The Specialty Wood Products Research Partnership

Progress on activities

2015-2020

SWP Report T107

Contents

Context: The Specialty Wood Products Research Partnership

The SWP programme aims to transform processing options for species other than radiata pine including eucalypts, Douglas-fir and cypresses, develop improved breeding stock to overcome current wood quality and forest health issues, and develop a new naturally durable eucalypt resource. The programme has an overarching aim of encouraging regional investment in specialty species with the focus initially on four target regions – the Eastern North Island, Central North Island, Marlborough/Nelson and Otago/Southland.

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.

The New Zealand forest industry is characterised by its almost total reliance on one species: radiata pine. This leaves the industry vulnerable to external risks, including changing markets and potentially devastating disease outbreaks.

The SWP's aim is to diversify the industry, by generating a broader range of higher-value, high-performing timber products from alternative species. Key global market tends identified include the 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 have the potential to complement the mainstream radiata pine industry through improving the performance of engineered wood products.

Original programme vision

'The SWP will catalyse the development of new industries based on species other than radiata pine, delivering high-value products, providing diversification, and mitigating the risks of growing a single species while supporting regional development. '

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

Research aims and timing

To optimise the delivery of value to the specialty wood products industry and the New Zealand economy, the research programme 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).

These research areas identified to achieve these three research aims over the seven years of the SWP programme are illustrated below:

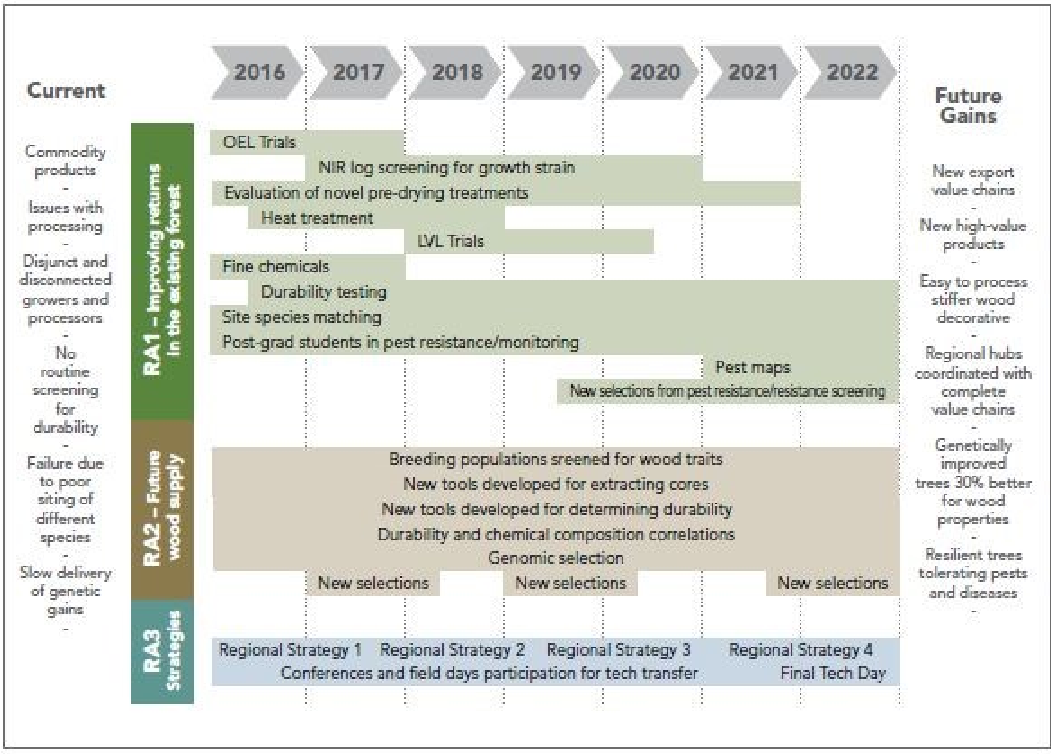


Fig 1. SWP seven-year high-level research plan

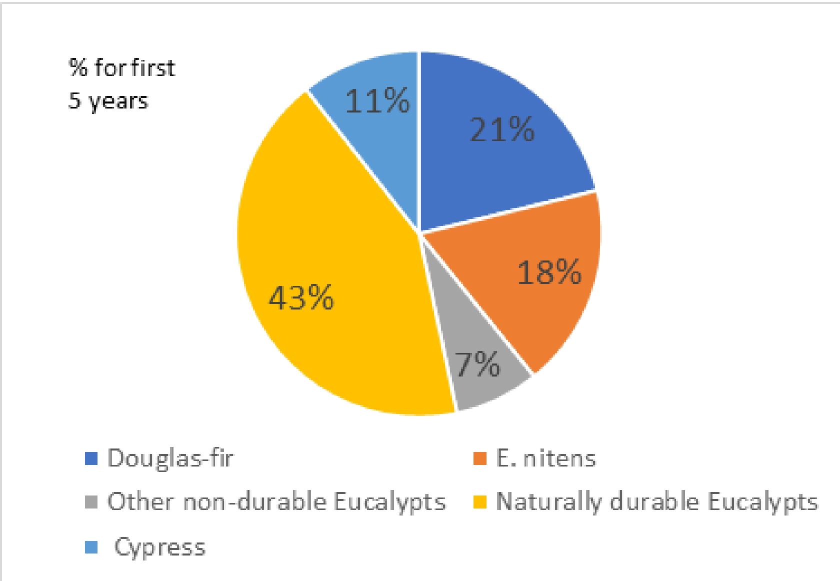


Fig 2. Allocation of SWP funding by species, 2015-2020

Full details of the original programme are available in the Specialty Wood Products Research Partnership Programme Description.

2. The Research Programme: progress to 2020

2.1 Douglas-fir

Douglas-fir is New Zealand's second most popular plantation species by area after radiata pine. The national resource is currently 103,410 ha (NEFD 2019). It has an international reputation as an excellent producer of structural timber, and is the species of choice for higher elevations, especially those with winter snowfall. Existing Douglas-fir growers in New Zealand are keen to see up to 40,000 hectares of the species planted, and have set targets for maintaining form, improving wood properties and disease tolerance and new product development, along with a separate work programme on overcoming the problem of wildings.

The SWP Douglas-fir programme predominantly involves tree breeding and timber processing research. It receives around 18% of the total SWP research budget.

Original anticipated outcomes by 2022:

- new selections for growth, tree health, form and wood stiffness are available from the breeding population
- next generation of breeding material established
- new products developed and tested
- high-value chemicals found naturally in trees extracted and identified.

Breeding advances

A Douglas-fir breeding workshop held at the beginning of the SWP defined breeding objectives for producing high quality wood products and for increased wood production. Industry direction resulted in updated breeding targets for growth and form, wood quality and resistance to Swiss Needle Cast (SNC):

- **growth** – targets are a 35-year rotation length; yield of 600 m^3 total recoverable volume (TRV) per hectare; average 20 m^3 per hectare mean annual increment (MAI)
- **form** should be maintained at the current level
- **wood stiffness** to be maintained at a minimum level of 8 GPa
- **needle retention** (indicating tolerance to SNC) – target set at needle retention of 3 years.

Developing sterile plants also ranked very highly as the threat of wildings is currently limiting planting opportunities. Work on sterility is being tackled in the Winning against Wildings programme, which is not part of SWP's portfolio.

In 2017, the Douglas-fir breeding plan was updated based on the targets identified above. New selections were made from breeding populations which included selections for tree form, a trait that had been neglected previously. Oregon and Washington provenances showed superior quality for overall breeding goals compared with Californian provenances.

Work on Douglas-fir genomics began at Scion in 2018, utilising the aligned Strategic Science Investment Fund (SSIF). Over one thousand superior trees were selected from each of two large Douglas-fir plantations, one each in the North and South Islands. These trees will have their genotype described as a precursor to an accelerated breeding programme.

Stiffness breeding values were determined for Douglas-fir progeny and it was found to be moderately heritable – this means there is good potential for incorporating this trait into the breeding programme.

Implementation of genomic resources developed by Oregon State University in the evaluation of New Zealand Douglas-fir breeding populations resulted in substantially improved prediction accuracy and response to selection compared with pedigree-based analysis. Thus, the currently available SNP array appears to be a useful genotyping platform for the New Zealand Douglas-fir breeding program.

New product development and testing

Douglas-fir thinnings were used to produce a new engineered wood product, OEL™ . The OEL (Optimised Engineered Lumber) technology produces laminated, finger-jointed structural products with known, uniform and reliable properties. Logs as short as one metre were identified as being suitable for the process, meaning OEL would provide the opportunity to add value to tapered or swept logs which otherwise would go for pulp. The results of the mechanical testing showed that the Douglas-fir OEL achieved the strength and stiffness properties of the New Zealand structural grade SG8. While this work was undertaken in 2016, the OEL™ technology has yet to be commercialised, for any species other than radiata, in New Zealand.

The demand for engineered wood products for high-rise construction is a global growth area, and Douglas-fir cross-laminated timber (CLT) is one product which is potentially suitable for this application. However, a comprehensive database of the mechanical properties and connection behaviour of Douglas-fir CLT is needed to meet Building Code requirements and thus enable designers to specify Douglas-fir CLT in building design.

Douglas-fir CLT panels were constructed at Xlam (Nelson) and transported to Christchurch for testing at the University of Canterbury's Department of Engineering. Initial tests confirmed that the Douglas-fir CLT had comparable strength properties to radiata pine CLT. The focus then moved to developing efficient lateral-load resisting systems for CLT buildings to test the product's ability to withstand earthquakes. Work on fasteners and connection systems for the panels is also part of the programme. Tests to date have provided strong technical evidence that CLT core walls provide efficient lateral load-resisting systems for mid-rise and high-rise timber buildings, and that the long, self-tapping screws used for connecting panels are strong, rigid and fit for purpose. The experimental results demonstrated generally excellent connection behaviour in Douglas-fir CLT and the research outcome will provide valuable technical information for engineers to specify Douglas-fir CLT in building design.

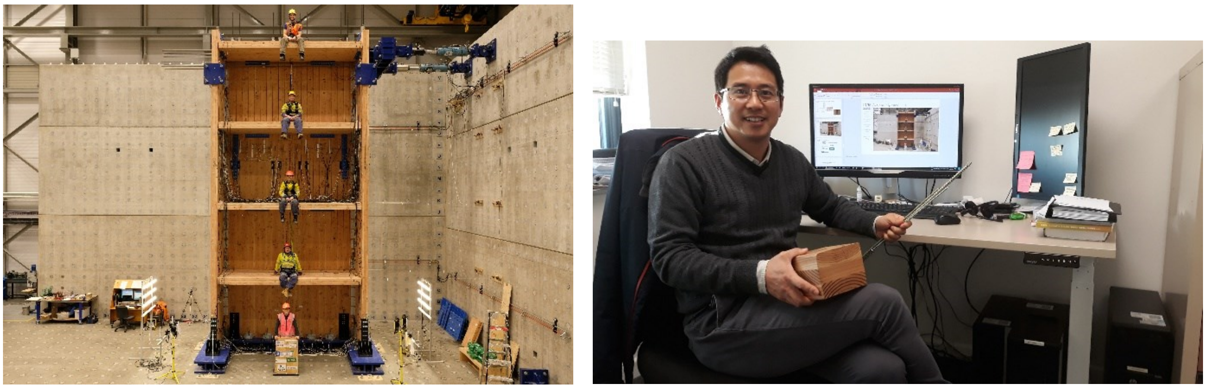


Fig 3:(left) The Douglas-fir CLT structure being tested in the University of Canterbury engineering lab (right) Dr Minghao Li with a sample of screws used to connect the CLT panels.

Thermal modification to increase Douglas-fir durability

Thermal modification involves heating wood to high temperatures (>180°C) in the absence of oxygen to alter the chemistry of the wood and consequently alter the wood properties. The aim is to increase durability (and stability in some timbers). Compared to other modification techniques, thermal modification is relatively cheap.

In Douglas-fir, thermal modification was expected to improve the durability of the sapwood, while maintaining the durability of the heartwood.

Results from trials at Scion show that in fact both sapwood and heartwood durability increase significantly following thermal modification. Fungal cellular tests (treating wood with fungal agents that cause it to rot) showed that the modified Douglas-fir performed almost as well as H3.2 treated radiata pine after 18 months.

The table below summarises other Douglas-fir durability work underway.

Durability trial type	Species	Status
Thermal modification	Douglas-fir	Fungal cellar - samples showing improved durability in both the heartwood and the sapwood. Longer term durability testing is required to confirm the durability of these treatments. Decking and flat panel trials will be installed 2020.
Framing	Douglas-fir	Most samples have failed. No need for further assessment.
	Douglas-fir	Treated with Boron - awaiting durability results
Decking	Douglas-fir	Treated with CCA - awaiting durability results Untreated heartwood and mixed sapwood/heartwood–awaiting results

2.2 Non-durable eucalypts

Over 22,000ha of eucalypts are recorded in the National Exotic Forest Description 2019. Three non-durable species which make up a significant proportion the total eucalypt area, and which are included in the SWP programme, are *Eucalyptus nitens*, *E. fastigata* and *E. regnans.*

The majority of New Zealand's *E. nitens* area is short-rotation crops in Southland, grown for export into pulp markets. There is a particular interest in extending the solid wood product range for *E. nitens* through breeding gains. Thanks to contributions from a major *E. nitens* grower and SWP partner from 2015-2020, more work has been done on *E. nitens* than either *E. fastigata* or *E. regnans.* SWP research aims to also extend the product range of *E. fastigata* and *E. regnans.*

Breeding advances

A focused breeding programme in *E. nitens* has the potential to lead to improved sawn timber properties – these include wood density, growth strain, stiffness, shrinkage/collapse and internal checking. A wood property genetics study resulted in the establishment of two new (fourth generation) seed-orchards that will produce improved germplasm specifically for solid wood products while simultaneously maintaining high-quality production for pulp.

Genomic selection to further boost genetic improvement of *E. nitens* breeding population has begun, leading to improved accuracy of estimated breeding values in the open-pollinated population.

Progeny trials for *E. fastigata*, already in their third cycle, were assessed for growth, form and adaptability. Results from this study indicated that there is good potential for genetic improvement of productivity and tree form. Wood stiffness was measured for the first time in this breeding population, with an average modulus of elasticity of ~12 GPA (MOE in gigapascal) and a moderate estimate of heritability.

The landowner of two breeding trials at Kaingaroa compartment 333 (*E. regnans* FR502/1 and *E. fastigata*) have signalled their desire to production thin these trials. This provides an opportunity to convert the trials to a seed stand, investigate the economics of production thinning in these species, and plan the thinning so the best trees per family are retained in case there was a need to make selections for a new round of progeny testing.

New product development and testing

E. nitens logs were used to produce OEL (Optimised Engineered Lumber) (using the same technique as with Douglas-fir). The results of the mechanical testing showed that the *E. nitens* OEL achieved the strength and stiffness properties of the New Zealand structural grade SG12.

Fig 4: A sample of E. nitens *OEL.*

Four different prediction models were used to select *E. nitens* logs with both low degrade during drying (good logs) and high degrade during drying (bad logs). Air-drying resulted in less degrade than kiln-drying and the thinner boards had less degrade than thicker boards (although this was not significant). No significant difference in levels of degrade were seen between boards cut from the predicted ‘good’ and ‘bad’ logs. This suggests that the underlying mechanisms causing checking and collapse are not well correlated to the tree properties that were measured in this study. As with previous studies, some logs consistently produced boards with low levels of degrade, and some logs consistently produced boards with high levels of degrade, irrespective of drying method.

In 2020 Specialty Timber Solutions, a North Canterbury firm, produced three kinds of flooring from unpruned *E. nitens* – solid, cross-laminated, and birch plywood-backed. The performance of these was compared to commercial engineered oak flooring. Overall, the differences between the engineered oak and the *E. nitens* boards were small, indicating that it should make a successful product (the *E. nitens* boards did have lower surface hardness than the oak however).

Research into the potential to use short rotation *E. fastigata* as a component of laminated veneer lumber (LVL) was completed, and a veneer stiffness model developed. This model is intended to be used as a decision tool identifying the potential suitability of a wood resource to supply a range of LVL grades. The output of the model indicates possible LVL layup grades and options.

A peeling and sawing study of 24-year-old *E. fastigata* logs at Juken NZ Ltd Masterton divided logs into three stiffness classes. The veneer produced showed very promising Metriguard stiffness values compared to radiata: even the lowest stiffness *E. fastigata* logs produced a higher average stiffness veneer than radiata. This high stiffness will enable the manufacture of new LVL products which cannot be made with radiata veneer.

In addition, a trial at Hexion examined the ‘glue-ability’ of the *E. fastigata* veneer produced and concluded that this species could be commercially bonded with standard phenolic formulations.

Thermal modification to increase durability and stability

Samples of *E. nitens* were thermally modified to examine impacts on timber characteristics. Results showed that durability and stability increased, and the colour darkened (but faded on exposure to sunlight). Stiffness was unchanged; strength was significantly reduced but still likely to be acceptable as appearance products.

Fig 5: Thermally modified E. nitens*, showing different outcomes from treatment at different temperatures.*

Durability work

The durability of the three 'non-durable' eucalypt species of interest to the SWP is being tested under a number of conditions – see below:

Durability trial type	Species	Status
Thermal modification	*E. nitens*	Durability improvement only slight, not enough for exterior products
Framing	*E. nitens*	Most samples have failed. No need for further assessment.
	E. regnans	Decay had developed in many of the samples
	E. regnans	Treated with Boron - awaiting durability results
	E. nitens	Treated with Boron - awaiting durability results
Decking	*E. regnans*	Treated with CCA - awaiting durability results Untreated heartwood and mixed sapwood/heartwood– awaiting results

Eucalypt health – a new biological control agent

Pre-EPA-application work to introduce a new biological control agent to control Eucalyptus tortoise beetle, *Paropsis Charybdis* was completed as part of SWP. The Australian native parasitoid *Eadya daenerys* targets the feeding larval life stage of P. *charybdis*. Scion conducted laboratory- based tests with female parasitoids each summer for four years to determine risk of release. Results showed that the ability of *Eadya daenerys* to internally parasitise non-target species (the broom and tutsan leaf beetle larvae) are minimal or nil impact in the field. Therefore, it was concluded that there is minimal risk to native beetles in New Zealand from the introduction of *Eadya*. The EPA application was approved in 2019, and the *Eadya daenerys* will be released into eucalypt forests in New Zealand in 2020. Unfortunately, all of the *E. daenerys* individuals that had been collected and raised at Scion were infected by either, or both, of a microsporidian or a sporozoan species. Scion immediately contacted its project partners and reported to MPI Risk Team on 13 March 2020 that the importation under NOR100169 was infested by secondary organisms and Scion would not be requesting their release from containment. Another attempt will be made to collect individuals from a new area hopefully not having the infections.

A 2019 study of the economic cost of Paropsis estimated potential losses of $400-$500 million and concluded that in most situations biological control would be more cost-effective than chemical control. Other work has looked at the level of paropsis browsing on both *E. nitens* and *E. bosistoana*, and found some families are more tolerant than others. Depending on the heritability of this tolerance in both tree species, it could be incorporated into future breeding programmes.

2.3 Durable eucalypts

Durable eucalypts are an emerging species group, considered to have excellent potential due to their ability to thrive in dryland environments and produce naturally durable timber requiring no chemical preservative treatment.

Work on durable eucalypts is managed by the New Zealand Dryland Forests Initiative. Major contributing partners are SWP, Proseed Ltd and the University of Canterbury School of Forestry.

Breeding advances

The project is an all-encompassing breeding, research and development initiative. Its vision is to build sustainable durable hardwood industries in New Zealand's north-eastern dryland regions, based on forests of eucalypts that grow rapidly and produce ground-durable heartwood. A network of breeding and demonstration trials has been established at over 30 locations across the northern and eastern North Island, and the north-eastern South Island. These trials form the foundation of the genetic improvement programme, with the initial focus on producing first generations of genetically improved planting stock of two species – *E. bosistoana*, and *E. globoidea*. Proseed Ltd are developing novel propagation techniques, now with the help of a recent One Billion Trees grant. The first issue of 300,000 improved plants (seedlings and clones) will be ready for the 2021 planting season.

The trial sites also provide the basis of much of the research into wood properties undertaken by a group of PhD researchers at the School of Forestry. Over 30 post-graduate and under-graduate students have been involved in the NZDFI's work to date. Research effort has gone into developing new techniques to assess important wood properties in young trees. Once the heritability of these properties is defined, findings can rapidly be fed back into the breeding programme so that selections include important wood quality parameters.

Wood properties – durability, growth strain, heartwood quantity and quality

Durability

Early in the NZDFI project, a number of vineyards installed *E. bosistoana* & *E. globoidea* posts. After a decade, in 2018 an assessment of the posts was undertaken at six vineyards. The posts were produced from mature trees (estimated to be >60 years-old). The feedback from vineyard owners/managers and the results of the decay assessments demonstrate that most of the durable eucalypt vineyard posts of both *E. bosistoana* and *E. globoidea* are continuing in service after more than 10 years with a very low percentage of broken posts. In one vineyard losses were equivalent to annual breakage of only 0.3% compared to an expected failure rate of 3-5% with CCA treated pine posts. In the drought conditions of 2017, some vineyards reported losses of 10 – 12% of posts.

Growth strain

A main factor restricting the use of plantation grown eucalypts for solid-wood processing is the frequent presence of large growth-stresses in these trees which cause splitting and distortion of the timber. The photo below shows the split in the stem of a young tree, the length/width of which is measured and used to rank that tree or family for splitting propensity.

Fig 6: Growth stresses in a young eucalypt stem.

The School of Forestry's 'Minimising Growth Strain' project is now complete. The research identified superior low-growth strain genotypes, and also helped establish clonal propagation protocols for cuttings.

Heartwood quantity and quality

Researchers at Callaghan Innovation developed a coring tool which enables the rapid extraction of cores from the stems of young trees. The amount of heartwood in the cores can then be assessed. A strong genetic component to heartwood quantity was identified, with some families having no heartwood and others having over 70 mm in six-year-old trees. These findings have been applied in early breeding selections.

Fig 7: Stem cores showing heartwood stained pin).

A <1% to >10% range in extractive content of *E. globoidea* was found in samples from trees that were 5 to 80 years old. The figure below shows the strong correlation of measured and predicted (using NIR) extractive content for *E. globoidea* heartwood. This, along with variation in heartwood diameter, suggests that screening trees for natural durability at a relative early stage of growth should be possible.

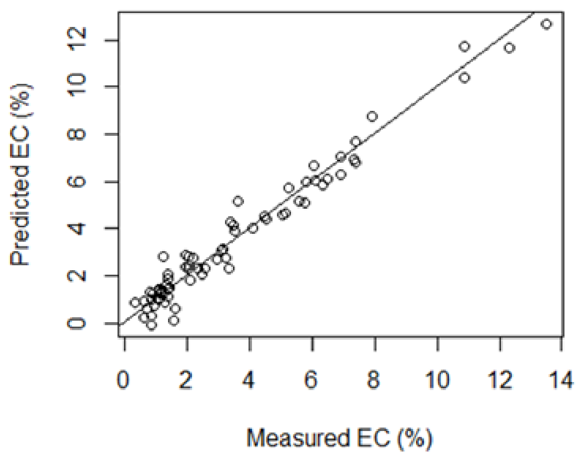


Fig 8: Correlation between the measured and predicted extractive content for E. globoidea heartwood.

Tests at two sites helped us to understand the correlation between NIR predicted extractive content and fungal decay levels. The figure below shows the relationship between predicted extractive content and mass loss. Generally, the samples with the high extractives had low mass loss.

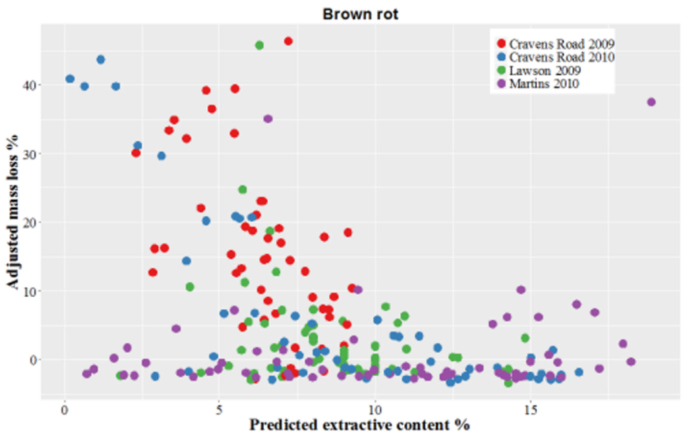


Fig 9:Relationship between predicted extractive content and mass loss.

Heartwood of 7-year-old NZ grown *E. bosistoana*, on average, met the performance of a Class 2 (above-ground) rated species. This can be interpreted as supporting data to include *E. bosistoana* for applications like decking. Additionally, some trees had no significant mass-loss (<3%), indicating that by genetic selection breeding Class 1 durable timber from short rotations should be possible.

Chemical components of the extractives of durable eucalypts were analysed for their impact on fungal growth. Preliminary results suggest that the type of compounds present may also be a deciding factor in decay rates, along with the overall level of extractives present, in the wood.

Measuring heartwood content in standing trees using electrical resistance

To speed up the assessment of heartwood in standing trees researchers at the University of Canterbury's Department of Electrical Engineering have developed a new tool which measures electrical resistance within the tree stem. As resistance differs between heartwood and sapwood, when the measuring probe is inserted into the tree in 1cm increments it gives profile of electrical resistance and hence determines the size of the heartwood core.

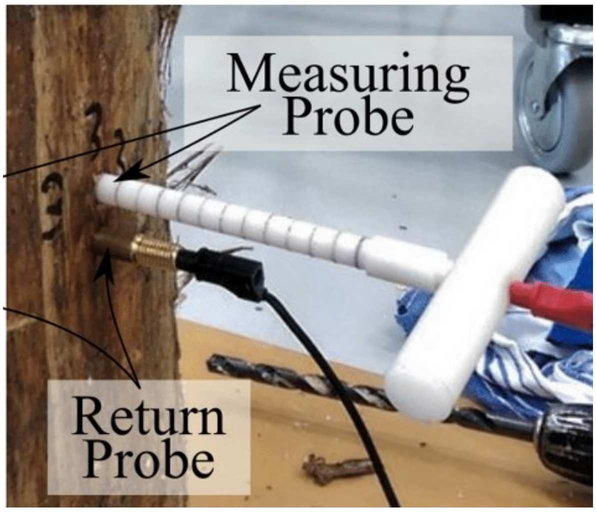


Fig 10: The new sapwood/heartwood testing tool which works by measuring changes in electrical resistance.

In other work, the feasibility of using synthetic aperture radar (SAR) to identify the heartwood/sapwood barrier in standing trees has been trialled using a range of species. Results show good results for cypress and potentially some eucalypt species.

Modelling stem properties

Models of *E. globoidea* stem taper and heartwood volume have now been developed, meaning in future it will be possible to better predict heartwood content of *E. globoidea.* Further work to determine the environmental factors that influence heartwood formation is in its final stages.

Fig 11: PhD student Daniel Bocniewicz assesses heartwood in 29-year-old E. globoidea.

New product development and testing

A key potential market identified for durable eucalypts is in engineered products such as laminated veneer lumber (LVL). This is because of the relatively high stiffness of eucalypts, even at a young age. Work on assessing the suitability of *E. bosistoana, E. globoidea*, and *E. quadrangulata* as an LVL component began in 2017 with the assistance of Nelson Pine Industries Ltd and has continued with peeling and gluing trials. Low growth strain has been identified as an important component of logs going into veneer production.

Fig 12: Representative veneers of E. bosistoana *(left) and* E. quadrangulata *(right).*

Essential oils in *E. bosistoana* foliage

Work to analyse the essential oils contained in E. bosistoana foliage is underway (with funding received from an external source). Essential oil composition may influence a tree's ability to tolerate insect attack; in addition, there may be potential to extract oils for pharmaceutical uses.

Research is looking at the exact composition of different oils, how this varies between sites, over the seasons and between families, and how insect browsing rates may be affected.

Growth models, economic models and market identification

Growth models for *E. bosistoana* and *E. globoidea* have been developed for low and high productivity sites and have been used to model predicted economic returns for durable eucalypt forests grown under various regimes. The two main potential growing regimes identified are: (i) a short-rotation post and pole regime, and (ii) a longer rotation sawlog regime. Two other regimes – continuous cover and permanent forests – are also considered to have good potential.

A report on the value of veneer, wood fibre and posts from improved *E. bosistoana* showed that the value of *E. bosistoana* produced under a 10- 20-year rotation exceeded growing costs (including an 8% IRR). It is thought that additional value could be added, particularly for smaller diameter trees, from selling peeler cores as ground-durable posts. New processing options - e.g. using a spindleless lathe - could add significantly to tree value. A review of international literature on wooden posts was also completed.

Durable eucalypt health

An *E. bosistoana* defoliation trial was examined to determine how well this species tolerates and recovers from defoliation. The figure below shows the variation in genetic susceptibility. There is natural variation in insect attack between families, with the least tolerant families having up to 7 times the proportion of damage per shoot than the most tolerant ones.

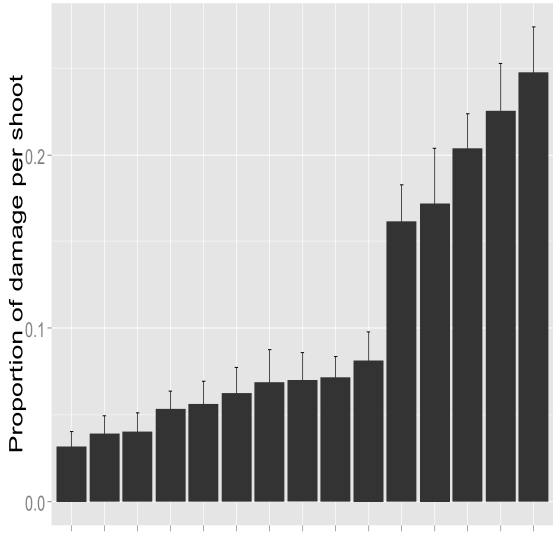


Fig 13:Natural variation in tolerance to insect browsing between E. bosistoana *families.*

Clear differences were seen in a South Island trial in the incidence and severity of natural insect pest damage sustained by different *E. bosistoana* families to *Paropsis charybdis*. Out of 15 *E. bosistoana* families that were assessed it was found that five families out-performed the single *E. globoidea* control – suggesting that eucalypts from the *Symphyomyrtus* group can be selected that will perform as well as those from the *Monocalyptus* group.

The eucalyptus variegated beetle EVB (*Paropsisterna variicollis*) was found in the Hawkes Bay in March 2016. NZDFI trials in this region were assessed for insect damage by species to get early indications of resistance to this new pest.

More recent research into susceptibility to paropsine damage showed that *E. macrorhyncha, E. cladocalyx*, and *E. globoidea* are more resistant compared to *E. bosistoana, E. tricarpa, E. quadrangulata* and *E. camaldulensis*. This is the case in both the North and South Islands. *E. tricarpa* was the most defoliated species. The research confirmed earlier work on variation between families, specifically E. bosistoana and E. tricarpa families in this case.

A NZDFI biosecurity risk management plan has been developed specifically to address concerns about the spreading of myrtle rust and EVB. Procedures for dealing with both foliage and wood samples are now in place, as are protocols for site visits and for when a suspected serious pest or disease risk is found in the field.

2.4 Cypresses

The total area of cypresses growing in New Zealand is around 9,825 ha (NEFD 2019). The three species of interest to the SWP programme are:

- *Cupressus macrocarpa*, a favourite New Zealand timber species but now seriously compromised by cypress canker, especially in the North Island
- *C. lusitanica* (Mexican cypress) – a fast-growing species which is less canker prone than macrocarpa
- *Chamaecyparis nootkatensis* (Yellow cedar) – hybrids of *Ch. Nootkatensis* are showing good potential in terms of growth, form and canker tolerance.

The cypresses represent around 11% of the overall SWP programme, and the overall priorities are to best maintain existing breeding populations, with a focus on growth, form, and canker tolerance, and where resources allow, select for improved wood properties.

The original anticipated outcomes for cypresses by 2022 were:

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

Breeding work

The breeding programme being funded by the SWP is a continuation of work done over several decades by the Forest Research Institute (now Scion).

C. lusitanica progeny trials were evaluated for growth and health (canker) indicating good selection possibilities to improve tree material. New selections were made to include in seed orchards, delivering new seed to industry in 5-7 years, and the third generation of *C. lusitanica* trials were established in 2017. The aim is to widen our knowledge of genotype by environment interaction in this species. In selecting the genotypes to be used in the trials there was a strong focus on better crown health by picking the best trees with the greatest tolerance for canker. The level of heartwood development may be included as part of the ranking process.

Two different sets of cypress trials featuring new genetic material were established in 2019:

1. Three large-scale trials to test new *C. macrocarpa* genotypes identified by Scion's tree breeders as canker tolerant
2. A series of small-scale trials to test 12 *Ch. nootkatensis* hybrids. These trials are being managed by the NZ Farm Forestry Association's Cypress Development Group and have been planted across a wide range of farm forestry properties.

Thermal modification to increase durability and stability

Cypresses have been included as part of the thermal modification programme at Scion. The main area of interest is whether thermal modification increases cypress durability, especially of non-durable sapwood. Early results (at 24 months) have been encouraging, with both the non-durable sapwood and relatively durable heartwood showing increased durability.

Other work on cypress durability is summarised below:

Durability trial type	Species	Status
Thermal modification	*C. lusitanica*	The thermally modified *C. lusitanica* is showing improved durability in both the heartwood and the sapwood in fungal cellar tests. Longer term durability testing is required to confirm the durability of these treatments.
	C. lusitanica	Decking and flat panel trials will be installed 2020
Framing	*C. lusitanica*	Decay had developed in many of the samples
	C. lusitanica	Treated with Boron - awaiting durability results
Decking	*C. lusitanica*	Treated with CCA - awaiting durability results
	C. lusitanica	Untreated heartwood and mixed sapwood/heartwood– awaiting results
Graveyard stakes	*C. ovensii*	Trial to be installed 2020
Fungal cellar	*C. ovensii*	Trial to be installed 2020

New product development and testing

On-going work is looking at whether young unpruned and unthinned cypress can be cost-effectively sawn into products suitable for high-value joinery. Both *C. lusitanica* and *C. ovensii* are being investigated, with timber from 20-year-old trees currently being air-dried and awaiting further analysis.

Fig 14: Boards sawn from young unpruned cypress, ready to be re-sawn, air-dried and then graded.

2.5 Site/species optimisation

A site/species mapping exercise reviewed the productivity potential of alternative species across a range of NZ sites. Species assessed were *E. fastigata, E. nitens, E. regnans, Sequoia sempervirens* (coastal redwood), *Pseudotsuga menziesii* (Douglas-fir), *Cupressus lusitanica*, and *C. macrocarpa*. The recommendations made provided a discussion base for the SWP workshop held in 2017 to decide priorities for research in this area. Participants came up with the following recommendations:

- establish commercial-scale demonstration trials of specialty timber species throughout New Zealand (underway)
- establish additional permanent sample plots (PSPs) for specialty timber species throughout New Zealand (underway)
- continue the monitoring of existing PSPs of specialty timber species throughout New Zealand (underway)
- elicit site-species mapping knowledge from existing experts and papers and incorporate into decision support systems.

The map below demonstrates the needle retention percentage for Douglas-fir trees with Swiss needle cast disease. Information like this can be used to optimise species to sites.

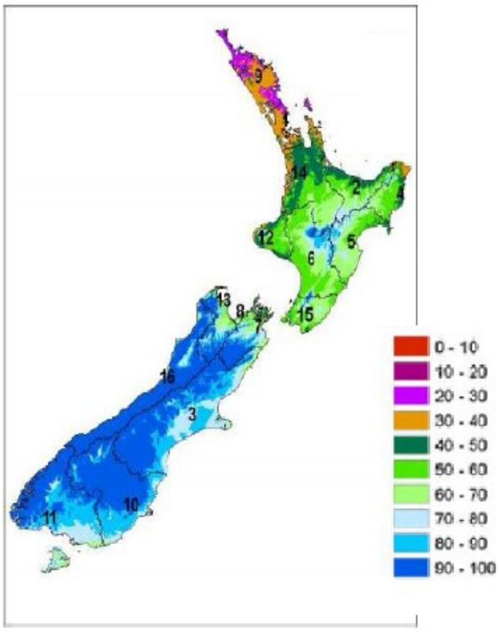


Fig 15: Douglas-fir needle retention throughout New Zealand

The site/species work has enabled an updated growth model for Douglas-fir to be produced. The model provides precise spatial information of Douglas-fir productivity throughout New Zealand and a range of management scenarios can be initially tested without the need to establish PSPs and silvicultural trials.

Current site-species mapping of eucalypts does not include durable species and the regional mapping scale limits utility for growers. To address these issues, site-species matching has been undertaken for *E. bosistoana* and *E. globoidea*, informed by micro-site variation. Fine-scale mapping of topography, weather, and soil conditions at two sites in Marlborough was undertaken, and tree survival and growth analysed under different micro-site conditions. The photo below shows growth variability within a NZDFI site.

Fig 16: Variation in growth across a durable eucalypt trial site.

Wind exposure and topographic protection index were found to be the two most important predictors for both species and *E. bosistoana* was relatively sensitive to soil moisture.

Another project identified the priority locations for new permanent sample plots (PSPs) for durable eucalypts. The maps are based on areas which species are known to be best suited to as well as locations of the existing PSPs.

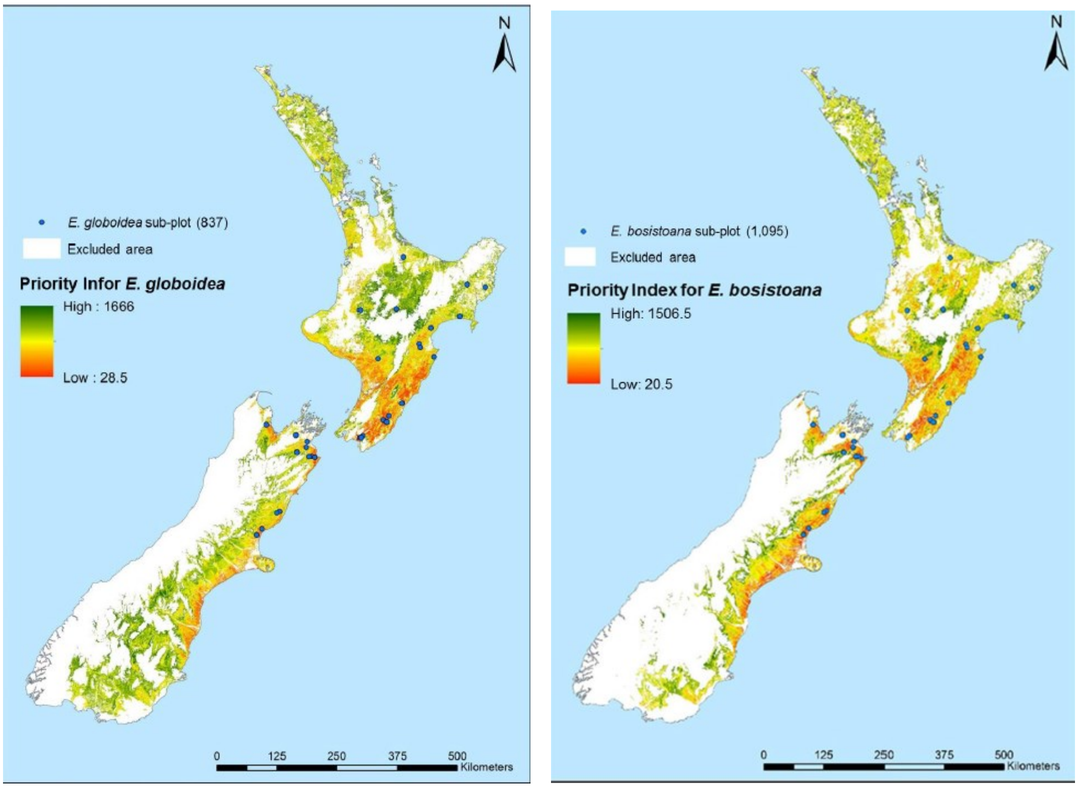


Fig 17: Existing PSPS (shown by blue dots) and optimal proposed locations for new PSPS in E. globoidea (left) and E. bosistoana (right).

The results showed that the existing PSPs adequately cover the east coast of Canterbury region, low-elevation zones in Tasman and Marlborough regions, and almost all of Manawatu-Wanganui and Hawke's Bay. The current PSP network for *E. bosistoana* is superior to that for *E. globoidea* as other regions such as Waikato, Bay of Plenty and Taranaki are all represented. The highest priority areas for *E. bosistoana* were in Rangitikei District and Taupo District. The high priority areas for *E. globoidea* were spread widely over the centre of the North Island including in the Rangitikei district, the Taupo district and its surrounding districts, Northland and Auckland regions, Tasman, Marlborough, Canterbury and Otago regions and eastern Southland.

A range of demonstration plots will be established across NZ to encourage further planting. To date the following species have been established in demonstration plots: *C. macrocarpa, C. leylandii, C. ovensii, E. fastigata, E. bosistoana, E. cladocalyx, E. globoidea, E. macrorhyncha, E. quadrangulata* & *E. tricarpa.*

2.6 Regional business investment cases

The SWP is tasked with developing four regional business investment cases as part of its overall programme. One of theses (the NZDFI Strategy) is complete, while work on the remaining three is in various stages of progress.

Investment case 1: NZDFI Strategy 2020-2030

The NZDFI team produced a strategy document looking out to 2030: 'Durable eucalypts: a multi-regional opportunity for New Zealand's drylands.'

Focus areas for the strategy are as follows:

- Identifying markets for durable eucalypts
- Modelling forest productivity and economic feasibility
- Working regionally to encourage new forests
- Breeding, propagation and trial management
- Education growers on durable eucalypt forest establishment and management
- Industry partnerships to build support and capability.

Investment case 2: Cypresses: a strategy for the New Zealand cypress industry

Work is underway to develop a strategy for the New Zealand cypress industry. Two industry sectors have been involved in a consultation process, and a workshop involving a range of industry stakeholders will be held in October 2020.

The workshop will seek to identify a vision for the sector, ensure stakeholders agree on some long-term objectives, and then begin work to develop an action plan, including identifying some people prepared to lead such an initiative.

Investment case 3: Douglas-fir processing strategy

Work is underway on a Douglas-fir Strategy, aims of which include:

1) Produce a guide, for existing and future Douglas-fir forest owners and processors, to identify and qualify opportunities for products and processing technologies that will add further value to the resource.
2) Support regional development of high value processing facilities focussed on Douglas-fir.
3) Identify opportunities to optimise Douglas-fir's value chain and deliver best value to its growers.

To date work has developed a picture of the geographic and chronological distribution of the resource and modelled likely supply from both production thinning and final harvest 2018-2052.

Investment case 4: Regional development of the specialty (alternative) timbers and small-scale sawmilling industries

Following work on the alternative species resource and the potential for small-scale sawmilling in Hawke's Bay Region, SWP is supporting two associated projects: (i) a nation-wide survey of small-scale sawmillers to investigate the potential to develop an industry group for the sector, and (ii) a pilot study towards developing a new mapping methodology to capture NZ's alternative species resource more accurately than is currently the case with the National Exotic Forest Description.

Response to the sawmillers' survey was excellent, and the likely next step will be for a workshop to be convened before the end of 2020. This will aim to develop an outline role and strategy for an industry association and identify a small steering group to seek funding for such an initiative.

The pilot mapping project identified a mapping technique using Artificial intelligence (AI) which, if resources become available, could be developed to greatly enhance knowledge of the alternative species resource. The pilot project revealed some major discrepancies between the NEFD data and the resource on the ground in Hawke' Bay.

Additional work: Woodscape models

A series of 'Woodscape' reports have been complete which form overarching work relevant to these regional investment cases. Woodscape models have (i) projected regional supply of specialty species and then (ii) the opportunities for regional processing based on log supply, the costs of different processing options, and product prices.

2.7 Annual nursery survey

A survey of nurseries was undertaken in June 2020. The table below shows the number of seedlings and the area planted (assuming a 900 stems per hectare stocking rate) since 2015 (data prior to the start of the SWP programme) up to 2019.

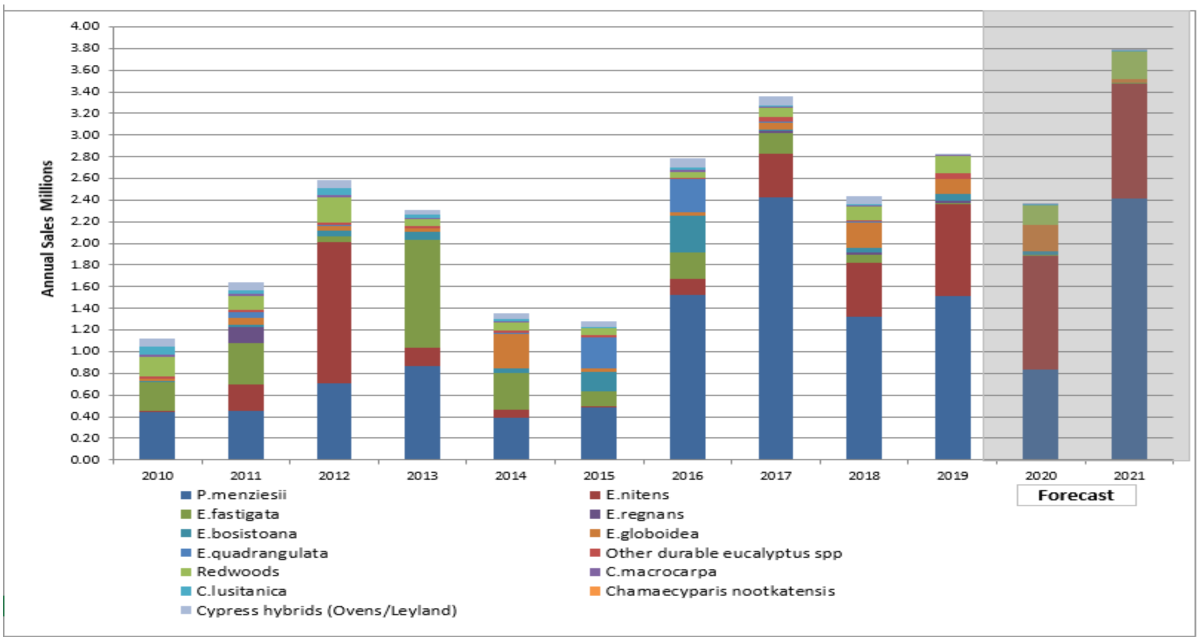
Species	Seedlings produced since 2015	Area planted since 2015 Ha
P. menziesii	7,275,015	8,083
E. nitens	1,898,348	2,109
E. fastigata	662,776	736
E. regnans	60,502	67
Naturally durable eucalypts*	1,887,883	2,098
Redwoods	492,574	547
Cypresses**	412,751	459
Total	12,689,849	14,100

* Naturally durable eucalypts consist of *E. bosistoana, E. globoidea, E. quadrangulata* and some other minor species.

** Cypresses consist of *C. macrocarpa, C. lusitanica, C. nootkatensis* and Ovens/Leyland hybrids.

It is assumed (but we have no data to confirm) that these plantings will be replanting for the Douglas-fir and ash eucalypts (*E. nitens, E. fastigata and E. regnans*) and new planting for the naturally durable eucalypts, redwoods and cypresses.

The figure below shows nursery seedlings produced from 2010 to 2019 and forecast numbers for 2020-2021 for species other than radiata pine.



Disclaimer:
The information shown is based on nursery information supplied. This information is reported as supplied and Buck Forestry Services shall not be liable for any issues relating to accuracy or reliablility of data supplied