



SPECIALTY WOOD PRODUCTS PROGRAMME UPDATE

Programme Manager: Marco Lausberg

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Highlights

A structural efficiency and cost-effective wall joint for Douglas-fir CLT has been proven. The wall hold down joints tested could be successfully repaired after testing. This would make building remediation after an earthquake event much faster and cheaper.

Preliminary analysis of growth and form data from *Eucalyptus quadrangulata* suggested heartwood quantity is under genetic control and not strongly correlated to tree diameter indicating the need to consider heartwood quantity as an independent trait to DBH (the top families for growth and form are not the same group that produce good heartwood volume). For *E. globoides* the heartwood diameter had a strong and positive correlation to DBH indicating that in general larger trees also have more heartwood. Unfortunately, heartwood diameter in *E. globoides* had a weak and unfavourable correlation to extractive content. This implies that the heartwood quantity and extractive content need to be independently selected in the breeding programme.

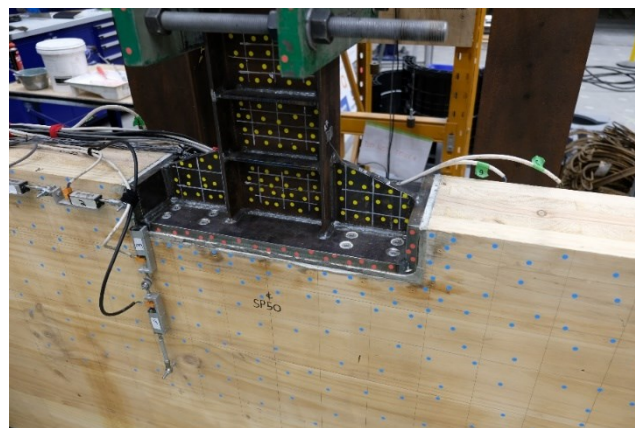
The feasibility of peeling posts from naturally durable eucalypt logs was trialled. It was found that the sapwood could be easily and cleanly removed from debarked logs. It is recommended that debarking be done prior to post manufacture as required depending on species and machine type used.

The thermally modified Douglas-fir and *C. lusitanica* are showing improved durability in both the heartwood and the sapwood samples.

RESEARCH PROGRESS: Q4 Year 6

Douglas-fir

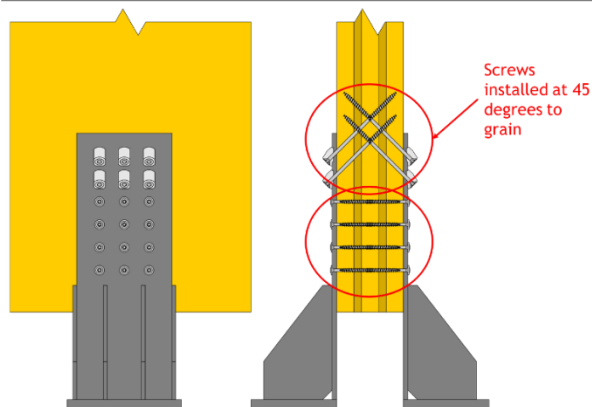
A series of experimental tests on Douglas-fir CLT with two types of critical connections were conducted in order to identify the suitable connection details for the shear wall design. It was found that the screwed steel-CLT connections to connect steel link beams to CLT wall panels in a coupled CLT shear wall system (picture below) provided a structural efficiency and cost effective joint.



For the hold-down connection design (picture below), steel hold-down brackets with mixed angle self-tapping screws provided an effective solution which is able to provide high strength, high stiffness and sufficiently ductile responses to simulated earthquakes.



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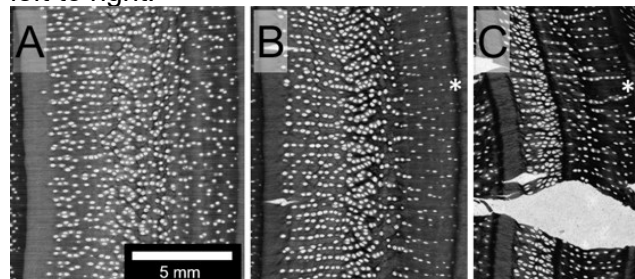
These hold-down connections can also be repaired to deliver the same strength as the original connection. Picture below shows the original screw holes filled with resin and the new holes only shifted by half the screw spacing. This would make building remediation after an earthquake event much faster and cheaper.



Non-durable eucalypts

A study was undertaken on *Eucalyptus nitens* samples to characterise and measure collapse and checking responses at a cellular level. The location of the collapse and checking within ring was also examined. The analysis of air, kiln, and oven-dried *E. nitens* showed that cell collapse was highly variable but generally more prominent in the outer third of growth rings. The figure below shows samples of A) air-dried, B) kiln-dried and C) oven-dried wood with the level

of both collapse and checking increasing from left to right.



Drying type had a significant effect on the profiles of cell collapse and vessel shape and size indicating that drying effects vary in relation to position that the collapse and checking occurs.

Naturally durable eucalypts

The breeding population of *E. quadrangulata* was assessed for growth and form. There was no relationship between the best families and the location from which they originated in Australia. Therefore, no provenance selection can be applied to future native stand collections. Preliminary analysis of the data suggested heartwood quantity is under genetic control in this trial and not strongly correlated to tree diameter indicating the need to consider heartwood quantity as an independent trait to DBH (the top families for growth and form are not the same group that produce good heartwood volume). A genetic improvement programme for this species can progress the key traits.

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The available heartwood quantity (diameter at 0.5 m stem height) and heartwood quality (NIR predicted extractive content) for ten NZDFI breeding trials was analysed with the intention to optimise sampling intensity and consequently reduce resource demands. Heartwood phenotyping is resource intensive and requires older/bigger trees delaying selection decisions and extending breeding cycles. The analysis concluded that accurate family and individual tree



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breeding values for heartwood quality can be obtained from the assessment of the heartwood obtained from 8 individuals per family and collecting 6 NIR spectra on each heartwood sample.

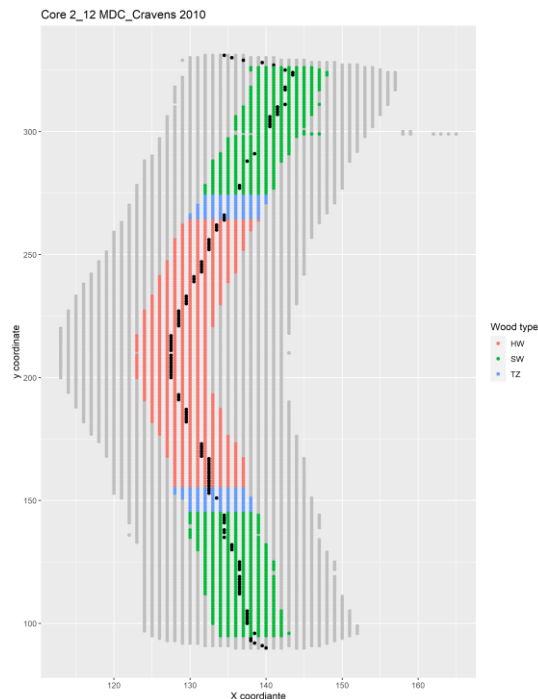


The phenotyping costs, per family in a trial can be as low as NZ\$ 125 but increases significantly if smaller trees are sampled or the coring equipment is not well maintained.

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A pilot study on 175 *E. bosistoana* cores indicated that NIR imaging can be used to a) identify heartwood and sapwood on a wood surface and b) assess heartwood quality (extractive content). The findings need to be validated through direct measurement of the extractive content rather than just predicted values for a similar technology.

The image below shows the centre of a core assessed by the algorithm as being heartwood (red), sapwood (green) or transition wood in between (blue).



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The Avery *E. globoidea* breeding trial site has been phenotyped for heartwood properties. Heartwood size ranged from 0 to 145mm and averaged 48mm. The extractive content averaged 8.3% and ranged from 0 to 24%. The heartwood diameter had a strong and positive correlation to DBH indicating that in general larger trees also have more heartwood. Unfortunately, heartwood diameter had a weak and unfavourable correlation to extractive content. This implies that the heartwood quantity and extractive content need to be independently selected in the breeding programme. It is worth noting that heartwood diameter was favourable correlated to extractive content in most of the *E. bosistoana* trials suggesting that trees with larger quantities of heartwood also tend to have a more extractives in that species.

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The feasibility of peeling posts from naturally durable eucalypt logs was trialled. Two different post producing mills (Posh and Morbark) were trialled with three different species (*E. bosistoana*, *E. quadrangulata* and *E. globoides*). It was found that the sapwood could be easily and cleanly removed from debarked logs (photos below show posts produced with the Posch machine).



On the logs that had not been de-barked prior to post production it was found that the bark could be successfully removed from the *E. bosistoana* and *E. quadrangulata* (sometimes two passes through the machine were needed) with the Posch machine but the thick bark on the *E. globoides* did cause issues such as blocking the machine and required frequently cleaning (photo below shows the *E. globoides* after one pass through the Posch machine).



The Morbark machine did struggle with bark on all species (photo below shows bark strips being cleared from the Morbark machine).



It is recommended that debarking be done prior to post manufacture as required depending on species and machine type used.

Cypresses

Two *Cupressus lusitanica* trials were assessed in the North Island. Heritability was moderate for diameter at breast height and canker severity score. No trait showed any significant genotype by environment interaction suggesting the best families on one site should also perform on another site (within the region covered by these two trials). Unfavourable genetic correlations were found between diameter at breast height and canker severity score, indicating that the continued selection for genotypes with improved diameter at breast height would also increase susceptibility to cypress canker. Additionally, unfavourable genetic correlations were found between branch size and diameter at breast height and should be considered in selection programs. The moderate heritability estimated for canker severity score indicates that breeding values for this trait could be predicted with acceptable accuracy and included in the breeding program for C.



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lusitanica, enabling the identification of genotypes with tolerance to canker severity to be deployed to locations where cypress canker is present in New Zealand.

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C. lusitanica and *C. macrocarpa* clones and hybrids were assessed for heartwood development in 4 trials (two ages per species 12 and 17 versus 12 and 18 respectively). In the *C. lusitanica* trials the overall average heartwood percentage increased from 26% in the young trees to just over 60% in the older trees. The *C. macrocarpa* showed higher heartwood percentages with 47% in the young trees to just under 80% in the older trees. The *C. macrocarpa* showed significantly higher susceptibility to canker.

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C. ovensii timber was tested at Scion following the sawing study on young untended cypress. In terms of bending stiffness, the *C. ovensii* achieved the SG6 structural grade, in terms of bending strength, the *C. ovensii* achieved the SG10 structural grade resulting in an overall grade of SG6. To assign a full structural grade the other strength properties tension, compression and shear need to be evaluated.

From the small clear testing there were very few obvious trends between height in tree, modulus of elasticity, modulus of rupture and nominal density across the inner and outer wood samples for the five trees assessed.

Pest management

A new polyphagous ambrosia beetle known as GAB, *Xylosandrus crassiusculus*, has been introduced into New Zealand in 2019. It is native to East Asia and has been a highly successful invader worldwide. Like

most invasive ambrosia beetles, *X. crassiusculus* can attack a wide range of woody plants. It was found that *E. fastigata* wood bolts soaked in ethanol did attract the beetles. See image below with characteristic frass noodles on the stem (sawdust released by the excavating adult).



Eucalyptus trees (among other hardwoods), but only those under stress (emitting ethanol as a stress response), will be under threat of attack from this pest, but may not be as susceptible as other species of woody trees in New Zealand.

Maintaining stress-free young trees within forest nurseries will be important to avoid attacks from this new pest.

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Until recently, it was thought that only two *Seiridium* species were associated with cypress canker disease in New Zealand; however, now there could be as many as six or even more species, which could have implications for management and resistance breeding programmes.

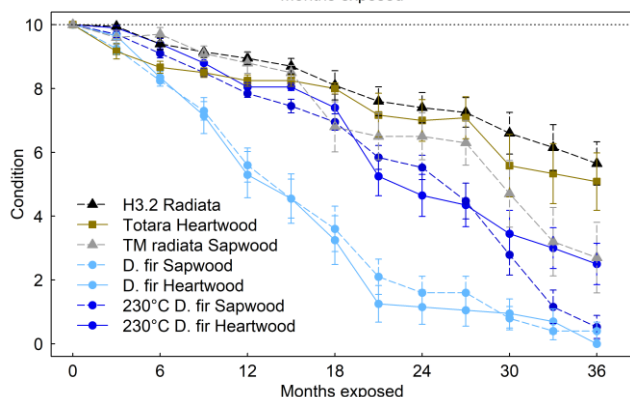
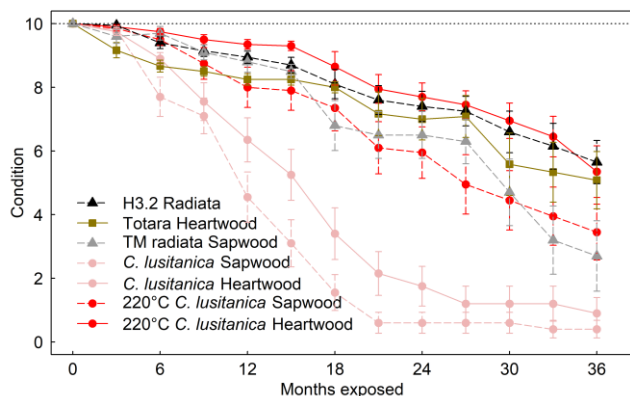
Durability

Durability screening of thermally modified Douglas-fir and *C. lusitanica* using the AWPC (Australasian Wood Preservation Committee, 2015) protocols for in-ground



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accelerated field simulator (AFS) test has been underway for 3 years. The two figures below show the results for the *C. lusitanica* and Douglas-fir respectively.



Since this is an accelerated screening test, the results shown here are not an exact ranking of the durability of the different sets but are an indication of whether there are durability improvements from the thermal modification, and whether it is worth investing in further field testing to better understand the durability of the thermally modified boards.

The modified *C. lusitanica* stakelets are in significantly better condition than the unmodified stakelets, suggesting improved durability of both the heartwood and the sapwood. The modified Douglas-fir stakelets have deteriorated over the last year, and are not performing as well as the *C. lusitanica*, but they are still showing improvement over the unmodified controls.

The thermally modified Douglas-fir and *C. lusitanica* are showing improved durability in both the heartwood and the sapwood. A set of soil jar fungal test have also been performed and those results are also positive, with the thermally modified *C. lusitanica* performing similarly to H3 CCA treated radiata pine and performing substantially better than the unmodified controls.

Longer term field durability testing is required to confirm the exact durability of these treatments.

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Durability stakes and stakelets were prepared from six different 15-year-old durable Eucalyptus species, (*E. bosistoana*, *E. quadrangulata*, *E. pilularis*, *E. sphaerocarpa*, *E. globoidea*, *E. muelleriana*). These Eucalyptus species had been selected as they are considered to have high natural durability. Control stake and stakelet samples from *Pinus radiata* sapwood, *Fagus sylvatica* (European beech), and H3.2 and H4 CCA treated *Pinus radiata* sapwood were also included in the test. The stakes were exposed outdoor at Scion's Whakarewarewa Graveyard, and the stakelets were installed in the Scion's Accelerated Decay House (with a temperature of 27°C and a relative humidity of 85%). After 5 years exposure the summary of the condition of the stakes by species is as follows:

- *E. bosistoana*, one stake has failed and the remaining 30 have well established decay or extensive established and deepening decay.
- *E. quadrangulata*, five stakes have failed, and the remaining 30 stakes have, well established to deep and severe decay.



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- *E. pilularis*, one stake has failed, and the remaining 41 stakes have well established to deep and severe decay.
- *E. sphaerocarpa*, all 50 stakes have well established to deep and severe decay.
- *E. globoidea*, two stake failures and the remaining 56 have well established to deep and severe decay.
- *E. muelleriana*, two stake failures and the remaining 54 stakes have well established to deep and severe decay.
- The differences in inner and outer heartwood between trees of the same species is minimal, except for trees where there has been stake failures.
- All the untreated *Pinus radiata* stakes have failed giving the group an average life of 2.1 years.
- The H3.2 CCA treated stakes are rated 10 to 9 (sound to minor decay) and the H4 treated stakes T to 4 (Trace to deep and severe decay).

Regional business cases

Two reports were produced using Woodscape modelling which examined 1) the markets for posts and poles in NZ and 2) the potential for making durable Eucalypt posts and veneers from a crop, using 3 regime options (15, 20- and 25-year rotations).

1) The costs of durable eucalypt posts were estimated to be \$890 per cubic metre when the costs of growing and processing, including profit margin were included. CCA treated pine posts and non-wood post retail prices were estimated. The CCA pine price was estimated to be \$741 and non-wood post (or composite post) prices ranged from \$1,006 to \$2,029. (All estimated Retail prices; 1m³ wooden posts or equivalent number of non-wooden posts).

Non-CCA treated posts have the advantage of being acceptable for use on organic farms and orchards and should be easier to recycle or dispose of after their useful life is over. End of life disposal costs for CCA treated posts are likely to be around \$75 per cubic metre.

Taking the eucalypt tree crop harvest volumes predicted from a 20-year rotation and the assumed conversion factors likely to be achieved, it was estimated that a forest harvest area of 60 ha per annum would be required to meet the post demand from organic growers. This implies a total forest estate dedicated to growing durable eucalypt posts of around 900ha. The Nelson / Marlborough demand is currently around 11 to 12,000 m³ per annum.

2) Making veneers and posts from a crop of durable eucalypt logs appears to be technically and financially viable at a scale suitable for the demand for naturally durable posts.

Overall, the data suggests that the 20-year regime would give better results than the 15-year regime and similar results to the 25-year regime with the benefit of the material being available slightly sooner. The longer rotations (20 to 25 years) gave better yields of veneers.

The total area of forest required to service the plant making the posts and veneers was estimated at being between 1,500 and 2,000 hectares, depending on the regime used.

Other

As part of the process for determining what the FGLT might invest in the future with regards to other species a report was written to summarise current and future potential of contingency species to mitigate biosecurity risk for the New Zealand Forest sector. Several species that are at the stage of readiness have been identified for consideration as contingency species for



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radiata pine. Other species able to produce different wood products than those that can be manufactured from radiata pine have been also identified. These have potential to expand the market opportunities for NZ's forestry industry. The next step in this process was to hold two workshops with various industry representatives to determine what criteria will be used to select the species that the FGL will be invested in. This process is ongoing.

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Reports and other outputs completed

Report No.	Document Title
SWP-T120	Assessment of NZDFI <i>Eucalyptus quadrangulata</i> Breeding Populations
SWP-T121	Recommended sampling intensity for phenotyping durable eucalypt breeding trials for heartwood quality
SWP-T122	The current and future potential of contingency species to mitigate biosecurity risk for the New Zealand Forest sector
SWP-T123	Feasibility trials - peeling posts of durable eucalypts
SWP-T124	Assessing heartwood in <i>E. bosistoana</i> cores from NIR hyperimages
SWP-T125	Spatial distribution of cell collapse in <i>Eucalyptus nitens</i> wood due to drying treatment
SWP-T126	Techno-economic analysis of veneers & posts from specialty wood species (durable eucalypts)
SWP-T127	Techno-economic analysis of posts from specialty wood species and radiata pine
SWP-T128	Experimental and Parametric Studies on Douglas-fir CLT Shear Walls with High-Capacity Connections
SWP-T129	<i>Cupressus xovensii</i> Bending Strength and Stiffness
SWP-T130	Forest Protection SSIF research on species other than radiata pine 2020/21
SWP-T131	Assessment of <i>Eucalyptus globoides</i> heartwood at Avery
SWP-T132	The decay resistance of six <i>Eucalyptus</i> species after five years exposure