Heartwood in *Eucalyptus bosistoana* (2010 plantings)

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Date: June 2017

Publication No: SWP-T028

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INTRODUCTION

As mentioned previously, 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. Heartwood quantity is partly under genetic control (Hillis, 1987). To maximise value of NZDFI plantations, trees which have 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 and Venäläinen, 2006; Li and Altaner, 2016b). High resource demands prevent this trait from being included in breeding programmes. However, the heartwood extractives are a main factor providing natural durability (Hawley et al., 1924). Extractive content is highly variable within *E. bosistoana*, varying at least 10-fold between trees (Sharma et al., 2014; Van Lierde, 2013). As the extractive content can be efficiently measured, NZDFI is selecting genotypes of high extractive content to increase the amount of ground-durable timber in the future deployment population.

The objective of this work is to screen the 2010 *E. bosistoana* breeding population for heartwood quantity (diameter) and quality (extractive content).

METHODS

Material

Eucalyptus bosistoana trees have been planted by NZDFI in 2010 at the ‘Martin’ site in Canterbury and the ‘Craven Road’ site in Marlborough. 41 open-pollinated families were planted in incomplete single-tree-plots. Blocks were 12 m × 10.8 m with 30 trees per plot in a 2.4 m ×1.8 m spacing. Each tree represent one family, and no family was repeated within a block. Trials were thinned and pruned previously. DBH measurements (2017) were available for all trees.

Sampling

A battery powered 14 mm inner-diameter increment corer was used to sample the trees. 650 trees representing 35 families were cored at Craven Road, and 1115 trees repressing 40 families were cored at Martin site. All living trees were cored in both sites. The minimum diameter at Craven Road was 24 mm and 30 mm at Martin. The number of individuals for each family ranged from 6 to 37 at Craven Road and from 7 to 50 at the Martin site. In total 1765 trees cores were collected for analysis. Full diameter cores were taken at the bottom of the tree trunk (i.e. ~50 cm height) through the pith.

Heartwood quantity

Heartwood was highlighted by applying a pH indicator (methyl orange) to the core surface in the green state. Heartwood changed colour to pink while no colour change occurred when applied to sapwood (Figure 1). 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 depth was calculated as the difference between the 2 measurements.

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

Extractive content

The surface of the cores was sanded (P 100) to expose clean wood before NIR spectra were collected with a fibre optics probe (Bruker) on the radial-tangential surface every 5 mm along the heartwood. The extractive content was predicted for each spectra using the previously developed model (Li and Altaner, 2016a). Heartwood extractive content for a tree was than calculated as weight average (representing cross sectional area) of the individual spectra. An alternative measure would be the extractive content at a given radial position.

Data analysis

Data was analysed in R (Team, 2014).

RESULTS

Tree diameter

Core length (under-bark diameter at ~0.5 m height) and 2017 DBH measurements (over-bark diameter at breast height) of the trees were compared. Generally a good correlation between the 2 measurements was found (Figure 2). Data were biased towards larger core length, especially for the Martin site. This can be explained by the fact that many trees at the Martin site had double leaders at breast height but were cored below the stem fork.

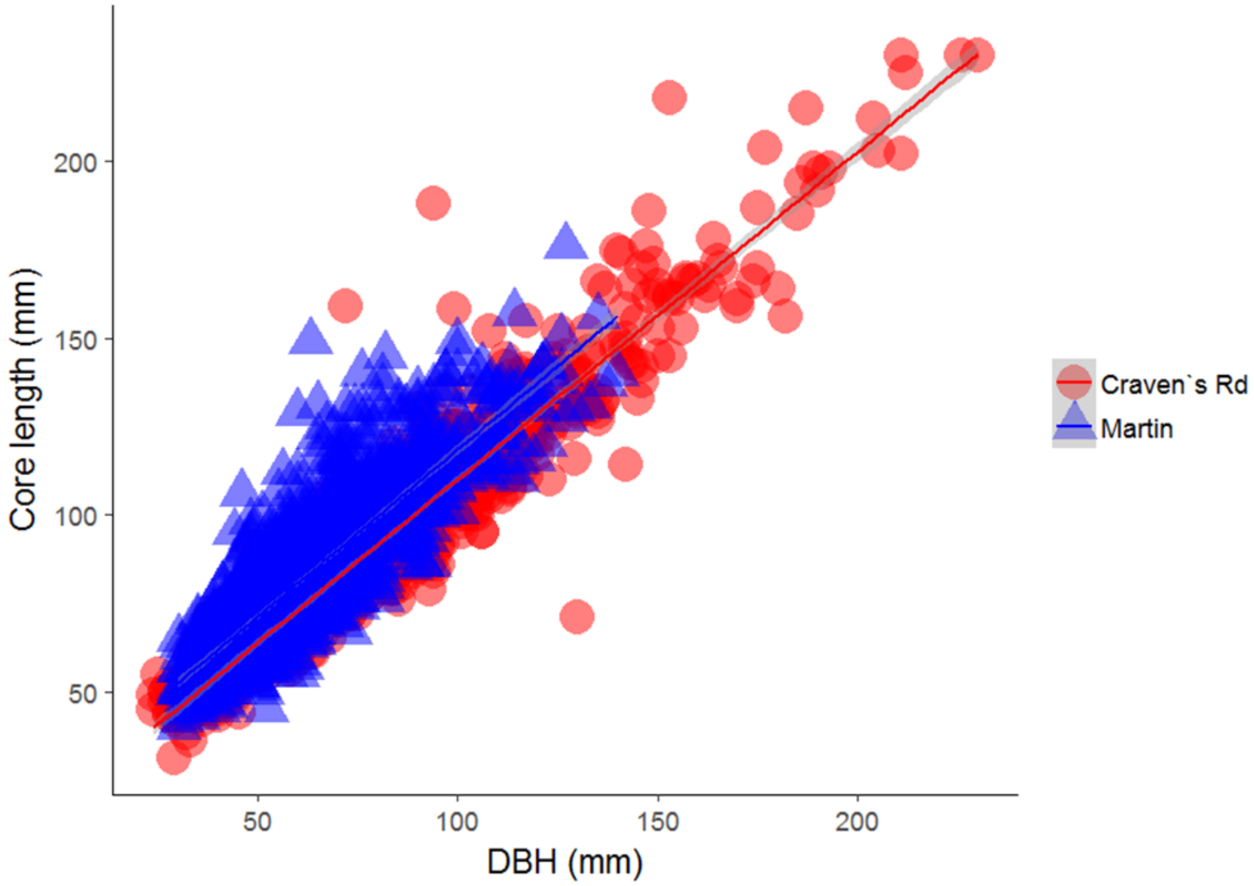

Figure 2: DBH (above-bark) in relation to core length (without bark) at the stem base for 7-year old *E. bosistoana* on 2 sites.

Wood cores

1351 of the 1765 *E. bosistoana* cores (76.54%) contained heartwood at age 7. The mean heartwood diameter over all 2 sites was 26.24 mm with a coefficient of variation (CV) of 0.88 (Table 1). The average sapwood diameter was 63.63 mm with a lower degree of variation. Trees were larger at Craven Road compared to Martin. The additional volume at Craven Road was largely sapwood. Therefore, although the trees were larger, they not more valuable. Variation was similar for the 2 sites, with heartwood diameter showing the largest variation among the measured heartwood properties.

Table 1: Summary statistics of 7-year old *E. bosistoana* heartwood features grown in NZ. CV = coefficient of variation, SD = standard deviation, CL= core length, HWD = heartwood diameter, SWD= sapwood diameter.

		Minimum (mm)	Maximum (mm)	Mean (mm)	CV	SD (mm)
Martin	CL (mm)	40	176	84.71	0.27	22.74
	DBH (mm)	30	140	64.18	0.32	20.45
	HWD (mm)	0	82	25.24	0.75	18.98
	SWD (mm)	20	144	59.47	0.25	14.60
Cravens Road	CL (mm)	31	230	98.73	0.36	35.86
	DBH (mm)	24	230	87.70	0.42	36.68
	HWD (mm)	0	175	27.96	1.04	29.07
	SWD (mm)	18	176	70.77	0.28	20.11
All	CL (mm)	31	230	89.87	0.32	29.07
	DBH (mm)	24	230	72.84	0.41	29.80
	HWD (mm)	0	175	26.24	0.88	23.24
	SWD (mm)	18	176	63.63	0.28	17.70

Core length and heartwood diameter

The heartwood diameter was correlated with core length (Figure 3). Larger trees generally have more heartwood. But large trees with little or no heartwood were also observed. This indicated that the largest trees do not necessarily produce the most target product (heartwood). If heartwood volume is under genetic control the value of the plantations can be increased through selection.

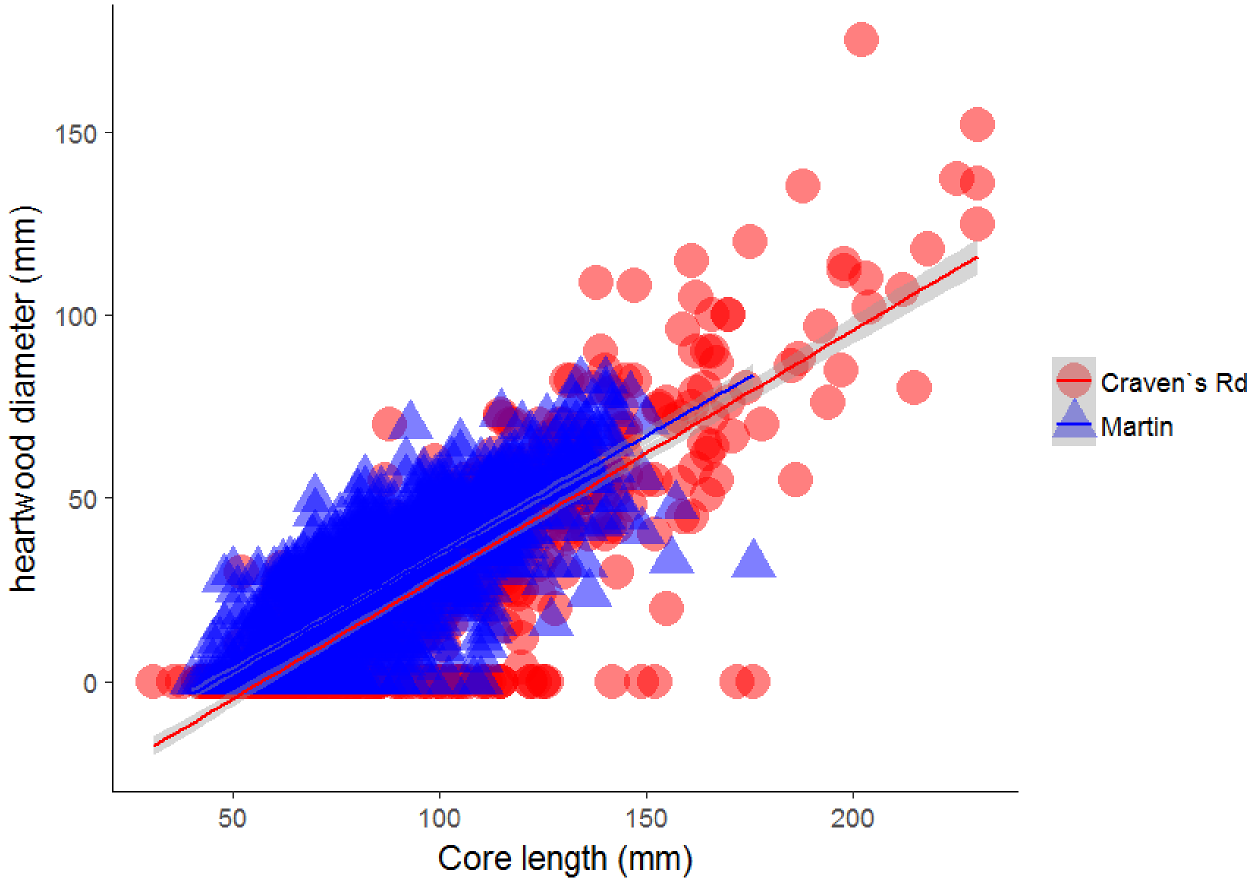

Figure 3: Heartwood diameter in relation to core length for 7-year old *E. bosistoana* on 2 sites.

Heartwood diameter and extractive content

Heartwood diameter and EC were not strongly correlated (Figure 4), i.e. trees with large quantities of heartwood do not necessarily have a high amount of extractives. Trees 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 0 to ~20% (Table 2). This large variability indicates a large variability in wood quality (natural durability). To produce a Class 1 durable product (AS5604, 2005) it is paramount to reduce this variability.

Table 2: predicted extractive content in 7-year old *E. bosistoana* heartwood grown the Martin site.

	Minimum (mm)	Maximum (mm)	Mean (mm)	CV	SD (mm)
EC (%)	0	19.75	6.03	0.66	3.97

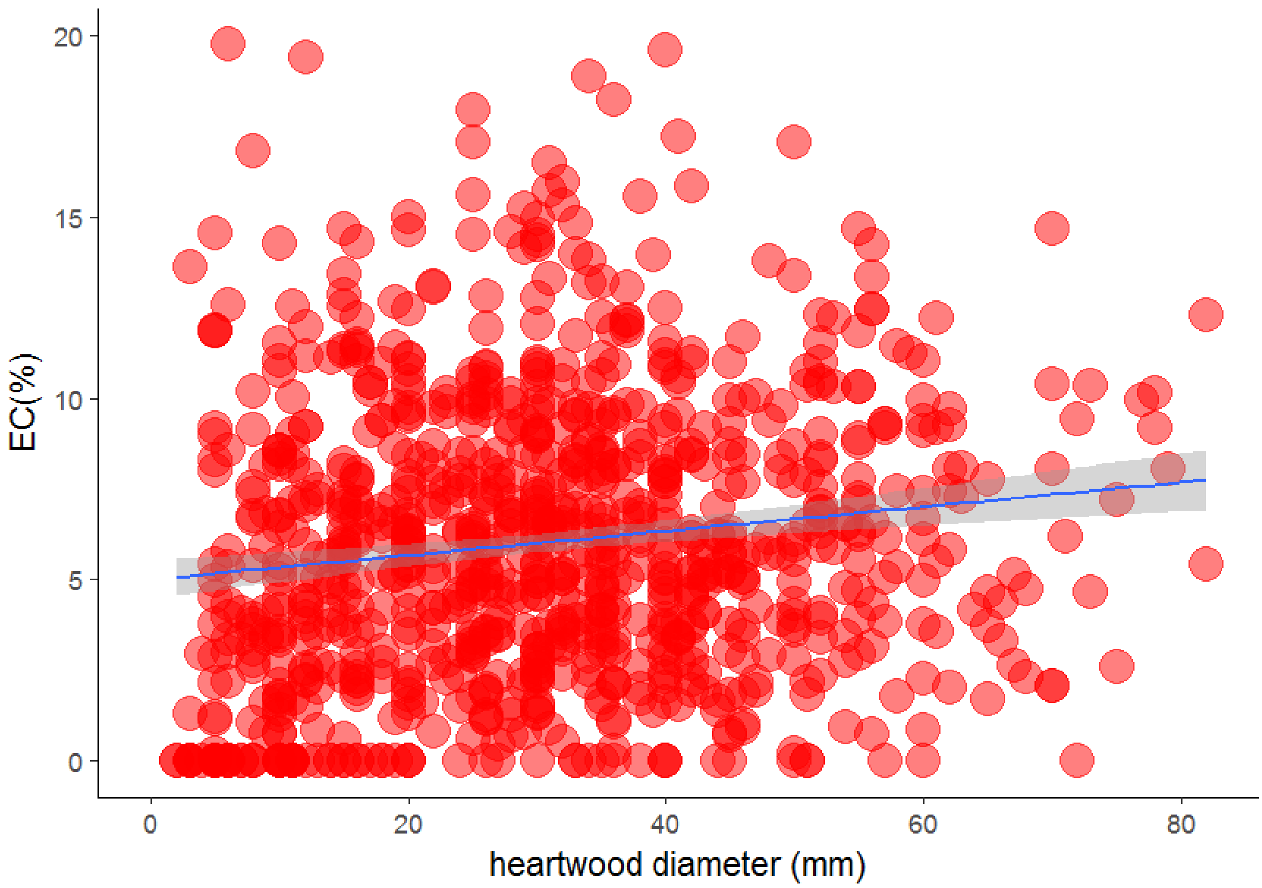

Figure 4: Heartwood diameter in relation to extractive content (EC) for 7-year old *E. bosistoana* (Martin site).

Family differences

Figure 5 shows the 41 assessed *E. bosistoana* families ranked for heartwood diameter at age 7 over both sites. Phenotypic variation in heartwood diameter was observed between the families. This indicated the possibility of genetic selection for heartwood volume. Similar statements can be made for extractive content (Figure 6). Preliminary analysis also showed an environmental / G x E influence as the family rankings of EC varied between the 2 sites.

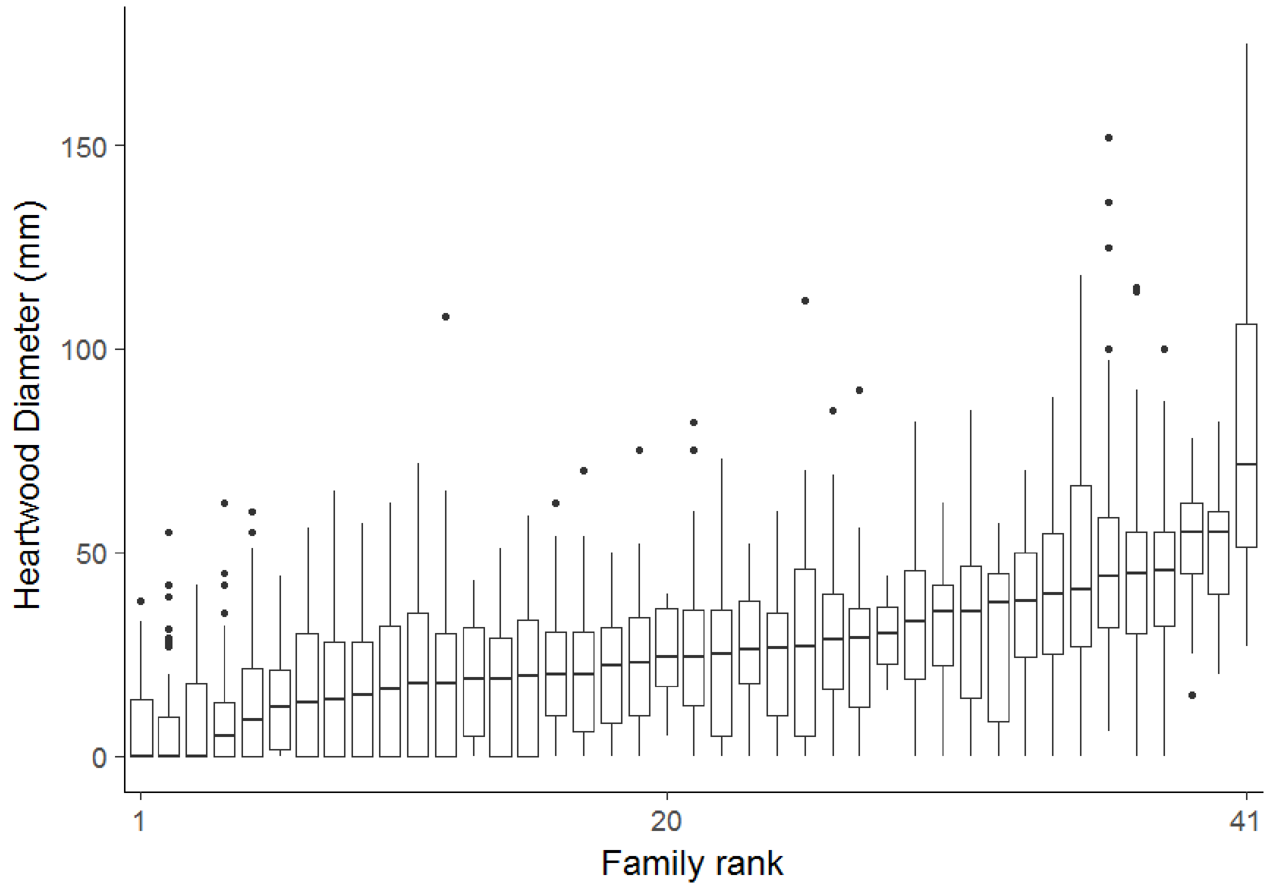

Figure 5: *E. bosistoana* families ranked for heartwood diameter at age 7 on 2 sites.

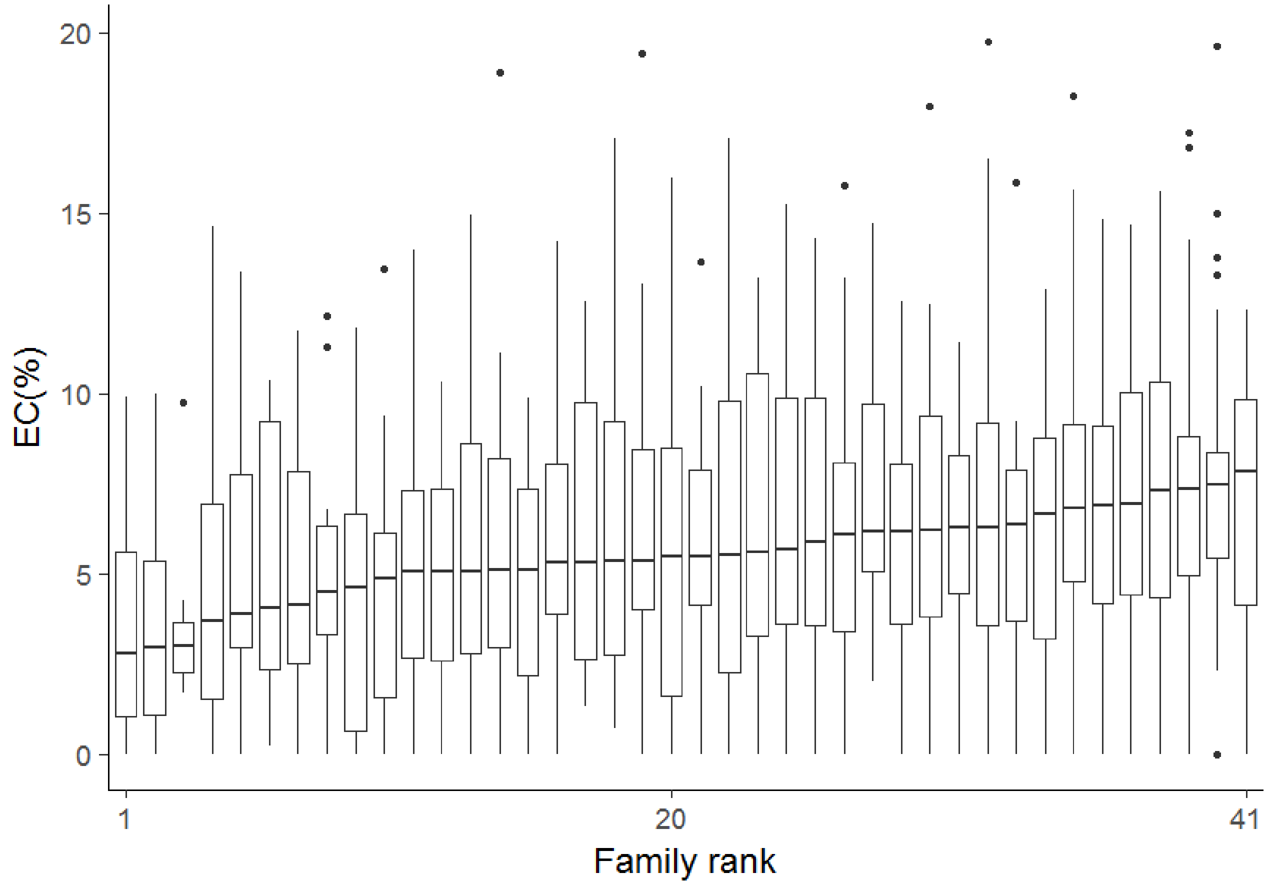

Figure 6: *E. bosistoana* families ranked for extractives content at age 7 on 2 sites.

CONCLUSION

- Variation in heartwood diameter between the families was observed, opening the possibility to improve heartwood diameter in *E. bosistoana* by selection of superior genotypes.
- The data is comparable to that obtained from the 2009 *E. bosistoana* breeding populations (Li and Altaner, 2016b).
- The data has been deposited in NZDFI's database and is now available for future analysis.
- The data will be used to select the 1st generation of improved *E. bosistoana*.
- Preliminary analysis indicated genetic x environment interaction.

At the time of writing this report collecting of NIR spectra from the cores obtained from Craven Road was on-going. This work will be completed shortly.

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