NZDFI NEW ZEALAND DRYLAND FORESTS INITIATIVE

breeding tomorrow's trees today

Durable Eucalypt Leaflet Series

Eucalyptus globoidea

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Why grow durable eucalypts?

New Zealand's agricultural landscapes need sustainable land use options adapted to droughts and floods which complement pastoral farming while reducing soil erosion, improving water quality and habitat for native biodiversity.

Eucalypts are renowned for their adaptability to droughty and eroding landscapes. They also provide excellent habitat for nectar-feeding birds and insects. With over 400 eucalypt species to select from there is a great opportunity to select appropriate species for the planting objective.

With CCA (copper chrome arsenic)-treated wood now banned for many uses by the USA and several European countries, there are significant international and domestic markets for naturally-durable hardwoods. The wood properties of New Zealand grown durable eucalypts ensure they can replace CCA treated material for many uses and are also ideal for a wide range of agricultural and land-based industrial applications, particularly for posts, poles and utility cross-arms as well as heavy structural timbers.

NZDFI (New Zealand Dryland Forests Initiative) has selected eucalypt species which can be sawn to produce durable hardwood. Using these species, NZDFI is committed to developing viable best-practice forest management systems to complement livestock farming. NZDFI wants to encourage planting durable hardwood forests and woodlots to protect steeplands and waterways, for shade and shelter, and to generate income from carbon credits and sustainable timber harvesting.

Why NZDFI have selected *E. globoidea?*

NZDFI have selected species that:

- Produce highly durable timber (Class 1 and 2 Australian Standard, AS5606-2005)
- Are drought tolerant
- Coppice vigorously after fire and harvesting
- Do not appear to spread as wildings
- Have the potential to sequester carbon faster than pine on drylands
- Provide nectar/pollen for native biodiversity.

NZDFI have selected ***E. globoidea*** as one of its suite of species because of its good durability (Class 2) and its consistent performance on a wide range of sites throughout New Zealand.

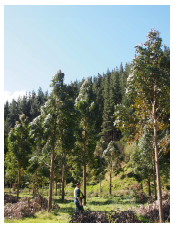

Figure 1: Seven year old *E. globoidea* Marlborough

Natural distribution in Australia

Found in Australia on gentle undulating country and hills near the coast, to mountain slopes and escarpments adjacent to tablelands but not inland of the ranges. Wide range through eastern New South Wales except the far north, and eastern Victoria except in areas where summers are too cool. Favours warm humid to sub-humid climate. Altitude range, near sea level to 1100 m (www. thewoodexplorer.com).

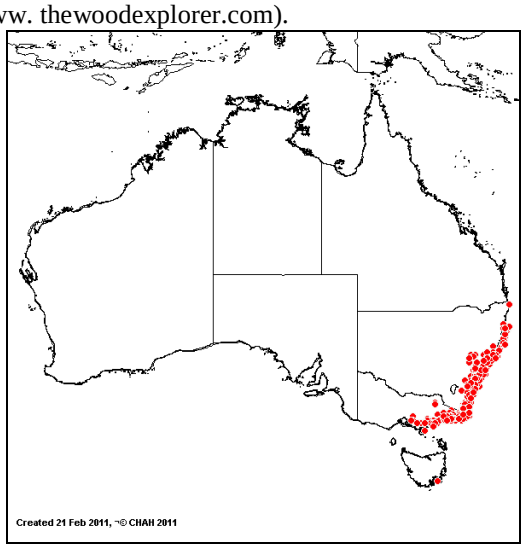

Figure 2: Map of Australia showing the natural distribution of *E. globoidea* (source Australia's Virtual Herbarium)-note Tasmanian record is cultivated, not natural.

Australian and New Zealand grown wood characteristics

The timber of *E. globoidea* is described as; "Heartwood is pale brown with a pinkish tinge. Sapwood is paler but not sharply differentiated; usually narrow. In Australia the wood is used for building framework (Bootle 1983). Haslett (1990) states "Although New Zealand material has slightly lower density and strength than Australian material, it is still suitable for structural uses, including framing, cross arms, and decking".

Origin/species	Modulus of Rupture (MPa)		Modulus of Elasticity (GPa)		Compression Parallel (MPa)		Hardness (kN)		Density (kg/m^3)		
	Green	12 %	Green	12%	Green	12%	Green	12%	Green	Air-Dry	Basic
Australia											
E. bosistoana	103	163	17	21	50	73	10	13	1180	1100	880
E. globoidea	92	133	14	17	43	68	6.8	8.8	1100	880	680
E. camaldulensis	64	101	8	11	33	55	5.3	7.5	1130	900	710
E. quadrangulata	**98**	**163**	**17**	**18**	**47**	**71**	**8.2**	**14**	**1230**	**1030**	**800**
New Zealand											
E. bosistoana	na	na	na	na	na	na	na	na	na	na	na
E. globoidea	81	132	7.7	15	38	67	4.5	6.9	na	805	635
E. camaldulensis	na	na	na	na	na	na	na	na	na	na	na
E. quadrangulata	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**
Pinus radiata	40	89	6.2	8.5	16	38	2.4	5.0	960	500	420

Table 1: Strength and density values for core DFI eucalypt timbers

Market opportunities

Currently New Zealand relies on radiata pine which makes up 90% of our plantation estate. Eucalypts account for only 1% of timber production yet New Zealand imports over $30 million of hardwood sawn timber and $240 million of

wooden furniture annually. New Zealand has nearly 25,000 ha of eucalypt plantations mostly of low durable species for short fibre pulp.

The banning of CCA-treated wood for many uses in the USA and parts of Europe opens up new opportunities for naturally-durable hardwoods. The substitution of CCA-treated pine with naturally durable hardwood will also reduce the production of hazardous timber waste. For example, in Marlborough broken posts from vineyard harvesting create up to 24,000 cubic metres of hazardous waste every year. There are no acceptable disposal facilities for this waste other than secure landfill, which in Marlborough costs $21 per cubic metre. Although more benign treatment methods are being actively researched to replace CCA, another advantage of the chemical free durable post eucalypts are their high strength.

NZDFI eucalypt hardwoods will match elite species like mahogany, rosewood and teak. They are highly durable and very stiff and strong. These properties ensure they are also ideal for a wide range of agricultural and land-based industrial applications, particularly for posts, poles and utility cross-arms as well heavy structural timbers. Other applications include for building wharves, jetties, bridges and for rail sleepers. Mature *E. globoidea* in the Bay of Plenty and Canterbury have been successfully sawn producing excellent sawn timber. *Eucalyptus globoidea* produced significantly higher volumes of dressing grade timber than *E. fastigata*, *E. muelleriana* or *E. pilularis* in a sawing study of 25-year-old trees because it was better at self-pruning than the other species tested (Jones et al. 2010).

A further application for selected durable eucalypt species could be for land-based wastewater disposal to produce post and pole wood with biofuel produced from residues. Durable eucalypts also have potential for bio-fuel due to their high wood densities.

Another advantage of durable eucalypts is a high rate of carbon sequestration because of their very high wood densities. The rapid growth rates of some species combined with, for some species, their wood being almost twice as dense, age for age as radiata pine makes them suitable as species for NZ's Emissions Trading Scheme.

New Zealand experience:

Neil Barr (1996) in his book selected eleven of the best eucalypt species for New Zealand which he named the "First Eleven" This selection was, in his words, because; "… someone has to warn intending growers of eucalypts for timber that the good ones have been sorted out. Indeed many of the early species brought across by miners and early Australian migrants have proved to be the best ones for milling. In the description of species and their timbers I have sorted out the 11 most proven ones". One of the eleven nominated by Barr was *E. globoidea*.

Clifton (1991) notes that for *E. globoidea* "Experience of utilisation with New Zealand material is limited. However, sufficient timber has fallen into the hands of craft furniture manufacturers in the Bay of Plenty-Waikato and in Christchurch to enable judgement to be passed on it. While it is a very heavy wood and therefore less desirable for some types of furniture, there are other items (bar stools for example) where a little extra weight is a good thing. *E. globoidea* is a very attractive wood. It has been made into at least one restaurant table which is a joy to behold. It has also been used for heavy structural work and for power pole cross-arms". Jones et al. (2010) report on a recent sawing study comparing four eucalypt species at age 25 years which showed that *E. globoidea* was as good or better than *E. fastigata*, *E. muelleriana* and *E. pilularis.* Somerville and Gatenby (1996) also reported on experiences sawing 60 year old *E. globoidea,* although they had a sawn conversion of 60%, there was a high proportion of reject material caused by knots, compression heart but this varied from tree to tree.

Weston (1957) reported that *E. globoidea* was widely planted in the past, but usually in small numbers and often in mixture with other species. Simmons (1927) reported on the impressive Little River stand of *E. globoidea* in Canterbury and McWhannell (1960) also extolled the virtues of planting *E. globoidea* and was very enthusiastic about its favourable wood properties. King (1980) noted that trees which were established in 1918 near the top of a steep dry easterly slope in the Wairarapa showed considerable variation from good specimens to supressed trees. He concluded that *E. globoidea* "should be tried on a limited scale for timber production on moderate sites".

Research trials:

Apart from some demonstration planting in the 1960s there has been little formal species trial plantings testing *E. globoidea* which reflects the early interest in traditional forest species rather than durable eucalypts. One of the better trial series with relevance to the NZDFI project was the hill country plantings of DSIR in the 1970s in the Wairarapa and Hawkes Bay Bulloch (1991). Shelbourne et al. (2002) reported that *E. globoidea* had the best diameter growth at age 22 years in the main Wairarapa trial, and was third equal in another Wairarapa trial at age 12 years (Table 2).

Site	Kahuiti	Kahuiti	Kahuiti	Kahuiti	Pakaraka	Pakaraka
Age (years)	22	22	12	12	12	12
Factor	DBH	Survival	DBH	Ht	DBH	Ht
Species/units	mm	%	mm	m	mm	m
E. globoidea	**342**	**28**	**122**	**4.7**	**244**	**8.6**
C. maculata	260	na	na		184	9
E. agglomerata	214	44	95	5.9	210	7.9
E. macroryncha	275	19	106	6.2	186	7.1
E. muelleriana	337	31	198	8.0	210	8.7
E. fastigata	300	64	147	9.0	292	11.4
E. obliqua	333	41	194	11	238	11.8
E. cladocalyx	265	13	122	8.3	248	13.4

Table 2: Performance of key species of interest in Kahuiti at age 22 years and a comparison of Kahuiti and Pakaraka trials at age 12 years (from Shelbourne et al. 2002)

A recent study of selected eucalypts in the Manawatu (Millner 2006) also demonstrated the consistent performance of *E. globoidea* compared to some other durable species (Table 3). The *E. globoidea* trees also had less possum browse than some of the other species tested.

Species	DBH	Ht	Possum browse	Wood density	Wood density Kahuiti	Wood density Pakaraka
	cm	m	%	kg/m^3	kg/m^3	kg/m^3
E. globoidea	**9.6**	**5.4**	**16.5**	**483**	**687**	**667**
E. agglomerata	8.3	5.6	32.9	500	615	Na
E. muelleriana	9.1	5.4	26.5	489	644	na
E. obliqua	10.6	6.5	10	438	522	539
E. cladocalyx	6.7	5.0	14.3	594	681	na

Table 3: Performance of species of interest in Manawatu at age 5 yrs and wood density from 24 year old trees in Wairarapa trials (from Millner 2006)

In 2003, Scion established a network of nine durable eucalypt trials through the North Island and Marlborough. In these trials *E. globoidea* was one of the most consistent performers across many of the sites (Nicholas 2008).

In 2004/2005, the Eucalypt Action Group of the New Zealand Farm Forestry Association, as part of a MAF Sustainable Farming Fund project, established plantings of 10 eucalypt species on many sites throughout New Zealand. The *E. globoidea* was established on 37 sites from cold alpine areas of the South Island to mild Northland sites. These trials placed *E. globoidea* as suitable for cool sites, defined as **200-275 frost free days/year** but not suitable for cold sites (100-200 frost free days/yr) (nzffa.org.nz).

Growth and form.

There is considerable experience with *E. globoidea* on milder areas in New Zealand, where it has grown well. While it is not a fast initial grower like some other eucalypts it is a consistent grower. Form is generally good although on fertile sites there may be a propensity to form double leaders.

There are fourteen permanent sample plots of *E. globoidea* in the Scion data base ranging from Canterbury to Northland. Based on site index calculations (Mean Top Height at age 15 yrs) the average of all PSP plots have a mean Site Index of 22 metres. There is wide variation between plots, two Bay of Plenty plots have a Site Index of nearly 30 metres, while two other plots in the same region are only 21 metres. A series of individual tree measurements from throughout the North Island average around 1.5 m height growth a year, which is not as fast as some faster growing eucalypts, but as indicated *E. globoidea* on fertile warm sites can achieve 2 m height growth over at least 15 years.

The most productive plots have recorded a Mean Annual Increment (MAI) of 30 to 35 m^3/ha/yr under-bark volume at age 12 years, given the high wood density this is an attractive carbon sequestration option on the very best sites managed for carbon production. The mean MAI of the 14 plots is only 13.2 m^3/ha/yr, reflecting lower production from

less productive sites and from stands thinned down to lower stockings for sawlog production. This highlights the need to have clear objectives in managing plantations for carbon or sawlogs.

Health

Without large plantations to inspect it is difficult to assess the health of *E. globoidea* throughout New Zealand although the 2004 pilot study of *Acrocercops laciniella* (Blackbutt Leafminer) damage on eucalypts in Northland identified *E. globoidea* as one of the healthier species assessed (Figure 3).
As shown in Table 3 it is less preferred by possums compared with some other species, but it has been almost decimated by deer when planted amongst native scrub in the Wairarapa.

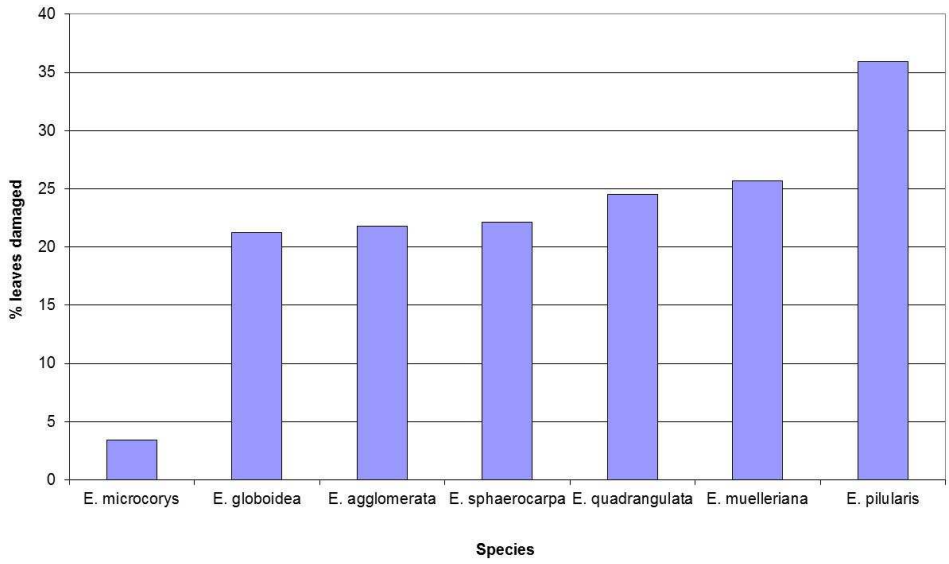

Figure 3: Health assessment of a sample of eucalypt trees in Northland (www.nzffa. org.nz)

Flowering

The flowering of eucalypts can be influenced by season and probably more importantly by seed source. Blakely (1934) suggests the flowering period for *E. globoidea* is April to June. Observations have been made of 7 year old trees flowering in Marlborough in November and December.
More information is required to be able to predict flowering in New Zealand.

NZDFI *E. globoidea* research programme

E. globoidea was selected for possible tree improvement development in 2005 following its success in extensive small trial plantings in 2003/04 in Marlborough and Canterbury.
The first step in tree improvement of this species came with the planting of a seed stand in 2005 on Marlborough Regional Forests land in the Waikakaho valley. This one hectare stand was planted from seed collected of three provenances of *E. globoidea* from it's natural range in Australia. This stand started flowering in November 2010 and the first collection of seed is planned later in 2013.
In 2006, a farm shelterbelt of *E. globoidea* was felled and sawn at a local mill to produce posts for local vineyards and high quality flooring (P. Millen, pers com).
When the NZDFI was formally established in July 2008, *E. globoidea* was selected as one of several key species identified for tree improvement.

Since then, NZDFI has established large base breeding populations of several naturally-durable eucalypt species including *E. globoidea* in dryland regions from which to select improved germplasm for commercial release. Individual provenances and trees with superior traits including wood properties, rapid growth and improved form will be selected at an early age for deployment. In collaboration with NZFFA members and regional land managers, NZDFI has planted breeding populations within Marlborough, Canterbury, Gisborne, Hawke's Bay and Wairarapa. Diverse sites will test the species across a range of environments and provide comparative data for screening individual families. Early

screening for growth and form with selection of the best provenances and individuals will be completed in 2015. Plans are for these to be available progressively to commercial nurseries from 2017.

Since 2008 Proseed has co-ordinated seed collection within Australia and NZ and donated this to the NZDFI. The target for each species is to collect seed from a minimum of 100 individual seed trees for each species from these remaining stands. Trees are very variable in their wild state therefore seed collections are made across a wide range of wild families in different areas to sample the full genetic diversity across climates and soil types. NZDFI seed collection sites extend across southern Queensland, New South Wales and Victoria. For some species, seed has been collected from NZ eucalypt plantations where the original provenance is known.

Successfully establishing large breeding populations of each species is critical to capture a broad range of genetic diversity from which to select multiple-traits and perhaps develop hybrids. For each species a target of 225 seedlings per family are grown. These have been planted to establish base populations of 7500 trees/species across three separate sites in the NZDFI regions. This will provide the broadest affordable genetic base to create elite breeding populations of the very best individual trees. For example, to have trees in the top 20% for growth, form, disease resistance, natural durability and drying, only one tree in up to 3000 is selected. Individual provenances and trees with superior traits including adaption to dryland conditions, fast growth, good form, early heartwood formation and ability to coppice can then be selected at an early age.

Extensive seed collections of *E. globoidea* from native stands in Australia were coordinated in 2009/10 by Proseed NZ and further selections were made by NZDFI from planted stands in the Bay of Plenty and Banks Peninsula, NZ. In 2011 an extensive breeding population trial was established at three locations in NZ. - 130 families from the Australian collection and 31 families from the NZ selections were represented in these trials.

In total of 26,640 seedlings were planted with the three sites chosen for these being Juken NZ's Ngamu forest in Central Wairarapa; Ian and Heather Atkinson's farm in southern Wairarapa and the Avery's property in coastal south Marlborough.

These breeding populations now provide the basis for significant genetic improvement of *E. globoidea* provided that NZDFI are successful with gaining sufficient funding to complete the research work that is needed.

***E. globoidea* Heartwood study – R.McConnochie, January 2011**

Back ground

In November 2010, *E.globoidea* trees were felled at the Waikakaho site near Blenheim to produce coppice material for the rooting of cuttings. Trees from a single row planting of Yadboro, Cann River and Boyne provenances were felled as well as trees from an adjacent mixed seedlot stand. Additional trees were felled from the same provenances at another trial site at Koromiko. Both plantings were 5-years old. Two 25 mm discs were cut from the base of the stem of each felled tree for the collection of heartwood and density data. One disc was used to measure heartwood formation by staining with methyl orange and calculating heartwood percentage.

A bark to bark block was cut from the second disc to determine basic wood density. Green volume was measured using the water displacement method. The blocks were then dried at 105^0C and the oven dry weight measured.

Additional 5 mm increment bark to bark increment cores were taken from the remaining trees in the provenance rows for density measurements. The samples were processed at the Marlborough Research Centre laboratory.

Results

The basic wood density and heartwood measurements is shown in Table 1.

Provenance	No. Samples	Mean UB Diameter (mm)	Density Statistics kg/m^3				Heartwood		
			Min	Max	Mean	Tukeys LSD	No. Samples	Ratio	Tukeys LSD
Boyne	35	84.0	369.2	546.0	461.7	A	28	0.20	A
Cann R	37	87.2	408.3	560.0	484.6	A	29	0.25	AB
Yadboro	35	92.8	385.0	580.0	469.2	A	28	0.30	B
Correlations:	Diameter and Heartwood	0.4							
	Diameter and Density	-0.1							

Table 1. Summary of Density and Heartwood results.

The average under bark diameter of the provenance samples varied from 84 mm to 93 mm, the largest being from Yadboro seed source.

The basic wood density across all provenances ranged from 369 – 580 kg/m^3 and a mean of 477 kg/m^3 (Figure 4). There was no significant difference between provenances in the density of trees sampled. There was no correlation between diameter and density of discs.

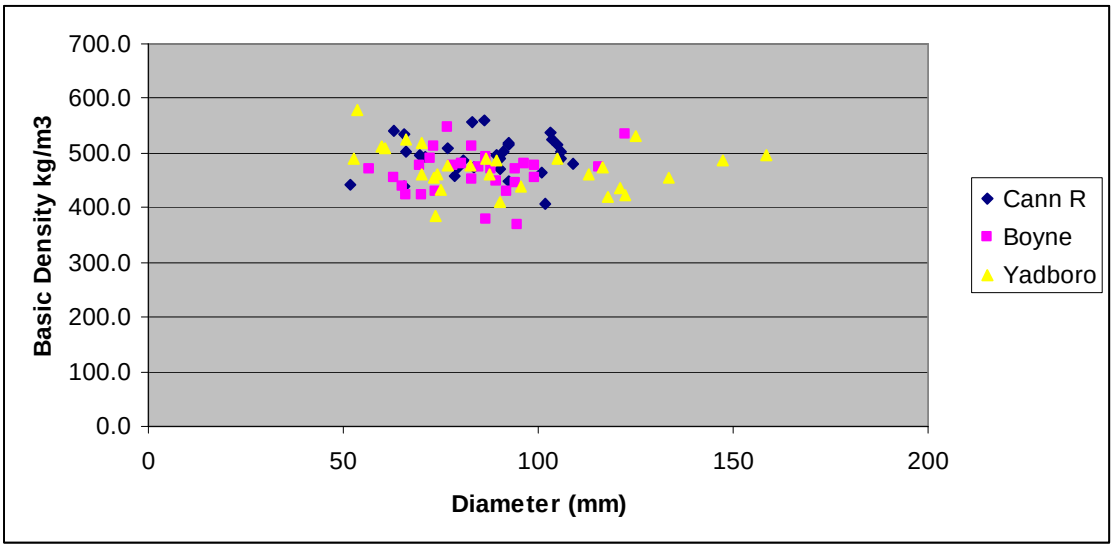

Figure 4: Wood density and disc diameter of sampled trees

Millner, 2006 reported a mean basic density of 477 kg/m3 on 5 year old *E.globoidea* from a trial in the hill country of the Tararua Ranges. These measurements were taken from 5 mm increment cores at breast height (1.4 m).

Heartwood was measured on the discs samples only (Figure 5). There was a small significant difference between the Boyne and Yadboro provenances, therefore only a very small gain is likely from selecting at a provenance level. The correlation between diameter and heartwood percentage is 0.4.

The variation between diameter and heartwood development among all samples is large, 7 – 62% of the cross section area (Figure 5).

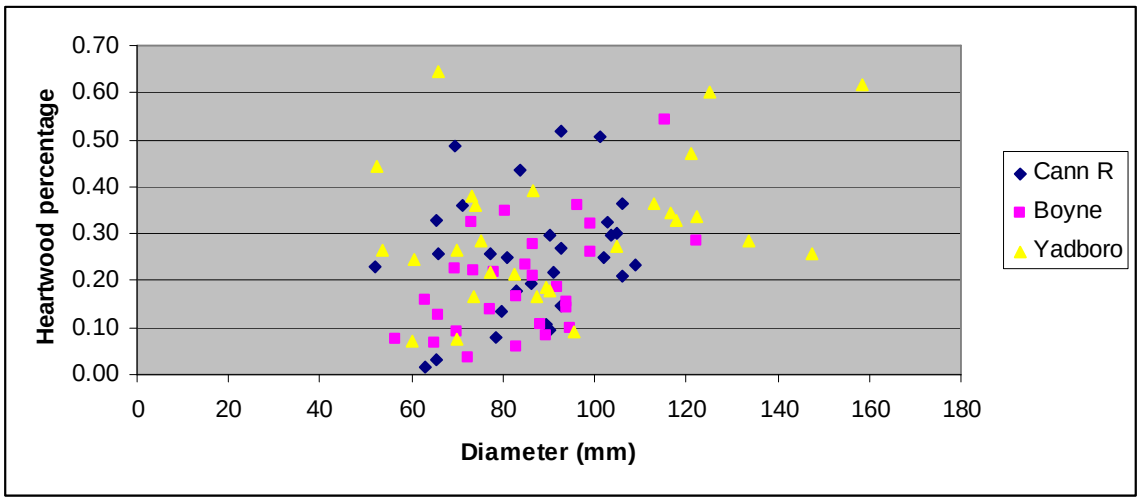

Figure 5: Heartwood percentage and disc diameter of sampled trees

Trees of similar diameter can have very different heartwood development, e.g. B3 and B9, there are also trees that have good diameter growth and high heartwood, eg. Samples Y8 and B3(Figure 6). Intensive selection of individuals within the breeding populations will capture trees with these ideal characteristics.

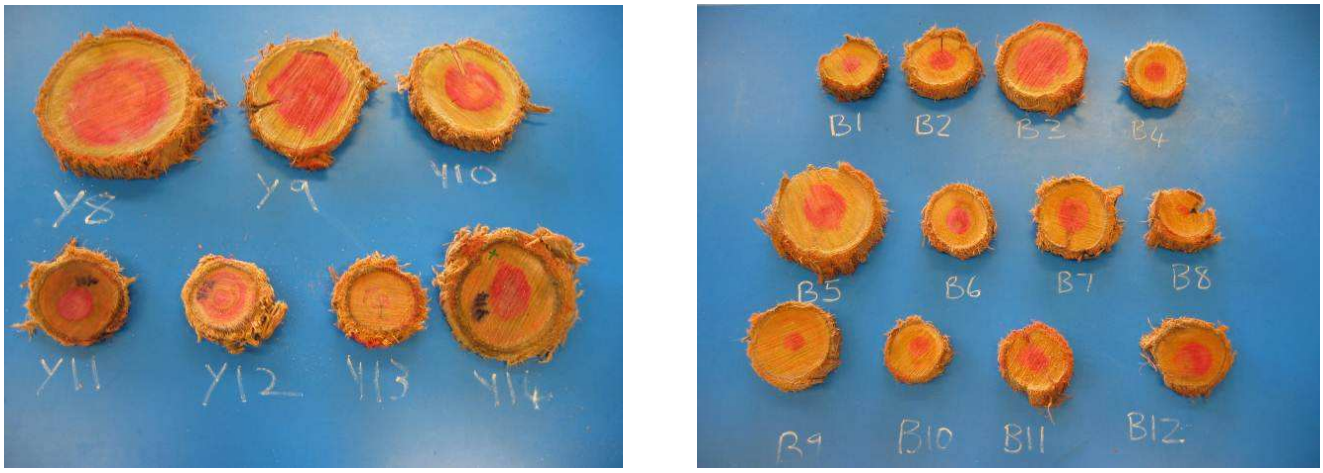

Fig. 6. Stained area indicating heartwood zone for two seedlots.

Data from 15 trees felled in a 9-year-old stand located at Welcome Bay, Bay of Plenty had an average heartwood percentage of 57% and under bark diameter of 21.5cm. These are disc measurements taken at stump height.

New Zealand management recommendations

Siting

The performance of *E. globoidea* has been quite consistent across many sites in New Zealand, but it is sensitive to severe frosts of the order -6 to -7ºC or greater.

Establishment

Eucalypts will perform best when cultivation, weed control and fertiliser are used for establishment. **Effective cultivation** can be achieved by deep ripping, rotary hoeing or mounding. Mounding can also provide some protection from ground frosts. If mechanical cultivation is not possible, soil in the planting spot should be loosened thoroughly with a spade.

Eucalypts require **weed free sites** in the first year of growth. This is critical to achieving good survival and growth. It is preferable to use a pre-plant spray such as glyphosate, to kill existing ground cover two to eight weeks before cultivation and/or planting. Hormone sprays should not be used.

Eucalypts can be damaged by some standard forestry herbicides, their sensitivity can be influenced by species, the soil type temperature and whether plants are flushing. Gardoprim, Gallant and Versatill have been used successfully over eucalypts but care is needed in hot conditions and sandy soils. Spraying directly over plants is not recommended.

Planting stock options vary from bare-rooted stock to container grown plants. Either is acceptable if the plants are well-grown and robust for their growing season. Bare-rooted seedlings should be lightly branched, about 45 cm tall, have a root collar of at least 7 mm in diameter.

Ideally, container-grown stock should be planted out when the plants are 15-25 cm tall and have 6-8 pairs of leaves. Large plants receive a considerable check at transplanting, and the root system is often deformed and constricted in the container.

Eucalypt seedlings generally **respond to fertiliser** applied to individual seedlings about one month after planting on weed-free sites. A general recommendation is apply 60 grams of urea or 80 grams of diammonium phosphate (DAP), in a spade slit 20 centimetres to one side of the seedling.

Spacing

Although there is no specific post/pole trials with eucalypts in New Zealand, evaluation of a eucalypt planting comparing close spaced trees with standard forestry spacing indicated a much higher of post quality material in the closer spacing. Therefore until further research data are available, it is recommended that pole crops be established at 3 m x 1.5 m (2222 stems/ha).

Silviculture

No clearwood pruning or thinning is anticipated in post stands, but a standard form pruning to remove double leaders and or heavy branches is recommended between the age of two and three years, but not earlier. *Eucalyptus globoidea* is one of the best eucalypts at self-pruning, however pruning off live branches would create a smaller knotty core.

Acknowledgement

The comments on earlier drafts from Heidi Dungey and Charlie Low (Scion) are most appreciated.

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Web links

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