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A Heartwood Durability Study on Leyland Cypresses

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
BACKGROUND.....	2
INTRODUCTION.....	3
METHODS	4
Taking the Cores	4
Measuring, Marking and Photographing the Cores.....	4
NIR Scanning of the Cores.....	4
Placing the Cores in the Fungal Cellars	5
Data Analysis	5
RESULTS.....	6
CONCLUSION	8
Future Work.....	8
REFERENCES.....	9

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EXECUTIVE SUMMARY

Leyland cypresses are hybrids between *Cupressus macrocarpa* and *Chamaecyparis nootkatensis*. They have been propagated vegetatively for at least 100 years and offer the opportunity to look at heartwood durability on ramets of the same clones across several sites.

This study was based on 10 ramets of three Leyland clones (Leighton Green, Green Spire and Naylor's Blue) at Strathallan forest, and 10 ramets of the same three Leyland clones and the "Ovensii" clone (*C. lusitanica* x *Ch. nootkatensis*) at Gwavas forest. Three bark to bark cores of 12 millimetre diameter were taken from each ramet using a motorised corer.

60-millimetre sections of heartwood were cut from each core from close to the pith and also just inside the heartwood / sapwood boundary. The distance from the pith to the heartwood / sapwood boundary was measured along with the distance from pith to bark. The rings of sapwood were counted. The percentage of heartwood, percentage of sapwood, number of sapwood rings and sapwood length were considered to be significantly different between clones, but no site differences were seen except for length of sapwood. There were no interactions between site and clone.

Heartwood colour differed by clone, with Green Spire having the brightest colour and highest percentage of heartwood, closely followed by Leighton Green and Ovensii. Naylor's Blue had the least amount of heartwood and less distinctive heartwood boundaries, with some trees having a patch of heartwood with sapwood on both sides. Photographs were taken of all cores before sections were cut.

Of the three fungi used in the Sutter trial, the white rot fungus (*Trametes versicolor*) caused the greatest weight loss. Weight loss for the two brown rot fungi (*Oligoporus placenta* and *Gloeophyllum trabeum*) was negative, probably because some fungal mycelia had added to the original weight. The control blocks and cores of *P. radiata* confirmed that the fungi were alive and operating at normal efficiency.

Site had the greatest effect, with wood from Strathallan suffering significantly greater weight loss than wood of the same clones from Gwavas. Clones varied in weight loss, but not significantly, and position within the tree was also not considered significant. The effect of site could elevate durability from class 3 (moderately durable) at Strathallan to class 2 (durable) at Gwavas if the test had been conducted for a longer timeframe.

There was some interaction between fungus and site explained by a (non-significant) greater weight gain of the brown rot with least effect (*Oligoporus placenta*) at Strathallan, which went against the trend shown by the other two fungi.

BACKGROUND

Leyland cypresses are hybrids between *Cupressus macrocarpa* and *Chamaecyparis nootkatensis*. They have been propagated vegetatively for at least 100 years and several clones have become popular in New Zealand. Dudley Franklin and John Miller became interested in the Leyland cypresses and planted trials in the mid-1980s. The trees in these trials have grown well and are now over 20 years old and contain good quantities of heartwood.

A study on western red cedar (*Thuja plicata*) in 1999 (DeBell *et al.*) looked at heartwood samples subjected to fungal cellar testing (Sutter tests) and found differences between trees. They also looked at the composition and quantities of various chemicals in the heartwood and found a link between increased quantities of a compound known as Tropolone and decreased decay as measured by weight loss.

The objectives of this study were to see whether the popular Leyland clones differed in heartwood durability and whether site influenced heartwood formation. Heartwood sections would be subjected to fungal cellar testing and decay would be inferred by weight loss. A further refinement was to use Near Infrared Resonance (NIR) imaging to see whether individual heartwood compounds could be identified cheaply.

The blocks of wood traditionally used in fungal cellar testing (Sutter blocks) are machined to dimensions of 35 by 35 by 7 millimetres. However, no trees were to be felled in this study, so it was decided to use 12-millimetre increment cores. It was determined that the containers used to isolate samples could take 60-millimetre lengths of the cores. The Sutter test uses three varieties of fungus (Table 1), hence three cores would be required from each tree.

Table 1: Description of fungal cultures

Type	Species	Culture
Brown-rot	<i>Gloeophyllum trabeum</i>	British standard
Brown-rot	<i>Oligoporus placenta</i>	FR07/02
White-rot	<i>Trametes versicolor</i>	British standard

INTRODUCTION

This study was based on the trial SD617/1 planted at Strathallan forest, near Invercargill, in 1984, and the trial WN365/3 planted at Gwavas forest, near Napier, in 1985. SD617/1 was designed to study an agroforestry scenario, with double rows of up to one hundred ramets of several Leyland clones at 2-metre spacing within rows and 10-metre spacing between rows. WN365/3 was planted as five replicates of paired 5-tree row plots at 3-metre by 3-metre spacing. Mortality was low at both sites and neither site had been thinned.

Based on the amount of variation in wood properties between ramets of Leyland clones in a study involving Silviscan in 2006, it was decided that 10 ramets of each clone would be required at each site. Three Leyland clones (Leighton Green, Green Spire and Naylor's Blue) were chosen at Strathallan forest and the same three Leyland clones and the "Ovensii" clone (*C. lusitanica* x *Ch. nootkatensis*) were chosen at Gwavas forest (Table 2). Trees were chosen as dominants or co-dominants of reasonable form and free from cypress canker.

Table 2. Clones used in the study

Clone name	Code	Female parent	Male parent
Green Spire	GS	<i>Chamaecyparis nootkatensis</i>	<i>Cupressus macrocarpa</i>
Leighton Green	LG	<i>Chamaecyparis nootkatensis</i>	<i>Cupressus macrocarpa</i>
Naylor's Blue	NB	<i>Chamaecyparis nootkatensis</i>	<i>Cupressus macrocarpa</i>
Ovensii	OV	<i>Chamaecyparis nootkatensis</i>	<i>Cupressus lusitanica</i>

METHODS

Taking the Cores

Three bark to bark cores of 12-millimetre diameter were taken at a height of 1.4 metres above ground from each ramet using a standard 12 mm increment corer powered by a motorised drill. The trees at Strathallan were virtually open-grown so had larger diameters than those at Gwavas. The corer could not reach right through the larger trees. A fourth core was taken at Gwavas as part of a proposed Silvscan study to look at microfibril angle changes over time, and the width of each ring was measured on this core.

Measuring, Marking and Photographing the Cores

The cores were measured from the pith, or from the centre of the innermost ring where the pith had been missed, to the heartwood boundary and to the outer edge of the core. The number of rings of sapwood was counted and fractions of a ring were estimated when the heartwood boundary fell within a ring. If the core had missed the pith, this was noted in the remarks with an estimate of how many rings had been missed.

Heartwood sections were marked as the inner 60 millimetres either side of the pith (sections 1 & 2) and outer sections of between 30 and 60 millimetres measured to include the last complete ring of heartwood (sections 3& 4). The number of rings in each section was counted, and if a small branch or compression wood was noticed then it was noted with a rating of severity from 1 to 4 (mild to severe). The measurements were entered onto a spreadsheet, which was later re-arranged to serve as a data entry form for weights before and after the fungal cellar testing.

When the sections in all cores had been marked, the cores were arranged by tree and clone within each site and all cores were photographed with a high-definition 25 megapixel camera. After photographing the cores, the heartwood sections were cut and the cores put into a dehumidifying room at 20° Celsius to dry down to 10% moisture content.

A segment of sapwood was cut from the end of each core to determine wood density.

A *Pinus radiata* sapwood control was also required to check whether the fungi were active. Six outerwood cores were taken from each of five 30-year-old *P. radiata* trees, growing on the SCION campus. The outer ring was not complete when the cores were taken, so this was trimmed off and a 60-millimetre section was cut from the outer end of the core. None of the *P. radiata* sections contained heartwood. A standard Scion untreated *P. radiata* sapwood control (35 x 35 x 7mm) was also included in the trial as a virulence control.

NIR Scanning of the Cores

When the cores were dry, they were packaged up and shipped to CSIRO wood property laboratory in Clayton Australia, where a flat surface was planed on a radial side of each core segment. Each core segment was then mounted onto the NIR spectroscope and NIR scans were made on each millimetre of core. This is part of the FFR research programme.

Placing the Cores in the Fungal Cellars

The core segments were then shipped back to New Zealand and taken to the laboratory. All samples were conditioned to constant weight at 12% equilibrium moisture content (emc) then weighed, packaged and sterilised by exposure to ethylene oxide gas. Using standard in-house "Sutter Trial" procedures, the cores were then placed aseptically into prepared Sutter agar containers. Test fungi used were brown rots *Gloeophyllum trabeum* (BAM Ebw 109) and *Oligoporus placenta* (07/02) and white rot *Trametes versicolor* (CTB 863 A). Incubation was for 6 weeks (brown rot) or 8 weeks (*T. versicolor*) at 26 °C and 75% RH.

Following incubation, cores were cleaned, air dried, reconditioned to constant weight at 12% emc and reweighed. Percentage weight loss for each core was calculated and means were determined for each fungus / treatment combination. A weight loss of no more than 2% is considered acceptable for this type of test.

Data Analysis

The data that were collected furnished two datasets. One contained measurements on the trees and cores, the other contained data on weights of core segments and the percentage weight change after the fungal cellar tests.

The measurement data were analysed using PROC GLM of the SAS statistical package. The significance of differences between means were estimated by the Tukey multiple range test option of PROC GLM. The model considered clone and position of the core segment within the tree to be fixed, and all other effects to be random. Interaction terms were included in the first iterations of the analysis, but were dropped if their effects were not significant.

RESULTS

The initial measurements furnished data on diameter growth, percentage of heartwood by area, rings of heartwood, rings of sapwood and the length of sapwood (Tables 3 & 4). The percentage of heartwood was high for Green Spire Leighton Green and Owensii, but much lower for Naylor's Blue, but some of this could be accounted for by the rather indistinct sapwood/ heartwood boundaries of the Naylor's Blue trees. Rings of Heartwood rings of sapwood and sapwood length all showed the same trend as percentage heartwood.

There was considerable variation in growth within all clones at each site, but clone means were ranked the same at both sites. Site showed a significant growth effect (Table 5), probably due to the wider spacing at the Strathallan site. Sapwood length was much greater at Strathallan, but would also be explained by the wider spacing.

Table 3. Clone means by site

Site	Clone	diameter			Percentage heartwood			Rings of heartwood			Rings of sapwood			Sapwood length (mm)		
		Mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max
G	GS	274 b	236	328	63.5 a	60.0	67.7	13.6 ab	11.4	14.5	6.4 ab	5.5	8.6	27.8 a	16.5	38
G	LG	332 a	263	381	61.2 a	55.0	67.3	12.7 c	11.1	13.6	7.3 b	6.4	8.9	36.1 b	26.0	50
G	NB	258 b	206	300	34.3 b	22.5	41.2	11.5 b	10.6	12.6	8.5 c	7.4	9.4	53.8 c	31.0	82
G	OV	330 a	298	363	65.1 a	55.4	73.2	13.7 a	12.6	14.9	6.3 a	5.1	7.4	31.9 ab	18.5	54
Least sig. diff		38			6.0			0.9			0.9	0.9		7.5		
S	GS	375 ab	235	501	62.3 a	50.0	79.3	14.2 a	12.1	15.8	5.8 a	4.3	7.9	39.4 a	13.0	54
S	LG	427 a	325	493	54.7 a	39.3	65.9	13.2 ab	11.5	14.8	6.8 ab	5.2	8.5	55.0 b	34.0	67
S	NB	336 b	243	444	39.9 b	21.7	56.1	11.8 b	8.3	14.6	8.2 b	5.4	11.7	61.6 b	21.5	94
Least sig. diff		73			9.6			1.5			1.5	1.5		11.3		

Table 4. Clone means over both sites (excluding Owensii)

Clone	diameter			Percentage heartwood			Rings of heartwood			Rings of sapwood			Sapwood length(mm)		
	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max
GS	325 b	235	501	62.9 a	50.0	79.3	13.9 a	11.4	15.8	6.1 a	4.3	8.6	35.0 a	9.0	52.0
LG	380 a	263	493	57.9 a	39.3	67.3	13.0 b	11.1	14.8	7.0 b	5.2	8.9	45.8 ab	30.0	67.0
NB	297 b	206	444	37.1 b	21.7	56.1	11.6 c	8.3	14.6	8.4 c	5.4	11.7	63.0 b	34.5	93.0
	40			25.1			0.8			0.8			23.5		

Table 5. Site means over 3 clones (excluding Owensii)

Site	diameter			Percentage heartwood			Rings of heartwood			Rings of sapwood			Sapwood length (mm)		
	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max
G	288 b	206	381	53.0	22.5	67.7	12.6	10.6	14.5	7.4	5.5	9.4	39.2 a	21.5	73.5
S	379 a	235	501	52.3	21.7	79.3	13.0	8.3	15.8	7.0	4.3	11.7	52.0 b	9.0	93.0
	27			15.0			0.6			0.6			14.0		

The main part of the study was weight loss caused by the three fungi. Mean weight loss is shown in Table 6. The brown rots were considered to have no effect, as weight loss was well within the 2% that has been set as a benchmark. An overall analysis across the clones common to both sites (dropping Owensii) was complicated by the presence of an interaction between fungus and clone, but by dropping out the fungus of least effect (*Oligoporus placenta*), the interaction disappeared.

Weight loss was more pronounced at the Strathallan site and a comparison with other studies showed that the two sites could be placed in different durability classes. This would elevate the wood from the Gwavas site to durability class two, which would enable the wood to be used in outdoor applications. Differences in weight loss due to position within the tree showed slightly less weight loss in the outer heartwood segments, but this was not considered significant.

Table 6. Mean percentage weight loss for clones and *P. radiata* controls by site and fungus

Species	Site	Clone	<i>Gloeophyllum trabeum</i> (brown rot)	<i>Oligoporus placenta</i> (brown rot)	<i>Trametes versicolor</i> (white rot)
Leyland	Gwavas	NB	-0.3	-0.6	0.8
Cypress		LG	-0.3	-0.5	1.0
Cores		GS	-0.4	-0.4	1.1
		OV	-0.6	-0.7	1.2
	Strathallan	NB	-0.1	-0.5	2.3
		LG	-0.1	-0.6	1.7
		GS	0.0	-0.7	1.8
radiata pine (cores)			9.1	19.6	4.0
radiata pine (blocks)			9.9	16.5	8.7

CONCLUSION

Of the three fungi used in the Sutter trial, the white rot fungus (*Trametes versicolor*) caused the greatest weight loss. Weight loss for the two brown rot fungi (*Oligoporus placenta* and *Gloeophyllum trabeum*) was negative, probably because some fungal mycelia had added to the original weight. The control blocks and cores of *P. radiata* confirmed that the fungi were alive and operating at normal efficiency.

Site had the greatest effect, with wood from Strathallan suffering significantly greater weight loss than wood of the same clones from Gwavas. Clones varied in weight loss but not significantly, and position within the tree was also not considered significant. The effect of site could elevate durability from class 3 (moderately durable) at Strathallan to class 2 (durable) at Gwavas if the test had been conducted for a longer timeframe.

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There was some interaction between fungus and site explained by a (non-significant) greater weight gain of the brown rot with least effect (*Oligoporus placenta*) at Strathallan, which went against the trend shown by the other two fungi.

If the testing had been done to European standards 113 (uses a 16 week exposure period) and 350-1, the durability ratings using the above weight loss results would indicate that Hawkes Bay cypress was durable (class 2) and Southland cypress was moderately durable (class 3). Radiata pine is considered not durable (class 5).

Future Work

There will be more data to strengthen the analyses in this report. Density for each tree can be calculated from sapwood core segments and this can be used to correlate with data obtained from the NIR scans, measurement and weight loss data.

REFERENCES

DeBell J. D.; Morrell J.J.; Gartner B. L. 1997: Tropolone content of increment cores as an indicator of decay resistance in western red cedar. Wood and Fiber Science 29(4) Pp 364-369