Technical Report

Heartwood in *Eucalyptus bosistoana* (2009 plantings)

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

The ultimate goal of the NZDFI breeding programme is to exploit variation in quantity and quality of extractive content to identify superior families in terms of heartwood content and quality. The objective of this study was to assess the 2009 Martin *E. bosistoana* breeding trial for heartwood quantity and extractive content – SWP WP062. The data was compared with other breeding trials planted at same site in 2010 or with the same genetics established at Cravens and Lawson in 2009. Site and tree age effects on heartwood features were observed, but could not be disentangled with the available data. This was the last of the 2009 and 2010 *E. bosistoana* breeding trial to be measured for heartwood and the combined data has now been used to select superior families to commence commercial plant production.

INTRODUCTION

A target product of NZDFI is ground-durable timber. NZDFI has established a series of breeding trials to deliver growers healthy plants, which produce good amounts of quality timber. The key wood property is natural durability. Natural durability describes the resistance of wood to decay by fungi and insects. Only heartwood, which contains bioactive extractive compounds, has natural durability (AS5604, 2005).

Heartwood quantity

The heartwood diameter varies within a species at a given age. Heartwood quantity is partly under genetic control (Hillis, 1987). To maximise value of NZDFI plantations, trees with a propensity to produce a large volume of heartwood should be selected in a breeding programme.

Heartwood quality

The measurement of natural durability is resource intensive (Harju & Venäläinen, 2006; Li & Altaner, 2016). The high resource demand prevent this trait from being included in breeding programmes. However, the heartwood extractives are a main factor providing natural durability (Hawley, Fleck, & Richards, 1924). Extractive content is highly variable within *E. bosistoana*, varying at least 10-fold between trees (Sharma, McLaughlin, Altaner, Chauhan, & Walker, 2014; Van Lierde, 2013). As the extractive content can be efficiently measured, NZDFI is selecting genotypes of high extractive content to increase the likelihood of ground-durable timber in the future deployment population.

The objective of this work was to screen the *E. bosistoana* breeding population planted at the Martin site in 2009 for heartwood quantity (diameter) and quality (extractive content).

METHODS

Material

52 families were panted in 2009 in a single tree plot design at Martins, North Canterbury. In total 3750 trees were planted. In March all surviving 2018 trees were assessed for growth and form. In July 2018 the trees with a diameter larger than 30 mm were cored at the base for heartwood assessment using a battery powered 14 mm inner-diameter increment corer.

Sampling

In total 937 cores were assessed for heartwood. Full diameter cores were taken at the bottom of the tree trunk (i.e. ~50 cm height) through the pith.

Heartwood was highlighted by applying a pH indicator (methyl orange) to the core surface in the green state (Figure 1). Heartwood changed colour to pink, while no colour change occurred when applied to sapwood. The total length of the core samples without bark as well as the length of the heartwood was measured in the green state with a ruler. Sapwood diameter was calculated as the difference between the 2 measurements. The radial-tangential surface of the cores was sanded (P 100) to expose a smooth and clean wood surface before NIR spectra were collected with a fibre optics probe (Bruker) every 5 mm along the heartwood. The extractive content was predicted for each spectra using the previously developed model (Li & Altaner, 2016a). Heartwood extractive content for a tree was than calculated as weight average (representing cross sectional stem area) of the individual spectra.

Figure 1 *E. bosistoana* cores stained with methyl orange. Heartwood is highlighted pink.

Data analysis

Data was analysed in R (Team, 2104).

RESULTS

Tree diameter

Summary statistics of core length (under-bark diameter at 0.5 m height) and 2018 DBH measurements (over-bark diameter at breast height) of the trees are given in Table 1. Generally, a good correlation between the two measurements was found (Figure 2) and the correlation was similar to that found earlier in other trials (SWP-T028, SWP-T046). Main factors contributing to differences were:

- taper as measurements were conducted at different heights,
- bark thickness as bark was removed from the cores,
- occasional loss of material (1-10 mm sapwood) while coring,
- double/multiple leaders (above coring height).

The occasional loss of sapwood was not relevant for heartwood rankings. It however, affected the accuracy of sapwood and core length data.

Wood cores

18% of the cores (172/937) did not change in colour on application of methyl orange indicating that they did not contain any heartwood. The mean heartwood diameter was 32.4 mm with a coefficient of variation of 0.71 (Table 1). The average sapwood diameter was 68.6 mm with a lower degree of variation (CV = 0.22).

Table 1 Summary statistic of 8.5-year old *E. bosistoana* heartwood features grown at the 2009 Martin site. CV= coefficient of variation, SD= standard variation, CL = core length, HWD= heartwood diameter, SWD = sapwood diameter.

Variable	Minimum (mm)	Maximum (mm)	Mean (mm)	CV	SD (mm)
DBH (mm)	42	156	92.5	0.24	21.8
CL (mm)	32	174	101.09	0.21	21.4
HWD (mm)	0	107	32.5	0.71	23.1
SWD (mm)	6	124	68.6	0.22	15.4

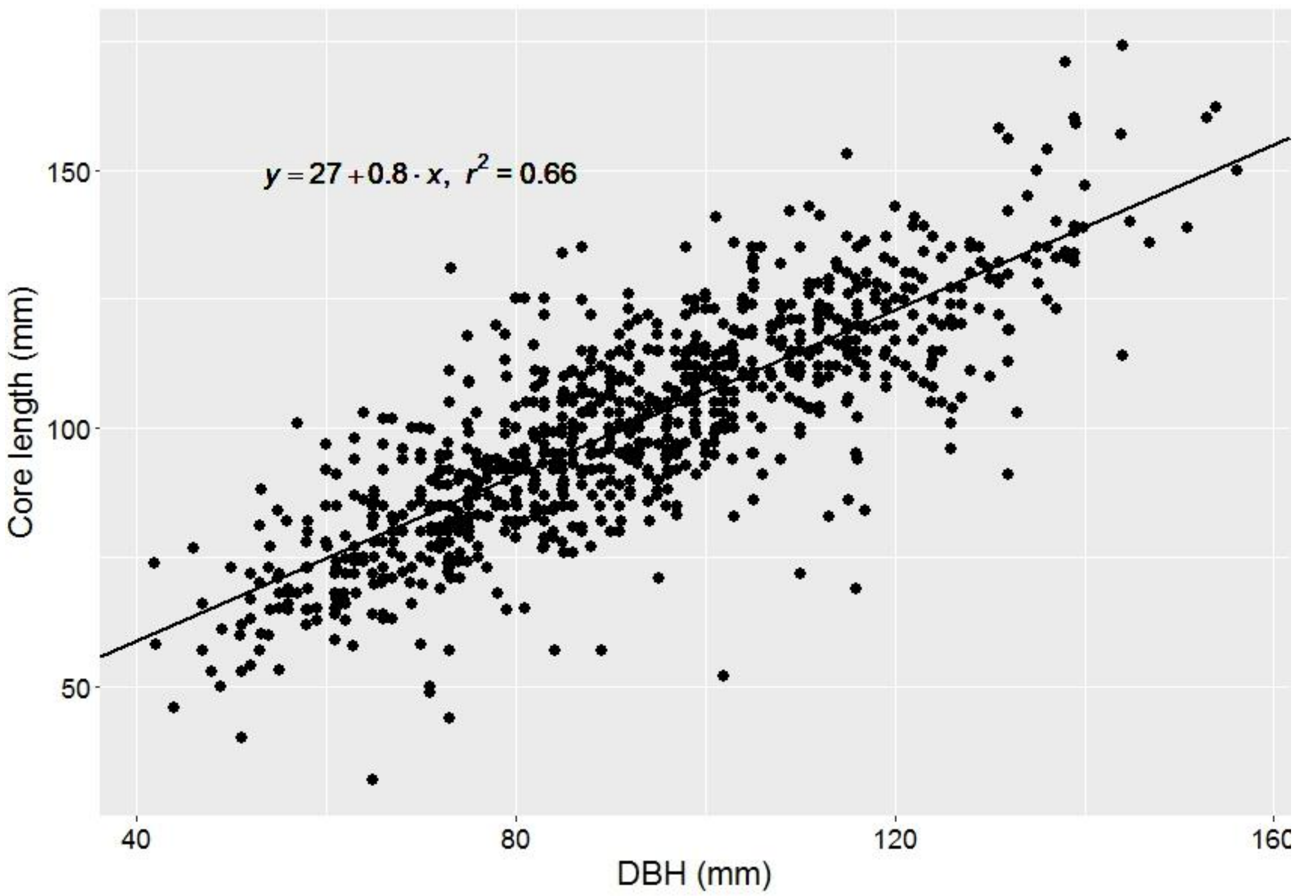

Figure 2 DBH (above-bark) in relation to core length (without bark) at the stem base for 8.5-year old *E. bosistoana* at Martin 2009.

Core length and heartwood diameter

The heartwood diameter was correlated to core length. Larger trees generally have more heartwood. But larger trees with little or no heartwood were also observed (Figure 3). This indicated that the largest trees do not necessarily produce the largest volume of the target product (heartwood). The same result was found in other trials (SWP-T028, SWP-T046). If heartwood volume is under genetic control, the value of the plantations can be increased through selection.

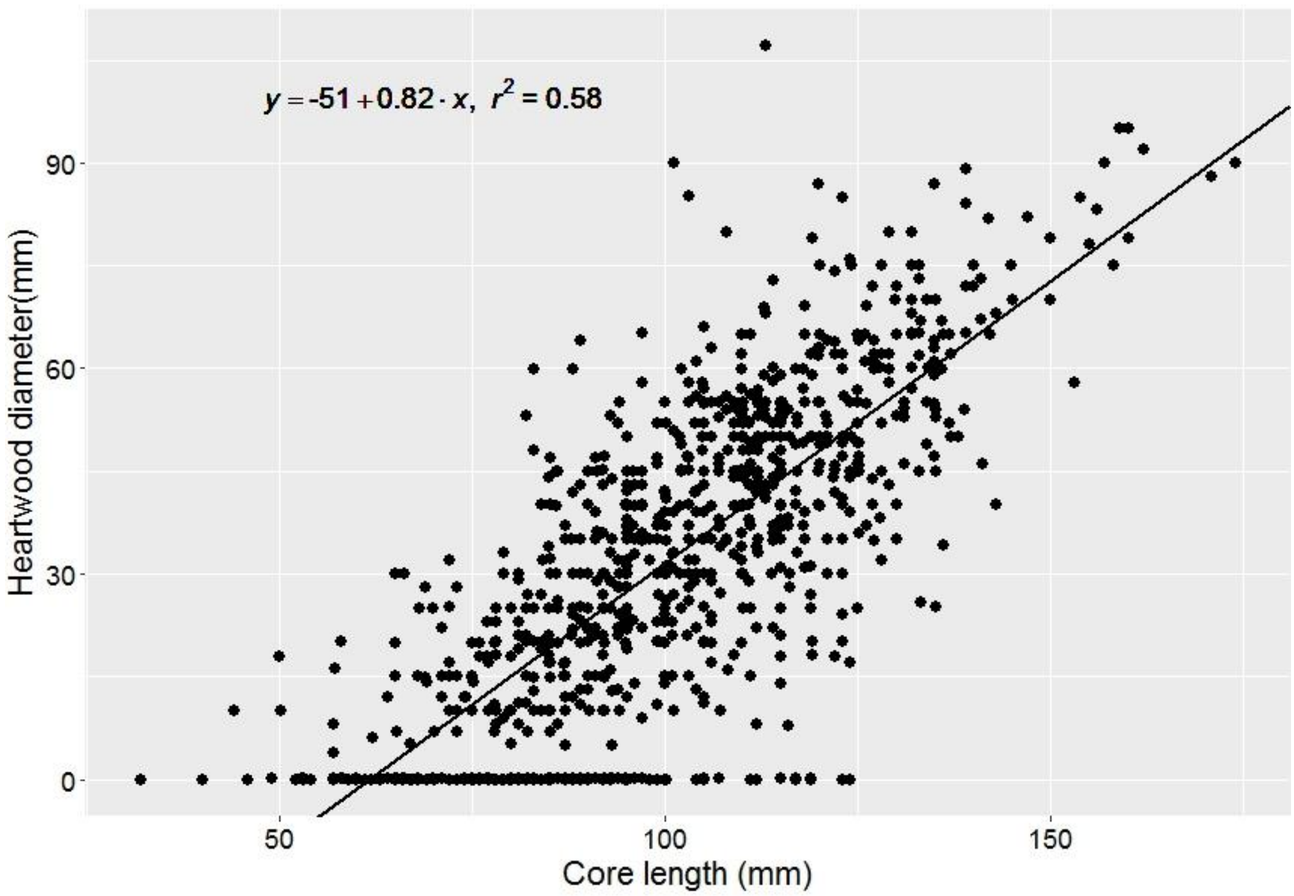

Figure 3 Heartwood diameter in relation to core length for 8.5-year old *E. bosistoana* at Martin 2009.

Heartwood diameter and extractive content (EC)

Heartwood diameter and EC were not strongly correlated (Figure 4) i.e. trees with larger quantities of heartwood did not necessarily have a high amount of extractives. Tress with high extractive content are more likely to have higher durability. It is important to note, that the extractive content showed a large variability ranging from ~1 to 21% (Table 2). This again confirmed earlier findings from other NZDFI *E. bosistoana* breeding trials at Avery, Martin and Craven Road (SWP-T046, T028). The genetic control of this large variability can be exploited to screen for wood quality in terms of heartwood content and quality.

Table 2 Predicted extractive content (NIR) in 8.5-year old *E. bosistoana* heartwood grown at Martins 2009.

	Minimum (mm)	Maximum (mm)	Mean (mm)	CV	SD (mm)
EC (%)	1.44	21.11	10.40	0.29	2.97

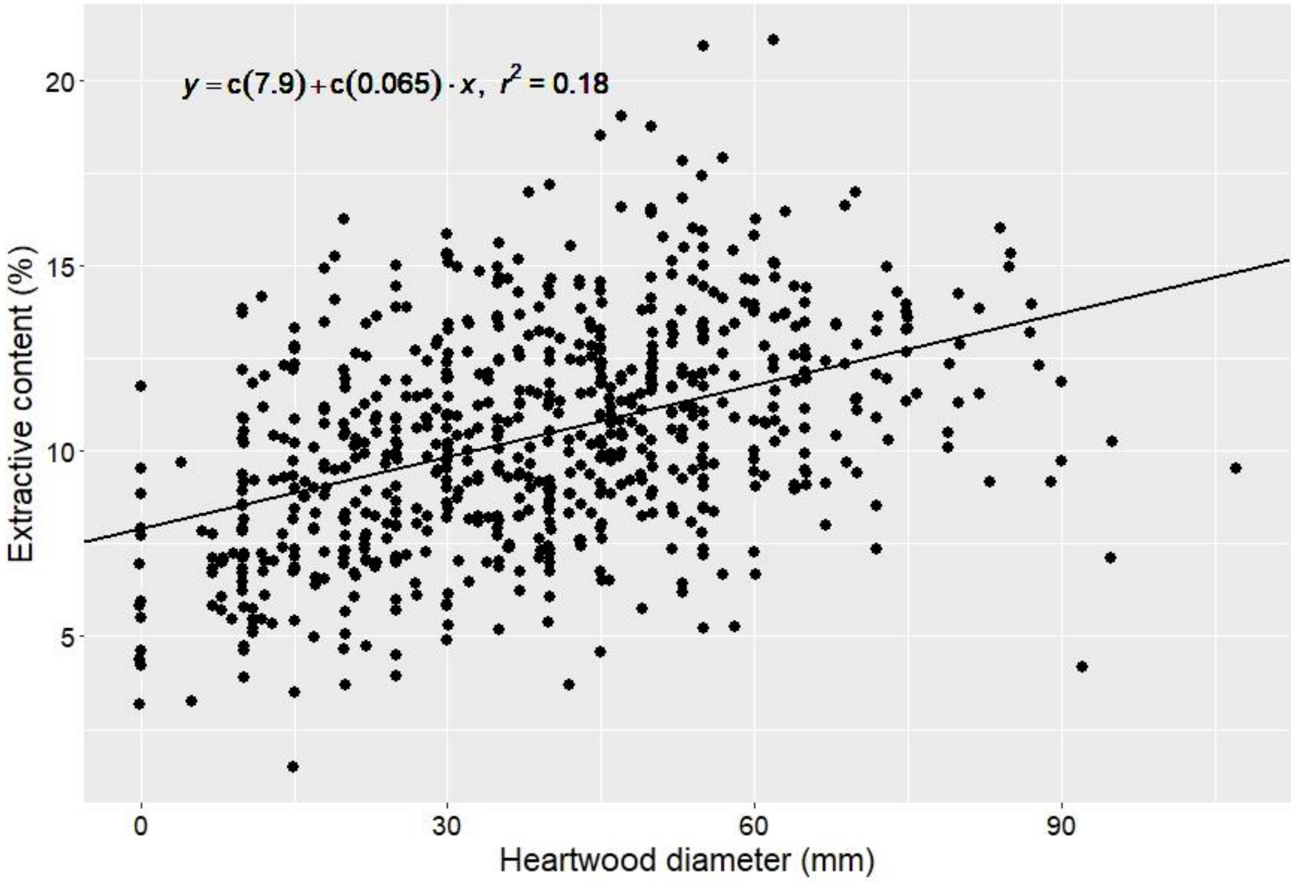

Figure 4 Heartwood diameter in relation to extractive content for 8.5 year old *E. bosistoana* at Martin.

Another trial, set up with different families at same Martin site in 2010, was measured for heartwood quantity and quality at age 6.5 year in 2017. The summary statistics are given in Table 3. All measured features differed significantly between two trials. The difference can be attributed to difference in tree age and genetic makeup, but the magnitude of the two factors cannot be separated as there was no overlap of these two factors between the trials. Consistent with a well described increase of heartwood diameter and extractive content with tree age, the Martin 2009 trial had larger heartwood diameter and higher extractive content as the trees were 2 years older when measured.

Table 3 Summary statistics of heartwood features of *E. bosistoana* breeding trials planted at the Martin site in 2009 and 2010. The two trials had no shared genetics. CV = coefficient of variation, SD = standard deviation, CL= core length, HWD = heartwood diameter, EC= extractive content.

	Tree age when measured (years)	Variables	Minimum (mm)	Maximum (mm)	Mean (mm)	CV	SD (mm)
Martin 2009	8.5	CL (mm)	32	174	101.1	0.21	21.38
		HWD (mm)	0	107	32.5	0.71	23.08
		EXC (%)	1.45	21.12	10.4	0.28	2.97
Martin 2010	6.5	CL (mm)	40	176	84.7	0.27	22.74
		HWD (mm)	0	82	25.2	0.75	18.98
		EC (%)	0	19.75	6.0	0.66	3.97

The Lawson and MDC Cravens *E. bosistoana* breeding trials planted in Marlborough in 2009 shared genetic material with the Martin 2009 trial assessed in this work. These trials were measured in 2017 at the age of 7.5 years. The summary statistics of the measured variables are given in Table 4. Like for growth (CL), heartwood features appeared to be influenced by site factors.

Table 4 Summary statistics of *E. bosistoana* heartwood features in breeding trials with shared genetics planted at Martins, Lawson and MDC Cravens in 2009. CV = coefficient of variation, SD = standard deviation, CL= core length, HWD = heartwood diameter, SWD = sapwood diameter, EC= extractive content.

	Tree Age when measured (years)	Variables	Minimum (mm)	Maximum (mm)	Mean (mm)	CV	SD (mm)
Martin 2009	8.5	CL (mm)	32	174	101	0.21	21.2
		HWD (mm)	0	107	32.3	0.71	22.8
		SWD (mm)	6	124	68.7	0.22	15.2
		EC (%)	3.1	21.1	10.5	0.63	2.9
Lawson 2009	7.5	CL (mm)	40	144	81	0.22	17.9
		HWD (mm)	0	80	15.6	1.19	18.2
		SWD (mm)	15	115	65.6	0.21	13.6
		EC (%)	0	13.3	4.6	0.25	2.7
MDC Cravens 2009	7.5	CL (mm)	27	217	103.6	0.34	34.8
		HWD (mm)	0	113	25	1.00	24.3
		SWD (mm)	2	178	78.6	0.28	22.1
		EC (%)	0	13.1	6.1	0.63	2.7

CONCLUSION

All six 2009 and 2010 *E. bosistoana* breeding trials have now been assessed for heartwood quantity and quality. The data has been used to identify superior families. These are now in commercial propagation via both, grafting into seed orchards as well as clonal propagation from coppice shoots of mother plants.

The data has been uploaded in NZDFI's breeding trial database.

The data will be further analysed in future to elucidate which site factors influence heartwood features by combining them with high resolution maps of site features.

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