CHAPTER 5 - SPECIES SELECTION, SEED SOURCE AND BREEDING

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The key to a successful eucalypt plantation is matching the right species to the right site. Many research trials have been established since the 1960s, some designed for the short term and others with a more robust design providing better data on species performance as well as growth data. The role of farm foresters in unofficial testing of species is also critical to developing an understanding of species performance.

A summary of results from eucalypt species trials carried out in New Zealand since the mid 1970s is presented below.

1977 New Zealand Forest Research Institute trials, Nelson, Southland and Central North Island

This group of trials was initiated by M.D. Wilcox to compare 21 eucalypt species on the basis of growth, stem form and response to climate and pests. Thirteen ash group species, (*E. regnans, E. delegatensis, E. dendromorpha, E. fastigata, E. oreades, E. fraxinoides, E. obliqua, E. sieberi, E. obliqua* x *E. regnans),* seven gums (*E. nitens, E. saligna, E. viminalis, E. dalrympleana, E. johstonii, E. gunii, E, dunii, E. cypellocarpa E. andrewsii, E. campanulata, E. stenostoma , E. triflora* and *E. saligna* were planted at two sites in the central North Island, at Golden Downs Forest near Nelson and at Longwood Forest in Southland.

At the coastal North Island site (Rotoehu, altitude 70 m) survival and diameter at breast height (DBH) at age 9 years were greater in the ash group (*E. fastigata, E. fraxinoides, E. oreades* and *E. regnans*) than in other species.

At the inland North Island site (Waiotapu, Kaingaroa Forest, altitude 380 m) differences at age 9 years were less apparent. The DBH of *E. obliqua* and *E. regnans* was slightly greater than that of other species. Poor growth and health of *E. nitens* observed at this site was unexpected in view of results from progeny trials located only a few km away.

See box in Chapter 3 for a summary of results from the North Island component of these trials.

In Nelson severe frosts caused considerable damage, *E. nitens, E. regnans* and *E. delegatensis* were the better performing species, with *E. nitens* the best.

In Southland, ranking of growth rate placed *E. nitens* first, followed by *E. fraxinoides* and *E. regnans*. Other species had grown more slowly.

1977 New Zealand Forest Products trials, Kinleith Forest, central North Island

Six ash group species (*E. delegatensis, E. fraxinoides, E. obliqua, E. oreades, E.regnans, E. sieberi*) and two gums (*E. glaucescens, E. nitens*) were planted, using nursery stock raised from one to six seedlots of each species. At age 11 years *E. fraxinoides, E. oreades* and *E. regnans* had the greatest DBH. Growth of *E. delegatensis* and *E. glaucescens, E. obliqua,* and *E. sieberi* was slower, and that of *E. nitens* intermediate.

In another provenance trial at the same site, the basal area/ha of *E. fastigata* at age 13 years (average of four provenances) exceeded that of *E. regnans* (five provenances) by 25%.

1978 New Zealand Forest Products trials, Northland

An unusual group of species, chosen by J. Henry for superior solid wood properties noted in Australia, was planted at Mahurangi Forest, north of Warkworth (altitude 60 m). They included *E. citriodora, E. cloeziana, E. diversicolor, E. jacksonii, E. laevopinea, C. maculata, E. microcorys, E. muelleriana, E. pilularis, E. pyrocarpa, E. resinifera,* and *E. saligna.* Rows of 20 trees of each species were planted in two adjacent blocks, with one or occasionally two rows of each species in each block. At age 9-10 years only four to five trees had survived in each row. Best growth was noted in *E. pilularis* and the closely-related *E. pyrocarpa, E. laevopinea, E. muelleriana, E. regnans* and *E. saligna.* At age 18 years the rankings were much the same. The two stringybarks (*E. laevopinea* and *E. muelleriana*) and *E. pilularis* showed good growth but variable tree form.

1979-80 Progeny Trials, central North Island

E. nitens trees were planted for open-pollinated progeny testing near Murupara (altitude 230 m) and at Rotoaira Forest on the slopes of Mt. Tongariro (altitude 700 m). Growth was satisfactory in spite of infestation by *Paropsis* beetles. Test results provided the foundation for a full-scale breeding programme with this species. Similar open-pollinated progeny tests with *E. fastigata* planted in Kaingaroa and Kinleith Forests in 1980 formed the basis for a parallel breeding programme. Both projects were supported by the Eucalypt Breeding Cooperative, with the objective being production of short fibre for pulp.

Earlier (1976) provenance/progeny trials with *E. regnans* did not continue beyond the second generation because vulnerability to pests and disease had discouraged industry use of this species.

1978-86 National Plant Materials Centre soil conservation trials

A trial established by the late R.L. Hathaway and B.T. Bulloch at Kahuiti in the Wairarapa region was designed to examine the ability of 49 eucalypt species to stabilise eroding soil for pastoral farming. Species tested included 13 of the 21 eucalypts planted in New Zealand Forest Research Institute trials in the central North Island as well as other potential sawtimber species.

Where several seedlots of a species were available, five replications of four-tree row plots were planted with material from each seedlot. Where only one seedlot was available, two adjacent rows of four trees were planted. Species examined included *E. cladocalyx, E. fastigata, E. globoidea, C. maculata, E. muelleriana, E. nitens, E. obliqua* and *E.regnans.*

At age 22 years trees were assessed for DBH, stem straightness, malformation, crown health and the potential number of 5 m sawlogs per tree.

In terms of DBH, the 12 species exhibiting best growth were *E. globoidea, E. muelleriana, E. obliqua, E. fraxinoides, E. regnans, E. cordata, E. delegatensis, E.fastigata, E. sieberi, E. cinerea, E. kartzoffiana* and *E. nitens.*

The ash group species and *E. nitens* exhibited the best combination of diameter growth, straight stems, least malformation, good crown health and largest number of sawlogs per tree. Most of the peppermints grew more slowly and were more sinuous than the ashes. Some of the gums grew well and most survived better on the eroded soil than other species. Superiority of *E. fastigata* and *E. obliqua* has been confirmed by results from other trials in the same region.

This report of good growth and health of *E. globoidea* and *E. muelleriana* in the Wairarapa, together with similar reports from Northland, indicates that these are species with potential for sawn timber production.

1978-1986 Extended East Coast trials

More trials were carried out at Kahuiti and nine other sites in the Wairarapa and Hawkes Bay regions at altitudes between 70 m (Waimarama) and 300 m (Pukeatua, near Martinborough). Mean annual rainfall was 1000-1300 mm, except at one site near Havelock North (850 mm). Typical hill soils in the region were derived from siltstone, mudstone and argillite. The species planted at most sites were *E. cordata, E. fastigata, E. fraxinoides, E. nitens, E. nitida, E. obliqua, E. ovata, E. pulchella, E. regnans,* and *E. rodwayii.*

At age 12 years tree height and DBH were found to vary between sites. Average height exceeded 10 m at only four locations. These were Clydebank (northern Hawkes Bay); Waimarama (central Hawkes Bay); Wimbledon (southern Hawkes Bay); and Pawanui (southern Hawkes Bay). Species performance can be summarised as follows:

- Havelock North (driest site): *E. pulchella,* followed by *E. obliqua* outstanding in terms of height, DBH and survival.
- Clydebank (highest rainfall): *E. nitens, E. obliqua* and *E. pulchella* outgrew all other species.
- Waimarama: *E. fastigata, E. fraxinoides, E. obliqua* and *E. regnans* showed little difference in growth rate.
- Kahuiti: Growth relatively slow. *E. fastigata, E. fraxinoides* and *E. obliqua* the best performers.
- Longbush: *E. fastigata, E. fraxinoides, E. obliqua* and *E. pulchella* the best performers.
- Wimbledon: Diameter growth good but survival rates often below 40%. *E. fastigata* outstripped *E. fraxinoides, E. obliqua* and *E. pulchella.*
- Pukeatua: Good survival. *E. fastigata, E. fraxinoides* and *E. pulchella* the best performers.

Overall ranking for survival and diameter growth placed *E. fastigata* and *E. obliqua* first, but *E. fraxinoides, E. pulchella* and *E. regnans* grew equally well at some sites.

1979 Te Whiti (Masterton)

An earlier trial at Te Whiti, near Masterton, included 35 eucalypt species planted in three plots of 12 trees. These were thinned to six trees per plot. When assessed at age 15 years, *E. botryoides* had greatest DBH, followed by *E. perriniana, E. nitens* and *E. fastigata. E. muelleriana* was ranked sixth.

1984 Whangarei

A trial with small row plots planted near Whangarei in Northland included 21 species. Of these *E. blaxlandii, E. crenulata, E. microcorys, E. pilularis, E. rodwayii* and *E. saligna* were additional to species tested in Hawkes Bay/Wairarapa. At age 14 years the best-performing species were *E. blaxlandii, E. fastigata, E. obliqua,* and *E. regnans. E. botryoides, E. globoidea, E. nitens, E. pilularis, E. saligna* and *E. sieberi* were ranked lower for growth rate.

1981 Species trials, Central Otago

Early growth and frost hardiness of 18 species, including nine tested in the North Island, were assessed at Tara Hills, Omarama. The site was irrigated due to its history of low rainfall. In 1982 and 1991 frost caused serious damage and in 1995 temperatures of -19.5ºC caused dieback in all species. Prior to this event, *E. gunnii* and *E. nitens* had shown best survival and growth, reaching a height of 11 m and DBH of 170 mm by age 10 years.

1988 New Zealand Forest Research Institute species trial, Hawkes Bay

A short-term coppiced fuelwood trial initiated by Tim Parker was planted at a riverside site near Clive (altitude 5 m, mean annual rainfall 800 mm) where the water table was high and

known to fluctuate. Species planted at 2 x 1 m spacing (5,000 stems/ha) included the coppicing gums *E. bicostata*, *E. cinerea*, *E. globulus*, *E. macarthurii*, *E. maidenii*, *E. nitens*, and *E. ovata*, as well as *E. botryoides*, *E. camaldulensis*, *E. fastigata*, *E. fraxinoides*, *E. regnans*, *E. saligna*, and *E. tereticornis*. By age 11 years the only species exhibiting reasonable survival and growth rates were *E. bicostata*, *E. botryoides*, *E. globulus*, *E. maidenii*, *E. nitens*, *E. ovata*, and *E. saligna*. Of these, *E. maidenii* was outstanding. *E. globulus* and *E. nitens* had grown well but their health was declining due to attack by a fungal leaf disease.

In a parallel trial at Patoka (altitude 350 m), a cooler, higher rainfall site southwest of Taradale, growth of *E. nitens* was rapid and health excellent. At age 11 years, *E. bicostata* and *E. maidenii* had both grown well, the height of *E. maidenii* (22.5 m) approaching that of *E. nitens* (24.9 m).

1988-1993 Species and provenance trials, Northland

This group of trials was established to provide the basis for a eucalypt pulpwood planting scheme. Four sites south of Kaikohe were planted with *E. fastigata*, *E. globulus*, *E. grandis*, *E. maidenii*, *E. nitens*, *E. regnans*, and *E. saligna*. At age 8 and 11 years, *E. fastigata* and *E. regnans* were considered to show best growth and health, followed by *E. maidenii*. Severe symptoms of a fungal leaf disease and a high mortality rate observed in *E. globulus* and *E. nitens* were probably evidence of poor adaptation to the warm, high rainfall conditions. Insect attack contributed to poor growth of *E. saligna*.

1992 New Zealand Forest Research Institute timber trials

With the assistance of Lottery Board funding, four species known to provide durable timber were planted at Titoki in Northland. Growth rates and health of *E. globoidea*, *E. muelleriana* and *E. pilularis* were all satisfactory, but *E. microcorys* grew more slowly. A parallel trial near Tauranga lost *E. pilularis*, *E. microcorys* and some *E. muelleriana* to frost soon after planting.

1993 *E. muelleriana* provenance/progeny trials

A comparison of the performance of 24 seedlots of *E. muelleriana* was attempted at two sites. Survival was good in a trial located near Whangarei, Northland, but severe frost damage occurred in 1994 at the site near Whakatane, Bay of Plenty.

1997 *E. pilularis* provenance/progeny trials

Eleven seedlots of *E. pilularis* were compared in a trial near Whangarei in Northland. Trees from single seedlots of *E. muelleriana* and *E. nitens* were included. This trial was repeated at a site near Te Puke, Bay of Plenty, where *E. regnans* was also included, but frost damage resulted in this trial being abandoned in 1998.

2003-2004 Scion Genetics stringybark species trials

Using large, well-buffered plots each containing 25-100 trees, these trials on nine sites from Northland to Marlborough were designed to examine the performance of 19 species chosen for the potential of their wood for sawing and other desirable qualities. *E. fastigata* and *E. nitens* were used as benchmark controls. Ten stringybark species were included, many

never before formally tested in New Zealand, also *tested were C. maculata*, *E. maidenii*, *E. microcorys*, *E. obliqua*, and *E. pilularis*.

The benchmark species *E. maidenii*, *E. fastigata* and *E. nitens* were ranked above the rest. The best performing stringybarks across the nine sites at age 3-4 years were *E. globoidea*, *E. eugenoides*, *E. cameronii*, *E. youmanii*, *E. laevopinea*, *E. calignosa*, *E. macroryncha*, *E. baxteri* and *E. blaxlandii*. Within this group *E pilularis* was also highly ranked.

2004-2005 New Zealand Farm Forestry Association stringybark species trials

With assistance from the Sustainable Farming Fund, the Eucalypt Action Group planted plots containing 15 trees of 16 species at 44 sites throughout the country. *E. fastigata* and *E. maidenii* were used as benchmarks. Five additional species were planted at some sites. Details of species/site combinations and results are given in Chapter 3.

Summary Points from the 1977-2005 trials outlined above

The main pattern emerging from the above trials is that no single eucalypt grows well on all sites between Northland and Bluff.

Ash Group

Although *E. fastigata* performed best in terms of growth rate and health over the widest range of North and South Island sites, this species did not tolerate very cold conditions but had the least disease and fewest insect pests.

E. obliqua had vigour and form equal to that of *E. fastigata* at sites in Hawkes Bay and the Wairarapa, but was prone to gum bleeding (kino) in exposed locations.

E. regnans grew rapidly and had good stem form.

Stringybarks *(& E. pilularis and E. microcorys)*

Stringybarks grown in New Zealand have a reputation for relative absence of fungal leaf disease and insect attack. *E. muelleriana* and *E. pilularis* grew best on frost-free sites. A tendency has been observed towards stem forking and the development of ramicorn branches, especially with *E. muelleriana* on fertile sites. It is hoped that other species adapted to Australian conditions on 1000 m altitude tableland sites (*E. cameroni*, *E. laevopinea* and *E. youmanii*) will combine similar wood properties with better cold and frost tolerance.

Performance of *E. globoidea* resembled that of *E. muelleriana*. *E. microcorys* is frost tender and grew more slowly than either *E. muelleriana* or *E. pilularis* on the same sites, although it does have superior wood characteristics.

Gums

On warmer sites, *E. maidenii* was more resistant to fungal leaf disease than either *E. globulus* or *E. nitens*.

Informal Trials

Many farm foresters have established informal trials over the last 100 years. While different species have gained favour in different cases, there are some notable examples. Thus the Okuti *E. globoidea* stand on Banks Peninsula clearly demonstrates the potential for this species, while *E. fastigata*, *E. muelleriana*, *E. globoidea* and *E. saligna* have performed well on many sites round the North Island. *E. muelleriana* has been particularly successful on coastal sand dune country in the south western North Island as have *E. pilularis* and *E. microcorys*, but only on the relatively frost free, northern dune slopes.

It is because of these type of experiences in species performance by farm foresters that those planting eucalypts should combine local knowledge and read the available literature to establish a short list of best candidates for their sites.

Tree breeding and production of genetically-improved seed

Tree breeding programmes in New Zealand for *E. nitens* and *E. fastigata* are well advanced compared to other eucalypt species. Breeders at Scion are beginning observations on the third generation of *E. nitens* and seed has been collected from second generation trials of *E. fastigata*. Although both programmes were designed with production of kraft pulp as the primary objective, selection criteria were therefore fast growth and good tree form, with some emphasis on high wood density (and high cellulose content in *E. nitens* to increase pulp yields). Growth and form are also important for solid wood utilisation, so the improved material is a valuable resource to all growers of these species.

In the breeding programme for *E. fastigata*, so far there has been no selection to reduce growth stress defects, internal checking or kino. Forking is a problem in some *E. fastigata* seedlots and an important issue for log quality improvement.

Breeding strategy involves the initial identification of parent trees in plantations in several countries (New Zealand, Australia and South Africa) and in natural stands of different provenances in Australia. Open-pollinated seed is collected from these trees and performance of the progeny is compared in field trials established in New Zealand. When trees reach an age at which growth patterns

give a reliable prediction of quality at harvest, new parents are selected from the best-performing families. For pulpwood, this stage is reached in five to eight years, but a longer period is needed for sawn timber.

Grafted material selected from progeny tests of both species has been planted in clonal breeding archives located at sites known to promote good flowering. In the North Island, *E. nitens* produces seed only in high altitude, cold and dry sites (e.g., Waiouru and Southland). The different clones are allowed to inter-pollinate, and the seed collected is used to establish the next progeny test. Grafted material selected from the best families is planted in orchards used for commercial seed production. These seed orchards are operated by Proseed NZ Ltd and by companies such as Southwood Export that own timber-producing plantations.

Natural open pollination by insects within a clonal archive is the easiest way to obtain a large number of genetic combinations from select parents. In future, characterisation of the DNA of each of the parents in the breeding archive, together with DNA fingerprinting of the progeny will ensure that new selections from each family do not all have the same male parent.

Seed stands

Growers may be interested in species for which no breeding programme has been established and no trials comparing seedlots of different geographic origin (provenances) have been planted. It is important in this case to use seedlots collected from at least 10 parents. This will avoid the risk of developing a plantation from a few inferior specimens. It is also wise to use seedlots from several different provenances. The temptation to collect seed from a few local trees should be resisted, unless there is good evidence that they are the progeny of a large number of parents. Seed collected in the past has often had few original parents, with the result that the progeny has been inbred and performance has been poor.

Scion Genetics breeders have suggested that seed producers in New Zealand should create seed stands of species for which there is no breeding programme. They have recommended that each stand should be composed of seedlots from several provenances, and that each provenance should be represented by at least 5-10 parent trees. The stand should be thinned so that a minimum of 50 of the best-formed and best-grown trees remain at final stocking. The stand can then be used for collection of seed suitable for commercial timber-producing plantations. The risk of inbreeding will have been greatly reduced and poorly-performing provenances and/or families will have been eliminated during thinning.

Seed producers prepared to invest more effort could develop an orchard of individually-identified trees derived from 25-50 open-pollinated families in approximately five different provenances. Some genetic improvement would result from selective thinning, which would leave only the best families and individuals for future seed production. The stand would then be a seed orchard and also a miniature breeding population, providing the basis for production of genetically-improved seed within two or three generations.

Key Points

- A great deal of species testing and breeding research has been undertaken for a large number of species.
- A considerable amount of trial work has provided information about the adaptation of different eucalypt species to specific site types.
- Growth rates of a single species are often different at different sites.
- Soundly-based recommendations about species choice can only be made if there is adequate knowledge about local conditions.
- Recent research effort on genetic improvement has concentrated on *E. nitens* and *E. fastigata* which have been grown on a large scale for fibre.
- Opportunities exist for the improvement of planting material derived from seed stands of lesser known species.

Suggested reading:

Barr 1996

Boland *et al.* 1984

Shelbourne *et al.* 2000b

Shelbourne *et al.* 2002

Wilcox 1982

Wilcox *et al.* 1985