

Early Height Growth of Durable Eucalypt Species

The measurement and analysis of NZDFI demonstration trials planted 2010-2014

SFF Project 13-024 30th June 2016

Introduction

In 2010 and 2011, NZDFI's research team supported twelve landowners in the Bay of Plenty, Gisborne, Hawke's Bay, Wairarapa and Canterbury regions to establish demonstration trials of eleven different durable eucalypt species. The trials were established at thirteen locations to test and assess individual species' performance across varying environmental conditions. These trials were established with funding from NZDFI supporters, landowners and the Ministry of Primary Industries (MPI) Sustainable Farming Fund (SFF) project 10-034.

Then in 2012, NZDFI supported one of the landowners to establish another trial within their northern Hawke's Bay estate which included six durable species. .

In summer 2012/13 NZDFI completed an assessment of height and survival within all the trials planted in 2010 and 2011. The results of this assessment were reported to landowners. Most trials were well established with the exception of two of the trials which had poor survival and growth due to inadequate soil drainage and severe weed competition - these were abandoned. In addition, one of the surviving trials was badly damaged by goats/deer leaving only eight blocks within this site undamaged.

In July 2013, NZDFI commenced another SFF project to extend the research into durable eucalypts by working alongside new landowners to plant new trials. This is SFF project 13-024 and is titled 'Enabling growers to maximise value from planting durable eucalypts'.

This project enabled NZDFI to support five new landowners to plant durable eucalypt trials at five new sites in 2013 followed by one of these landowners, plus another five new landowners, planting trials at seven new sites in 2014.

The number of species represented in the 2013 trials was reduced to six as only six species' seedlings were available for planting that year. However, the number of species was increased to eight in most of the trials planted in 2014.

These new trials were established in Hawke's Bay, Wairarapa and Canterbury regions as well as in Rangitikei and Taumaranui districts (Horizons-Manawatu region); Taupo district and the Nelson region.

During the period November 2015 to June 2016, NZDFI completed an assessment of survival and the height of all live trees within a total of 538 individual trial blocks spread across these 25 sites.

Appendix One is a map showing the location of the NZDFI demonstration trial sites.

This report provides an analysis of all height data recorded for each species within these trial blocks.

Eucalypt species selected for planting in demonstration trials

All eucalypt species selected by NZDFI for research produce timber of high natural durability. Species were also selected based on their proven frost and drought tolerance as demonstrated through NZ farm forester observations or records and/or from observations and records of their occurrence in Australia. For most species, broad-based unimproved seed lots were imported from Australia and root trainer seedlings were propagated for planting into trials.

The species planted in 2010 were *E. argophloia*, *E. bosistoana*, *E. globoidea* and *E. quadrangulata*. In 2011 these were all included along with another seven species; *E. camaldulensis*, *E. cladocalyx*, *E. eugenoides*, *E. longifolia*, *E. macrorhyncha*, *E. notabilis* and *E. tricarpa*, giving a total of eleven.

In 2013 the species planted was reduced to only *E. bosistoana*, *E. camaldulensis*, *E. cladocalyx*, *E. globoidea*, *E. macrorhyncha*, and *E. tricarpa*, but then expanded for the 2014 trials to include *E. longifolia* and *E. quadrangulata*.

Table One below presents the botanical name, common name and durability classifications (ref: Australian Standard AS 5604) for all species planted. In addition to these species, a small number of landowners chose to include trial blocks of other durable eucalypt species. While these other trial blocks were measured, the data have not been included in this report.

Table One: Natural durability classification of species included in NZDFI trials planted 2010-2014

Botanical name	Common name	AS 5604 In ground durability	AS 5604 Above ground
<i>E. argophloia</i> *	Qld western white gum	1	1
<i>E. bosistoana</i>	Coastal grey box	1	1
<i>E. camaldulensis</i>	Red river gum	2	1
<i>E. cladocalyx</i>	Sugar gum	1	1
<i>E. eugenoides</i>	Thinned leaved stringy bark	3	2
<i>E. globoidea</i>	White stringy bark	2	-
<i>E. longifolia</i>	Woollybutt	1	1
<i>E. macrorhyncha</i>	Red stringy bark	3	1
<i>E. notabilis</i>	Blue mountains mahogany	-	-
<i>E. quadrangulata</i>	White topped box	2	2
<i>E. tricarpa</i>	Red ironbark	1	1

Note * durability classification reported in State of Queensland, Department of Agriculture, Fisheries and Forestry, *E. argophloia* fact sheet 2013.

Appendix Two presents a matrix of the species planted at each trial site.

Demonstration trial designs

The objective of these trials is to assess individual species' performance across varying environmental conditions and compare the long term adaptability, form and productivity of each species.

The trials established in 2010, 2011 and 2012 were planted with 49 trees per block in a square spacing of 2.8 m between trees and between rows. At most sites all species were represented and replicated by planting in two or three trial blocks across each site.

The trials established in 2013 and 2014 were planted with 100 trees per block with either 2.8 m or 2.3 m square spacing. At most sites all species were replicated by planting in two trial blocks except at one site in Hawkes Bay where trial block replicates of a number of species were planted at both the closer and wider spacing. Also two sites in Canterbury that were planted in 2014 have only one replicate of each species.

The increase in trial block size from 49 trees to 100 trees was to create larger plots to ensure greater accuracy for measuring stand productivity over a full rotation of up to 30 years for a saw log regime. The inclusion of trial blocks

planted at 2.3 m square spacing is to allow measurement of the development and growth of trees under a short rotation post/pole regime of 15-18 years and to compare these with the performance of trees planted at 2.8 m which are intended to be managed under a saw log regime.

Mean Annual Height Increment (MAHI) Analysis

Measuring early height growth of young trees demonstrates their ability (or lack of) to establish successfully and provides a basis for comparative assessment of early growth rates of each species across many sites. While not every NZDFI trial site/block did establish successfully, there are a large number with partial or full success with some or all species surviving.

From November 2015 to June 2016, NZDFI completed height measurements within most surviving trial blocks of each species at the 25 sites. As the age of trees within the trials varies, the overall analysis of all height measurements has been undertaken by calculating the mean annual height increment (MAHI) i.e. the average height increase per year for each species across all sites.

The MAHI for each species is shown in Table 2 and ranges from 0.98 m for *E. quadrangulata* to 0.56 m for *E. argophloia*.

Table Two: The mean annual height increment (MAHI) for all species based on all height data from 2010-2014 trials

Species	MAHI (metres) across all sites	Species	MAHI (metres) across all sites
<i>E. quadrangulata</i>	0.98	<i>E. macrorhyncha</i>	0.76
<i>E. globoidea</i>	0.91	<i>E. longifolia</i>	0.75
<i>E. cladocalyx</i>	0.87	<i>E. tricarpa</i>	0.66
<i>E. camaldulensis</i>	0.84	<i>E. notabilis</i>	0.62
<i>E. bosistoana</i>	0.80	<i>E. argophloia</i>	0.56
<i>E. eugenioides</i>	0.78		

Because the trials are located across a diversity of sites and regions, landowners need to know the comparative growth rates between the species growing on their trial site.

Furthermore, NZDFI wants to demonstrate the comparative differences between the sites in MAHI of each species. Trial blocks are replicated two to three times at each site and the variation in growth between trial blocks of the same species can be significant. This is due to microsite variation (different aspect, soils, drainage or wind exposure) between the trial blocks combining favorably or unfavorably with the natural genetic variation within the mostly unimproved broad-based seed lots represented in the trial.

A simple measure of the potential effects of microsite and genetics for each species is obtained by calculating the MAHI for the tallest twenty five percent (25%) of the trees at each site and then calculating the percentage difference between this and the MAHI for all heights of all trees.

Appendix 3 includes a table and a graph for each species that presents the MAHI for all trees and the MAHI for the tallest 25% of trees of each species at all sites that were measured.

This analysis shows there is significant variation in the early height growth between the sites. The site with the fastest growth of most species (Site 26) has MAHIs that are as much as three to four times greater than MAHIs of the same species at sites with the slowest height growth.

Significant microsite/genetic variation is also evident at all sites. This is expressed by the percentage difference between the MAHI of all trees of one species compared to the MAHI of the tallest 25% of trees. Some species have less than 20% difference in MAHI on a given site, while for others the difference is over 50%.

These demonstrates the importance of needing to learn where to optimally match these species to sites as well as the fact that there will significant improvement in growth of the species included in NZDFI's tree improvement programme.

Permanent Sample Plot (PSP) establishment and measurement programme completed

The long-term measurement of permanent sample plots (PSPs) is necessary to capture and understand the 'site x species' differences that influence species' performance across the diversity of NZDFI's trial sites. Data from PSPs will provide the basis for site adaptability and potential productivity of each species to be mapped.

Some sites with two to three replicate trial blocks planted per species have wide variation in growth and survival between blocks of the same species due to microsite variation. So, as the trials develop, at least two blocks of each species can be selected within all trial sites and established as PSPs within NZDFI's site register. PSPs can only be established within individual blocks where (i) at least 60% of the original trees planted have survived and (ii) a minimum of 80% of the surviving stems are of sufficient height for the measurement of stem diameter at breast height (DBH being 1.4 m). In addition all surviving trees are measured for height, crown height and central stem formation. Observations of flowering are also recorded which NZDFI plans to analyse and report on separately.

As the NZDFI sites were planted over four years, the first PSPs were established during the 2013/14 summer in some faster growing trials planted in 2010 and 2011. That summer NZDFI also started establishing PSPs in some of the breeding populations as well as some of the older stands of durable eucalypts planted in Marlborough in 2003-2007. By May 2014 there were 102 PSPs established, measured and data recorded within NZDFI site register.

This work continued in the summer of 2014/15 through significant in-kind support from the University of Canterbury with the number of PSPs increasing to 123. The NZDFI mensuration programme from November 2015 to June 2016 included measuring all tree heights to produce the data already analysed in this report. At this time we also completed additional height and diameter re-measurements in the 129 PSPs established in the two previous years. We also established another 70 PSPs. This brings the number of PSPs to a total of 207.

Appendix 4 provides a table of NZDFI's PSPs by region and species.

All blocks of those species selected for NZDFI's tree improvement programme were given priority for PSP establishment and measurement. This includes *E. argophloia*, *E. bosistoana*, *E. globoidea*, *E. quadrangulata* and *E. tricarpa*. Trial blocks of other species were selected in the following order of priority as time and resources permitted during a site visit: *E. cladocalyx*, *E. macrorhyncha*, *E. camaldulensis*, *E. longfolia*, *E. notabilis* and *E. eugenoides*. In addition, a small number of PSPs were established and data recorded in NZDFI's site register for some of the other species of interest that had been planted by several landowners in their own trial blocks.

The establishment of PSPs at NZDFI sites has been significantly assisted by the development and use of individual geo-referenced site maps that display the accurate layout of each NZDFI trial as well as map and number individual trees within each block. These maps allow the NZDFI team to better understand the layout of the trials so that blocks selected for PSP measurement can be found quickly and individual trees accurately identified for measurement.

These site maps have been completed across all NZDFI demonstration trials and breeding populations along with a location map to assist with re-visits to continue measurement. The use of a mini iPad ensures both maps can be viewed on screen and individual tree measurements recorded in a geo-spatial format that aligns with the geo-referenced maps. This has significantly increased accuracy and reduced time required for data entry and processing. As the mini iPad has mobile connectivity data can be sent directly for storage in NZDFI's site register.

Through until June 2016, NZDFI have been using Microsoft Excel as basic database for recording all measurements. However, from July 2016 the transfer of all data will commence into a relational database called Katmandoo,

developed specifically for forest research applications. This will allow all NZDFI data to be entered and accessible by multiple researchers in a format suited to rapid analysis and review.

Future PSP measurement programme

The ongoing measurement of PSPs is essential to capture productivity data that will support development of growth models. Thinning operations and then eventual harvest of the trials offer the opportunity to measure the real value which these high density species offer in terms of carbon sequestration under the Emissions Trading Scheme and to predict the potential value of merchantable posts, poles and saw logs at time of harvest. Felled stems can be measured for taper and form, and total tree biomass could be measured.

Therefore, in the 2016/17 summer NZDFI plan to continue some re-measurement of PSPs with the University of Canterbury support by supporting summer scholarships for UC forestry students. The extent of re-measurement and any establishment of new PSPs will depend on the level of funding that NZDFI's partners, supporters and landowners can provide.

However, NZDFI wants to significantly expand on the success of research effort already completed by continuing to collaborate with our trial landowners to seek funding for a three year research project starting 1 July 2017. This new project will target development of decision support tools/system for new forest growers to successfully match species to site with models to predict productivity and thereby potential value.

A combination of the data from NZDFI's extensive PSP network can be combined with a process-based modelling approach to develop and ground truth models able to be applied to a wide range of sites, ages and environments. Critical to achieving this will be re measurement of PSP's already established and establishing new PSP's in the trials planted in 2013 and 2014.

In addition, as older trials are thinned by landowners, the stem taper of fallen trees can be measured and the data used to develop taper functions for some or all of NZDFI species. The heartwood percentage up the stem can also be measured and total biomass productivity assessed by weighing the entire crown and stem of a sample of thinned trees. Ideally the project will include intensive within- and between-site soil sampling to provide detailed soil mapping of all NZDFI sites that will assist with understanding the significant MAHI differences between the species at different sites.

As NZDFI's trials offer the opportunity for ongoing valuable research to the wider forestry and farm forestry sectors, additional funding will be sought from NZDFI supporters, the NZ Forest Growers' Levy Trust and MPI's Sustainable Farming Fund for this new project to commence from 1st July 2017.

Report contributors:

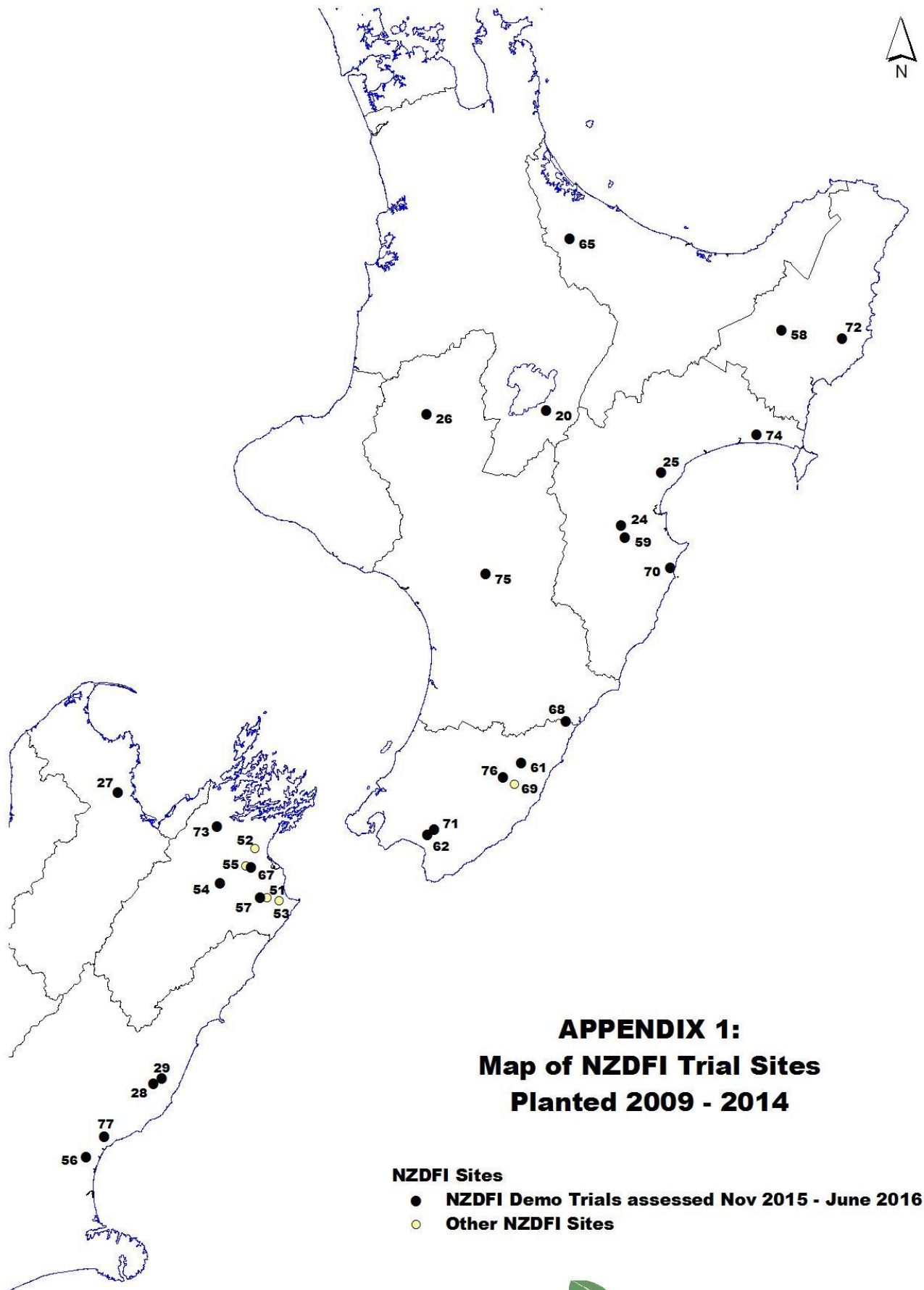
Paul Millen, Jack Burgess, Ruth McConnochie, Roger May and Kevan Buck.

Other NZDFI SFF Project 13-024 reports available:

- Durable Eucalypt Species Selection Update - 15th May 2010
- Report on summer 2013 assessment of 2011 Eucalypt Species/Demonstration Trials
- Report on proposed silvicultural management regimes and permanent sample plot measurement strategy for NZDFI species demonstration trials and breeding populations - 30th November 2013

SUPPORTERS:





**APPENDIX 1:
Map of NZDFI Trial Sites
Planted 2009 - 2014**

NZDFI Sites

- NZDFI Demo Trials assessed Nov 2015 - June 2016
- Other NZDFI Sites