SPECIALTY WOOD PRODUCTS PROGRAMME UPDATE

Programme Manager: Marco Lausberg

Issue Number: 5
Date: July 2019

Summary

Highlights after the 4th year of investing in speciality species included:

- Douglas-fir CLT performed very well – can be used efficiently in mid-rise and high-rise timber buildings
- Peeling of young (15 years-old) durable *E. bosistoana* showed very high stiffness values (16.6 GPa).
- Mechanical testing of a range of young eucalypts (16 years-old) showed some had higher small clear bending strength and stiffness properties than the highest density radiata pine
- Thermal modification reduced both the degree of swelling and the rate of swelling for *Cupressus lusitanica* and *Eucalyptus nitens*.
- There is opportunity to breed for pest tolerance in naturally durable eucalypts and *E. nitens* and for stiffness in Douglas-fir.

RESEARCH PROGRESS: Year 4

Douglas-fir

CLT (cross laminated Timber) was made from Douglas-fir lumber. Both connections and core-walls were tested in this project. Figure below shows one of the configurations of screw alignment that was tested.

It was found that mixed angle screwed connections showed significant displacement capacity, high strength and stiffness and are suitable for seismic design of CLT buildings with moderate or high ductility in New Zealand. The experimental testing results provided strong technical evidence that the CLT core-walls can provide more efficient lateral load resisting systems for mid-rise and high-rise timber buildings.

Stiffness breeding values were determined for Douglas-fir progeny and it was found to be moderately heritable, had low genotype by environment interaction. Good potential exists for improvement in this trait in the New Zealand Douglas-fir breeding programme.

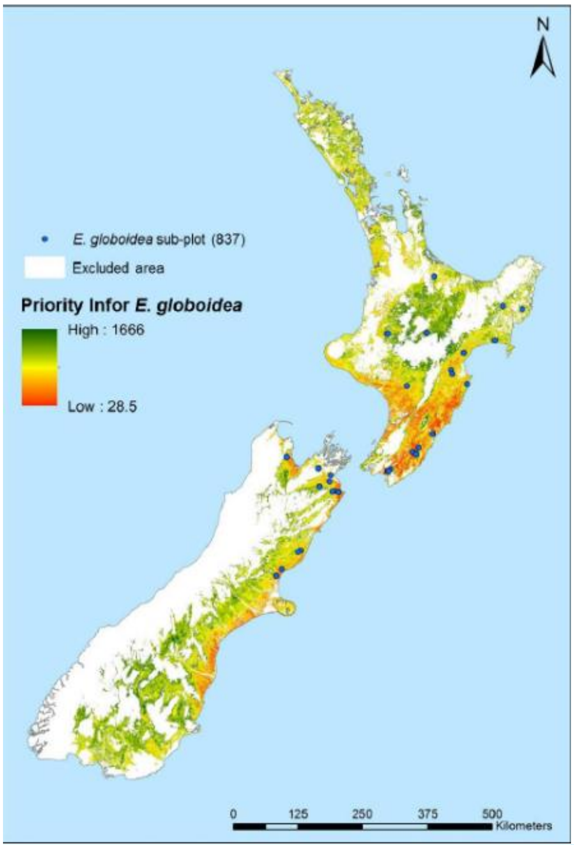
Implementation of genomics in Douglas-fir resulted in increased prediction accuracy and response to selection not only for genotyped but also for non-genotyped individuals when compared with pedigree-based analysis approach.

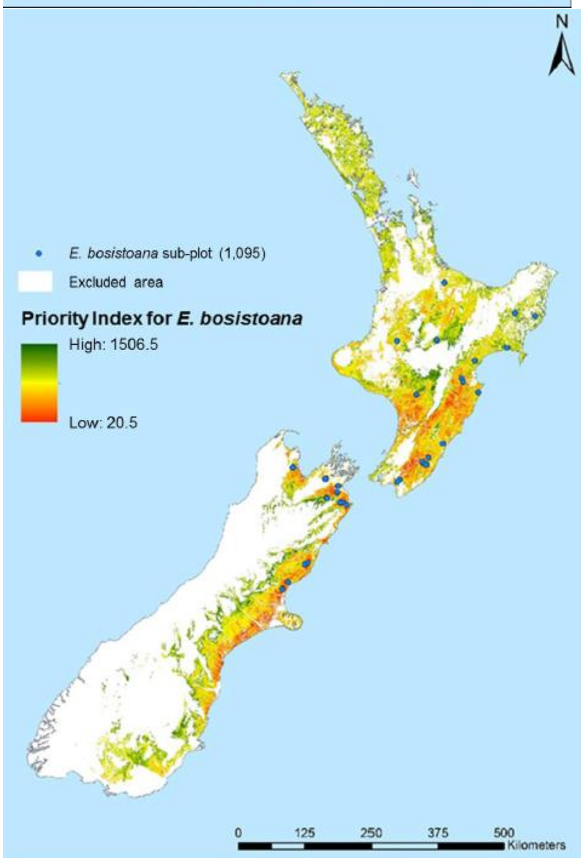
Naturally durable eucalypts

A project looking at gaps in PSP locations for *E. globoidea* and *E. bosistoana* showed that the existing PSPs of the two species adequately covered the east coast of Canterbury region, low-elevation zones in Tasman and Marlborough regions, and almost all of the Manawatu-Wanganui and Hawke's Bay regions. The current PSP network for *E. bosistoana* was superior to that for *E. globoidea* as it also represented other regions such as Waikato, Bay of Plenty and Taranaki regions. The highest priority areas for new PSP establishment 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. The two figures below show the priority areas (in dark green) to establish PSP's for both species respectively.

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

SPECIALITY WOOD PRODUCTS PROGRAMME UPDATE





Hybrid growth models were developed for *E. globoidea* and *E. bosistoana* and they documented that topographic, wind exposure, morphometric protection, position index and distance from ridge top significantly influenced juvenile height growth and survival proportion. These topographic indices were also found to be significant for between-site juvenile height growth and survival proportion, along with temperature. Overall, each of the final models had high precision and minimal bias, therefore are able to predict juvenile tree height yield and survival proportion.

A study examining the potential to use NIR to predict growth strain found that there was a moderate positive association between veneer splitting length and growth-strain ($r = 0.73$), but no significant association with wood stiffness. A linear relationship was found between NIR band shifts and mechanical strain in **dry** lumber. No correlation was found, however, between growth-strain of **green** stems as measured by strain gauges and the NIR spectra in reflection mode. Challenges included excessive signal overlap at high moisture content, lower signal-to-noise ratio of diffuse reflection compared with transmission NIR spectroscopy, and variations in growth-strain. Raman spectroscopy could be used to non-destructively estimate growth-strain with moderate accuracy, but was negatively affected by the inhomogeneity of wood, instrumental instability, and fluorescence effects. Figure below shows the growth strain in a board forming a split.

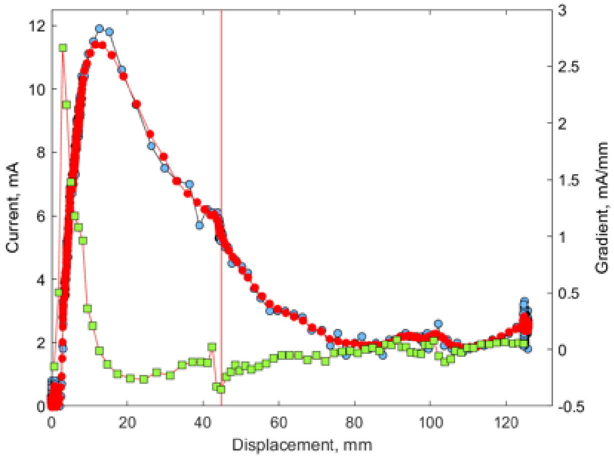
Heartwood quantity and quality were measured in *E. bosistoana.* The data is being used to identify superior families which are now in commercial propagation via both, grafting into seed orchards as well as clonal propagation from coppice shoots of mother plants. Figure below shows bark to bark cores from a number of trees showing the variation in heartwood size (stained pink).

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

The first regional strategy has been completed which covers the NZDFI durable eucalypts. The strategy identified six key focus areas where skills, knowledge, resources and investment are needed to continue to build the capability required to establish a new durable hardwood industry. Focus areas include identifying markets, modelling forest productivity and economic feasibility. Initial economic modelling showed a 15 year peeler pole regime on a high productivity site giving reasonable financial return.

The development of the sapwood depth tool has continued with a more portable version being produced (see figure below).

This is used to determine where the boundary of the sapwood and heartwood occurs and hence the proportion of desired heartwood within a tree. Figure below shows the electrical current and current gradient against radial position in the stem of *E. nitens* sample. The vertical redline shows the measured heartwood position. If the tool can be commercialised then field measures of heartwood % will be much faster.

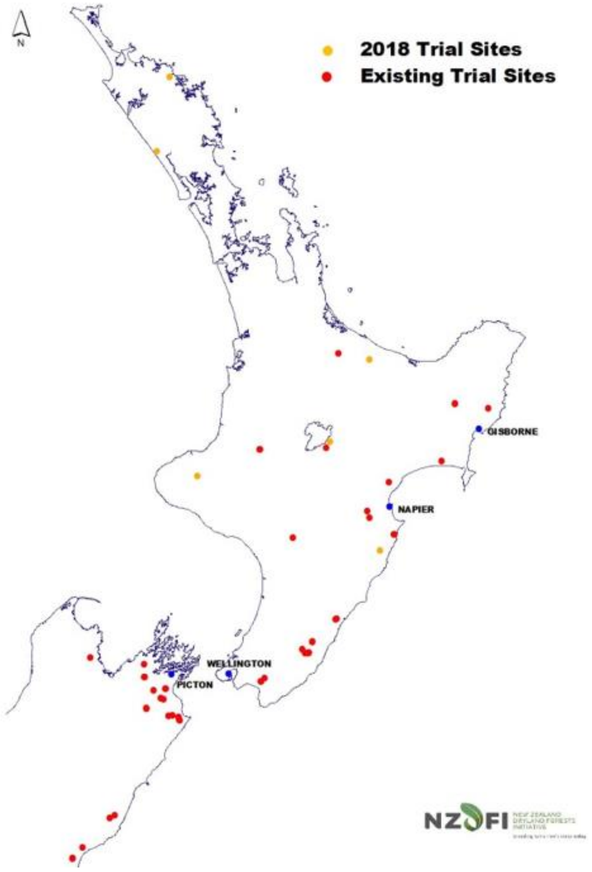


A small (7 logs) peeling trial at NPI demonstrated that rotary peeled veneers of good surface quality can be obtained from 15 year old *E. bosistoana* and *E. quadrangulata* trees grown in New Zealand.
The image below shows the logs that were peeled.

The dynamic stiffness of the *E. bosistoana* veneers averaged 16.6 GPa. One of the *E. quadrangulata* logs did show heart and veneer splitting (shown in the bottom right of the images below).

The veneers are now available for further research, for example gluing trials.

Demonstration trials of NZDFI species are strategically located on different sites with varying environmental conditions and are predominantly spread across North Island East Coast regions as well as Marlborough and north Canterbury. They are now providing data to assess species health, adaptability and performance across a matrix of sites with a variety of management. Once trees have grown to sufficient size PSPs can be installed in the species blocks to provide ongoing species productivity data. Figure below shows the locations of trial sites.



Cypresses

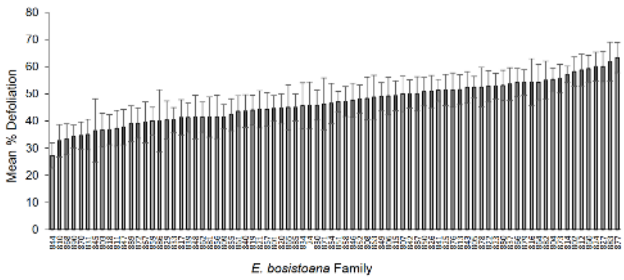
Genetic correlations between cypress canker severity score, growth and form traits in *C. lusitanica* were examined on two sties (5 and 10 years-old). Unfavourable genetic correlations were found between diameter and canker severity score, indicating that fast growing trees will be more susceptible to cypress canker. Genetic correlations between sites was very close to one, suggesting weak G×E interactions. The moderate heritability found for canker severity score showed that selecting for resistant tree genotypes is possible. Complex trade-offs between tree growth and canker severity, and the unfavourable genetic correlation between branching size and diameter should be considered in the cypress breeding program.

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883   Email: forestgrowersresearch@fgr.nz   Web: www.fgr.nz

Pest management

A study examining the economics of Paropsis impact revealed that the potential value lost due to damage is between $400-$500M. It concluded that in most situations, biological control was found to be more cost effective than chemical control. Large plantations (>40 ha) will need to be protected by chemical control only when damage is severe.

Assessment of *E. bosistoana* trees damaged by EVB (*Paropsisterna variicollis*) revealed that defoliation varied significantly between individuals, ranging from 5% to 90% of the upper third of tree crowns. There is sufficient variation in defoliation sustained by different *E. bosistoana* families to warrant continued investigation into potentially heritable differences in susceptibility to paropsine attack. Figure below displays the variation in family averages – ranging from 27 to 63%.

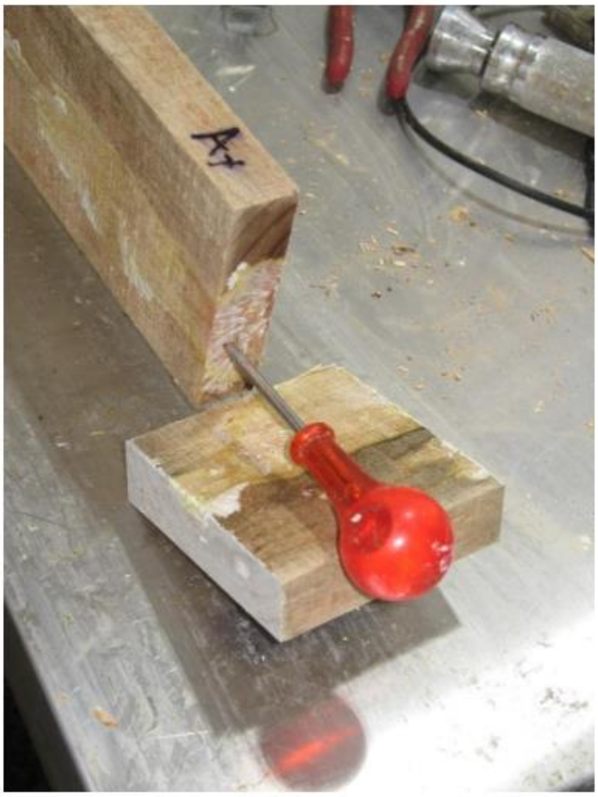


The EPA application to release a new biocontrol agent (*Eadya daenerys*) for parasitising *paropsis* was successful, both the staff assessment report, and the final decision document agreed that the likely benefits outweighed any risks for New Zealand of introducing a new agent. Also the prospects of locating a suitable biological control agent for the recently introduced pest *Paropsisterna variicollis* (EVB) was strengthened when a high proportion of *P. variicollis* larvae were found browsing *E. globulus* plantations in Victoria were infested with a species of *Eadya* (*braconidae*).

A project recording the level of paropsis browsing on *E. nitens* found that there was considerable variation of palatability (defoliation from *P. charybdis*) scores, ranging from low to moderate (10-60%), resulting in low, but statistically significant, estimates of heritability (0.15) for resistance to *P. charybdis* feeding.

Durability

Framing tests of untreated *Cupressus lusitanica*, Douglas-fir, *E. nitens* and *E. regnans* were tested at Scion and it was found that decay had developed in many of the samples of all species. This trial has another 12 months to run before final results are available. Figure below shows the decay in an *E. nitens* sample after 6 months exposure.



Six eucalypt species were evaluated for durability in stakelet and stake trials. Trees were only 15 years-old and grown in Northland. Species tested were *E bosistoana, E. quadrangulata, E. pilularis, E. sphaerocarpa, E. globoidea,* and *E. muelleriana.* After two years exposure the stakelets showed a significant number failing for each species and the remainder having deepening or severe decay. The stakes test showed a range of minor to established decay with two of the *E. quadrangulata* stakes failing. The figure below shows a samples of the *E. pilularis* stakes. These results confirm that we have to understand how durability varies by site, species and age to have confidence in durability values for a species.

Other

A report covered the current and projected supply of Douglas-fir, Cypresses and *E. nitens* logs across all the major wood supply regions of New Zealand (Woodscape model). For most species and regions there are highly variable volumes of supply over time, which makes developing processing of, and markets for, the wood products from these species challenging. For some species and regions there are issues which limit the likelihood of expanded plantings. For example;

- Douglas-fir in the North Island – major growers have concerns over the impact of Swiss Needle Cast on crop productivity and are likely to convert Douglas-fir stands to *Pinus radiata* as they are more confident in the returns from that approach
- Douglas-fir in the South Island – there are major barriers to expanding Douglas-fir, or even restocking of Douglas-fir, due to concerns over the spread of wildings onto neighbouring land.
- Cypress species – some regions with large areas of Cypress plantings have issues with crop and log quality, these are sufficient to suggest that it is a barrier to replanting or expansion of the area in cypresses.

The economics for the species for a range of products was examined. Cypresses had potential to deliver the best in terms of economics particular with a solar kiln and small sawmill. Eucalyptus relied on lower log prices in order to be economic – for example making OEL from cheap low grade *E. nitens* logs was predicted to be economically viable.

Mechanical properties

Small clear bending strength samples were cut from 16 year old trees of the following species: *E. bosistoana, E. quadrangulata, E. pilularis, E. sphaerocarpa, E. globoidea* and *E. muelleriana.* *E. bosistoana* had the highest density, stiffness and strength. It also had no significant radial trend in wood properties. The other species showed inner parts of the tree and lower parts of the stem tended to have lower density, stiffness and strength when compared to outer portions or higher up the stem. Comparing the six species as 16 year old trees against New Zealand grown radiata pine small clear values showed that:

- *E. bosistoana, E. quadrangulata, E. pilularis* and *E. sphaerocarpa* all had higher small clear bending strength and stiffness properties than the highest density radiata pine;
- Stiffness and bending strength of young Northland *E. globoidea* & *E. muelleriana* was comparable to radiata pine with a nominal density of around 550kg/m^3.

The annual nursery survey documented the seedlings produced in 2018 and also the predicted demand for seedling in 2019 and 2020. The table below shows the production of seedlings since 2015 for the species in our program.

Species	Seedlings produced since 2015
P. menziesii	8,519,807
E. nitens	3,058,732
E. fastigata	863,716
E. regnans	101,262
Naturally durable eucalypts*	2,253,090
Redwoods	913,537
Cypresses**	601,573

* 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 and cypresses.

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

Dimensional stability rankings

Dimensional changes caused by changes in wood moisture content can have a large impact on how the wood performs in service. Poor dimensional stability can lead to cracking, poor paint adhesion and problems with clearances in moving parts like doors and windows. To better understand this the dimensional stability of 16 different wood types were compared (8 species, plus variations such as modified wood, or different tree ages). The table below shows the % change in both the radial and tangential direction after long term humidity cycling for each species tested.

Species	Radial change (%/%RH)	Tangential change (%/%RH)
Accoya	0.005	0.009
220°C TM *C. lusitanica*	0.013	0.014
210°C TM *E. nitens*	0.010	0.016
Kebony	0.012	0.017
TM Ash	0.013	0.019
TM Radiata pine	0.015	0.023
160°C TM *E. nitens*	0.012	0.025
185°C TM *E. nitens*	0.016	0.026
Douglas-fir thinnings	0.018	0.030
Douglas-fir	0.024	0.039
Radiata pine	0.021	0.040
C. x ovensii	0.022	0.044
C. lusitanica	0.024	0.045
E. nitens (SWE)	0.023	0.046
E. nitens (JF)	0.032	0.046
E. regnans	0.034	0.053
E. fastigata	0.037	0.056
E. globoidea	0.039	0.060

Not surprisingly Accoya has the lowest dimensional change (due to the altering of the chemical structure which inhibits moisture movement), followed by the different species of thermally modified wood and the Kebony (commercial furfurylated wood). *E. fastigata* and *E. globoidea* had the highest dimensional change. The Douglas-fir thinnings has a slightly lower dimensional change than the commercial Douglas-fir boards, and the *E. nitens* from SouthWood Exports has a slightly lower dimensional change to the *E. nitens* from John Fairweather.

Thermal modification reduced both the degree of swelling and the rate of swelling for all the species included in this testing (*C. lusitanica, E. nitens,* radiata pine).

The following reports can be found on www.fgr.nz

Reports completed

Report No.	Document Title
SWP-T064	The decay resistance of three wood species used as framing
SWP-T065	Optimising new PSP locations
SWP-T066	The decay resistance of 6 Eucalyptus species in stake & stakelet trials after two years exposure
SWP-T067	Economic impact of eucalyptus tortoise beetle (Paropsis charybdis) in New Zealand
SWP-T068	Identifying processing opportunities for key specialty tree species – resource analysis
SWP-T069	Extending durable eucalypt species research by establishing new demonstration trials in 2018
SWP-T070	Hybrid growth models for *Eucalyptus globoidea* and *E. bosistoana*
SWP-T071	Molecular deformation of wood and cellulose studied by near infrared and Raman spectroscopy
SWP-T072	Heartwood in *Eucalyptus bosistoana* (2009 plantings)
SWP-T073	Identifying processing opportunities for key specialty tree species; - processing options analysis using the WoodScape model
SWP-T074	Dimensional Stability of Specialty Species
SWP-T075	Evaluation of wood stiffness in Douglas-fir progeny test FR280_2 and FR280_3
SWP-T076	NZDFI Regional Strategic Plan document
SWP-T077	Sapwood depth tool – proof of concept field prototype
SWP-T078	Susceptibility of Eucalyptus bosistoana families to EVB defoliation
SWP-T079	Rotary peeling of 15 year old *E. bosistoana* and *E. quadrangulata*
SWP-T080	Assessing the Bending and Density Properties of six Eucalypt Species
SWP-T081	Forest Protection SSIF research on species other than radiata pine 2018/19
SWP-M01	Genetic correlations between cypress canker severity score, growth and form traits in Cupressus lusitanica in New Zealand
SWP-T083	Assessed defoliation of Eucalyptus nitens breeding population to quantify genetic basis of palatability to Paropsis charybdis
SWP-T084	Implementation of genomic selection in provenance/progeny test of Douglas-fir
SWP-T085	Experimental studies on Douglas-fir CLT connections and core-walls

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz