Variation in adaptability and productivity between durable eucalypt species in different New Zealand environments

A comparison of the performance of six eucalypt species planted in 2018 NZDFI demonstration trials.

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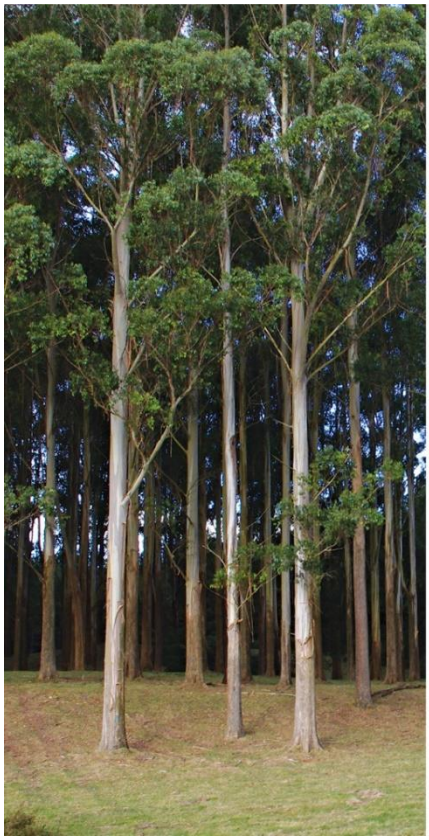

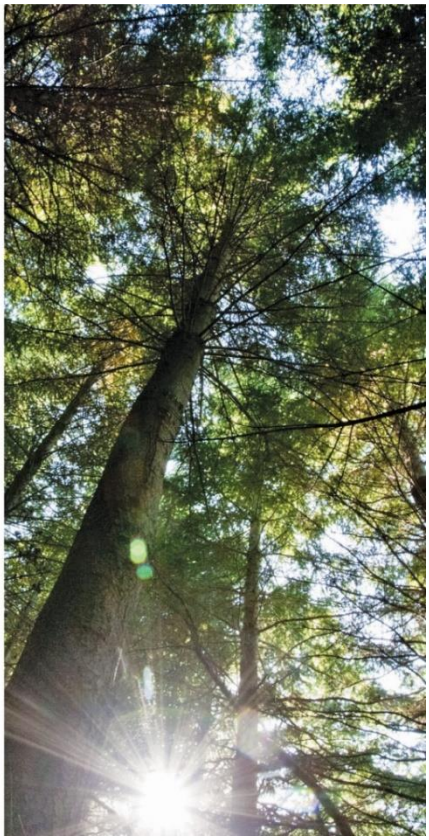

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EXECUTIVE SUMMARY

This report follows on from SWP Technical Report T164: *Variation in adaptability and productivity between durable eucalypt species in different New Zealand environments*[1]. SWP-T164 provides comprehensive results and analysis from NZ Dryland Forest Innovation's fourteen demonstration trials planted between 2011 and 2014, where eleven durable eucalypt species were planted across a range of site types in the North Island and north-eastern South Island.

A further eight demonstration trials were planted in 2018, thanks to funding from the Specialty Wood Products Research Partnership (SWP). These trials were assessed for survival at 12 months and for growth between the ages of 2.8 years and 4.8 years. This report presents results from these assessments.

Six species were included in the 2018 trials, all of which had been planted in earlier trials. The 2018 trials include tree stocks raised from improved and unimproved genetic material, and provide the first quantified expression of genetic gain by NZDFI's tree breeding programme. The trials are testing up to nine different genetic tree stock types and also extend the range of environments under research.

The four main species deployed in the 2018 trials are *E. bosistoana, E. globoidea, E. macrorhyncha* and *E. quadrangulata* and incorporated seedling plants of all four and clonal plants of *E. bosistoana.* In addition, two other class 1 durable species, *E. cladocalyx* and *E. tricar*pa, were planted in a few of these new trials as they had demonstrated their adaptability to extreme dryland sites in the 2011 to 2014 trials.

Overall, the growth measurements show that significant improvements in mean top height/mean annual increment (MTHMAI) have been achieved through selection and site-species matching compared to the 2011-2014 trials. *E. globoidea* has performed consistently well across a range of the 2018 sites, with some exceptionally high growth rates on more temperate sites seen in seedlings selected from NZDFI's Waikakaho seedling seed stand. In addition, selected *E. bosistoana*, *E. macrorhyncha* and *E. quadrangulata* are all exhibiting significantly improved growth rates in the 2018 trials compared with the 2011-2014 series.

The survival assessments confirm the importance of site/species matching for good early survival, especially the avoidance of frost-prone sites for some species.

In summary, the demonstration trials planted in 2011-2014 and 2018 have provided informative data about the growth performance and site adaptability of eleven eucalypt species across a broad range of site types. They have also enabled comparisons of different sources of genetic material, and demonstrated the exciting potential to achieve gains through genetic improvement.

Forest growers can use this knowledge to plant the best genetics on optimal sites where the species will not be affected by adverse climatic or environmental factors.

[1] https://fgr.nz/documents/download/10700?512264193

INTRODUCTION

Background

New Zealand Dryland Forests Innovation[2] (NZDFI) was established as a public/private collaborative initiative in 2008. Its aim was to undertake tree breeding and forestry research to develop genetically improved drought-tolerant eucalypts that produce high-quality naturally ground-durable hardwood. NZDFI have developed a vision for a sustainable durable hardwood industry based on a total of 60,000 hectares of eucalypt forests being established in twelve regional wood-supply catchments centred around future processing hubs (5,000 hectares per catchment) by 2050. Our focus started in geographic regions with less than 1000 mm/yr average rainfall and where a new hardwood forestry option could diversify regional economic development. See Our vision - NZ Dryland Forests Innovation (nzdfi.org.nz)

NZDFI's unique research focus and strategic vision is to deliver improved plants and forestry knowledge to enable growers to select and grow eucalypt species suited to their site. This will enable a new forestry investment opportunity that will diversify Aotearoa New Zealand's future wood supply – that is, to grow eucalypts that will produce high-quality durable timber that meets the requirements of domestic and international markets.

The NZDFI demonstration trial network

NZDFI's breeding, research and development programme centres around a comprehensive network of demonstration trials established across much of the North Island and north-eastern South Island (Fig 1). These trials have been established thanks to the cooperation of landowners who host the trials, and often contribute significantly to their establishment and maintenance.

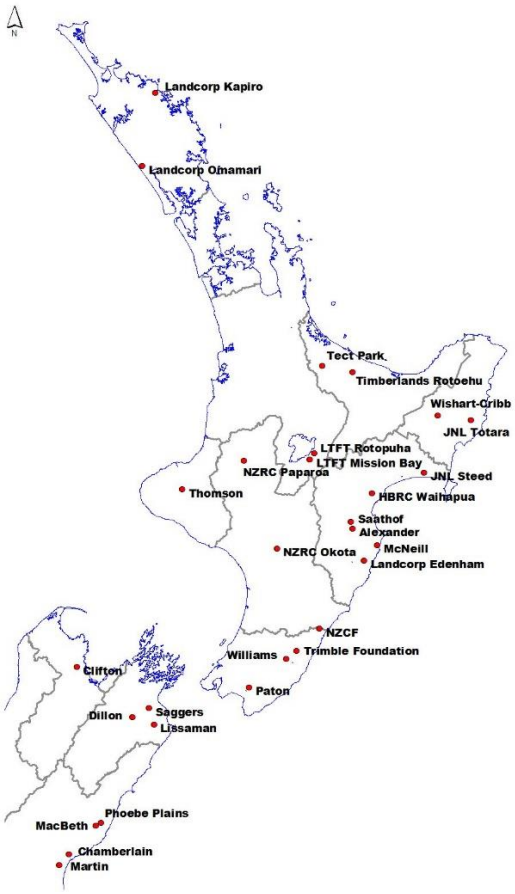

Fig 1: NZDFI demonstration trials planted 2011-2018.

[2] The organisation was called NZ Dryland Forests Initiative until 2023

Fourteen trials were established between 2011 and 2014, across North Island regions, Marlborough and North Canterbury. Full details describing the species choice and other factors about these trials, including results from recent analyses, are provided in SWP Technical Report-T164: *Variation in adaptability and productivity between durable eucalypt species in different New Zealand environments*.

SWP-T164 provides detailed evaluations of variation in tree survival, growth and stem form of eleven eucalypt species that were assessed in three groupings based on their wood durability and colour: class 1 brown heartwood, class 2 and 3 brown heartwood and class 1 and 2 red heartwood. The assessments were made at ages ranging from seven to eleven years. For each species, the relative performance of the seed sources across different trial sites and climatic factors is reported.

The 2018 trial series

A further eight sites were established in 2018, and early evaluations of these trials are covered in this report. Six species were selected, all of which had been planted in earlier trials, and included tree stocks raised from improved and unimproved genetic material.

The 2018 trials extended the range of environments under research and tested up to nine different genetic tree stock types. The four main species deployed in the trials are *E. bosistoana, E. globoidea, E. macrorhyncha* and *E. quadrangulata* and incorporated seedling plants of all four and clonal plants of *E. bosistoana.* In addition, two other class 1 durable species, *E. cladocalyx* and *E. tricar*pa, were planted in a few of these new trials as they had demonstrated their adaptability to extreme dryland sites in the 2011 to 2014 trials.

METHODS

Germplasm planted in the demonstration trials

Seedlings of the following species were propagated at Morgans Rd Nursery, Blenheim for deployment in the trials:

- *E. bosistoana* Family Collection (FFS) – A mix of individual families. The early age 4-year assessment of the NZDFI 2009/10 progeny trials identified the top 10 families and seed in store from these families was combined to produce this seedlot.
- *E. bosistoana* Provenance Forest Stand (PFS) – Commercial seedlot 16/619 Gippsland, SE Australia.
- *E. cladocalyx* Seedling Seed Orchard (SSO) – First generation seed imported from Hamilton Seed Orchard, Australia.
- *E. globoidea* Provenance Forest Stand (PFS) – Commercial seedlot 10/714 Cann River, Australia.
- *E. globoidea* Seedling Seed Stand (SSS) – 20 individual families selected from a mixed provenance planting at Waikakaho, Marlborough.
- *E. macrorhyncha* Seedling Seed Stand (SSS) –12 individual families selected from a mixed provenance planting at Waikakaho, Marlborough.
- E. *quadrangulata* Family Collection (FFS) – A mix of individual families collected from native stands in Australian and planted in the NZDFI 2016 breeding population trials.
- *E. tricarpa* Family Collection (FFS) – Mixed Australian seedlot of 4 families planted in NZDFI 2016 breeding population trials.

Cuttings were propagated at Proseed NZ, Amberley from young seedling coppice grown for the MPI Sustainable Farming Fund Project 407602 and selected for low growth strain. The same families were planted in the 2009 and 2012 NZDFI progeny trials.

- *E. bosistoana* Clonal Cuttings (CCS) – Mix of clones from 60 families.

Site selection and trial design

Eight demonstration trials were planted in collaboration with five landowners, comprising both large corporate landowners and farm foresters (Fig 2). Three of the landowners already host demonstration trials planted in previous years.

Each seedlot was established in the same design used for the 2011 to 2014 trials i.e. a 100-tree block, 10 trees by 10 trees and at a square 2.8m or 2.3m spacing, with two or three replications across the trial site. Trial site descriptions are detailed in Appendix 1.

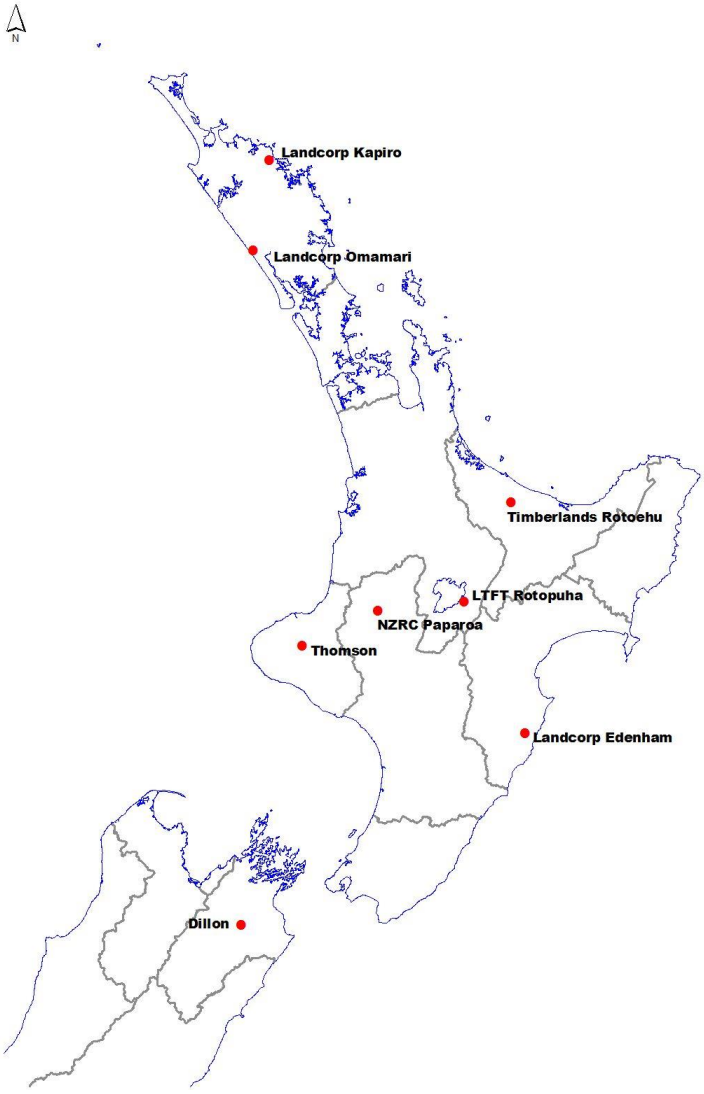

Fig 2: 2018 trial plantings locations.

RESULTS

Survival assessment at 12 months

All sites were visited in the year following planting to assess survival and identify the reason for any significant failures that had occurred.

E. bosistoana is represented by both seedlings and the first clonal plants that were produced by Proseed for testing. Overall, most blocks planted had survival above 90% at all sites except the frost-affected Lake Taupo Forest Trust (LTFT) site and in the frost-affected blocks at the Landcorp Edenham site.

E. cladocalyx is suited to only low rainfall/low humidity sites and is susceptible to frosts exceeding around minus 2 degrees. It was therefore deployed in only three sites, Landcorp's Omamari and Edenham properties and at Dillons in Marlborough. One block in the Edenham trial area was affected by frost and the Dillon site was also slightly frosted following planting with this resulting in an average 42% survival across the three blocks.

E. globoidea **and** ***E. macrorhyncha*** had excellent survival in most trial blocks at all sites. Exceptions were all the blocks in the LTFT site and frost-affected blocks at the Landcorp Edenham site.

E. quadrangulata had survival above 90% with the exception of the LTFT (19%) and Landcorp Edenham (70%) sites.

E. tricarpa is suited to low rainfall/low humidity sites and was therefore deployed in only two sites, Landcorp Edenham (Hawkes Bay) and at Dillons in Marlborough. Overall, excellent survival (90% plus) was recorded in all trial blocks at both sites except in the frost-affected block at the Landcorp Edenham site.

In summary, survival for all species was high except at the LTFT Rotopuha site and the blocks located on the south facing slope at Landcorp Edenham. These Edenham blocks have been excluded from further measurement. However, some of the frosted blocks at LTFT Rotopuha have recovered by coppicing and were included in the 2022 measurement.

Growth measurement

The trials ranged in ages at last measurement from 2.8 to 4.8 years. Tree height and diameter at breast height (DBH) of all surviving trees was recorded. The tallest 25% of trees of each species at all sites measured during 2021-2023 was used to calculate the mean top height annual increment (MTHMAI) i.e. the average height increase per year for each species. This enables a comparison between species at any given site, and between the same species at different sites (Fig 3).

Fig 3: Overall species comparisons for average height growth at all sites.

Not all species and genetic material were planted in every trial planted in 2018, however the average MTHMAI across all sites is shown in Fig 4.

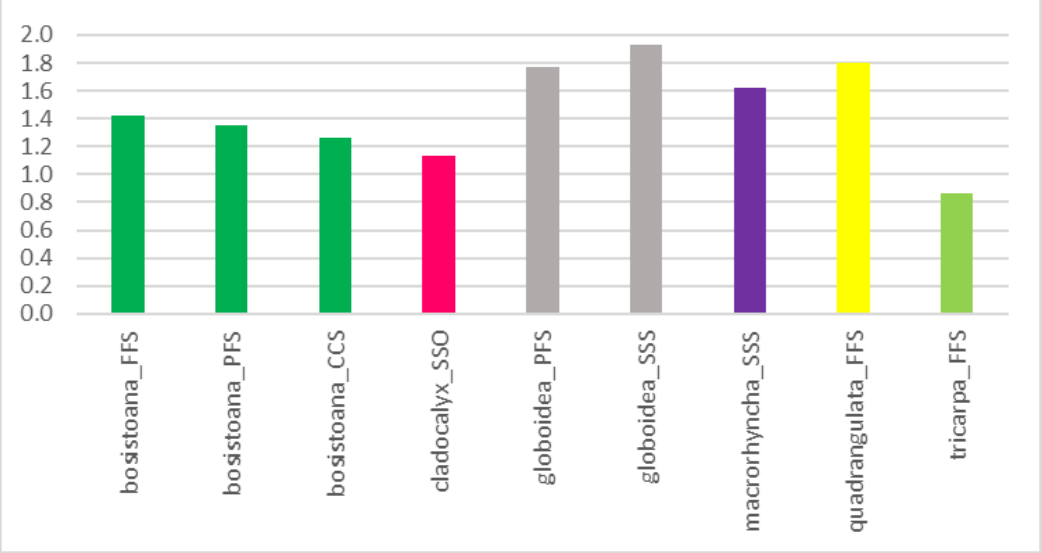

Fig 4: Average Mean Top Height Annual Increment (MTHAI) across all 2018 trial sites.

Comparing these MTHAI results with the 2011-2014 trials.

By comparison the average MTHMAI measured across the 2011-2014 sites reported in SWP T164 for these species are shown in Fig 5. The same seedlots of *E. bosistoana, E. cladocalyx* and *E. globoidea* were planted in the 2011-2014 and 2018 trials.

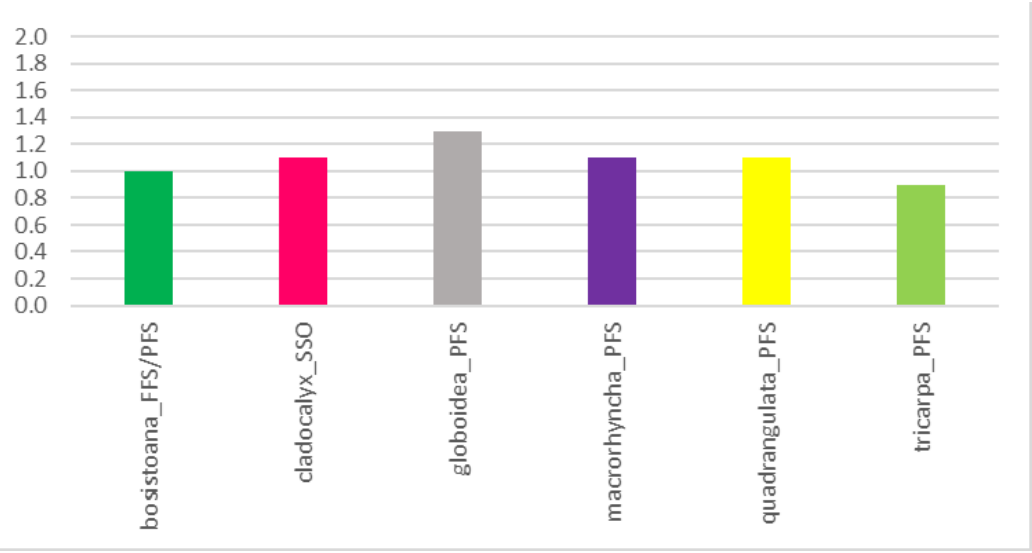

Fig 5: Average Mean Top Height Annual Increment (MTHAI) across all 2011-2014 trial sites.

***E. globoidea*:** the *E. globoidea* seedlot planted in the 2011-2014 trials was a provenance seedlot collected from Cann River in a mix with a Yadboro provenance seedlot in 2011 and a NZ landrace seedlot from Purerua included in the 2013 trials. The seedlot deployed in the 2018 trials was collected from the Waikakaho seedling seed stand planted in 2005 with seedlots collected from four provenance collections across the natural range: Angara, Boyne, Cann River and Yadboro. Outcrossing among these provenances has produced progeny that demonstrate much greater vigour in the 2018 trials.

Average MTHMAI in the 2018 trials is 1.9m compared to 1.7m in the blocks planted with the Cann River provenance seedlot and significantly higher than 1.3m recorded in the 2011-2014 trials. At two of the 2018 trials (NZRC Paparoa and Landcorp Kapiro) *E. globoidea* productivity exceeded 2.5m MTHMAI which is significantly more than 1.9m - the highest previously recorded in the 2014 Hawkes Bay Regional Council (HBRC) Waihapua trial.

E. macrorhyncha: similar outcrossing vigour is demonstrated by the *E. macrorhyncha* 2018 trial blocks planted with a Waikakaho seed stand seedlot that includes a mix of five provenances from across the natural range; Bundarra, Clare, Gunning, Stromlo and Avoca. Outcrossing among these provenances has produced progeny that demonstrate greater vigour than the 2011-2014 trials that were planted with a mix of three provenance collections, Gunning, Stromlo and Uriana.

Average MTHMAI in the 2018 trials is 1.6m compared to 1.1m in the 2011-2014 trials while at the Dillons site a 30% increase in MTHMAI was seen in the 2018 trial compared to the 2011 trial that is alongside on a very similar site.

E. bosistoana: there are three genetic sources of *E. bosistoana* represented in the 2018 trials. The first is a family seedlot (FFS) mix of individual families planted in the NZDFI 2009/10 progeny trials. The early age 4-year assessment of the trials identified the top 10 families and seed in store from these families was combined to produce this seedlot. The second is a commercial seedlot from Gippsland provenance (PFS) imported by Proseed. And the third is mixed family cuttings produced from seedling coppice and selected for low growth strain. There is no difference in the overall means of the three genetic tree stocks of *E. bosistoana* across all sites.

The average MTHMAI (2.4m) of the two seedling seedlots planted at Landcorp Kapiro is the best growth recorded for the species across all sites. This result is an increase in MTHMAI of more than 100% when compared to the average of 1.0m across all sites planted in the 2011-2014 trials. This demonstrates the very large gains in productivity that can be achieved with correct species-site matching.

E. quadrangulata is best suited to higher rainfall and sheltered sites. The seedlot deployed in the 2018 trials is a mix of the families planted in the 2016 progeny trials, whereas the 2011-2014 trials were planted with a provenance seedlot from Mt Skanzi.

MTHMAI in the 2018 trials is 1.8m and this is a significant increase in productivity compared to 1.1m reported for the 2011-2014 trials that include warmer, wetter sites. The maximum MTHMAI recorded is 2.7m at Landcorp Kapiro which significantly exceeds the highest MTHMAI of 1.5m recorded in Alexander (2011) and HBRC Waihapua (2014). MTHMAI at the Landcorp Kapiro and Landcorp Edenham is comparable to Waikakaho *E. globoidea* SSS.

E. cladocalyx was only planted at three sites, Landcorp Omamari, Landcorp Edenham and Dillons. The species is susceptible to frosts and has performed poorly at the Dillons site. There are some well grown trees of *E. cladocalyx* at the Landcorp Edenham site but growth is generally highly variable across the blocks. The same seedlot from Hamilton seed orchard was planted in the 2011-2014 and 2018 trials and MTHMAI, 1.1m is averaged across all sites.

E. tricarpa is the poorest performer overall with a MTHMAI of 0.9m. When located on less frost-prone sites in the 2011-2014 trials *E. tricarpa* recorded a higher MTHMAI of 1.2m. The seedlot planted in the 2018 trials had a narrow genetic base of just 4 families, whereas the 2011-14 trials were planted with the Tucker Box provenance seedlot.

The relationship between diameter at breast height (DBH) and height for each species is shown in Fig 6. Data from these trials will supplement our datasets for growth model development.

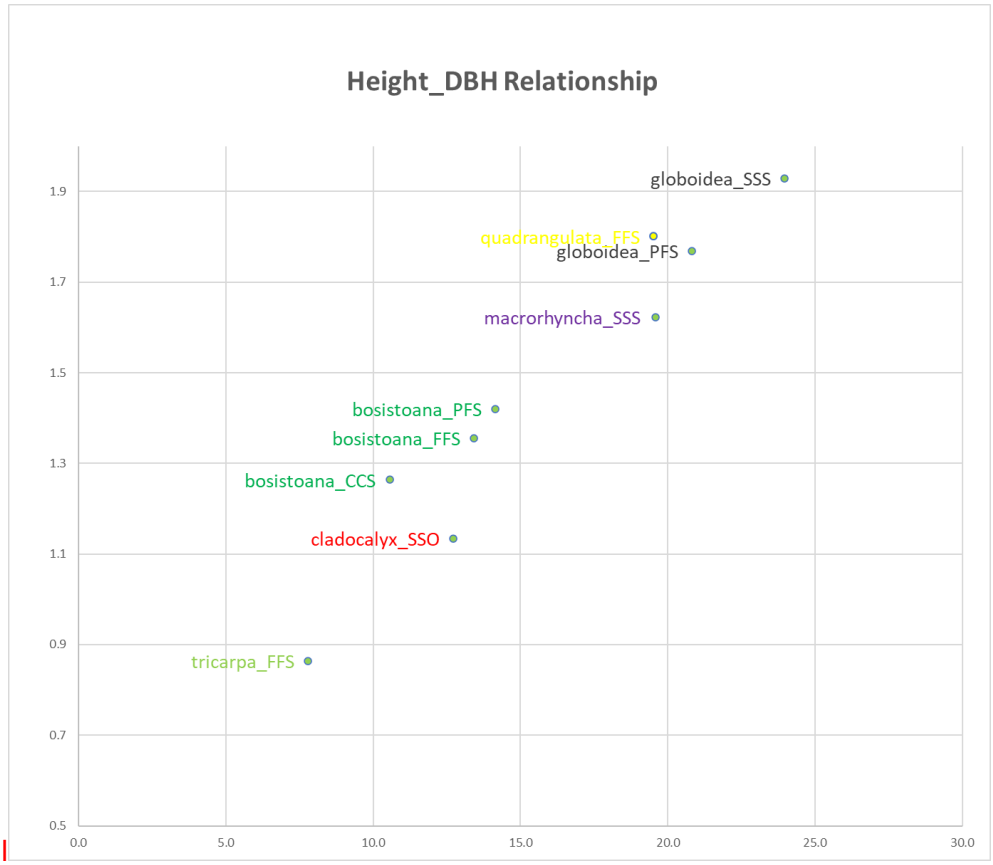

Fig 6: Relationship between diameter at breast height and top height for all species.

DISCUSSION

This series of trials planted in 2018 has expanded the knowledge of species-site adaptability and growth. At the trial sites with higher rainfall and fewer frost days, these temperate eucalypt species are demonstrating outstanding annual height and diameter growth.

E. globoidea is consistently the best species; it is least affected by insect browsing and generally has good stem straightness, light branching and is self-pruning once canopy closure occurs. Survival can be affected on colder sites by frosts during establishment and occasionally in the winter following establishment. Sometimes frost-damaged trees can recover by coppicing. Some toppling was observed in *E. globoidea* blocks at NZRC Paparoa, Landcorp Kapiro and Timberlands Rotoehu.

The results recorded in the trial blocks planted with the *E. globoidea* Waikakaho seedlot demonstrate the first quantified expression of genetic gain by NZDFI's tree breeding programme. Forest growers will achieve increased yield from stands planted with the Waikakaho SSS seedlot.

Since the trials were planted in 2018, NZDFI's breeding programme has started to produce improved *E. globoidea* seed. In 2020 seed was collected from selected individuals of the best performing families in the 2011 breeding population. Seed from 34 elite trees was used to produce 3,000 seedlings established in pedigreed seedling seed stands at five sites in 2021. Early flowering is evident and out crossing within these stands will produce 2nd generation improved seed for future forest plantings. The establishment of PSPs in these stands will provide future data on genetic gain and site productivity.

A large-scale collection from NZDFI's three progeny trials (two sites located in the Wairarapa and one in Marlborough) was undertaken in 2023 to produce a commercial seedlot. In addition, a small seed orchard established by Proseed with grafted clonal plants of elite trees from the breeding population has started production of open pollinated seed with the first commercial seedlot collected in 2023.

These first generation seedlots will produce trees with improved adaptability, productivity, form and wood properties. However, further deployment of genetic gain trials is needed to fully quantify the level of improvement and to demonstrate its value to forest growers of this species.

E. macrorhyncha has performed particularly well at the NZRC Paparoa and Landcorp Edenham sites. The species is self-pruning and the best trees have developed straight single leader stems, have shed all branches from two thirds of the stem and formed a very light crown of well-spaced branches. *E. macrorhyncha* is not suited to sites with poor drainage as demonstrated at the Landcorp Kapiro site or high humidity with poor crown health observed at the Timberlands Rotoehu site.

The Waikakaho *E. macrorhyncha* seedlot deployed in the 2018 trials demonstrates significant genetic gain in growth and this seedlot is recommended for future commercial planting of this species.

E. bosistoana planted in wet areas had acceptable survival and growth. At the Landcorp Kapiro site *E. bosistoana* was planted in water-soaked areas and is achieving good growth and survival. There is no significant difference between the performance of the three different sources of *E. bosistoana* planted in these trials. However, across all sites the best seedlot comprised of a mix of the top individual families identified in the early age 4-year assessment of the NZDFI 2009/10 progeny trials. This seedlot was also planted in the 2011 demonstration trials and a provenance seedlot from Cann River was planted in the 2013/14 trials. The analysis of the data collected in the earlier set of trials did not differentiate between the different seedlots.

E. bosistoana cuttings were planted at five sites and are generally vigorous and healthy. They were propagated at Proseed NZ, Amberley from young seedling coppice grown for the MPI Sustainable Farming Fund Project 407602 and selected for low growth strain. The same families were planted in the 2009 and 2012 NZDFI progeny trials. A large programme to produce *E. bosistoana* cuttings was undertaken at Proseed, Amberley in 2021 as part of NZDFI's One Billion Trees Project. These have been established in progeny trials and genetic gain trials and evaluated alongside a provenance seedlot from Gippsland and a Xylogen-branded seedlot collected from the 2009/10 progeny trials at Cravens Rd, Marlborough.

E. quadrangulata has been seasonally defoliated at all sites but is capable of recovering and achieved growth rates similar to *E. macrorhyncha* on most sites. The MTHMAI in the 2018 trials is 1.8m and this is a significant increase in productivity compared 1.1m reported for the 2011-2014 trials. The seedlot deployed in the 2018 trials is a mix of the families planted in the 2016 progeny trials. An earlier progeny trial was planted in 2011 with only 20 families and selections from these trials have been grafted and established in a clonal seed orchard at Proseed. Growth and form have been measured at both 2016 trial sites, wood property sampling and analysis has been completed at one site only. There is no floral or seed development in the Proseed orchard or the NZDFI trials so the deployment of improved seed is delayed until this commences.

E. cladocalyx and ***E. tricarpa*** were only planted at three and two sites respectively. Both species are susceptible to frosts and have performed poorly at the Dillons site. There are some well-grown trees of *E. cladocalyx* at the Landcorp Edenham site but growth is generally highly variable across the blocks despite the seedlot being sourced from the 1st generation Hamilton seedling seed orchard in Australia. Further genetic improvement of this species could be advanced by selecting elite trees with better frost tolerance and wood properties in the NZDFI demonstration trials and collecting seed for the establishment of a seed stand. The species has developed early and abundant flowering on many individuals at most sites. There has been a recent Victoria State

Government funded R&D project led by Forestry Australia to re-measure the ALRTIG and other *E. cladocalyx* trials and to promote farm forestry in Victoria (Lacy 2023). Productivity models have been developed for *E. cladocalyx*, and NZDFI's demonstration trial data sets could be used to test the model's application in New Zealand.

E. tricarpa is the poorest performer overall with a MTHMAI of 0.9m. The seedlot planted in the 2018 trials had a narrow genetic base of just 4 families. It produces a highly valued red timber and a small breeding population was planted in 2011 and 2017. The 2011 trials planted at two Marlborough sites show some families are performing better than the demonstration trials. When located on less frost-prone sites in the 2011-2014 trials *E. tricarpa* recorded a higher MTHMAI of 1.2m. At the Dillons site it has also been browsed by *Paropsisterna variicollis* (Eucalypt variegated beetle).

Trials planted in 2021

In 2021 another series of demonstration trials was established at three sites, Hawkes Bay, Rotorua and Marlborough. Unfortunately, all three have been impacted by climatic events. The Rotorua site was severely frosted and has been abandoned; the *E. globoidea* blocks in the Marlborough site were also frosted and the Hawkes Bay site has some slip damage following Cyclone Gabrielle. The species planted are *E. bosistoana, E. globoidea, E. quadrangulata, E. cladocalyx* and *E. tricarpa.* The genetic origins are described in Appendix 3 and include the Xylogene-branded genetically improved seedlots of *E. bosistoana* and *E. globoidea. E. quadrangulata* and *E. bosistoana* cuttings propagated from young seedlings of selected top families are also planted in these trials.

CONCLUSIONS

The demonstration trials planted in 2011-2014 and 2018 have provided informative data about species performance across a broad range of site types and comparisons of different sources of genetic material.

A key learning from all the demonstration trials established since 2011 by NZDFI is that there are specific site requirements for each species to achieve optimal growth. Forest growers can use this knowledge to select species to match sites, or at least to plant on sites where any given species should not be affected by adverse climatic or environmental factors.

Appendix 1 of this report shows how the trial sites vary in rainfall, temperatures and geology. The survival and growth of all species planted at the Landcorp Kapiro site and NZRC Paparoa sites is excellent. *E. globoidea, E. macrorhyncha* and *E. quadrangulata* had equally good growth. The Landcorp Omamari site is a highly exposed site with shallow soils and growth across all species was comparatively poor. The LTFT Rotopuha and Dillon sites are lower rainfall, colder sites affected by frosts. The LTFT site is located inland at 565m altitude and on pumice soils.

As the breeding trials age, more individuals begin to produce seed and broaden the outcrossing among the families. Poor performing families can be rogued to further improve the genetic quality of the seed. Further genetic gain trials and silvicultural trials are required to capture these incremental changes in the genetics and quantify the productivity of the best genetic material of these species. The introduction of genomics to derive pedigree and relationship information in the breeding populations will improve breeding values.

Ongoing measurement of the PSPs in these trials will monitor the growth and health of the species as they age and provide a resource for additional studies.

ACKNOWLEDGEMENTS

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- the NZDFI partners; Proseed NZ, University of Canterbury and Marlborough Research Centre Trust
- the MBIE/FGR Specialty Wood Products programme and its industry partners
- Forest Growers Levy Trust
- NZ Farm Forestry Association
- PF Olsen, Pamu/Landcorp and Timberlands personnel that assisted with PSP measurements.

APPENDICES

Appendix 1. Trial site descriptions

Trial description													Silviculture			PSPs and status			Environmental					
Site ID	Site name	Region	Easting	Northing	Site description	Site prep	No. species	No. blocks planted	Tree spacing (m)	Trees per block	Trees per site	Surrounding vegetation	Thinned	Pruned	Event	No. PSPs established	No. PSPs measured 2021-2023	PSP status	No. Frost-free days	Rainfall	Feb max	July min	Altitude (m)	Base Geology
35	Landcorp Kapiro	Northland	1682193	6111552	Grass cover & old pine cutover; easy slope	Pre plant aerial spray	4	15	2.3 x 2.3	100	1500	Eucalypt forest	No	Yes		15	15	Continue measurement	365	1601	23	7	161	basalt
36	Landcorp Omamari	Northland	1667365	6026607	Grass cover; moderate to steep slope	Pre plant aerial spray	5	19	2.8 x 2.8	100	1900	Grassland	No	No		18	18	Continue measurement	364	1209	24	6	95	sandstone
39	LTFT Rotopuha	Waikato	1866688	5694389	Pine cutover; flat to easy slope	Pre plant aerial spray	4	21	2.8 x 2.8	100	2100	Pine forest	No	No	Frost post planting	10	10	Continue measurement	185	1230	21	1	565	ignimbrite
41	Timberlands Rotoehu	Bay of Plenty	1911237	5788789	Pine cutover; moderate slope	Pre plant aerial spray	4	18	variable	100	1800	Eucalypt forest	No	No		18	18	Continue measurement	351	2035	22	1	331	rhyolite
26	NZRC Paparoa	Horizons	1785613	5685723	Grass cover; flat to moderate slope	Pre plant spot spray	4	18	2.8 x 2.8	100	1800	Eucalypt forest	No	Yes		18	18	Continue measurement	256	1563	24	2	153	sandstone
38	Landcorp Edenham	Hawkes Bay	1924532	5570402	Pine cutover; moderate slope	Pre plant aerial spray	6	24	2.3 x 2.3	100	2400	Eucalypt forest	No	Yes	Frost post planting	16	16	Continue measurement	251	1156	22	2	184	gravel
37	Thomson	Taranaki	1714266	5652642	Pine cutover; moderate slope	Pre plant aerial spray	5	10	2.8 x 2.8	100	1000	Eucalypt/pine forest	No	No	Grass/weed competition post planting	8	8	Continue measurement	235	2116	21	3	220	sandstone
54	Dillon	Marlborough	1656217	5389133	Grass cover; moderate slope	Pre plant spot spray	6	21	2.8 x 2.8	100	2100	Grassland	No	No	Frost post planting	20	20	Continue measurement	183	692	23	0	249	gravel

Appendix 2. Mean Top Height Mean Annual Increment summary: 2018 trials

Species	MTHMAI (m)								
	Landcorp Kapiro	Landcorp Omamari	LTFT Rotopuha	Timberlands Rotoehu	NZRC Paparoa	Landcorp Edenham	Thomson	Dillon	**Overall mean**
bosistoana_FFS	2.2	1.1	1.0	1.5	1.6	1.6	1.1	1.3	**1.4**
bosistoana_PFS	2.5	0.9	0.9	1.3	1.8	1.4	1.2	0.9	**1.4**
bosistoana_CCS		1.2	0.8	1.2		1.5		1.6	**1.3**
cladocalyx_SSO		1.1				1.5		0.8	**1.1**
globoidea_PFS		1.3	1.1		2.7	2.2		1.5	**1.8**
globoidea_SSS	2.6	1.1	1.1	2.1	2.8	2.3	1.9	1.6	**1.9**
macrorhyncha_SSS	2.2	1.1	1.1	1.6	2.2	2.1	1.7	1.0	**1.6**
quadrangulata_FFS	2.7	1.0		1.7	2.2	2.2	1.9	0.9	**1.8**
tricarpa_FFS						1.0		0.7	**0.9**

Appendix 3. Genetic origin of stock planted in the 2021 demonstration trial series

Species		Origin
E.globoidea	PFS	Cann River Seedlot 10/714, Glenbervie Seedlot 11/627
E.globoidea	FFS	Ex.Atkinson Progeny Trial. Mix of 35 families collected 2020. Xylogene branded seedlot.
E.bosistoana	PFS	Seedlot 16/619 Noorinbee Gippsland
E.bosistoana	FFS	Ex. Cravens Rd Progeny trial. Mix of 13 families collected 2020. Xylogene branded seedlot. Ex. Clonal SO. Mix of 13 families collected 2020. Xylogene branded seedlot
E.bosistoana	CCS	Clone 3600. Ex. Woodville trial.
E.quadrangulata	PFS	Sheas Nob SF Seedlot 14/713 and Webbs Barn SSO 21/712
E.quadrangulata	CCS	Mix of Clones. Ex Woodville trial
E.cladocalyx	SSO	Hamilton Seed Orchard Seedlot 20/505
E.tricarpa	PFS	Tucker Box Seedlot 21/711