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Eucalyptus globoidea - a durable hardwood for planting in the Bay of Plenty region

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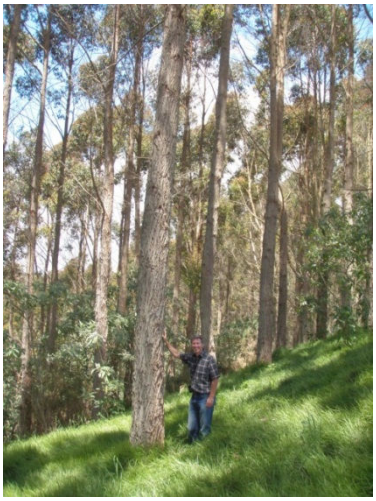
A report prepared for the Bay of Plenty Regional Council



SUPPORTERS: NEW ZEALAND FARM FORESTRY ASSOCIATION; MARLBOROUGH RESEARCH CENTRE; MARLBOROUGH DISTRICT COUNCIL; Sustainable Farming Fund; GISBORNE DISTRICT COUNCIL; UC UNIVERSITY OF CANTERBURY; greater WELLINGTON REGIONAL COUNCIL; PROSEED; HAWKE'S BAY REGIONAL COUNCIL; Vineyard Timbers Ltd; Marlborough Lines; Environment Canterbury Regional Council; AGMARDT; Bay of Plenty REGIONAL COUNCIL

Eucalyptus globoidea – a durable hardwood for planting in the Bay of Plenty

Executive Summary

Eucalyptus globoidea is one of the durable hardwood eucalypt species under tree improvement research and development by the New Zealand Dryland Forests Initiative. The species was recognised by New Zealand Farm Forestry founder Neil Barr as one of the better dozen performing eucalypts in New Zealand, with Bay of Plenty plantings contributing to this status.

E. globoidea is a class 2 durable hardwood that is well adapted to NZ soils and can survive light frosts which makes it one of the more site tolerant durable eucalypts for much of the North Island. It is also less prone to insect damage than many other eucalypt species.

There is increasing interest in the use of naturally ground durable timbers and eucalypts have the added advantage of being very strong as well as chemical-free. This makes them ideal for posts and poles as well as many other end uses such as crossarms and decking etc.

The recommendation of *E. globoidea* as a durable hardwood species for the Bay of Plenty is based on data collected in successful woodlots/plantations in the region and the sawing studies of locally grown logs.

There are several well managed woodlots/plantations in the Bay of Plenty that demonstrate its regional potential with some stands measured recording over 30 m^3/ha/yr.

Several sawing studies of *E. globoidea* grown in the Bay of Plenty have provided evidence of its potential to produce high grade timber; the most relevant is a study of 25 year old trees that showed *E. globoidea* can produce higher yields of good quality timber than other species tested. This sawing study also showed *E. globoidea* does not have internal growth stresses that create problems for sawing and nor are there drying problems, both which can be a problem with some eucalypt species.

In summary, NZDFI has selected this species due to its adaptability to the North Island and recommends it for wider planting in the Bay of Plenty.

Eucalyptus globoidea – a durable hardwood for planting in the Bay of Plenty

Introduction

This report has been prepared as a part of the NZDFI's extension programme that was agreed with Simon Stokes of the Bay of Plenty Regional Council (BoPRC) in May 2011. BoPRC had decided to support the NZDFI's programme as 'the project fits with the Council's interest and increasing knowledge requirement with regards to tree species that can be successfully grown for a variety of uses within the Bay of Plenty under an increased temperature and drought prone climate change scenario'.

The potential of durable hardwood eucalypt species is of interest to all land managers using tantalised posts or timber. In particular, Bay of Plenty industries such as kiwifruit orchards, landscapers, vineyards, farmers etc. are all potential users of durable eucalypts for posts and sawn timber. With many durable eucalypts to select from, following research NZDFI recommend *E. globoidea* as a durable species to plant in the Bay of Plenty.

The selection of *E. globoidea* is underpinned by Neil Barr (1996) who selected this species as being one of the eleven best eucalypt species for New Zealand. 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".

This report provides an account of utilisation of historical plantings in the BoP and introduces new information based on more recent trials of *E. globoidea* in the BoP and other NZ regions.

Why consider durable eucalypts for BoP?

The benign climate of much of the Bay of Plenty is suited to growing eucalypt trees. Eucalypts have been a century old feature of the landscape from early farm plantings through to kiwifruit shelter and, in the last few decades, plantations for short fibre pulp.

Despite this, BoP has few eucalypt woodlots and plantations grown for high quality solid timber production. This is not unusual as there are only about 25,000 ha in New Zealand, with these mostly low durable species for short fibre pulp. 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 $50 million of sawn timber and over $200 million of wooden furniture and furniture parts annually.

The banning of CCA-treated wood for many uses in the USA and parts of Europe opens up new opportunities for naturally-durable hardwoods, this is especially important for those in the organic industry. 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 is their high strength.

Ground durable eucalypt hardwoods are durable, 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.

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 eucalypt residues have good 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. making them suitable as species for NZ's Emissions Trading Scheme.

NZDFI objectives will contribute to Bay of Plenty's sustainability goals including:

Economic

- New economic development by landowners investing in growing eucalypt woodlots to create a regional hardwood industry.
- Diversifing BoP's timber supply with high quality durable hardwood that will substitute for imported hardwoods that may be logged unsustainably.
- Reducing the dependence on CCA treated pine of BoP's horticultural industry, so forestalling international market resistance to CCA use in agricultural systems growing food.
- Providing options for those growing organic products

Social

- Transferring to farmers and foresters, regional land managers, scientists and consultants, the knowledge and resources needed to establish and manage improved germplasm of durable timber species in NZ drylands.
- Establishing New Zealand as an internationally recognized world leader in the research and breeding of durable eucalypts and the production of high quality hardwoods.

Environmental

- Developing a resilient forestry option for regions that are predicted to experience more frequent prolonged droughts as a result of climate change.
- Producing naturally durable timber that will substitute for treated pines and thereby reduce hazardous wood waste flows.
- Encouraging the planting of durable eucalypts that also:
    - have rapid growth rates and high wood densities offering the potential for rapid carbon sequestration rates.
    - combat soil erosion as they have extensive root systems that coppice (resprout) following felling or after fire.
    - can be planted in farm shelterbelts/woodlots and thinned for fence posts for on farm use reducing carbon emissions and energy consumption.
    - provide year round nectar/pollen for native biodiversity and bee keeping.

Natural distribution of *E. globoidea* in Australia

Found in south eastern Australia on gentle undulating country and hills near the coast, to mountain slopes and escarpments adjacent to tablelands but not inland of the ranges (Boland et al 2006). It covers a 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).

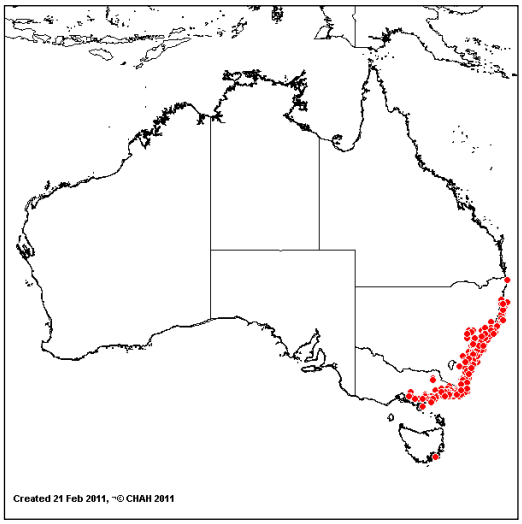


Figure 1: Map of Australia showing the natural distribution of *E. globoidea* (source Australia's Virtual Herbarium)-note Tasmanian record is cultivated, not natural.

New Zealand Historical Stands

Barr (1996) records the following notable stands in the Bay of Plenty "The original Hewett plantations at Omanawa Tauranga, County Council and Harbour Board Plantations at Whakatane, and some State forest areas. Later plantings on the Brann property at Te Puke".

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"

Description of Timber and Utilisation

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 (Table 1), it is still suitable for structural uses, including framing, cross arms, and decking."

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".

Table 1: Strength and density values for *E. globoidea* and *P. radiata* timber

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. globoidea	92	133	14	17	43	68	6.8	8.8	1100	880	680
New Zealand											
E. globoidea	81	132	7.7	15	38	67	4.5	6.9	na	805	635
Pinus radiata	40	89	6.2	8.5	16	38	2.4	5.0	960	500	420

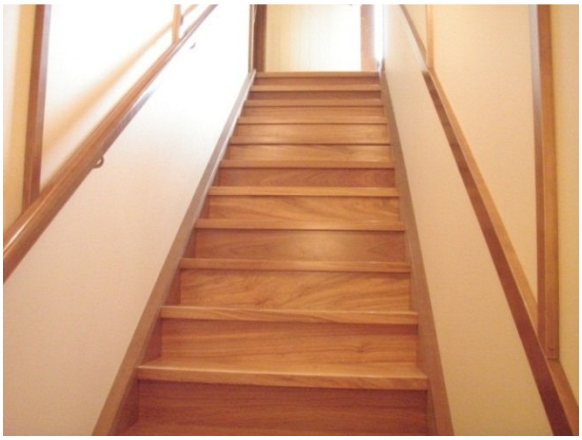


Figure 2: Staircase made from New Zealand grown *E. globoidea*

Figure 3: New Zealand grown *E. globoidea* solid timber floor

Sawing Study

Jones et al. (2010) report on a recent sawing study comparing 15 trees each from 25 year old *E. globoidea, E. fastigata*, *E. muelleriana* and *E. pilularis* grown in Rotoehu Forest in the Bay of Plenty. The butt and second logs were quarter-sawn and flat-sawn respectively.

Figure 4: 25 year old *E. globoidea* from Rotoehu forest used in sawing trial

Figure 5: Discs from *E. globoidea* showing high levels of heartwood (81%)

Figure 6: *E. globoidea* log being sawn, note lack of log movement as saw exits log

Average DBH of the *E. globoidea* sample logs was 472 mm, which was less than the *E. fastigata* but greater than the *E. muelleriana* and *E. pilularis.* The average outerwood basic density was 543 kg/m^3 with a range of 442-620, this was the second highest density of the species sampled just behind the *E.*

muelleriana, but was lower than that recorded from 40 year old trees in a Whakatane stand. The heartwood percentage of the *E. globoidea* at 2.7 m was 81% which was similar to the other species and similar to the 40 trees assessed previously at Whakatane. In a young fast grown stand near Tauranga at age 9 yrs ground level discs of *E. globoidea* averaged 76% heartwood which was higher than nearby stands of *E. muelleriana* and *E. pilularis* (J. Tombleson pers comm). The grade recovery of *E. globoidea* for clears and No.1 cuttings were superior or equal to the other species (Figure 7).

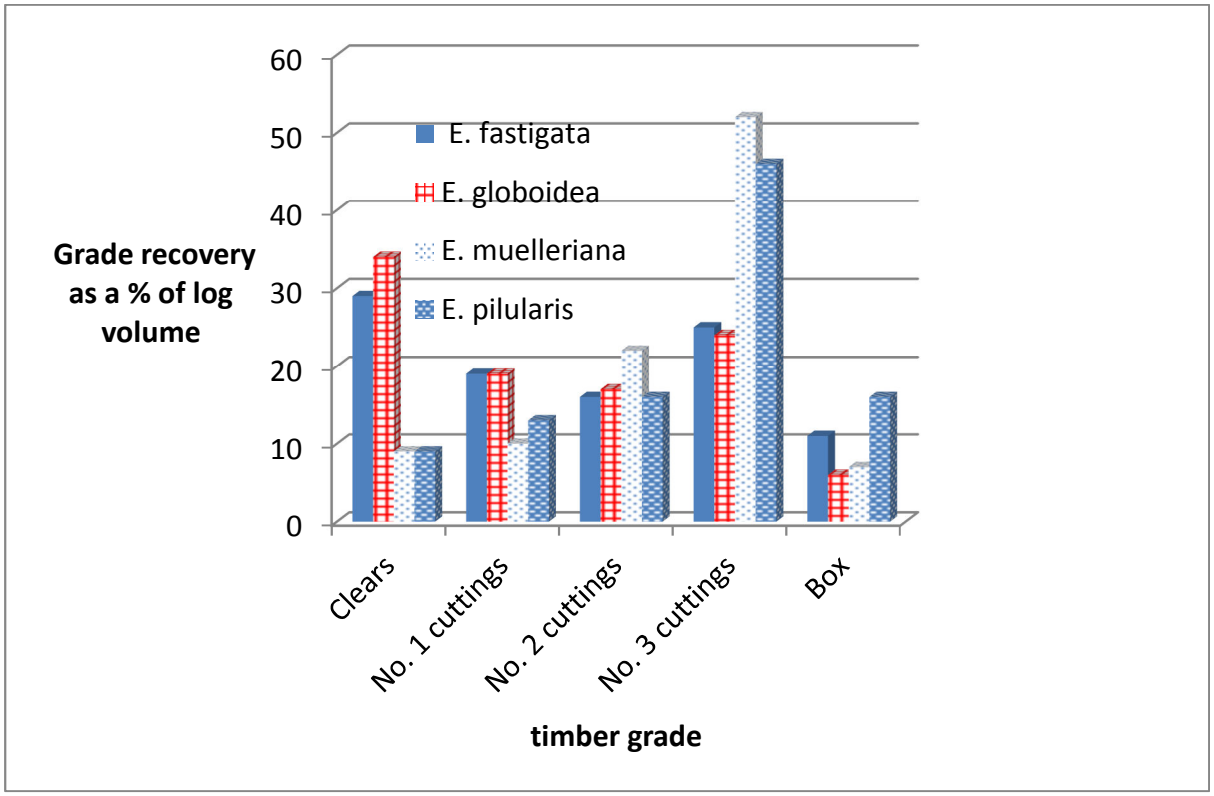


Figure 7: Visual board grade recovery of air dried timber (from Jones et al 2010)

The total sawn board recovery was 44, 55, 58 and 57% for *E. fastigata*, *E. globoidea*, *E. muelleriana* and *E. pilularis* respectively. Kino (gum bleeding) was higher in *E. fastigata* compared with the other species, *E. fastigata* had 6% of boards with kino present, *E. globoidea* 1% and the other two species less than 1 %. Both *E. fastigata* and *E. globoidea* had 3% of boards affected by internal checking while there was none recorded for the other two species. Board distortion, bow and crook, was related to sawing techniques and differed little between species. It was reported that "The boards of all species had high values of density, modulus of elasticity and surface hardness, and machine grades of MSG10 to MSG15".

Somerville and Gatenby (1996) also reported on experiences sawing 60 year old *E. globoidea* from Matakana Island, 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.

In the late 1970s one of the authors was involved in a NZFS sawing study of *E.globoidea* from the Waimana stand near Whakatane which had been established for engineering timbers for the local harbour board. These logs were sawn without any major problems.

Mature *E. globoidea* that had been grown in a farm woodlot at Omanawa, in the Bay of Plenty have been successfully sawn producing excellent sawn timber (Mike Moores, Tauriko sawmill, pers comm 2011).

Growth of *E. globoidea* in the Bay of Plenty

There is a good record of *E. globoidea* growing well in milder areas of New Zealand. While initially not a fast grower like some other eucalypts, it has good adaptability and survival. Form is generally good although on fertile sites although 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 averages of all PSP plots have a mean Site Index of 22 metres. There is wide variation between plots, with four Bay of Plenty plots having a Site Index of nearly 30 metres, while two other plots in the same region are only 21 metres. This may be due to poor site conditions or tree genetics in the slower growing plots.

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 above *E. globoidea* on fertile warm sites can achieve 2 m height growth over at least 15 years.

The most productive plots in the Bay of Plenty 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.

Table 2: Bay of Plenty *E. globoidea* growth plot data

Site/Plot	Age	SPH	Mean DBH	MTD*	Mean ht	Mean CrHt	MTH*	BA	Vol	MAI # vol	Site Index
	yr	Stems /ha	cm	cm	m	m	m	m^2/ha	m^3/ha	m^3/ha /yr	m @ 15yrs
1/1	12	480	34.8	40.9	21	11.8	23.1	45.77	358.1	30.48	28.0
1/2	12	400	37.4	43.1	23	13.4	24.2	44.04	370.4	31.52	29.2
2/1	18	260	35.3	na	24	11.6	25.5	25.5	133.4	7.4	21.6
2/2	18	150	34.5	na	23.5	12.5	24.5	14	71.8	4.00	20.7
3/1	7	714	22.0	na	14.7	7.5	na	na	na	na	31.5
3/2	7	969	21.6	na	15.0	8.0	na	na	na	na	31.9

* MTD mean top diameter, MTH mean top height; Mean of largest diameter 100 trees/hectare

Mean Annual Increment

na not available

Figure 8: 18 year old E. globoidea stand Paengaroa

Figure 9: 12 year old *E. globoidea* stand Welcome Bay

Figure 10: 29 year old *E. globoidea* tree Paengaroa

Recent Research trials:

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** (Figure 11) but not suitable for cold sites (100-200 frost free days/yr) (nzffa.org.nz). 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.

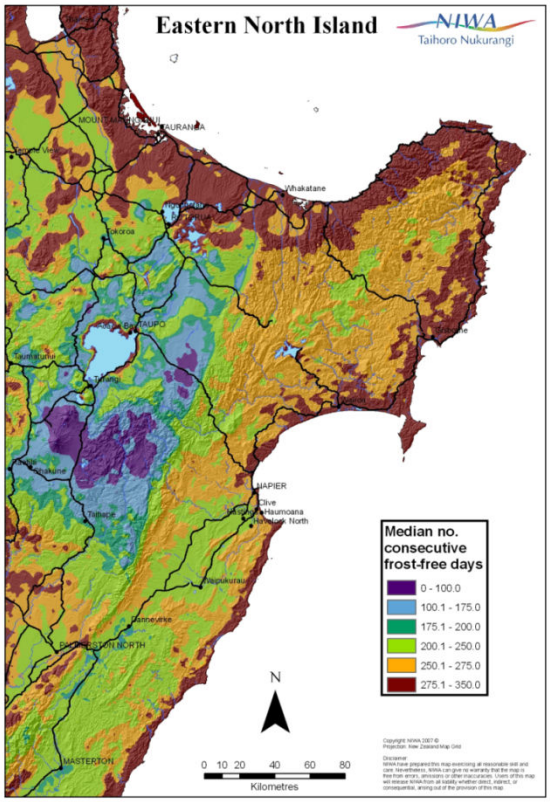


Figure 11: Frost profile for Bay of Plenty and surrounding regions, *E. globoidea* is suggested for regions with 200-275 frost free days/year

Figure 12: 7 year old *E. globoidea* near Opotiki

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 13). This excellent health is also supported by the healthy appearance of *E. globoidea* in the national sets of eucalypt trials.
In a Manawatu planting *E. globoidea* was less preferred by possums compared with some other durable eucalypt species (Millner 2006), but it has been almost decimated by deer when planted amongst native scrub in the Wairarapa.

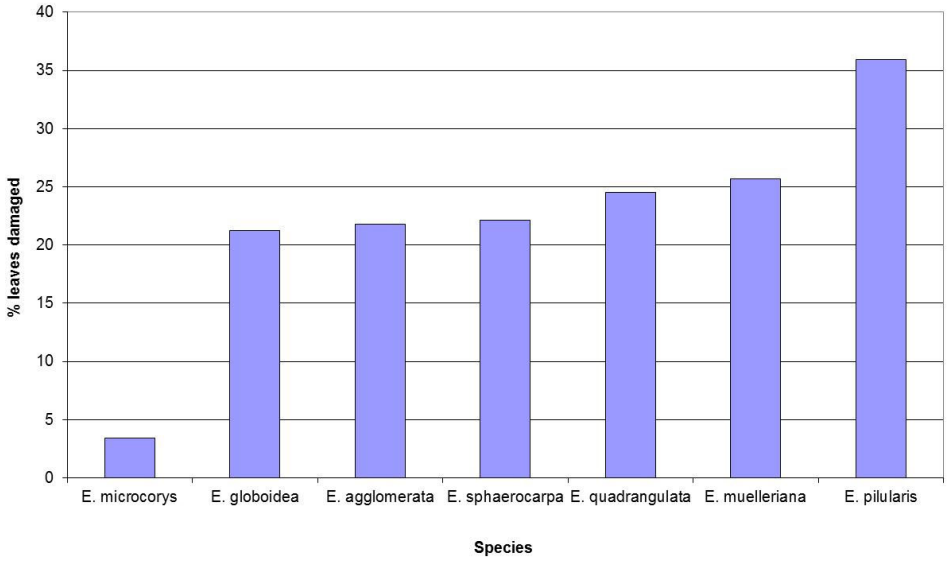


Figure 13: Health assessment of a sample of eucalypt trees in Northland (www.nzffa. org.nz)

Flowering

The flowering of eucalypts can be influenced by season and probably more importantly by seed source. Blakely (1934) and Boland et al (2006) both suggest the flowering period for *E. globoidea* is April to June. More information is required to be able to predict flowering in New Zealand.

Management

Although there is no specific post/pole trials with eucalypts in New Zealand, evaluation of a eucalypt planting near Katikati comparing close spaced trees with standard forestry spacing indicated a much higher of post quality material in the closer spacing (Nicholas unpublished data). 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), but sawlog crops established at 3 m x 3 m (1111stems/ha). 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.

NZDFI *E. globoidea* research programme 2003-2012

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 near Blenheim. This one hectare stand was planted from seed collected of three provenances of *E. globoidea* from its natural range in Australia. This stand started flowering in November 2010 and the first collection of seed is planned for later in 2012.

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 (Figure 14).

When the NZDFI was formally established in July 2008, *E. globoidea* was selected as one of several key species identified for tree improvement.

Figure 14 High quality *E. globoidea* flooring in a Marlborough house

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

Back ground

In November 2010, *E.globoidea* trees were felled at the Waikakaho site 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
A summary of basic wood density and heartwood measurements is presented in Table 3.

Table 3. Summary of Density and Heartwood results.

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						

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. There was no significant difference between provenances in the density of trees sampled. There was no correlation between diameter and density of discs.
Millner, (2006) reported a mean basic density of 477 kg/m^3 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).

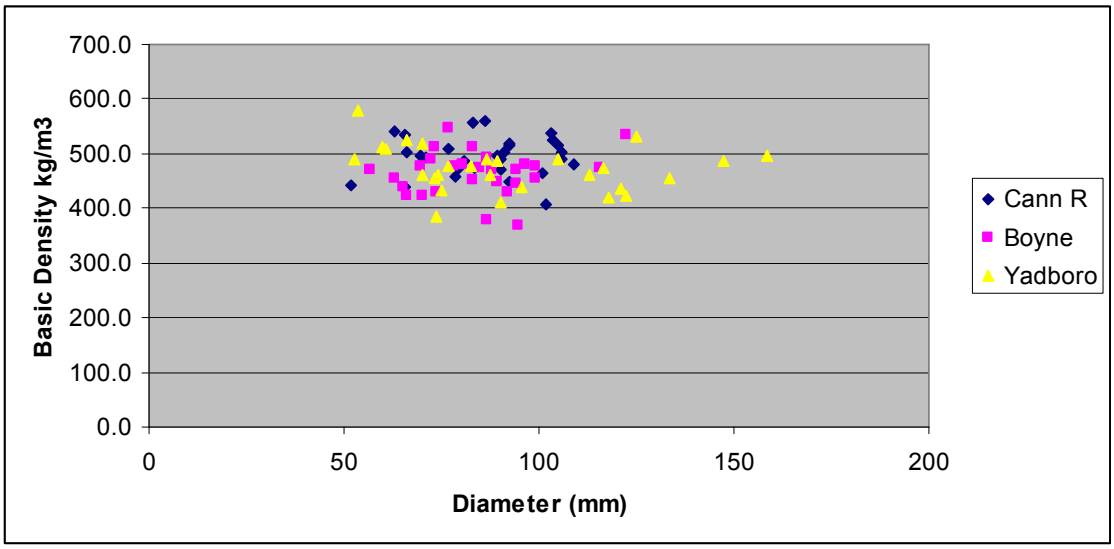


Figure 14: Wood density and disc diameter of sampled trees

Heartwood was measured on the discs samples only. 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. 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, e.g. Samples Y8 and B3 (Figure 15). Intensive selection of individuals within the breeding populations will capture trees with these ideal characteristics.

Fig. 15. Stained area indicating heartwood zone for two seedlots.

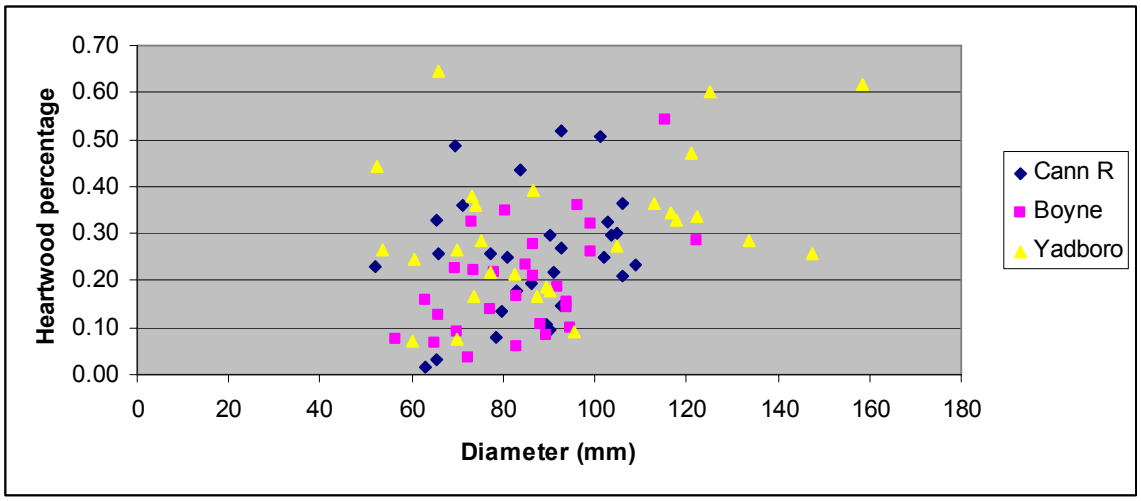


Figure 16: Heartwood percentage and disc diameter of sampled trees

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.

NZDFI *E. globoidea* tree improvement programme

Extensive seed collections 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.

NZDFI extension programme in BoP

NZDFI also established in 2011 eleven durable eucalypt demonstration trials, planted in conjunction with host landowners across NZ east coast regions, including BoP. These demonstration trials include *E. globoidea* along with up to 11 different eucalypt species and radiata pine for comparative purposes. The trials are strategically located in different locales that offer variation in climate, aspect and altitude, also soils and proximity to the coast. These diverse trial sites will test the species across a range of environments to provide comparative data for screening species and to extend our knowledge on species productivity on different sites.

A NZDFI demonstration trial was established in spring 2011 at the TECT Park between Rotorua and Tauranga.

The species planted were:

- *E argophloia*
- *E bosistoana*
- *E camaldulensis*
- *E cladocalyx*
- *E eugenoides*
- *E globoidea*

- *E longifolia*
- *E macrorhyncha*
- *E quadrangulata*
- *E tricarpa*
- *Pinus radiata*

Such trials are critical to determining the best durable species options for the Bay of Plenty. If these can be replicated in other parts of the region a better understanding of the attributes of these durable eucalypts will evolve.

This demonstration trial will be the focus for a field day that will be held in BoP in early 2013. The field day will be planned and coordinated with the local branch of the NZFFA and BoP regional council staff.

Conclusion

Evaluation of the performance of *E. globoidea* in the Bay of Plenty confirms its potential for planting for durable timber production. This is based on analysis of existing stands and the experience from sawing Bay of Plenty grown trees.

NZDFI initiatives, such as the recently established demonstration trial will provide new information on the capabilities of *E. globoidea* in the region. Other national projects under the NZDFI banner will also contribute to the development of *E. globoidea* and other durable eucalypt planting material that will support the establishment of a regional resource of durable eucalypt timber. This provides Bay of Plenty land owners with new forestry options for timber and post wood production for sustainable harvesting and income from carbon credits.

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