-performance wood products. No single company has the knowledge, scale of resources and infrastructure to drive this new export-oriented enterprise alone. The SWP is supported by parties currently growing specialty species, who believe in their future and have confidence that challenges associated with these species will be overcome by the research programme.

RESEARCH AIMS

Overall, we aim to optimise the value of the specialty wood products industry and the New Zealand economy. The research has three distinct aims:

1. **Research Aim 1** (RA1): Improving returns from the current value chain until new germplasm is delivered (current resource).
2. **Research Aim 2** (RA2): Creating a superior, more readily processed and consistent wood supply for the future (future resource).
3. **Research Aim 3** (RA3): Delivering higher-value products to export markets through embedding regional strategies (with strong support in kind from co-investors).

The division of funding between the three Research Aims is shown in Figure 4.

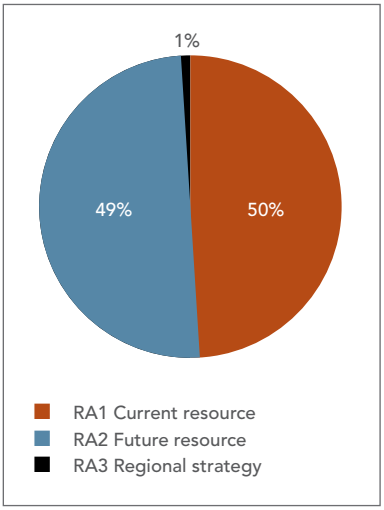


Figure 4: Investment by Research Aim (total funding of $1.97million p.a.)

Research Aim 1 (RA1): Improving returns from the current value chain until new germplasm is delivered (current resource)

RA1 focuses on adding value to trees already growing that are nearing maturity, meaning a shorter time between achieving research outcomes and delivering value to the industry. Douglas-fir and the non-durable eucalypts *(E. nitens, E. fastigata* and *E. regnans)* are the main focus of research effort in RA1.

RA1 will improve returns by extracting more value from the existing resource, and ensuring new plantings deliver their inherent maximum value until improved germplasm is available.

RA1 also includes pest and disease and site/species mapping research efforts.

To add value to the existing Douglas-fir resource, new, higher margin products/processes need to be identified to increase the current value of logs. A new product, OEL™ (optimised engineered lumber), is being tested, and the opportunity to extract fine chemicals is being explored.

For the non-durable eucalypts, the programme is initially focusing on *E. nitens* as there is a considerable resource available in a single region, Southland. A SWP investor, Southwood Exports Ltd, has committed to cash co-funding and in-kind contributions. To make *E. nitens* amenable for solid wood processing, lumber stability and drying issues need to be resolved. Various research approaches are tackling these issues, including developing technology to measure growth strain in trees and logs, evaluating novel lumber drying techniques, and thermal modification. In 2018, LVL trials will examine the feasibility of making pure eucalypt LVL or adding eucalypt veneers to radiata LVL. This will deliver a stiffer product and open up new markets which can't be met with current radiata pine LVL.

The programme will deliver improved returns from the existing resource, addressing different processing challenges for each species, by:

- better segregation of logs at the mill prior to processing (Douglas-fir, eucalypts)
- mitigating internal checking and collapse in collapse-prone eucalypt species through novel drying approaches (eucalypts)
- developing new, higher-value products (Douglas-fir, eucalypts).

The programme will also ensure that returns from new plantings of specialty species will be maximised until new germplasm is delivered by:

- identifying optimal site/species/product options for the target regions, taking into account pest and disease distribution
- screening for pest and disease tolerance.

Research Aim 2 (RA2): Creating a superior, more readily processed and consistent wood supply for the future (future resource).

Many of the existing speciality species breeding populations have targeted increasing volume. To grow reliable raw material for new value chains, the breeding populations must be carefully screened for desirable wood properties such as low growth-strain, durability and heartwood content, reduced checking, collapse and shrinkage, and increased tolerance to pests and diseases.

RA2 will, through addressing these aspects, improve the profitability and sustainability of processing specialty wood products. New molecular genetics technologies will revolutionise the speed and accuracy of delivering genetic gain. Multiple traits can be selected at the same time as soon as sufficient material is available for DNA extraction and genotyping. Rapid propagation methods will deliver these selections to the forest grower.

The programme will deliver a future wood supply that is readily processed and consistently delivers high returns along the entire value chain, by:

- screening for desired wood traits in the existing breeding populations
- testing genomics technologies in at least two species for the rapid realisation of the genetic gain through genomic selection and vegetative propagation.

RA2 Species priorities:

Douglas-fir: priorities are improved volume production, improved wood quality, and improved tolerance to Swiss needle cast (SNC).

Non-durable eucalypts: priorities are improved form, volume, solid wood properties and pest and disease tolerance.

Cypresses: the most critical issue is cypress canker which has severely limited new plantings. The priority is to develop new canker-tolerant germplasm.

New tools and technologies will be developed under RA2 to assess solid wood traits in standing eucalypt trees. The measure of success in RA2 will be increased plantings of improved genotypes.

Research Aim 3 (RA3): Delivering higher-value products to export markets through embedding regional strategies (with strong support in kind from co-investors)

RA3 is the delivery mechanism for the research outcomes. Implementation of RAs 1 and 2 needs to be regionally based. Specialty species are much less tolerant of climatic and site variation than radiata pine, and therefore recommendations will need to be made at least at the regional level to ensure the success of new plantings. Our key industry investors are committed to increasing the value and volume of their businesses and have identified significant export market opportunities if they can deliver fit-for-purpose specialty wood products. SWP will collaborate with investors and other agencies to develop four regional strategies to deliver specialty wood products, and will promote their implementation in our target regions: the North Island east coast, the central North Island, Nelson/Marlborough and Otago/Southland.

RESEARCH AIMS INTEGRATION

The three Research Aims are closely integrated (Figure 5). The left hand side of the figure represents the project areas under RA1, focusing on the current resource. The right-hand side details the project areas in RA2 (future resource), and RA3 (regional strategy) is in the centre. There is some overlap, with pest and disease work and new tools being represented in both RAs 1 and 2.

This figure highlights the importance of the site/species selection and productivity research and the reliance of the programme on the regional strategy to deliver the benefits to New Zealand.

➔ Figure 5: Research Aims integration

RESEARCH TIMING: A SEVEN-YEAR PLAN

Figure 6 describes the proposed high-level seven-year plan by research area (RA). It provides details of the anticipated timing of the major projects over the seven-year life of the programme. Current issues are on the left (such as the lack of fast screening technology for durability available), moving through to the future gains possible on the right (such as easier-to-process timber).

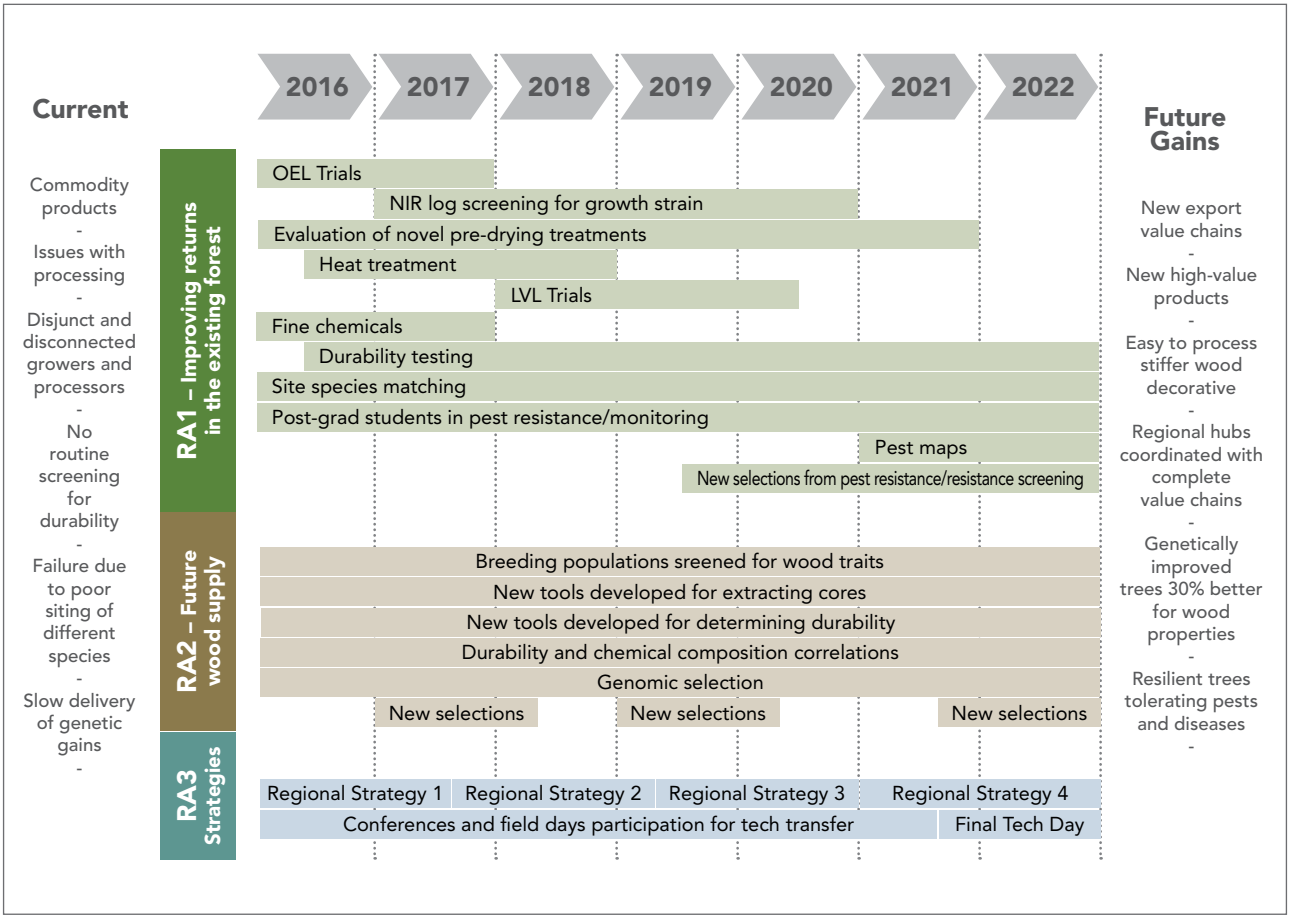


Figure 6: Seven-year high level research plan

There is flexibility in the plan and, depending on the priories set by industry, there will be changes to ensure it remains aligned with commercial needs. Regular expert reviews of the programme are scheduled throughout the seven years to ensure that the highest quality science is being undertaken and the needs of SWP investors, and commercial objectives, are being addressed.

RESEARCH PROGRAMME

The following section summarises the activities that will be undertaken by species/species group and in the site/species research area.

The allocation of total SWP funding by research area is as follows:

1.	Douglas-fir	18%
2.	Non-durable eucalypts *(Eucalyptus nitens, E. fastigata* and *E. regnans)*	28%
3.	Naturally durable eucalypts	36%
4.	Cypresses (including hybrids)	6%
5.	Site/species optimisation	12%

DOUGLAS-FIR

Douglas-fir *(Pseudotsuga menziesii)* is a species with an international reputation for good structural timber. Large industries in USA and Canada are based around a huge resource of natural and replanted stands. The New Zealand resource is currently around 104,000 hectares or about 6% of the exotic forest estate.

The location and age-class distribution of Douglas-fir are shown in Figures 7 and 8.

Douglas-fir is a pioneer species that can grow well on land with thin or eroded topsoil unsuited to agriculture. It can live for a long time, exceeding 1000 years, but grows fast enough in New Zealand to produce sawlogs on rotations of less than 50 years. Early growth in older stands was generally much slower than radiata pine, but it can mature at higher stocking and is capable of high volume production exceeding 50m³ per hectare (CAI – cumulative annual increment) per year after 40 years (at this age radiata pine CAI is typically lower than this). A better understanding of mycorrhizae and genetic improvement has led to appreciably faster early growth in younger stands.

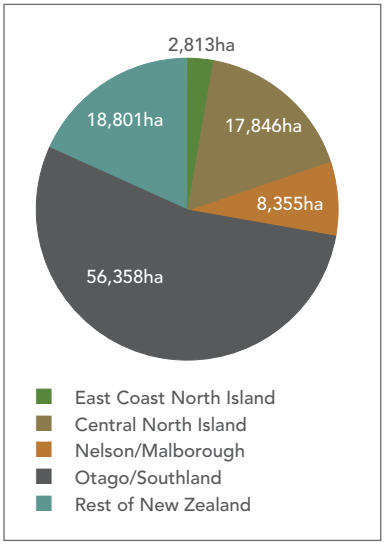


Figure 7: Douglas-fir planted areas by region

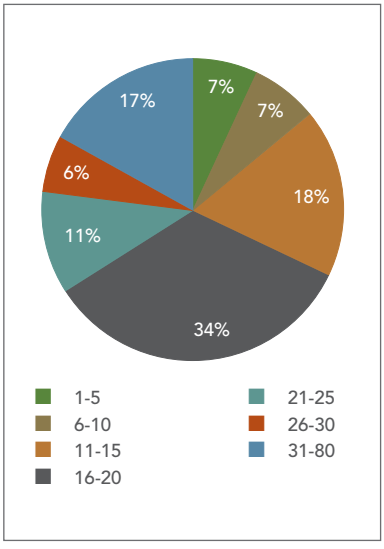


Figure 8: Douglas-fir age classes

Douglas-fir is the species of choice for higher elevation sites with winter snowfall, although it is prone to malformation on very exposed sites. Its ability to spread from windblown seed is a drawback on some South Island sites, where wildings are causing concern. First generation seed orchards based on fast growing elite trees with stiff timber are now producing enough seed to satisfy demand. Progeny trials have demonstrated that wood stiffness, diameter growth, straightness and tolerance to Swiss needle cast (SNC) are heritable. Researchers in the USA and Canada have mapped a large part of the Douglas-fir genome and marker resources are available through various organisations.

Selection to deliver gains for improved volume production, improved wood quality and improved tolerance to SNC are planned within the programme. Following a workshop of Douglas-fir growers, the industry has set a new planting target of an additional 40,000 ha by 2050.

Research programme: five key aims

1. The target for growth is a 35-year rotation length and yield of 600m^3 TRV (total recoverable volume) per ha, 20m^3 per ha MAI (mean annual increment).
2. Form to be maintained at 1996 progeny trial levels.
3. Wood stiffness to be maintained at a minimum level of 8 GPa.
4. Needle retention indicating tolerance to SNC is included in the overall objective as a secondary trait and the long-term target of 3 years' needle retention.
5. A separate Wildings Management Programme which began in October 2016 includes the aim of delivering sterile plants. (The delivery of sterile plants cannot be an aim in a breeding programme.).

Tree breeding activities

- Updates to breeding plan and strategy targeting the five key aims.
- Measure the 1996 breeding trials for growth, form, disease tolerance and wood stiffness, test the genomic selection for application in the breeding programme.
- Establish next-generation breeding trials, including progeny of un-tested trees in existing seed orchards to enable the genetic gain of the seed orchards to be quantified.
- Develop international connections to enhance the programme.

Wood processing activities

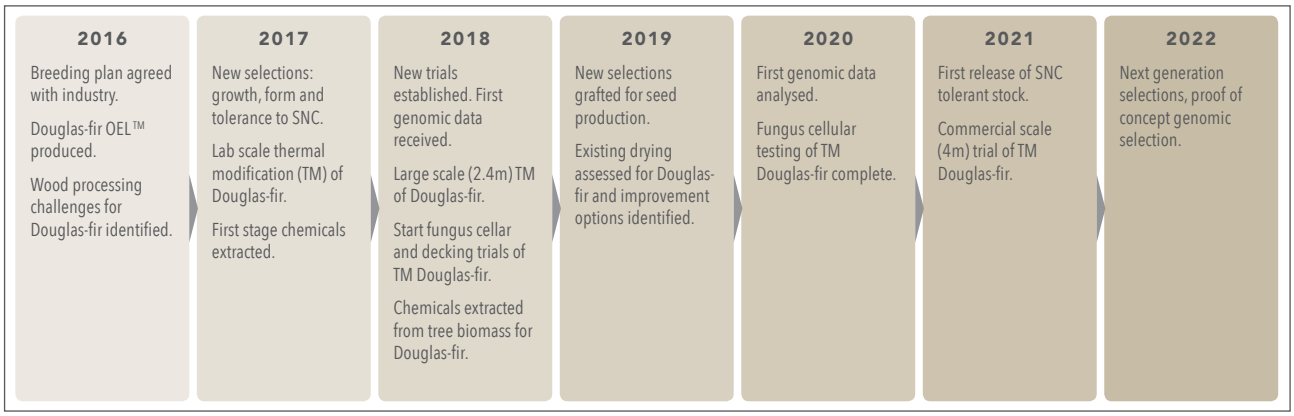
- The Douglas-fir industry is currently looking for an opportunity to improve the value of the thinning logs, top logs and poorly formed clearfell logs. The target is an increase in value of $70/m^3. The project has identified a technology OEL™ which takes 1-metre long logs and produces structural products with known, uniform and reliable properties. The OEL™ process is owned by Wood Engineering Technology Ltd (WET).

Mature Douglas-fir, Otago.

Douglas-fir: outcomes to 2022

- New selections for growth, form, tree health and wood stiffness made available from the breeding population.
- Establish next generation of breeding material.
- Douglas-fir thinnings OEL™ scoping study undertaken (completed June 2016):
  - Douglas-fir OEL™ achieved the strength and stiffness properties of the New Zealand structural grade SG8.
- Extract and identify high value chemicals found naturally in trees (foliage, wood and bark) using supercritical carbon dioxide ($scCO_2$) on a range of species including Douglas-fir.

Timeline



Linkages

Internal to the programme

- Site species mapping (RA1).
- Regional strategy (RA3):
  - Swiss needle cast is the main barrier to new planting in the central North Island.
  - Processing options that deliver high value thinnings would improve profitability and increase plantings of Douglas-fir.
  - The problem with wildings is halting planting in some areas in Otago and Southland. Significant reductions in seed dispersal, or preferably sterile plants, would overcome this barrier.

External to the programme

- Oregon State University.
- New Zealand universities.
- International and national genotyping contractors as required.

NON-DURABLE EUCALYPTS

The total area of plantation non-durable eucalypts is approximately 23,000ha.

MPI's National Exotic Forest Description (NEFD) data combines the areas and age classes distribution of all eucalypt species together (including the three species in our programme – *Eucalyptus nitens, E. fastigata* and *E. regnans*).

The location and age-class distribution of non-durable eucalypt plantations are shown in Figures 9 and 10, and highlight the fact that Otago/Southland and the central North Island regions hold the bulk of the eucalypt resource. *E. delegatensis* likely forms a major component of plantings older than 25 years.

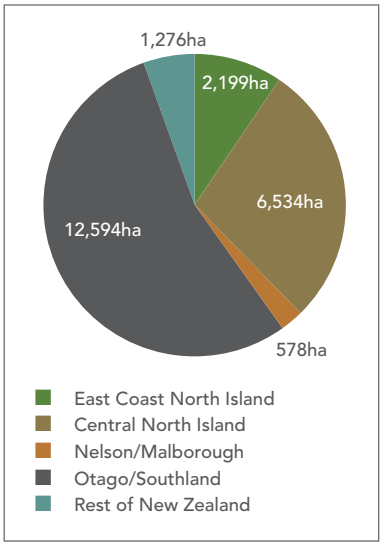


Figure 9: Non-durable eucalypts planted areas by region (ha)

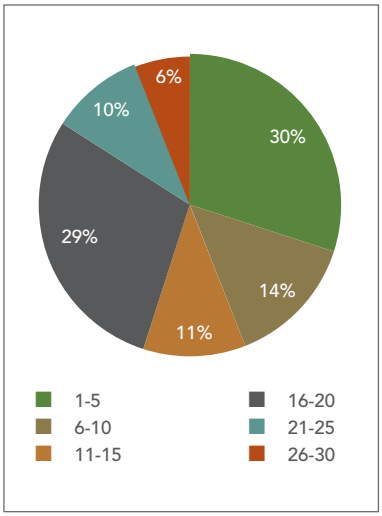


Figure 10: Non-durable eucalypts – age class distribution of trees to age 30 years (20,700ha)

1. Eucalyptus fastigata and Eucalyptus regnans

Many eucalypt species from southeast Australia were introduced to New Zealand in the late nineteenth century and were widely planted for shelter and amenity. Some of a group known as the 'ash eucalypts' proved to be very fast growing and well adapted to many localities.

The ash eucalypts principally occur in New South Wales, Victoria and Tasmania. They are amongst the most important commercial eucalypts in Australia still being harvested for sawn timber and pulpwood. *Eucalyptus fastigata* is found throughout the New South Wales highlands and tablelands while *E. regnans* occurs in the eastern and southern Victorian mountains and ranges as well as in northern and south eastern Tasmania.

Their 'ashes' popular name is due to the pale colour of the wood, similar to English ash *(Fraxinus)*. Their wood is of lower density than some other eucalypts but is denser, harder and stronger than radiata pine.

A group of these ashes, including *E. fastigata* and *E. regnans*, was selected by the former New Zealand Forest Service for deployment in New Zealand, and the former Forest Research Institute began a eucalypt breeding programme in the mid 1970s.

E. fastigata is one of the healthiest and most adaptable eucalypt species that can be grown in New Zealand. It is capable of producing a high volume per hectare at high stockings. It is tolerant of light frosts and has few insect and disease issues. It is suitable for quarter-sawing, and has moderately durable decorative heartwood that can be seasoned without collapse. It can also be used to produce short fibre pulp for fine printing paper.

E. regnans was also selected by the New Zealand Forest Service to complement *E. fastigata*. It is closely related but has better form and can have fast growth rates at an early age, up to 3 metres per year.

Both species are intolerant of coastal exposure and severe drought, with the best growth on well drained and sheltered inland locations.

While both species have been widely planted throughout New Zealand, significant new planting has only occurred in the central North Island region in recent years to re-establish a pulp wood resource, and in some cases for carbon sequestration.

E. fastigata and *E. regnans* both now have a genetic improvement history of nearly 40 years in New Zealand and third generation seed is available. The primary breeding objectives for these species have been around volume and form, but attention in selection was also paid to pest and disease tolerance for *E. regnans*. Substantial estimates of genetic gains have been predicted in the populations, indicating successful breeding strategies.

Selection for economically important production traits across a larger number of sites is necessary to improve the reliability of these species' performance in different environments. Under the SWP programme there is considerable interest in fast-growing eucalypts for solid wood production, and this requires a number of new traits to be included in the breeding objectives.

This work programme will focus on developing these eucalypt breeding populations towards improved solid wood properties. Another important part of increasing confidence in eucalypt forests is to integrate pest tolerance assessment methods into the breeding programmes, and align this with likely future biocontrol methods.

Tree breeding activities

- Breeding plan updates.
- Research on non-destructive methods to screen for solid wood properties.
- Progeny trial assessment and development of methods for continuous phenotyping of pest tolerance.
- Grafting of new selections for seed production.
- Establishment of progeny trials.
- New seed orchards for solid wood properties.

Wood processing activities

- In partnership with Juken New Zealand Ltd, undertake commercial scale LVL trials targeting higher mechanical properties than currently available with radiata pine-only LVL.

Non-durable eucalypts: outcomes 2022

- Improved selection methods. Recommendations of best genotypes for solid wood production.
- Turnover of breeding populations to the next generation.
- New selections available for seed orchards for solid wood production.

Timeline

2016

Literature reviews completed for:

- Wood processing challenges eucalypts
- Drying options for eucalypts
- Sawing of eucalypts
- Peeling of eucalypts.

2017

Breeding trials and assessments.

Juken NZ Ltd peeling trial.

2018

Quantitative genetic evaluation for *E. fastigata*, screening of breeding populations for pests and diseases where present.

First species Laminated Veneer Lumber LVL industry trials completed (either *E. nitens* or other eucalypts).

2019

New selections for *E. fastigata*.

Successful lab scale *E. nitens* drying techniques applied to at least one other eucalypt.

Second species Laminated Veneer Lumber LVL industry trials completed (either *E. nitens* or other eucalypts).

2020

Quantitative genetic evaluation for *E. regnans*, screening of breeding populations for pests and disease where present.

Successful novel drying techniques scaled up to 2.4m for two eucalypts.

2021

New selections for *E. regnans*. New selections grafted for seed production.

Commercial scale trial of successful novel drying technique on at least one species (either *E. nitens* or other non-durable eucalypts).

2022

Genotypes tolerant to pests/diseased identified, new progeny trials established.

Linkages

Internal to the programme

- Evaluation of novel pre-drying treatments (RA1).
- Site species mapping (RA1).
- Regional strategy (RA3):
  - *E. regnans* needs good rainfall, fertile sites and cooler temperatures but on the right site will grow extremely fast. *E. fastigata* is more tolerant to a wider range of sites. LVL trials are planned for these species to evaluate their performance in this product. Successful trials would encourage Juken NZ Ltd and/or Nelson Pine to develop a product which in turn would give confidence to plant these species.
- Forest protection research aligned with insects and fungi on species other than radiata pine (RA1).

External to the programme

- New Zealand universities
- International universities
- National and international genotyping providers as appropriate.

E. nitens, age 28 years, North Canterbury.

2. Eucalyptus nitens

Eucalyptus nitens is the most important commercially planted eucalypt in New Zealand. *E. nitens* is the best species at sites of 500-700 metres in the central North Island and is the eucalypt species most likely to be successful in the South Island. *E. nitens* is presently distributed across the country, the largest areas being in Southland and the central North Island. It is a fast-growing species suitable for pulp and solid wood production.

E. nitens was introduced to New Zealand in the 1920s, and a breeding programme was initiated in the mid-1970s. The first cycle of the breeding programme targeted better growth, form and tolerance to environmental stresses. In recent years there has been an increased interest in breeding this species for solid wood products.

Selection of the fourth generation is underway in the current breeding programme. Third-generation progeny trials in Southland have been assessed for growth, form and wood density, and one was also assessed for solid wood properties. Target wood quality traits in the breeding programme are high wood density, low growth strain, low shrinkage, and low internal checking and collapse.

Environmentally friendly methods to control foliar diseases mainly caused by the leaf-eating beetles, *Paropsis charybdis*, are also being studied. Phenotypic assessment methods will be developed to measure the genetic variation in tolerance to *Paropsis* in the breeding population. If genetic variation is detected, this can be integrated into the breeding programme.

Selections for pulp and solid wood populations were made from SWP investor Southwood Export Ltd's production seed orchards in 2015. Wood properties such as wood shrinkage and collapse, internal checking, and growth stress in the *E. nitens* population have already indicated moderate estimated heritabilities, and so are suitable for improvement by breeding. To achieve more accuracy in selections for solid wood properties, non-destructive sampling methods and more data collection are still required. Implementing genomic selection technologies into these breeding programmes can accelerate genetic improvement by identifying more accurate pedigrees and shortening the time to selection.

Tree breeding activities

- Breeding plan updates.
- Research on implementation of genomic selection.
- Research on non-destructive methods to screen for solid wood properties.
- Progeny trial assessment and development of methods for continuous phenotyping of pest tolerance traits.
- New selections available for seed orchards for solid wood production.
- Establishment of progeny trials.
- New seed orchards for solid wood properties.

Wood processing activities

- Undertake literature reviews:
  - 'Wood Processing Challenges and Opportunities for Douglas-fir and Several *Eucalyptus* Species – A Review'
  - Review of the sawing strategies, techniques, equipment, identify issues for sawing *Eucalyptus* logs and lumber
  - Review the opportunities and identify issues for peeling and LVL from non-durable *Eucalyptus*.
- The *E. nitens* industry is looking for an opportunity to improve the value of the 18-year-old trees which are currently grown for the export chip market. The project has identified a technology OEL™ which takes 1 metre-long logs and produces structural products with known, uniform and reliable properties.
- Drying timber is one of the most time-consuming and expensive steps in timber production. Drying eucalypts leads to a significant loss of value through checking and collapse unless these issues are mitigated.
- Develop new products using thermal modification aiming to improve durability, stability and provide a range of market-acceptable colours.
- Set up long-term graveyard, fungal cellar and wall frame durability tests on a range species including species of interest to the SWP.
- Extract and identify high value chemicals found naturally in trees (foliage, wood and bark) using supercritical carbon dioxide ($scCO_2$) on a range species including *E. nitens*.

E. nitens, flooring produced by John Fairweather Specialty Timbers, North Canterbury.

Eucalyptus nitens: outcomes to 2022

- Literature reviews on wood processing and products (completed September 2016).
- *Eucalyptus nitens* OEL™ scoping study undertaken (completed September 2016):
  - *E. nitens* OEL™ achieved the strength and stiffness properties of the New Zealand structural grade SG12 with superior economic results than when using the OEL™ technology on 30-year rotation radiata pine. The OEL™ process will need to be optimised for *E. nitens* to improve finger-jointing and lamination.
- Develop non-destructive screening methods to determine the propensity for internal checking. Develop novel drying approaches to reduce propensity for internal checking whilst increasing drying speed.
- If the thermal modification proves to be successful, explore the commercial feasibility.
- Following successful extraction and identification of high value chemicals, explore the commercial feasibility.
- Improved selection methods including genomics.
- Recommendations of best genotypes for solid wood production.
- Turnover of breeding populations to the next generation and seed orchards targeted at solid wood production.

Timeline

2016

Selections made for production seed orchards, updates to breeding plan.

E. nitens OEL™ produced.

Literature reviews completed for:

- Wood processing challenges eucalypts
- Drying options for eucalypts
- Sawing of eucalypts
- Peeling of eucalypts.

Laboratory novel drying of *E. nitens*.

Lab scale thermal modification of *E. nitens*.

2017

Development of assessment for pest tolerance. Seed orchards established.

Develop a non-destructive screening method detecting likelihood for internal checking on *E. nitens*.

Lab scale drying of check prone *E. nitens*.

First stage chemicals extracted.

Large scale (2.4m) thermal modification of *E. nitens*.

2018

NIR methods to screen wood quality, validation of pest tolerance assessment method.

Chemicals extracted from tree biomass for *E. nitens*.

Consider decking trials for TM *E. nitens*

First species Laminated Veneer Lumber LVL industry trials completed (either *E. nitens* or other eucalypts).

2019

Second set of genomic data and additional progeny trial data analysed.

Fungus cellar testing of TM *E. nitens* complete.

Second species Laminated Veneer Lumber LVL industry trials completed (either *E. nitens* or other eucalypts).

2020

Screening of breeding population for natural tolerance to pests on-going.

Successful novel drying techniques scaled up 2.4m.

2021

New selections for seed production initiated.

Commercial scale trial of successful novel drying technique on at least one species (either *E. nitens* or other non-durable eucalypts).

Commercial scale trial of TM nitens using low-degrade process.

2022

Genotypes tolerant to pests identified, new progeny trials established, new selections grafted.

Linkages

Internal to the programme

- Site species mapping (RA1).
- Regional strategy (RA3):
  - The bulk of the *E. nitens* resource is located in Southland. To add value to the logs (currently exported as chip), several wood quality/processing barriers need to be overcome. The OEL™ product has shown good technical performance and work on improved drying for solidwood products would provide options.
  - Forest protection research aligned with insects and fungi on species other than radiata pine (RA1).

External to the programme

- New Zealand universities.
- International and national genotyping providers as appropriate.
- International universities.
- EMBRAPA (The Brazilian Agricultural Research Corporation).

NATURALLY DURABLE EUCALYPTS

Early interest in growing eucalypts to produce naturally durable hardwood in New Zealand led to dozens of species being tested by early settlers followed by the former New Zealand Forest Service and Department of Railways during the 1920s and 1930s. Interest in durable eucalypts was revived in the 1970s, with the research work undertaken by the Ministry of Works and Development Plant Division, New Zealand Forest Research Institute and later Scion.

However, while many durable species were successfully growing in trials, there was little exploration of the genetic variability of these species until the New Zealand Dryland Forests Initiative (NZDFI) was established in 2008.

The NZDFI is a collaborative tree breeding and forestry research project which aims to produce genetically improved drought tolerant eucalypts and encourage new planting. The high-quality, naturally ground-durable hardwood produced has potential markets in New Zealand's agricultural, transport and energy sectors as well as in a range of high-value markets overseas.

NZDFI pursues a strategy that involves carefully matching species to sites and end-products, with a focus on sites that have a rainfall less than 1000 mm/year and regions that need new land-use and manufacturing options to diversify their economic development.

NZDFI has restricted the choice of species to concentrate efforts and resources on a few promising species that are drought tolerant and produce durable heartwood. The strategy is to tackle specific environments with species able to produce durable solid wood products. The three principal species for genetic improvement are:

• *E. bosistoana*	Coast grey box	*Class 1 durability
• *E. globoidea*	White stringy bark	*Class 2
• *E. quadrangulata*	White-topped box	*Class 2

*Australian Standard AS5604-2005

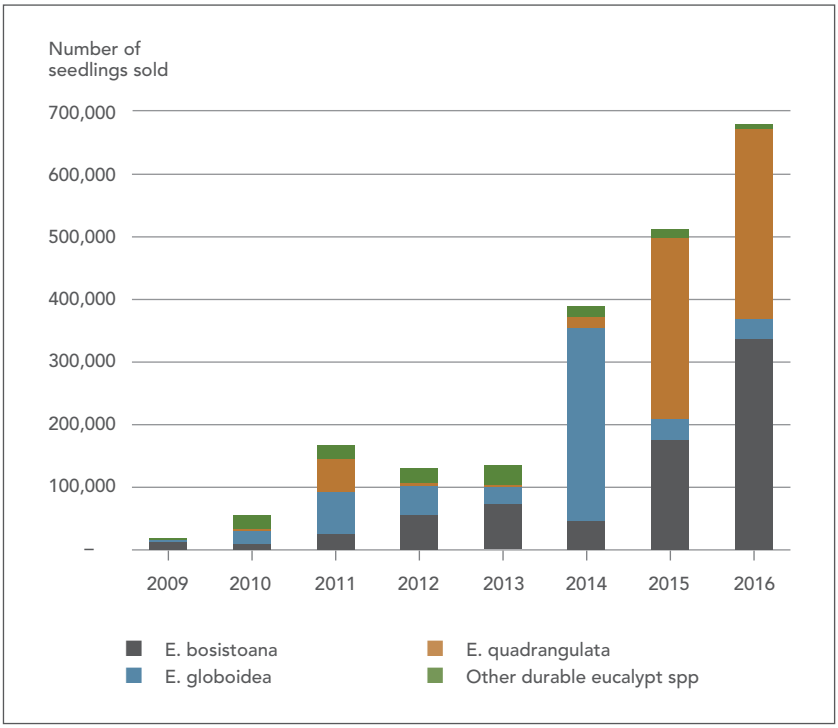
Two other species, *E.argophloia* and *E. tricarp*a, are also included to a lesser extent in the breeding programme, mainly because of their potential to hybridise with the three main species.

E. bosistoana is found along the coast of eastern Victoria and southern New South Wales. This Class 1 durable species was historically used for poles, sleepers and fences in Australia. The basic density and dry MoE of *E. bosistoana* was recorded at 880 kg/m^3 and 21 GPa, respectively. This compares with respective average figures of 400-420 kg/m^3 and 8.23 GPa for radiata pine (Radiata Pine Breeding Company/NZ Wood). The species was almost cut to exhaustion in the 1920s because of its high durability and stability. There are successful NZDFI trials of this species from Northland to North Canterbury. NZDFI commenced the first structured seed collection and breeding programme for this species in 2008.

E. globoidea occupies much of the same natural range as *E. bosistoana* along coastal eastern Victoria and southern New South Wales. However, it is found on a wider variety of sites including gravelly loams, clays and skeletal soils. *E. globoidea* is rated as a Class 2 durable hardwood with a basic density of 680 kg/m^3 and a MoE of 17 GPa in mature trees. There are many successful trials and woodlots of *E. globoidea* growing throughout the North Island and New Zealand plantation material is reported to have sawn well with basic densities ranging from 527-623 kg/m^3 with MoE of around 14 GPa at less than 30 years of age. NZDFI commenced a large-scale seed collection and breeding programme for this species in 2010.

E. quadrangulata has a fairly limited distribution, being predominantly found on heavy soils and sheltered sites in the tablelands of New South Wales and southern Queensland where the mean annual rainfall is 900-1700 mm. A dry MoE of 18 GPa and basic density 800 kg/m^3 for the species has been reported. While there has been little experience with growing *E. quadrangulata* in New Zealand, it was evaluated by Forests New South Wales for its suitability as a plantation species. However it does not feature in any breeding programme apart from NZDFI's, with their work commencing in 2010.

There are currently an estimated 900 ha of naturally durable eucalypts planted. Figure 11 shows the nursery sales of the naturally durable eucalypts, indicating that the majority of these trees are less than 5 years old.



➔ Figure 11: Durable eucalypt nursery sales by species

E. globoidea, age 4 years, Hawkes Bay.

Research programme

The core part of the NZDFI programme is tree breeding. The breeding programme is complemented by research on site/species matching, the development of growth and yield models, and protocols to manage tree health.

The aim is to rapidly supply improved genetic material by making early selections of healthy trees with rapid growth from the established breeding populations that can produce durable timber on drylands. Early gains are possible: NZDFI's trials are large enough to capture a broad range of genetic diversity, and early selection and rapid assessment techniques are being used to remove the worst individuals/families of the large numbers established for each species.

Equal importance is placed on wood quantity, wood quality, and adaptation, with the key traits to improve being:

- **wood quantity:** stem form, stem diameter, tree height
- **wood quality:** as first priority, durability (extractive quantity and heartwood volume) and growth-strain. Data will also be available for stiffness (acoustic resonance), density, volumetric shrinkage (collapse) and twist (spiral grain). This latter set of properties is expected to be at acceptable levels but will be monitored to avoid surprises.
- **adaptation:** ability to coppice (propagation), survival to frost, drought, and tolerance to pests.

More details can be found in the NZDFI Breeding Plan (www.nzdfi.org.nz).

Activities

- Breeding plan updates.
- Ongoing assessments and management of breeding populations of *E. argophloia, E. bosistoana, E. globoidea, E. quadrangulata* and *E. tricarpa*.
- Research on novel methods to screen for solid wood properties.
- Research and application of pest tolerance assessment methods for all species.
- Intensive site assessment by genotype and analysis with climate data to provide basis for site/species matching and growth models.
- Grafting of new selections for seed production.
- Seed collection and establishment of progeny trials.

Durable eucalypts: outcomes to 2022

- Development of novel wood quality selection methods to screen *E. argophloia, E. bosistoana, E. globoidea, E. quadrangulata* and *E. tricarpa* breeding populations.
- Identification of pest-tolerant genotypes.
- Selections made of best genotypes for productivity, solid wood production and pest tolerance.
- Site/species matching decision-support tools including growth models available on-line to growers.
- Best selections deployed in seed orchards to produce first generation seed for commercial sale.
- First generation progeny established in new breeding populations.
- Proof of concept manufacturing of posts and LVL.

Timeline

1. Breeding plan

2016	2017	2018	2019	2020	2021	2022
First selections for growth and form grafted for seed production. Novel assessments commence for wood quality and pest tolerance.	Breeding plan updated. Commence screening selections for wood quality and pest tolerance. Site species matching under development.	Continue grafting selections for growth, form, wood quality and pest tolerance. Develop clonal propagation. Bulk up seed orchards.	First release of improved durable eucalypt seed. Site species matching tool and early growth models available. Continue screening selections for wood quality and pest tolerance.	Breeding plan updated. Deployment of 1st generation progeny trials. Refine site species matching tool and growth models.	Continue deployment of 1st gen progeny trials. Establish trials to test site species matching tool. Outcrossing.	Commence assessment of 1st gen progeny trials and trials to test site species matching tool. Establish second breeding generation.

2. Durability projects

N.B. Durability research within the SWP includes a range species as well as durable eucalypts.

2016	2017	2018	2019	2020	2021	2022
First round of in-ground durability graveyard trials setup.	Framing durability trials setup.	Framing durability trials assessed at 1 year. Second round of in-ground durability graveyard trials setup.	Framing durability trials final assessment.	Five year assessment of First round of in-ground durability graveyard trials.		Five year assessment of second round of in-ground durability graveyard trials.

Linkages

Internal to the programme

- Site species matching (RA1).
- Durability testing (RA1).
- Developing a future superior wood supply (RA2).
- Regional strategy (RA3):
  - Durable eucalypts adapted to New Zealand's dryland east coast regions have been selected to provide the basis for a future supply of superior-quality wood through improved breeding and delivery of genetic gain.

External to the programme

- University of Canterbury (outside core NZDFI research group):
  - David Leung – propagation
  - Bill Heffernan – heartwood detection
  - Michael Hayes – wood quality tools
  - Pieter Pelser – population structure
- International collaborators:
  - Laurie Cookson, Tasmania – durability
  - Oregon State University, USA – heartwood formation
  - Hamburg University, Germany – extractives
  - CSIRO Australian Tree Seed Centre – species and genetics.

NZDFI trial, Hawkes Bay.

CYPRESSES

Cypresses originate from the Americas, and are known for their durable, scented timber. There are a number of cypress species, some introduced into New Zealand as early as the 1860s. These introductions were supplemented by a number of commercial clones and hybrids, introduced in the late 1970s.

The total area of cypresses in New Zealand is about 10,000 ha, of which almost half (4,700 ha) are found in the West Coast Region. The NEFD data reports all the areas and age class distribution of cypresses together. The location and age-class distribution of cypress plantations are shown in Figures 12 and 13.

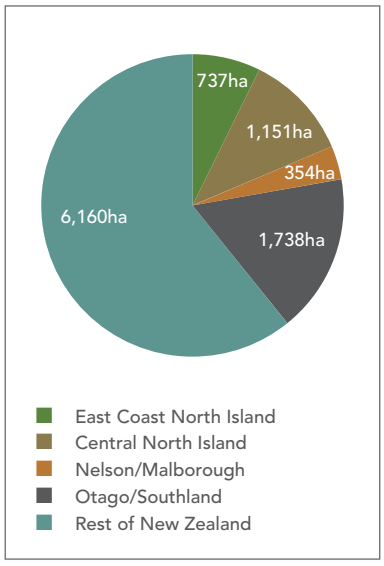


Figure 12: Cypresses – planted areas by region

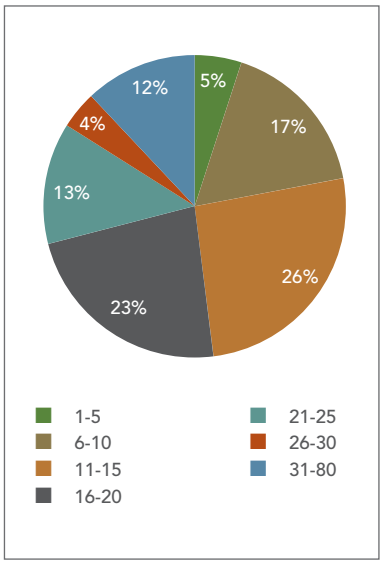


Figure 13: Cypresses – age class distribution

Typically, cypress sawlog rotations are 30-40 years. However, cypresses are capable of rapid early growth and can be grown at a high stocking to increase early volume production so that over 400 m^3 per hectare is possible by age 20.

Cupressus macrocarpa

Cupressus macrocarpa is the cypress most familiar to the New Zealand timber industry. *C. macrocarpa* was an early introduction from California, and was widely planted for shelter and amenity as it proved to be fast growing and well adapted to many localities, particularly around the coast. Farm foresters began growing woodlots once its favourable timber properties were recognised and there is now a well-established domestic demand for 'macrocarpa' timber. Unfortunately, *C. macrocarpa's* growth in the North Island is now compromised by cypress canker. Breeding work on *C. macrocarpa* was started in 1983, and breeding for tolerance to canker has been the focus of the most recent selections.

Cupressus lusitanica

Cupressus lusitanica is native to Mexico and Central America, where it is widely found in mountain ranges at 1,200-3,000 metres elevation. The species is fast growing, produces high quality timber and tolerates a wide range of environmental conditions. It is also more resistant to cypress canker than *C. macrocarpa* but is sensitive to salt so is largely an inland species. Breeding for volume, form, branching and removing any genotypes with canker symptoms are the focus of the SWP programme. Establishment of third generation *C. lusitanica* breeding populations is underway, aimed at improving tree growth and form and increasing the tolerance to canker.

Chamaecyparis nootkatensis

Chamaecyparis nootkatensis (yellow cedar) is relatively slow growing but has good form and very high wood durability. This species has an existing breeding programme in Canada, and our breeding plan includes investigating the potential for hybrids with *Ch. nootkatensis*.

In recent years, controlled crossing of cypresses has been undertaken to produce new hybrids that are now being tested for commercial deployment. Further hybrid research has its focus on implementing vegetative propagation methods via setting of cuttings using stool plants and testing this material in the forest environment.

The cypresses represent only a small portion (approximately 6%) of the overall SWP programme, and the priorities are to best maintain the breeding populations (growth, form, canker tolerance) and where resources allow, select for improved wood properties.

Activities

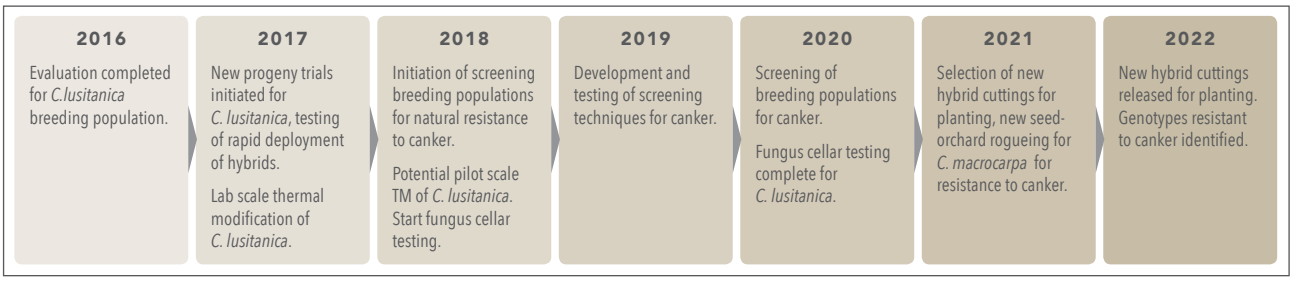
- Assessment of cypress hybrid seedling blocks planted in 2015.
- Turning over breeding populations of the 2006 *C. lusitanica* breeding population trials.
- Establishment of the next generation of *C. lusitanica*.
- Establishment of hybrid cuttings to test rapid deployment of hybrids from seed.
- Maintenance of cypress stool-plants.
- Release of new genetic material via nurseries and seed orchards.

Cypresses: outcomes to 2022

- Identification of canker-resistant genotypes.
- Identification of the best pathway to market for hybrid clones.
- Turnover of breeding populations to the next generation as required.
- New orchard seed available for *C. macrocarpa*.
- New hybrid cuttings released for planting.

Ovens cypress, a promising cypress hybrid.

Timeline



Linkages

Internal to the programme

- Site species mapping (RA1).
- Regional strategy (RA3):
  - In terms of suitable siting, Nelson/Marlborough and the central North Island offer the best sites.

External to the programme

- Ministry of Forestry and Range, British Columbia.

SITE/SPECIES OPTIMISATION

Information on how our specialty species perform on specific sites is needed to guide potential growers on what to plant where and also give confidence that the recommended species will thrive in the areas identified. The species in our programme are more site-sensitive than radiata pine, and we need to minimise planting failure if we are going to achieve our stated planting targets.

Activities by our main research providers which relate to modelling the impact of site on the survival, growth and performance of our species are described as follows:

Site/species research led by the University of Canterbury and the Marlborough Research Centre Trust

University of Canterbury and the Marlborough Research Centre Trust activities focus on naturally durable eucalypts. Projects include:

- establishing new permanent sample plots of naturally durable eucalypts. These will be installed over a wide range of sites (spanning variation in soil types, temperature and rainfall), allowing the modelling and prediction of growth, heartwood development and pest and disease tolerance. Performance within sites will be assessed to understand the impact of micro-site variation
- determining volume and taper functions for both whole tree and heartwood components. These functions don't yet exist for the durable eucalypt species and are required to predict yields and evaluate silvicultural regimes
- planting further demonstration plots on a range of sites to allow tree growers to see how well the species perform on a local site.

Site/species research led by Scion

The focus of the Scion site/species mapping projects is around Douglas-fir, non-durable eucalypts and cypresses. Projects include:

- establishing demonstration plots of Douglas-fir, *E. fastigata*, *E. nitens* and cypresses
- producing carbon look-up tables for species other than radiata pine and Douglas-fir. It is likely some of the SWP species will be covered in this work which is funded through SLMaCC (Sustainable Land Management and Climate Change Research Programme)
- a proposed series of maps showing site/species suitability across New Zealand.

REGIONAL STRATEGIES

The success of the SWP programme will be demonstrated through the development of new value chains in targeted regions. These value chains will be based on existing and new processing capability and technology, and they will deliver specialty wood products into international markets. Sound business cases for investment will be developed, and uptake of our research by our investors will be achieved through effective technology transfer, and through strong and enduring stakeholder relationships.

We will deliver specialty wood products to market by:

- developing strategies in four regions – east coast North Island, central North Island, Nelson/Marlborough and Otago/Southland
- ensuring professional development of the forestry and wood processing industries in these regions using a range of mechanisms
- developing initial proof-of-value cases for rapid uptake.

Our first regional strategy will focus on the east coast North Island and Nelson/Marlborough. The focus will be on establishing durable eucalypt forests in these relatively dry east coast regions. It will be led by the NZ Dryland Forests Initiative (NZDFI), and will succeed by engaging with central government, regional government and those in the forestry and agriculture sectors including NZDFI's landowners, stakeholders and other supporters.

ANTICIPATED BENEFITS TO NEW ZEALAND

We predict exports of $350million per annum by 2030 into global markets demanding chemical-free, stiff and attractive timbers, rising to $3.6billion pa by 2050, as well as significant spill-over benefits from regional employment and a strong domestic market.

End users of this research will have routes to market, delivering MBIE's priorities under the programme '*Biological Industries for Emerging Industries and Minor Forestry Species*'.

Table 1: Overall benefits expected: export value, new plantings and other

Benefits anticipated	Year	Total new specialty species planted area ha	Other benefits
$100M pa exports	2024	25,000	30,000m^3 *E. nitens* processing facility for export to Japan
$200M pa exports	2027	60,000	Two regional value chains established
$350M pa exports	2030		
$600M pa exports	2032	100,000	Two more regional value chains established
$3.6B pa exports	2050		

Table 2 shows the expected benefit to New Zealand by species. The benefits rely on three areas of development:

- improving processing of the existing resource which will lift the value of the product produced significantly
- establishing processing facilities to manufacture new products
- establishing significant areas of new planting (across all species).

Table 2: Expected benefits by species

Species	Annual harvest m3	Value increase	New planting by 2050
Non-durable eucalypts	460,000	From $90 to 1,000/m^3	54,000ha
Douglas-fir	1.4 million	$70/m^3	40,000ha
Douglas-fir thinnings	400,000		
Cypresses	140,000	10% (productivity)	
Durable eucalypts	50,000 (from 2030)		100,000ha
Durable eucalypts LVL		$800/m^3 (from 2030)	
Durable eucalypts sawn		$2,500/m^3 (from 2040)	

INVESTORS AND KEY PEOPLE

Investors

- Ministry for Business, Innovation & Employment
- Blakely Pacific Ltd
- City Forests Ltd
- Ernslaw One
- Forest Growers Levy Trust
- Juken New Zealand Ltd
- Lake Taupo and Rotoaira Forest Trusts
- Marlborough Lines
- New Zealand Farm Forestry Association
- Proseed Ltd
- Scion (aligned core funding)
- Southwood Exports Ltd
- Te Tumu Paeroa
- Timberlands Ltd
- Vineyard Timbers Ltd

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- Doug Gaunt
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- Rosie Sargent
  Scion
- Shaun Foster
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Key research providers

- Marlborough Research Centre Trust
- Scion
- University of Canterbury School of Forestry

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Specialty Wood Products

Research Partnership