# NZDFI seed collection from elite trees for breeding programme

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# EXECUTIVE SUMMARY

Ongoing tree improvement via traditional intergenerational breeding cycles is the principal focus of NZDFI's research and development strategy.

Collecting seed from elite trees within our trials is one of the necessary steps to achieving this.

Following completion of productivity, form and wood properties assessments, elite families have been identified within NZDFI's *Eucalyptus bosistoana* and *E. globoidea* breeding populations and plus trees selected within these families for seed collection.

Under this project 126 individual tree collections have been made from all three *E. globoidea* progeny trials planted in 2011 including:

1. 73 seedlots collected at the Atkinson trial located in Wairarapa.

2. 8 seedlots collected at Juken NZ's Ngaumu trial located in Wairarapa.

3. 61 seedlots collected at the Avery trial located in Marlborough.

These seedlots are being held in storage by Proseed for future deployment in 2nd generation progeny trials along with a bulk seedlot of surplus seed combined for commercial deployment by NZDFI under the XyloGene brand should there be demand.

There have also been 23 individual seedlots collected from a mix of families within the 2009 & 2010 *E. bosistoana/melliodora* progeny trial located at Marlborough District Council's Cravens Road reserve. These have been delivered to Morgans Road to propagate seedlings so that a taxonomic evaluation can be made for any phenotypic hybrids.

*E. macrorhyncha* has been extensively tested in NZDFI demonstration trials and has proven its adaptability in cold and dry environments. These trials were deployed with a mix of native (Australian) forest genetics. Under a separate project (ITP-FN001) some of these trials have been re-assessed. A selection of 36 plus trees producing seed were identified across seven sites and individual collections made. These could be deployed to establish one or two sites with second-generation NZ landrace seedling seed stands as an immediate low-cost step to providing a future seed source with moderate genetic improvement. The seedlots will also be stored for possible deployment in a future breeding programme.

# INTRODUCTION

Tree improvement via traditional intergenerational breeding cycles to produce genetically improved seedlings is the principal focus of NZDFI's research and development strategy. Collecting seed from elite trees within our trials is one of the necessary steps to achieving this.

Selecting elite trees is based on:

1. **Capturing as much variability as possible**. NZDFI commissioned extensive seed collections and imports from the Australian natural (unimproved) populations to establish broad-based breeding populations. The natural populations of most eucalypt species are highly variable with a propensity for hybridising and selfing. These large family collections are being rogued to remove poor performing individuals and families with selections of elite families/trees being made to advance a second generation.

2. **Broadening the adaptability of eucalypts**. NZDFI has tested species over multiple environments to evaluate genetics x environment and elite genotypes have been selected that are productive across a broad range of NZ environments.

3. **Optimising genetic diversity for next breeding cycle**. The age of sexual maturity of eucalypts is variable both between families and within families. The onset of anthesis and subsequent seed production can also be seasonally sporadic. A high representation of families must flower together with weather conditions that favour the dispersal of pollen by insects to ensure outcrossing. Successive annual collections of seed from elite trees are required.

# METHODS

## Progeny trials converted to seed orchards

Following completion of productivity, form and wood properties assessments, elite families have been identified within NZDFI's *Eucalyptus bosistoana* and *E. globoidea* breeding populations with five progeny trials under management as seedling seed stands.

### *Eucalyptus globoidea* breeding population - established 2011

Three sites planted in 2011 make up this breeding population. These have been assessed and thinned at different ages in response to the variable growth between and within each site.

The Atkinson site, in southern Wairarapa, is ex-pasture with the trial planted on a fertile river terrace slope. There were 8,640 trees planted representing 144 families. The trial was assessed and thinned in stages between 2015 and 2021.

The Avery site is located south of Seddon, Marlborough, on a steep eroding ex-pasture hill slope characteristically named Poverty Knob by the landowner as it is drought prone and has low productivity. There were 10,728 trees planted representing 161 families. There was a two-year drought following planting resulting in losses with 8% of trial blocks being subsequently abandoned. The trial was assessed and thinned in 2021.

The Juken NZ Ngaumu Forest site is located east of Masterton on a north facing hill slope that was a pine cutover and root raked to accommodate the design of trial blocks. There were 7,200 trees planted representing 113 families. Both poor air drainage and frost at the bottom of the slope impacted on survival across 30% of the trial blocks. These were excluded from the trial assessment completed in 2018 prior to thinning and pruning of the entire trial by Juken NZ.

In 2021 a full trait analysis was completed with the results showing a good correlation of family performance across all three *E. globoidea* progeny trials. This analysis ranked all families and the top 20 were selected for seed collection. Elite trees from these top ranked families were identified at each trial site.

This included 177 elite trees at the Atkinson progeny trial, 124 at Avery and 77 at Ngaumu. In March 2023, further analysis was undertaken to identify 'outliers' – i.e. are elite trees within low ranked families. There were 8 identified in the Atkinson trial and 17 identified in the Avery trial.

This project included making collections in all three of these *E. globoidea* progeny trials of individual seedlots from elite trees producing seed.

### *Eucalyptus bosistoana* breeding population – established 2009 & 2010

There are two of six *E. bosistoana* progeny trials established at the Marlborough District Council Craven Road reserve site in 2009 and 2010. These are alongside each other on an undulating river reserve within the floodway of the Wairau River. A total of 5,250 trees were planted representing 93 families. An early frost severely impacted on survival across 25% of the 2009 trial blocks. The surviving trial blocks were assessed and thinned twice before a third assessment was undertaken in September 2019 followed by thinning in January 2020.

To assist NZDFI in planning its breeding programme for *E. bosistoana*, a University of Canterbury PhD student has recently completed a study of genetic relatedness within NZDFI's *E. bosistoana* breeding populations. The need for this was apparent when some families planted in 2010 were observed to be displaying very different morphology and slower growth compared to those planted in 2009.

The study, which used genetic markers and taxonomy, found that the 2010 families displaying different morphology are in fact *E. melliodora* (Yellow box); also that some 2009 families are natural hybrids between the two species*. E. melliodora* is an abundant eucalypt species in the open forests and woodlands of eastern New South Wales, where these families were inadvertently originally collected. *E. melliodora* produces a class 1 durable hardwood that is termite resistant. It has been used for heavy engineering construction, poles, sleepers, fencing and firewood. It is also prized for producing high quality honey.

The first seed collected from a mix of the 2009 and 2010 trees was sown to produce seedlings that were established in a trial in 2021. The seedlings displayed either *E. bosistoana* or *E. melliodora* morphology and a trial measurement in January 2023 assessed a 40:60 mix. It is not clear from Proseed records if the seed sown included collections from trees that have recently been genotyped as *E. melliodora.* Also, as there are naturally occurring hybrids, there is a possibility that outcrossing occurred between the species within the breeding population and produced viable hybrid seed. There is no seed remaining from the earlier seedlot.

Therefore, this current project included collecting individual seedlots from a mix of individuals of both the *E. bosistoana* or *E. melliodora* families across both the 2009 and 2010 progeny trials.

### *Eucalyptus macrorhyncha* – NZDFI demonstration trials/PSPs

*E. macrorhyncha* was first identified twenty years ago as a potential NZ plantation species and was subsequently established in a succession of NZDFI regional demonstration trials. These trials have revealed that *E. macrorhyncha* has good site versatility and high natural insect tolerance. Australian publications report the species produces a class 2-3 pink-brown hardwood useful for above ground applications, and flowers in autumn producing nectar and pollen for bees and native birds. Selection and improvement of *E. macrorhyncha* could diversify and extend planting of durable hardwood forests to colder dry NZ environments.

Under SWP WP200 NZDFI planned a two-stage project to evaluate the plantation potential of *E. macrorhyncha* for NZ environments and to identify individual candidates for inclusion in a future breeding programme. During stage one, conducted during March–August 2023, trials were visited and candidate trees carrying mature seed were identified for collection.

**Seed collection – all species**

Seed was collected by cutting off branches using a pole saw and then stripping the seed capsules from the branches. A ladder was used at some sites to make collections from tall trees.

Individual plus tree collections were dried in bins then the seed extracted and delivered to Proseed for cleaning, weighing and storage.

**Figure 1.** Collection being made from an 18-year-old *E. macrorhyncha* plus tree in MRF Waikakaho trial, Marlborough

**Figure 2.** Collection being made from a 12-year-old *E. globoidea* plus tree in Atkinson trial, southern Wairarapa

# RESULTS

1. Atkinson 2011 *E. globoidea* elite tree seed collection completed – 73 seedlots collected (milestone target 70). Seed was extracted, bagged and delivered to Proseed. Proseed has cleaned individual seedlots and put into storage 3-5 g of seed for future second generation progeny trials. The surplus has been combined into a bulk seedlot for commercial deployment by NZDFI under the XyloGene brand.

2. Juken NZ Ngaumu 2011 *E. globoidea* elite trees marked up and seed collection completed – 8 seedlots collected (milestone target 30). All candidate seed trees were checked and many had unripe seed. Seed was extracted, bagged and delivered to Proseed. Proseed has cleaned individual seedlots and put into storage 3-5 g of seed for future second generation progeny trials. The surplus has been combined into a bulk seedlot for commercial deployment by NZDFI under the XyloGene brand.

3. Avery 2011 *E. globoidea* elite tree seed collection completed – 61 seedlots collected (milestone target 45). Seed was extracted, bagged and delivered to Proseed. Proseed has cleaned individual seedlots and put into storage 3-5 g of seed for future second generation progeny trials. The surplus has been combined into a bulk seedlot for commercial deployment by NZDFI under the XyloGene brand.

   There have been a total of 126 *E. globoidea* seedlots collected across the 2011 breeding population. Based on a germination rate of 100 viables per gram these individual seedlots could be used to produce over 300 seedlings for selection of between 150-200 first grade plantable seedlings for pedigreed deployment.

   The bulk *E. globoidea* XG seedlot collected is a total of 9.525 kg. This is being held in storage by Proseed for sale should there be demand for improved seed by forest growers and nurseries. Based on successful germination of 100 viables per gram and a 70% nursery factor, this seed could produce around 650,000 first grade plantable seedlings.

4. MDC Cravens 2009/2010 *E. bosistoana/melliodora* collection – 23 seedlots collected (milestone target 20). 13 seedlots from 9 families of *E. bosistoana* collected and 10 seedlots from 7 families of *E. melliodora* collected. Seed has been extracted, bagged and delivered to Morgans Road to propagate seedlings for taxonomic phenotypic evaluation.

5. *E. macrorhyncha* candidate tree collections – 36 seedlots from 7 sites. These are listed in Appendix 1. Seed was extracted and weighed by Proseed in October. A total of 1.8 kg of seed was collected. Based on a germination rate of 40 viables per gram, up to 9 grams of each seedlot (a total of approximately 300 grams) have been put into storage by Proseed for:
   a. Potential deployment of seedling seed stands.
   b. Potential deployment in pedigreed breeding trials.
   c. Potential deployment in silvicultural trials.

   The remaining 1.5 kg of seed has been combined into a bulk seedlot for sale if there is demand by growers for this species. Based on successful germination of 40 viables per gram and a 70% nursery factor, this seed could produce around 42,000 first grade plantable seedlings.

# CONCLUSION

## Further Work

1. *E. globoidea* – a second generation breeding population is planned for future establishment once sufficient seed from elite trees from the top families has been collected. However, some of the seedlots collected will be used by Proseed staff this coming spring to produce root stock to attempt further grafting of ortet selections to bulk up the seed orchard.

2. *E. bosistoana/melliodora* – Morgans Road will propagate seedlings for a taxonomic evaluation of the phenotypes for any hybrids. If any new hybrids are produced, then these could be checked using genomic markers.

3. *E. macrorhyncha* – plus tree collections could be deployed to establish one or two sites with second generation NZ landrace seedling seed stands that can be rogued prior to flowering and producing seed. This could be an immediate low-cost step to providing a future seed source with moderate genetic improvement.

   The plus tree collections could be deployed in silvicultural trials that would also provide data for future development of growth models.

   The individual seedlots stored could be included in future deployment of a New Zealand breeding programme that would require sourcing a large infusion of Australian collections from the species' natural distribution.

# ACKNOWLEDGEMENTS


**NZDFI 2011 *E. globoidea* trial host forest growers and farm foresters**

- Heather Atkinson, Wharerata, Wairarapa
- Juken NZ, Masteron forestry office staff, Wairarapa
- Fraser Avery, Bonavaree, Marlborough

**NZDFI 2009 & 2010 *E. bosistoana* trial host**

- Marlborough District Council staff

**Marlborough Regional Forests/Proseed/Vineyard Timbers 2005 *E. macrorhyncha* trial**

- Philip Woodward, M&R Forestland Management

**NZDFI 2011-2018 *E. macrorhyncha* demonstration trial host forest growers and farm foresters**

- Landcorp, Northland and Hawkes Bay
- Timberlands, Bay of Plenty
- Lake Taupo Forest Trust, Waikato
- Cribb, Gisborne
- R. Alexander, Hawkes Bay
- McNeill, Hawkes Bay
- Hawkes Bay Regional Council
- NZ Redwood Company, Taumaranui
- G. Williams, Wairarapa
- Trimble Foundation, Wairarapa
- Saggers, Marlborough
- Dillon, Marlborough
- R. Grose, Marlborough
- R. MacBeth, Canterbury

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# APPENDICES

## Appendix 1: NZDFI *E. macrorhyncha* plus tree collections - 2023

| Location | Tree No. Block_Tree Location | Est.date | DBH (mm) | Height (m) | Origin | Collection date | Clean weight (kg) |
|---|---|---|---|---|---|---|---|
| MRF Waikakaho | 1 | 2005 | 367 | 21.3 | NA | 21-Jun-23 | 0.260 |
| MRF Waikakaho | 2 | 2005 | 340 | 21.2 | NA | 21-Jun-23 | 0.187 |
| MRF Waikakaho | 3 | 2005 | 345 | 22.9 | Gunning | 21-Jun-23 | 0.082 |
| MRF Waikakaho | 4 | 2005 | 315 | 16.9 | Bundarra | 21-Jun-23 | 0.151 |
| MRF Waikakaho | 5 | 2005 | 350 | 21.6 | Gunning | 21-Jun-23 | 0.037 |
| MRF Waikakaho | 6 | 2005 | 372 | 19.2 | Stromlo | 21-Jun-23 | 0.133 |
| MRF Waikakaho | 7 | 2005 | 380 | 18.8 | Bundarra | 21-Jun-23 | 0.046 |
| MRF Waikakaho | 8 | 2005 | 317 | 20.3 | Gunning | 21-Jun-23 | 0.034 |
| MRF Waikakaho | 9 | 2005 | 303 | 17.5 | Stromlo | 21-Jun-23 | 0.027 |
| MRF Waikakaho | 10 | 2005 | 322 | 21.0 | NA | 21-Jun-23 | 0.076 |
| MRF Waikakaho | 11 | 2005 | 332 | 18.8 | NA | 21-Jun-23 | 0.010 |
| MRF Waikakaho | 12 | 2005 | 430 | 18.5 | Gunning | 21-Jun-23 | 0.179 |
| MRF Waikakaho | 13 | 2005 | 361 | 19.8 | Bundarra | 21-Jun-23 | 0.005 |
| MRF Waikakaho | 14 | 2005 | 430 | 20.7 | Bundarra | 21-Jun-23 | 0.050 |
| Dillon | 5_22 | 2011 | 187 | 10.8 | Gunning/Stromolo/Uriarra | 5-Apr-23 | 0.011 |
| Dillon | 21_14 | 2011 | 157 | 9.5 | Gunning/Stromolo/Uriarra | 5-Apr-23 | 0.008 |
| Dillon | 21_29 | 2011 | 163 | 9.2 | Gunning/Stromolo/Uriarra | 5-Apr-23 | 0.008 |
| Saggers | 18_16 | 2011 | 251 | 11.9 | Gunning/Stromolo/Uriarra | 26-May-23 | 0.028 |
| Alexander | 2_24 | 2011 | 240 | 11.9 | Gunning/Stromolo/Uriarra | 1-Jun-23 | 0.006 |
| Alexander | 12_10 | 2011 | 239 | 117 | Gunning/Stromolo/Uriarra | 1-Jun-23 | 0.021 |
| Alexander | 22_15 | 2011 | 228 | 127 | Gunning/Stromolo/Uriarra | 1-Jun-23 | 0.012 |
| Alexander | 22_21 | 2011 | 252 | 133 | Gunning/Stromolo/Uriarra | 1-Jun-23 | 0.005 |
| Macbeth | | 2014 | 173 | 9.6 | Waikakaho | 12-Apr-23 | 0.009 |
| Grose | 1 | 2008 | 214 | 14.1 | Gunning/Stromolo | 24-Aug-23 | 0.004 |
| Grose | 2 | 2008 | 256 | 14.5 | Gunning/Stromolo | 24-Aug-23 | 0.017 |
| Grose | 3 | 2008 | 217 | 15.2 | Gunning/Stromolo | 24-Aug-23 | 0.028 |
| Grose | 4 | 2008 | 335 | 15.9 | Gunning/Stromolo | 24-Aug-23 | 0.058 |
| Grose | 5 | 2006/09 | 285 | 17 | Gunning/Clare/Uriarra | 24-Aug-23 | 0.012 |
| Grose | 6 | 2006/09 | 259 | 16 | Gunning/Clare/Uriarra | 24-Aug-23 | 0.025 |
| Grose | 7 | 2006/09 | 278 | 16 | Gunning/Clare/Uriarra | 24-Aug-23 | 0.021 |
| Grose | 8 | 2006/09 | 241 | 14.8 | Gunning/Clare/Uriarra | 24-Aug-23 | 0.051 |
| Grose | 9 | 2006/09 | 225 | 15 | Gunning/Clare/Uriarra | 24-Aug-23 | 0.128 |
| Grose | 10 | 2006/09 | 241 | 14.8 | Gunning/Clare/Uriarra | 24-Aug-23 | 0.020 |
| MRF Para | 1 | 2005 | 339 | 19.3 | Avoca | 24-Aug-23 | 0.024 |
| MRF Para | 2 | 2005 | 423 | 17 | Gunning | 24-Aug-23 | 0.032 |
| MRF Para | 3 | 2005 | 428 | 18.6 | Gunning | 24-Aug-23 | 0.013 |