

Commercial in Confidence

**Potential applications of the native  
hardwood resource available to  
VicForests as wood composite  
products.**

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## Summary

### Objectives

This report provides background information for the potential applications of the native eucalypt hardwood resource available to VicForests with a specific reference to wood composites.

The eucalypt species targeted were:

Genus	Species	Common Name
<i>Eucalyptus</i>	<i>delegatensis</i>	Alpine Ash
<i>Eucalyptus</i>	<i>bicostata</i> / <i>pseudoglobulus</i> / <i>maidenii</i> / <i>globulus</i>	Mixed Blue Gum Species
<i>Eucalyptus</i>	<i>baxteri</i>	Brown Stringybark
<i>Eucalyptus</i>	<i>rubida</i>	Candlebark
<i>Eucalyptus</i>	<i>fastigata</i>	Cut-tail
<i>Eucalyptus</i>	<i>cypellocarpa</i>	Mountain Grey Gum
<i>Eucalyptus</i>	<i>dalrympleana</i>	Mountain Gum
<i>Eucalyptus</i>	<i>denticulata</i>	Errinundra Shining Gum
<i>Eucalyptus</i>	<i>regnans</i>	Mountain Ash
<i>Eucalyptus</i>	<i>obliqua</i>	Messmate
<i>Eucalyptus</i>	<i>dives</i>	Broad-leaved Peppermint
<i>Eucalyptus</i>	<i>radiata</i>	Narrow-leaved Peppermint
<i>Eucalyptus</i>	<i>elata</i>	River Peppermint
<i>Eucalyptus</i>	<i>macrorhyncha</i>	Red Stringybark
<i>Eucalyptus</i>	<i>nitens</i>	Shining Gum
<i>Eucalyptus</i>	<i>botryoidies</i>	Southern Mahogany
<i>Eucalyptus</i>	<i>sieberi</i>	Silvertop
<i>Eucalyptus</i>	<i>viminalis</i>	Manna Gum
<i>Eucalyptus</i>	<i>globoidea</i>	White Stringybark
<i>Eucalyptus</i>	<i>consideniana</i>	Yertchuk
<i>Eucalyptus</i>	<i>muelleriana</i>	Yellow Stringybark

The wood composites targeted included:

- Medium Density Fibreboard (MDF)
- Particleboard
- Hardboard
- Oriented Strandboard (OSB)
- Plywood
- Laminated Veneer Lumber (LVL)
- Glulam
- Scrimber
- Cement Board

## ***Key Findings and Recommendations***

### **Eucalypt Wood Composites**

Appendix 1 contains the currently known details of the physical wood properties for each of the individual target species. The physical properties described include basic density, saturated moisture content, air dry density, hardness, strength, durability rating, lyctus susceptibility and shrinkage values. These timber characteristics are mostly average values only and may not be relevant to specific sites. There is little available information on individual species chemical attributes.

Very few of the target species were found in the publicly available literature with regard to composite products, and only veneer and cement board products produced results in any of the target species. These were:

- Veneers: *E. obliqua*, *E. sieberi*, *E. nitens*, *E. globulus*, *E. regnans* and *E. delegatensis*
- Species used in making or trialling cement board: *E. nitens*, *E. globulus*, *E. viminalis*

Non-target eucalypt species that have been plantation grown have been used in composite products and are reported in the available literature to a limited extent. These results are also summarised in the body of the document.

In 1997-98 CSIRO was commissioned by the Department of Natural Resources and Environment to trial some of the target species to determine suitability for the production of MDF, OSB and LVL in East Gippsland. The results have been summarised in the body of this report.

In general, composite wood products manufactured from eucalypt timbers tend to exhibit high strength (MOR) and stiffness (MOE) properties, but have issues relating to internal bond strength of the glues and resins used in their manufacture. However, the traditional resins used in composite manufacture in Australia have been developed for softwoods and are not optimal for eucalypt wood composite manufacture. Resins that have been developed to suit eucalypt wood composite manufacture are not generally publicly available due to commercial sensitivities, but eucalypt specific resins should ensure that wood composite products made from eucalypt timber would pass all structural requirements in the relevant standards. Fibre preparation techniques as described in the literature would also need to be modified to minimise the production of fines, and the inherent extractives in eucalypt timber are likely to need pre-treatment to ensure consistent internal bond strengths could be maintained. In addition, the resulting composite products are often quite heavy, due to the higher density of eucalypt timber, and work may need to be undertaken to reduce the weight of the resultant product either through blending with lower density species or pre-treatment of the wood in-feed to reduce density.

Previous research investigating native Australian hardwood species for their potential in composite products showed that basic density was the best indicator for the suitability of a given wood for use in a given composite form. High density tends to result in poor penetration of glues and poor conformability of the wood components for forming and pressing. High density woods also tend to produce more fines, which can also lead to poor or uneven bond strength (particularly in MDF). High extractive



levels are often associated with higher density woods, and the extractives can again inhibit glue penetration or interfere with glue curing. In composites where the wood components are larger (e.g. plywood, LVL, glulam), swelling pressures with higher density species can also be a problem. Combined, these issues create difficulties for consistency in mechanical and physical performance as wood composite products which require novel solutions to be developed to combat these issues.

The basic densities of the mature target eucalypt hardwood species were generally higher (~500–800 kg/m<sup>3</sup>) than those considered optimal for wood composites (this varies by product, but the optimal range is generally between 400–600 kg/m<sup>3</sup>). Some of the target species at the lower end of the basic density range (e.g. *E. regnans*, *E. delegatensis*, and *E. nitens* - <525 kg/m<sup>3</sup>) may be suitable, or some of the younger thinnings from the available hardwood resource, could be suitable for further work to investigate composite wood products, but further investment would be required to develop or test existing experimental bonding systems and production systems for these species.

Peeled veneer is being produced in Tasmania from native hardwood resources as are glulam beams in Victoria. Published information regarding the preference of eucalypt hardwoods in a production environment is difficult to access due to the lack of published information and commercial sensitivities.



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## Introduction

Appendix 1 collates all the available wood property data for 22 of the Victorian eucalypt species listed in the objective. The physical properties described include basic density, saturated moisture content, air dry density, hardness, strength, durability rating, lyctus susceptibility and shrinkage values. These timber characteristics are mostly average values only and may not be relevant to specific sites. There is little available information on individual species chemical attributes in published papers.

To determine the suitability of listed Victorian eucalypt species for composite products a literature search of the commonwealth agricultural bureau abstracts (CABI) was undertaken. The results obtained from this search were limited, so the search was widened to include references to any eucalypt species. Further information has been summarised here from investigations undertaken by CSIRO using Victorian species and other eucalypt species in trials no longer considered commercial-in-confidence. The literature search covered the following forest products: medium density fibreboard (MDF), particleboard, hardboard, oriented strandboard (OSB), plywood, laminated veneer lumber (LVL), glulam, Scrimber and cement board.

It should be noted that only information available in the public domain (including some company websites) has been detailed in this report. CSIRO reports that are considered commercial in confidence have not been described, nor have non-peer reviewed reports that may be part of conference proceedings.

## Species Properties

CSIRO has previously been involved with two projects that investigated Australian native perennials having potential commercial use through regional plantings feeding into a wood composites industry. These projects were the WA CALM Search project and CRC Plant-Based Management of Dryland Salinity FloraSeach project. After screening for a number of physical and chemical properties including whole wood basic density, extractives content (hot water and dichloromethane), cellulose content, pH and buffering capacity and fibre length, it was found that the most relevant property for determining the suitability of a species for reconstituted wood-based composites feedstock was basic density. Although the target hardwood species in this report were not included in the afore-mentioned projects the target wood characteristics would be unlikely to change. Table 1 lists the preferred wood basic densities for the range of wood composite products discussed in this report.

**Table 1:** Preferred wood basic densities for composite products

PRODUCT	Basic Density Range (kg/m <sup>3</sup> )
Medium Density Fibreboard (MDF)	Less than 600
Particleboard	Less than 450
Hardboard	Full range of densities are acceptable
Oriented Strandboard (OSB)	Less than 550
Plywood	Less than 600
Laminated Veneer Lumber (LVL)	Less than 600
Glulam	Less than 700
Scrimber	Less than 500
Cement Board	Less than 600

The estimated mean basic densities of the target Victorian hardwood species and *Pinus radiata* are shown in Table 2. Densities for the mature eucalypt species range from 500 – 750 kg/m<sup>3</sup>. *P. radiata* has been included in Table 2 as the majority of wood composite products in southern Australia are manufactured from radiata pine, and in comparison, *P. radiata* has an average basic density of 425 kg/m<sup>3</sup>.

**Table 2:** Basic densities of targeted species for this study. Data is predominantly for mature trees but younger trees are included where data exists (CSIRO in-house data base).

Species	Basic Density (kg/m <sup>3</sup> )	
	Mature	Immature
<i>Pinus radiata</i>	425	
<i>Eucalyptus regnans</i>	500	424 (35 y.o.)
<i>Eucalyptus delegatensis</i>	511	
<i>Eucalyptus nitens</i>	524	
<i>Eucalyptus dalrympleana</i>	532	
<i>Eucalyptus rubida</i>	538	545 (18-28 y.o.)
<i>Eucalyptus viminalis</i>	559	
<i>Eucalyptus fastigata</i>	561	
<i>Eucalyptus radiata</i>	593	545 (15-25 y.o.)
<i>Eucalyptus obliqua</i>	599	543 (15-25 y.o.)
<i>Eucalyptus dives</i>	610	557 (17-25 y.o.)
<i>Eucalyptus baxteri</i>	613	
<i>Eucalyptus globoidea</i>	652	
<i>Eucalyptus cypellocarpa</i>	666	
<i>Eucalyptus sieberi</i>	668	
<i>Eucalyptus globulus</i>	672	561 (17-23 y.o.)
<i>Eucalyptus macrorhyncha</i>	697	
<i>Eucalyptus muelleriana</i>	697	
<i>Eucalyptus botryoides</i>	708	
<i>Eucalyptus consideriana</i>	710	
<i>Eucalyptus maidenii</i>	750	

Due to the large variation in basic densities within many of the target species, further analysis may be warranted for some of the target species suitability for wood composite products, particularly in the case of *E. regnans*, *E. delegatensis*, *E. nitens*, *E. dalrympleana*, *E. rubida*, *E. radiata*, *E. viminalis*, *E. fastigata* and *E. obliqua*, all of which have mean basic densities below 600 kg/m<sup>3</sup>. In particular younger examples of these species (less than 15 years old) may exhibit more beneficial density attributes.

Although basic density has been found to be the most useful property in determining the suitability for wood composite products, other wood properties also impact suitability. For example log decay could greatly increase the fines content of MDF operations and produce a residual detritus deleterious to adhesive bonding. In addition, the presence of kino and gum veins may also impact on bonding quality. Log decay, kino and gum veins are largely a result of environmental (on-site) conditions, and it is not possible to estimate the extent of these attributes in the target Victorian hardwood species without a comprehensive site survey.

## Wood-Based Composite Products

### Medium Density Fibreboard (MDF)

In 1998 CSIRO carried out a limited investigation into preparing MDF from three eucalypt species sampled from the East Gippsland region. This study was funded under the umbrella of the Forest and Wood Products Research and Development Corporation (FWPRDC) with contributing members being the Department of Conservation and Natural Resources (DCNR) and several sawmill companies. OSB and LVL were also trialled with similar species from the same region.

The species trialled in MDF<sup>1</sup> form were:

- *E. obliqua* 'mature' and 20 y.o.
- *E. sieberi* 'mature' and 15 y.o.
- *E. globoidea* 'mature'

Some preliminary trials were carried out on plantation grown *E. grandis* and *E. globulus* to determine processing conditions for fibre production. An in-house control using *P. radiata* was made for comparative purposes.

This work found that a higher than normal MDF panel density (~700 kg/m<sup>3</sup>) was needed to obtain sufficient mechanical properties in 100% eucalypt panels. Panel densities in the range 900-1000 kg/m<sup>3</sup> were required to produce panels having sufficient integrity. The furnish was very dusty (high proportion of fractured fibres) with a high surface area resulting in high resin consumption or poor resin distribution.

Some specific results of experimental trials using experimental phenol-formaldehyde resin at a loading of 12% resulted in:

- Young *E. sieberi* panels of high density (~1000 kg/m<sup>3</sup>) gave very high internal bond strengths of about 2000 kPa (where typical MDF would be ~750 kPa). High flexural properties were also encountered, ~74 MPa (MOR) and ~6.4 GPa (MOE), approximately twice that of typical commercial MDF. Much

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<sup>1</sup> R.S.P. Coutts *et al.* Evaluation of East Gippsland Hardwoods for MDF Production. Confidential Client Report No. 350. CSIRO Forestry and Forest Products. (1998).

reduced thickness swell was also found (~3%) as would be expected with this panel density compared to a typical commercial panel thickness swell of ~10%.

- Mature *E. sieberi* panels at densities of ~900 kg/m<sup>3</sup> gave flexural properties of 43-46 MPa (MOR) and 4.6-5.3 GPa (MOE) and internal bond strengths ranging from 575-1185 kPa. Thickness swells were again very low ~3-4%.

Further results from this study showed the poor resin quality of urea-formaldehyde (UF) resins when used for bonding eucalypt species. Trials using commercial UF in panels of ~800-850 kg/m<sup>3</sup> density and 10% resin loading resulted in internal bonds of only 160-280 kPa with *E. obliqua*. No flexural property results were available. Higher resin loadings (12%) improved the internal bond strengths in *E. globoidea* and *E. sieberi* to ~500 kPa. Another resin, methylene diphenyl di-isocyanate resin (MDI) was used with *E. globoidea* in a small trial at ~800 kg/m<sup>3</sup> panel density which resulted in internal bond strengths of 525-550 kPa, still below the target ~750 kPa.

Another research project carried out by CSIRO was the Western Australia Search Project<sup>2</sup> for the WA Department of Conservation and Land Management (CALM), which was funded by the Natural Heritage Trust. This project trialled 51 perennial hardwood species indigenous to Western Australia (with some overlap to SE Australia) for properties such as basic density, cellulose content, hot water solubles, pH and buffering capacities. Nineteen species were then selected for processing into MDF using the CSIRO MDF pilot plant (including blow-line drier) in limited trials. The same species were used for processing into particleboard (see later section). Although the species were not related to the target eucalypt species in this report, the study offers insight into the use of Australian hardwood species in medium density fibreboard.

From the WA Search project, results for the two eucalypt species are shown in Table 3. For modest panel densities of approximately 800 kg/m<sup>3</sup>, high internal bond strengths were obtained, as were good MOR and MOE properties. The thickness swell was also broadly within acceptable levels.

**Table 3:** Mechanical and physical properties of MDF prepared from two eucalypt species in the WA Search project<sup>2</sup>.

Species	Panel Density (kg/m <sup>3</sup> )	MOR (MPa)	MOE (MPa)	IBS (kPa)	Thickness Swell (%)
<i>E. loxophleba</i>	837 ±114	35 ±2	3167 ±163	2040 ±222	11.1 ±1.7
<i>E. rudis</i>	795 ±16	39 ±3	3750 ±24	1758 ±204	8.6 ±0.5
Std. Commercial MDF	725	38	3000	750	8-12
Australian Std. Minimum Values	-	28	2500	600	8 (MR) -12

<sup>2</sup> G. Olsen *et al.* Search Project. Western Australia Department of Conservation and Land Management. (2004).

Although the WA Search study was limited in processing variables, with regard to fibre and panel fabrication, many hardwood species were able to be fabricated into MDF with varying degrees of success. High fines content was found for native hardwood species and this required higher panel densities to be prepared, to fill equivalent volume which resulted in higher internal bond strengths.

These Australian studies showed that it is possible to produce MDF from a eucalypt furnish but with higher densities than those currently used in the industry. Further studies may be warranted in order to reduce panel density while attaining superior strength and flexural properties and satisfactory internal bond strength. Panel density could be reduced either through blending with lower density species or pre-treatment to reduce the density of the wood in-feed.

In Australia, MDF is almost wholly made from *P. radiata* softwood. Only small amounts of eucalypt hardwood are known to be blended with softwood material in the surfaces of panels to increase surface density for improved finishes. MDF manufactured overseas does use 100% eucalypt feed stock which is likely to be of relatively low basic density. For example, MDF mills in Spain, Portugal and Tunisia make use of plantation eucalypts (e.g. *E. globulus*)<sup>3</sup>. Of the hundreds of MDF mills in China it would be assumed that many mills use eucalypt species in 100% or mixed proportions along with other non-eucalypt hardwoods. The plantation size of eucalypts in China is thought to be in the order of 5 million hectares. However, there is little in the literature about the technical aspects of using such plantation grown eucalypts in MDF, and no references for the target Victorian hardwood species were found. Two species, *E. deglupta* and *E. urophylla*, have been used in Indonesia<sup>4</sup>, but the only recent information that has been obtained from their web site<sup>5</sup> suggests they may have moved to *Acacia mangium* and *Gmelina arborea* as a feedstock. Thailand appears to be using *E. camaldulensis* and rubber wood species as a blended feedstock in MDF production<sup>6</sup>. In this reference, surface roughness was investigated in commercially manufactured boards.

Brazil has extensive eucalypt plantations for the pulp and paper industry and has six large MDF mills. Specific information on feedstock is difficult to obtain. Once again, because of the large plantings of eucalypts (thought to be in the order of 3.5 million ha) it is possible that eucalypt species form part of the feedstock entering these mills.

Plantation grown *Eucalyptus saligna* in Brazil was used to prepare MDF at a laboratory scale<sup>7</sup> with a target panel density of 770 kg/m<sup>3</sup> and varying thicknesses. Acceptable panels were made with good mechanical and physical properties using urea-formaldehyde and a wax emulsion.

Published information regarding the preference of eucalypt hardwoods in a production environment is difficult to access due to the lack of published information and commercial sensitivity.

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<sup>3</sup> Mr. K. Merrett. Fibertech Pty Ltd. Personal communication.

<sup>4</sup> Anon. Competitive Advantages of PT Sumalindo Lestari Jaya. Asian Timber. OCT 1996 pp 42-45.

<sup>5</sup> <http://www.sumalindo.com/>

<sup>6</sup> S. Hiziroglu and P. Kosonkorn. Evaluation of surface roughness of Thai medium density fiberboard (MDF). Building and Environment. 41 (4) pp 527-533 (2006).

<sup>7</sup> A. M. Krzysik *et al.* Medium density Fiberboard from *Eucalyptus saligna*. Forest Products Journal. 41 (10) pp 47-50. (2001).



## Particleboard

Particleboard is another reconstituted wood product wholly manufactured from *P. radiata* in Australia, with no known hardwood addition. Feedstocks to particleboard mills are usually sawmill off-cuts and/or plantation thinnings. Some 'regrind' (recycled particleboard) is used as core material in some mills. The preference for softwood in particleboard is due to the conformability of the particulate material when hot pressed into panels. Conformability is the ability of the wood to compress into the next particle to ensure maximum bonding area, which is also a function of density. The Victorian hardwood species generally have a higher density than that of *P. radiata* and when used to produce particleboard, result in a much heavier panel.

Particleboard was also trialled by CSIRO Forestry and Forest Products in the WA Search Project referred to in the MDF section previously (see Footnote 2). The same species were trialled at the laboratory scale for their mechanical and physical performance in particleboard form. A wide range of eucalypt and non-eucalypt species were trialled in particleboard form resulting in modest flexural properties and internal bond strengths compared to commercial particleboard. In general, flexural properties and internal bond strengths were acceptable for many species and comparable to *Pinus radiata* controls and Australian Standard minimums. Only two species performed in a way that allowed conformability between wood particles, neither of them was a *Eucalyptus* species.

Only limited trials were carried out using Australian eucalypt species in particleboard panel form. Resin design and particle geometry (flaking technology) are two areas of study that could improve mechanical and physical performance of particleboard products based on Victorian eucalypt species.

The use of hardwoods in particleboard manufacture overseas is known, especially in Europe where recycling laws ensure wide use, largely from necessity rather than legislation alone. Urban and commercial recycled European woods are lower in density compared to Victorian eucalypt species (444 kg/m<sup>3</sup> for oak through to 374 kg/m<sup>3</sup> for spruce with a cross species mean of 410 kg/m<sup>3</sup>)<sup>8</sup>, hence their use in particleboard is less problematic. There is also an issue of chip quality and fines with using eucalypts as detritus from chips and fines results in increased surface area and thus increased resin consumption, which may lead to poor panel performance if resin starved.

The literature is limited regarding the use of specific eucalypt species for particleboard production and little is known of overseas mills specifically using *Eucalyptus* species as feedstock. The earliest reports refer to Brazilian work by C.R. Haselein *et al.*<sup>9</sup> combining *E. grandis* with a *Cecropia* species in 1989. This work was able to determine a 50:50 (by weight) mixture produced best results. The same authors blended *E. grandis* with acacia (*Acacia mearnsii*) and pine (*P. elliotii*)

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<sup>8</sup> Premyslovska *et al*, Basic density of wood of different forest types, Bioclimatology and Natural Hazards, International Scientific Conference, Slovakia September 2007, ISBN 978-80-228-17-60-8

<sup>9</sup> C. R. Haselein *et al.* Manufacture of particleboard from eucalypt (*E. grandis*) and embuaba (*Cecropia* sp.) wood. *Revista Arvore* : 13 (1) pp 67-84 (1989).



species in a three species blend for particleboard manufacture<sup>10</sup>. Unfortunately this paper was only published in Portuguese with an English abstract and further detail is not available.

A particleboard was made from *E. grandis* designed for exterior use with tannin adhesive resin<sup>11</sup>. The panels were prepared on a mill scale (13.4×2.4 m) and were made with phenol-melamine-urea-formaldehyde (PMUF) adhesives. These tannin bonded particleboard outperformed the pine particleboard in this exterior application. Particleboard is normally an interior use panel and fabricated with UF or MUF resin. Flooring particleboard is made with phenol-formaldehyde resin (PF) and sometimes tannin is added to the formulation.

Studies by Gamage and Setunge<sup>12</sup> made use of *E. regnans* and *E. obliqua* sawdust mill residue to prepare laboratory particleboard. Particleboard panels were prepared in three layer arrangements – fine particles in the surface layers and coarse particles in the core. Improved pressing times for 100% hardwood particleboard was made by increasing the moisture content of the particulate furnish prior to hot pressing. They also modeled process variables to optimize panel making and validate the model with actual flexural properties<sup>13</sup>. No company has yet taken up the results to produce a commercial product.

Plantation *E. globulus* was trialled in laboratory experiments to improve bonding in the manufacture of particleboard in Portugal<sup>14</sup>. It was found that pre-treatment (oven-drying, water extraction, and ageing in sunlight) of the hardwood prior to bonding improved shear strength (laboratory test coupons) over fresh timber. Extended drying, ageing and extraction of water soluble compounds (steeping in water) pre-treatments all improved bonding in the particleboard.

## Hardboard

Hardboards are high density panels (~1100kg/m<sup>3</sup> density) used in floor lining, house frame bracing, doors and furniture. The use of eucalypts in the production of hardboard is advantageous in giving high density and stable panels. During production, wet pulp is hot pressed on a screen and the entire mass is plasticised and thermoformed in the press at the same time as dewatering the mass with the aid of a wire mesh. No adhesive is used in the production of hardboard and as such the product is not particularly durable on exposure to moisture.

Published literature specific to the use of eucalypts in the manufacture of hardboard is limited, and the only paper found was a 1966 reference<sup>15</sup> to a trial using an unspecified mix of eucalypt species, which found eucalypt hardboard panels had less

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<sup>10</sup> C. R. Haselein *et al.* Modelling of mixtures of three wood species in structural particleboard manufacturing. *Floresta* 33 (3) : pp 311-320 (2003).

<sup>11</sup> I. A. van Niekerk and A. Pizi. Characteristic industrial technology for exterior Eucalyptus particle board. *Holz als Roh- und Werkstoff* 52 pp 109-112. (1994).

<sup>12</sup> D. Pannipitiya *et al.* Investigation of hot-pressing process for manufacturing hardwood particleboard. ISEC-4 Structural Engineering and Construction Conference, 26-28 Sept, 2007, Melbourne, Australia.

<sup>13</sup> G. Nirdosha and S. Setunge. Formulation and process modelling of particleboard production using hardwood sawmill wastes using experimental design. *Composite Structures* 75 pp 520-523 (2006).

<sup>14</sup> M. Cruz *et al.* Effect of surface treatment on the bondability of pine and eucalypt with UF resins

<sup>15</sup> A. Chambers. Eucalypt and Radiata Pine Hardboard Comparison of Production Methods. APITTA 19 (5) xx-xxiii. (1966).



water absorption properties than panels made from *Pinus radiata*. Previously three species have been listed as being used to manufacture hardboard in Victoria; *E. obliqua*, *E. viminalis*, and *E. radiata*, while *E. fastigata* and *E. delegatensis* were used to manufacture hardboard in NSW and Tasmania respectively<sup>16</sup>.

### OSB (Oriented Strand Board)

OSB is not currently manufactured in Australia, although the product enjoys wide use in the northern hemisphere. This is related to the need for intense cladding for thermal insulation in building construction in the northern hemisphere, an issue not relevant to Australia. In addition to use as cladding, OSB is also used for flooring, the webbing in I-Joists, packaging and interior panelling. OSB has been manufactured from a wide variety of softwood and hardwood species in North America and Europe. In the production of OSB, strands of wood are orientated in a three layer arrangement, mimicking that of plywood, whereby outer face strands are arranged lengthways in the longest direction of the panel and the core strand arranged crossways. This allows greater load bearing capability. OSB has been able to displace approximately 50 % of plywood use in the United States market place since the 1980s.

OSB was trialled by CSIRO as a potential product with several East Gippsland species in 1998 for the DCNR<sup>17</sup>. The three eucalypt species processed were:

- *E. fastigata* - 45 y.o.
- *E. cypellocarpa* - 45 and 42 y.o.
- *E. sieberi* - 25 y.o.

Liquid phenol-formaldehyde (PF) resin was used to fabricate OSB panels using individual eucalypt species. High density OSB panels were fabricated to improve the mechanical properties with these high density species. There was consistently low internal bond strength for *E. cypellocarpa* and *E. sieberi*. This relates to limited compaction of flakes and thus a lowering of bonding area between flakes.

Some mechanical and physical properties obtained from this trial show:

- Improved flexural strength using thin flakes (0.3 vs 0.6 mm)
- Comparable flexural strengths with varying densities found for *E. sieberi* and *E. cypellocarpa*
- Internal bond strengths were met against standards (345 kPa) for *E. fastigata* but not *E. cypellocarpa* and *E. sieberi*.

The report also indicated that some of the issues that arose with this study may be related to the size of the test panels produced. The laboratory sized panels may not perform in the same way as full size commercial panels, and this should be taken into consideration when assessing the results from this study. The study also concluded that improved resin systems were needed to fabricate OSB panels from these three species.

<sup>16</sup> "Eucalypts for wood production" W.E. Hillis and A.G. Brown. Eds. CSIRO-Academic Press (1984).

<sup>17</sup> Coutts *et al.* Evaluation of East Gippsland Hardwoods for OSB Production. Client Report No. 343 CSIRO Forestry and Forest Products (1998).

A further improvement, not trialled in this study, was the potential benefit of blending eucalypt species having a range of high and low basic density in order to improve mechanical and physical performance. In 2001, CSIRO trialled plantation eucalypts in OSB panels for a farm forestry project supported by RIRDC<sup>18</sup>. The eucalypt plantation was 17 years-old and located in a high rainfall region (>700 mm per annum) at Uriarra, outside Canberra. The species and their breast height basic densities are described in Table 4. OSB panels were fabricated with a commercially available PF resin and were tested for flexural properties, internal bond strength and thickness swell. Tests showed good results compared to the Canadian Standard, but again confirmed a need for improved resin technology when internal bond strengths were compared with high strength results obtained using a CSIRO experimental PF resin system. The report also covered cyclic environmental conditioning, showing a need to reduce panel density or risk panel delamination. *P. radiata* was used to lower panel density, increase surface contact between flakes and to fill surface voids in the finished OSB panels. In this case, blending with lower density wood alleviated weight problems without reducing panel performance.

**Table 4:** Eucalypt species and mean basic densities (and standard deviations) of plantation wood used by CSIRO in an OSB trial.

Species	Basic Density at Breast Height (kg/m <sup>3</sup> (std dev))
<i>E. kartzoffiana</i>	496 (27)
<i>E. badjensis</i>	498 (20)
<i>E. benthamii</i>	511 (16)
<i>E. macarthurii</i>	524 (33)
<i>E. viminalis</i>	525 (26)
<i>E. nitens</i>	556 (28)
<i>E. smithii</i>	568 (12)
<i>E. globulus ssp bicostata</i>	576 (36)

A Brazilian study<sup>19</sup> that used *E. grandis* and *E. urophylla* in non-oriented and oriented boards showed that *E. grandis* was the better performing species. OSB was also prepared from blends of *E. grandis* and *Pinus elliottii* with a final recommendation of 75 or 50% *E. grandis* to 25 or 50% *P. elliottii* as optimum ratios<sup>20</sup>. Fast-growing plantation *E. urophylla* from China, at 3 years of age, was processed into OSB with

<sup>18</sup> G. Freischmidt *et al.* Farm Forestry Seed and Information Support Project. Project 13b: Wood Properties, Composites Assessment. Part 1: Oriented Strandboard. Rural Industries Research and Development Corporation Project No CSF 56A. (2001). Level 2, 15 National Circuit, BARTON, ACT 2600.

<sup>19</sup> F. Gouveia *et al.* The use of *E. grandis* (W. Hill ex Maiden) and *Eucalyptus urophylla* (S.T. Balke) for the production of non-oriented and oriented strand board. *Revista Arvore* 24 (1) pp7-12 (2000).

<sup>20</sup> F. Gouveia *et al.* Oriented strand boards production from a mixture of *Eucalyptus grandis* (W. Hill ex Maiden) and *Pinus elliottii* (Engelm). *Brasil Florestal*. 22 (77) pp21-27 (2003).

good results<sup>21</sup> with optimum processing variables using liquid PF resin being: 700 kg/m<sup>3</sup> panel density, 9% resin loading and a hot-pressing time of 0.8 min/mm of panel thickness.

Further Brazilian work trialed *E. grandis* in OSB form with varying resin levels, wax additions and face to core weight proportions. Higher resin loadings (from 3 to 6%) improved mechanical and physical properties and a 60% by weight core layer improved panel flexural properties<sup>22</sup>.

A 2005 study used *E. dunnii* and *Pinus taeda* in laminated veneer lumber (LVL) and the LVL, in turn, was used as the flanges in I-Joists<sup>23</sup>. The webbing in the same I-joists was made from the same eucalypt and pine in OSB and plywood form. It was found that I-Joists with the best flexural performance were those with flanges of eucalypt rather than pine. In the case of webs, I-joists made with OSB performed better than plywood in stiffness. This paper was published in Portuguese with an English abstract and further detail on these trials requires a full translation of the paper.

Plantation grown eucalypts were used to trial the effects of acetylated flakes (chemically modified flakes to improve water repellency) in OSB panels and compared with non-acetylated flakes<sup>24</sup>. Pine flakes were used to keep the eucalypt OSB panel densities within an acceptable target of 700 kg/m<sup>3</sup>. The species and their densities are described in Table 5. This trial showed that acetylated flake panels were more stable and absorbed less water, but had poor nail withdrawal resistance, lower flexural strength and lower longitudinal compressive strength.

**Table 5:** Eucalypt species plus pine and their basic densities in a flake acetylation trial (Footnote 24).

Species	Wood Density (kg/m <sup>3</sup> )
<i>E. grandis</i>	550
<i>E. urophylla</i>	610
<i>E. cloeziana</i>	700
<i>Pinus elliottii</i>	450

Recently an Australian company, Lignor<sup>25</sup>, developed technology to use plantation *Eucalyptus globulus* in an engineered strand lumber (ESL) project to be operational in

<sup>21</sup> Q. Tong *et al.* Initiative Study of Oriented Strand Board from Eucalypts. Symposium on Utilization of Agricultural And Forestry Residue. Nanjing, China. Oct 21-Nov 3 2001. pp229-243.

<sup>22</sup> S. Iwakiri *et al.* Production of OSB from *Eucalyptus grandis* with different resin content, wax sizing, and face to core layer ratios. *Ciencia Florestal* 13 (1) pp89-94 (2003).

<sup>23</sup> A. Pedrosa *et al.* Production of I-Joists with wood panels of *Pinus taeda* (L) and *Eucalyptus dunnii* (Maiden). *Floesta* 35 (3) pp443-449 (2005).

<sup>24</sup> C.P.T. Cabral *et al.* Properties of OSB manufactures with wood strands of *Eucalyptus grandis*, *E. urophylla*, *E. cloeziana* and *Pinus elliottii*. *Revista Arvore*. 30 (4) pp659-667 (2006).

<sup>25</sup> <http://www.lignor.com/>

Western Australia. Strands of wood, similar to that prepared for OSB are resinated with a non-formaldehyde based resin pMDI, oriented with all the flakes in one direction and hot pressed into billets, which can then be cut to size for various products. The intended structural use was similar to that of LVL as load bearing beams but other products such as flooring bearers, joists, headers, columns, roof rafters, flanges and window frames are also possible. Obviously the technology surrounding the Lignor product is commercial in confidence and further detail on the adhesives used is not available. Unfortunately, the Western Australian project has been placed in abeyance due to a lack of finance. In the mean time, Lignor is pursuing joint partnerships in China.

## Veneers

Plywood and laminated veneer lumber (LVL) for the Australian market are nearly always manufactured from softwood pine and require trees of a size and quality where they are able to be machine peeled. Hardwoods are generally used as overlay or decorative veneers, and these decorative veneers are largely produced by slicing rather than peeling. Nevertheless, eucalypt species have been used for peeling and reported in the literature for some time with the species having been trialled in peeling and drying trials; *E. delegatensis*, *E. obliqua*, *E. regnans*, and *E. sieberana* (*sieberi*)<sup>26,27,28</sup>. A number of papers have reported success in producing plywoods from species such as *E. sieberi*<sup>29</sup>, *E. fastigata*<sup>30</sup>, *E. nitens*<sup>35</sup>, *E. delegatensis*<sup>31,32</sup>, *E. globulus*<sup>33</sup> and other eucalypts.

More recently, a Chinese study reported on the anatomical differences between *E. obliqua*, *E. delegatensis* and *E. regnans* that affected veneer shrinkage and plywood quality<sup>34</sup>. In another study, *E. globulus* plywood was prepared with a resol-tannin adhesive to replace the phenol component of PF resin systems<sup>35</sup>.

In 2005 the Malaysian based timber company the Ta Ann Group committed to develop two rotary veneer peeling mills in Tasmania. The first of the mills opened in 2007, with second opening in 2008. Both of the mills use a combination of *E. oliqua*,

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<sup>26</sup> Veneer Production. Rep. For. Prod. Aust. 1946-47 pp39-40. (1947).

<sup>27</sup> E. L. Ellwood. For. Prod. New Lett. CSIRO Aust. (No. 182) pp1-2. (1950).

<sup>28</sup> J. W. Gottstein and B. McCombe. Recent studies on Seasoning 'Ash' type hardwoods. Collapse intensified by heating while green. For. Prod. News Lett. CSIRO. Aust (No. 216) pp1-2. (1956).

<sup>29</sup> H. Harada *et al.* Preliminary microscopic studies of wood structure and adhesion in plywood. *For. Prod. J.* 18 (2) pp86-90. (1968).

<sup>30</sup> E. Ksiazek and J. Wade. Regrowth eucalypt for plywood production. Technical Paper – Forestry commission of NSW (No. 43) 16 pp. (1989).

<sup>31</sup> J. Wade. Peeling and gluing of New South Wales eucalypts. Technical Paper- Forestry commission of NSW (No. 55) i+15 pp. (1991).

<sup>32</sup> J. Wade and E. Ksiazek. Alpine ash (*E. delegatensis* R.T. Bak) for plywood production. Technical Paper – Forestry Commission of NSW (No. 52) ii+24 pp. (1990).

<sup>33</sup> G. Vazquez *et al.* *Eucalyptus globulus* plywoods prepared with tannin phenol-formaldehyde adhesives. Recent Research Developments in Chemical Engineering 4 (1) pp 313-325. (2000).

<sup>34</sup> Rong Jun Zhao *et al.* Eucalypt wood Anatomical and physical properties and their effects on plywood veneer quality. Chinese Forestry Science and Technology. 6 (3) pp33-39. (2007).

<sup>35</sup> P.M. Stefani *et al.* Processing conditions analysis of *Eucalyptus globulus* plywood bonded with resol-tannin adhesives. Bioresource technology 99 (13) pp 5977-5980. (2008)



*E. regnans* and *E. delegatensis* as wood in feed and export the veneer to produce plywood<sup>36</sup>.

No references for LVL production from eucalypts were found in the literature. However, in 1996 CSIRO was responsible for a trial of eucalypt hardwoods from the Victorian central highlands and East Gippsland<sup>37</sup>. The species investigated are shown in Table 6. The results of this trial showed excellent mechanical properties for all species. Although heavier than pine-based LVL of the same thickness, the only adverse finding was a lower shear strength compared to pine LVL and LVL prepared from Vic ash or Tasmanian oak.

**Table 6:** Eucalypt species and their locations used in a CSIRO LVL trial.

Location	Species
Central Highlands	<i>E. regnans</i>
	<i>E. delegatensis</i>
East Gippsland	<i>E. sieberi</i>
	<i>E. globoidea</i>
	<i>E. fastigata</i>
	<i>E. obliqua</i>
	<i>E. cypellocarpa</i>

## Glulam

Glulam is a product consisting of short, clear segments of seasoned timber being bonded together (using room temperature cure resin) to form load bearing beams. In Victoria, most glulam is made from *Pinus radiata* with some feature beams being made from *E. regnans*<sup>38</sup> and cypress pines (*Callitris* family). Slash pine, Tasmanian oak, spotted gum, blackbutt, ironbark, Sydney blue gum and jarrah have also been used elsewhere in Australia<sup>39</sup>.

Glulam products are also associated with ‘finger-joining’ technology, which increases the lengths of short clear timbers. Accurately machined joints are glued together with room temperature cure resins and the longer beams lengths bonded together with the finger joints staggered. In Victorian ITC Ltd are currently producing Glulam products made from finger jointing and laminating Victorian Ash species (*E. regnans*, *E. delegatensis* and *E. obliqua*) to produce structural beams and staircase components. The resin used by ITC Ltd in the production of these glulam beams is commercially sensitive information, but as the products are being sold, the resultant products have presumably passed all Australian standards.

<sup>36</sup> [www.forestrytas.com.au](http://www.forestrytas.com.au)

<sup>37</sup> B. McCombe *et al.* The Production of Laminated Veneer Lumber (LVL) Victorian Residue Logs. CSIRO Forestry and Forest Products. Client Report (No. 196). 1996.

<sup>38</sup> ITC Limited: [www.itclimited.com.au/timber/supalam/index.php](http://www.itclimited.com.au/timber/supalam/index.php)

<sup>39</sup> Glue Laminated Timber Association of Australia. <http://www.gltaa.com/>

## Scrimber

The reconstituted wood-based product ‘Scrimber’ was developed by CSIRO in the late 1970s to make use of plantation thinnings and short rotation forestry plantings. Scrimber does not require mature trees for production as the wood resource is broken down (scrimmed) and reassembled using adhesive bonding. This produces a large billet of composite wood, which is cut to size for load bearing building and construction uses.

Plantation thinnings of *Eucalyptus globulus* and *E. pilularis* were used in early trials (1980 and 1981) by CSIRO using different resins such as urea-formaldehyde, tannin and isocyanates. The wood was reported to have scrimmed well and was successfully bonded, but no mechanical performances were presented in the report<sup>40</sup>. A 1990 trial in conjunction with the Victorian Department of Conservation and Environment - Lands and Forests Division<sup>41</sup>, processed *E. sieberi* thinnings into Scrimber beams. While only a small (in number) trial was undertaken, the resultant beams were reported to have excellent stiffness, although there were issues with bond starvation during resin application.

Another series of eucalypt trials was carried out by Georgia Pacific at the closed Mount Gambier plant in the mid 1990s. Young plantation *E. grandis* was processed with a proprietary resin system. No data is available from this trial, but it was successful in terms of resultant Scrimber beams being produced.

The scrimber technology was sold to the US where it was developed further, and a scrimber factory is now nearing completion in Mississippi based on immature southern yellow pine thinnings<sup>42</sup>. No technical details are available regarding the resins to be used in the production of this *Scrimtek* product.

## Cement Board

Australia has long used wood fibre reinforced cement board for exterior cladding in housing construction. Wood fibres replaced asbestos in the late 1970s and early 1980s. Two other types of cement bonded panels are made in the USA, Europe, India and Asia. These use wood in the form of strands or particles, with cement being used to bind the panel together. These products are used as exterior building cladding including ceiling and roofing material. The biggest markets occur in Europe and Asia. Cement board is a durable building material in tropical climates and is cost effective in developing countries<sup>43</sup>.

Cement board can be made with long wood strands called ‘wood-wool’, which are typically 250 mm long, 1-5 mm wide and 0.2-0.5 mm thick. The wood-wool is mixed with cement and preformed into a retaining frame, and the assembly is clamped under low pressure for 24 hours to set and cure. The same procedure can also be carried out

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<sup>40</sup> Documentation for trials reside with CSIRO Material Science and Engineering. Clayton, Vic.

<sup>41</sup> R. A. Jago. A Preliminary Evaluation of Silvertop Ash regrowth for the Manufacture of Scrimber. Technical Report No. 13. DCE-LFD. 378 Cotham Road, Kew 3101. (1990).

<sup>42</sup> [www.scrimtec.com](http://www.scrimtec.com)

<sup>43</sup> P.G. Warden *et al.* Farm Forestry Seed and Information Support Project. Project 13b: Wood Properties, Composites Assessment. Part 2: Cement Board. Rural Industries Research and Development Corporation Project No CSF 56A. (2001). Level 2, 15 National Circuit, BARTON, ACT 2600.

with wood particles, which have been produced by hammer milling wood flakes. Some loosely bound wood-wool can be seen as insulation material in walls and ceilings in older buildings.

Fibre-cement board used in Australia is largely made from selected long fibre pine pulp imported from New Zealand. Cement boards are generally made from pine and spruce, poplar and eucalypt (the latter in India and S.E. Asia). The earliest use of eucalypt wood in cement board found in the literature appears to be Indonesian work that found poor quality boards when *E. deglupta* was used as the wood-wool component in board form<sup>44</sup>. A second related report discovered plantation site was important to board quality: where lowland *E. deglupta* gave a poor result compared to highland grown (altitude. 1500 m) *E. deglupta*, which met specifications<sup>45</sup>.

Not all woods are suitable for bonding with cement and this is largely due to water soluble extractives adulterating the cement and inhibiting proper cure. Work carried out between 2000 and 2002 looked at a number of eucalypt species suitable for cement board. These species are listed in Table 7.

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<sup>44</sup> R.N. Kamil and B. Ginoga. Laporan, Lembaga Penelitian Hasil Hutan. (No. 54) iii + 17 pp. (1975).

<sup>45</sup> S.K. Paribotro. Proceedings of the Eighth World Forestry Congress, Jakarta, 16-28 Oct. 1978. World Forestry Congress: Forestry for industrial development. (No. FID-1/7-14). ii + 3pp.

**Table 7:** Eucalyptus species from three studies to determine their suitability for use in cement board.

Species	Age (Years)	Reference
<i>E. pellita</i>	>10 (est.)	46
<i>E. urophylla</i>		
<i>E. polybractea</i>	<5 (est.)	47
<i>E. horistes</i>		
<i>E. kochii</i>		
<i>E. augustissima</i>		
<i>E. loxophleba ssp lissophloia</i>		
<i>E. globulus ssp bicostata</i>		
<i>E. smithii</i>		
<i>E. nitens</i>	17	48
<i>E. viminalis</i>		
<i>E. macarthurii</i>		
<i>E. benthamii</i>		
<i>E. badjensis</i>		
<i>E. kartzoffiana</i>		

The results of the trials showed, from the first group of eucalypts, that both species were suitable for a wood-wool cement board. They were also able to show the relationship between the higher increase in water soluble heartwood extractives and poorer compatibility with cement cure. The second study in Table 7 is that of five ‘mallee’ eucalypts, which were chipped, fabricated into cement board and tested for their flexural properties. The first three species listed were stronger and more water resistant than the last two species listed. The last group of seven eucalypt species in Table 7 were obtained from two different sites located outside Canberra, ACT (see also OSB and cement board trials). Different sites proved different compatibility with cement and showed *E. badjensis* having the highest compatibility.

Laboratory scale wood-wool cement boards were prepared with plantation grown *E. tereticornis* and *E. grandis* in the Philippines<sup>49</sup>. A preference was given to the

<sup>46</sup> K. E. Semple *et al.* Screening species, provenances and families of tropical acacias and eucalypts for compatibility with Portland cement. Proceedings of - The International Conference on Forestry and Forest Products Research (CFFPR 2001) Kuala Lumpur, Malaysia 1-3 Oct. 2001.

<sup>47</sup> K.E. Semple *et al.* The suitability of five Western Australian mallee eucalypt species for wood-cement products. *Industrial Crops and Products*. 16 (2) pp89-100. (2002)

<sup>48</sup> K. E. Semple *et al.* Wood-cement composites in the Asia-Pacific Region. Proceedings of a workshop held at Rydges Hotel, Canberra, Australia, 10 Dec. 2000.

eucalypts over rubberwood for suitability with cement as there was no need to soak the chips prior to fabrication into cement board to remove cure inhibiting extractives.

Eucalypt species have been trialled in Brazil to fabricate a cement-bonded wood particleboard. Six 18 year-old eucalypts, listed in Table 8, were individually blended with rubberwood and made into laboratory size panels 45x45 cm and 13 mm thick<sup>50</sup>. All six eucalypt species were found to be compatible with rubberwood and Portland cement in the fabrication of cement-bonded particleboard.

**Table 8:** Eucalyptus species blended with rubberwood in the production of cement-bonded particleboard.<sup>50</sup>

Species
<i>E. camaldulensis</i>
<i>E. citriodora</i>
<i>E. cloeziana</i>
<i>E. grandis</i>
<i>E. pilularis</i>
<i>E. urophylla</i>

An experimental trial was carried out by CSIRO in 2001 to prepare cement-bonded flake board where OSB strands were mixed with a cement formulation and the preformed panels clamped for 24 hours to cure<sup>51</sup>. The same farm forestry eucalypt species (Table 4) were trialled in flake form bound with Portland cement. The resultant panels were acceptable in mechanical performance. However, improvements were made to *E. badjensis*, *E. smithii*, and *E. viminalis* by cold water extraction prior to cement bonding.

<sup>49</sup> D. A. Eusebio *et al.* Manufacture of low-cost wood-cement composites in the Philippines using plantation-grown Australian species:1. Eucalypts. Wood-cement composite in the Asia-Pacific

<sup>50</sup> E. Y. A. Okino *et al.* Cement-bonded wood particleboard with a mixture of eucalypt and rubberwood. Cement and Concrete Composites. 26 (6) pp729-734. (2004).

<sup>51</sup> P.G. Warden *et al.* Farm Forestry Seed and Information Support Project. Project 13b: Wood Properties, Composites Assessment. Part 2: Cement Board. Rural Industries Research and Development Corporation Project No CSF 56A. (2001). Level 2, 15 National Circuit, BARTON, ACT 2600.

## Conclusions

### Eucalypt Wood Composites

Very few target eucalypt species were found in the peer reviewed literature with regard to composite products, only veneer and cement board products produced results in any of the target Victorian hardwood species.

These were:

- Veneers: *E. obliqua*, *E. sieberi*, *E. nitens*, *E. globulus*, *E. regnans* and *E. delegatensis*
- Species used in making or trialling cement board: *E. nitens*, *E. globulus*, *E. viminalis*

Non-target eucalypt species, plantation grown, have been used in composite products and are reported in the literature to a limited extent. Those results were summarised in the body of this report.

It is possible to manufacture wood composite products from the eucalypts. Generally wood composite products made from eucalypt species exhibit high strength (MOR) and stiffness (MOE) properties, but may have issues with internal bond strength and thickness swell due to poor matching of resins. Additional investigations in the lower density species, particularly younger examples of the lower density species, may be warranted in order to produce an alternative feedstock for the composite wood industry.

Commercial production of veneer and glulam products in Australia from native hardwoods is occurring, albeit on a relatively small scale, showing that the bonding and resin issues can be overcome. The resins used in commercial products are understandably not available in the public domain but the commercial success of these products indicates that the resultant products have passed Australian standards for mechanical and physical properties.

Research investigating native Australian hardwood species for their potential in composite products showed that basic density was the best indicator of suitability for use in a given composite form. To briefly summarise, high density tends to result in poor penetration of glues and poor conformability of the wood components for forming and pressing. High density species also tend to produce more fines (when refined), which can also lead to poor or uneven bond strength (particularly in MDF). High extractive levels are often associated with higher density woods, and the extractives can again inhibit glue penetration or interfere with glue curing. The basic densities of the Victorian eucalypt species are generally higher than those that would be considered optimal for composite products. Further complications for composite fabrication are likely to exist particularly with some of the target Victorian species (e.g. *E. elata*, *E. radiata*, *E. dives*) in that kino and gum vein issues would interfere with veneer quality and are likely to cause bonding problems. These issues combined create difficulties for product quality and consistency in mechanical and physical performance. High density wood also tends to create high density composite products and can be an issue for handling and workability.



In Australia, reconstituted wood-based composites are nearly all made from the softwood *Pinus radiata*, with only hardboard, a small amount of plywood and veneer overlays and some structural glulam beams being produced with eucalypt hardwoods. However, that these products are being produced from native hardwood timber shows the potential for further product development in this area.



## **Appendix 1: Mechanical properties**

## Alpine Ash

### 1. Nomenclature<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus delegatensis</i>
<b>Standard trade name:</b>	Alpine ash
<b>Local names:</b>	stringy gum, swamp gum, white mountain ash, Australian oak, Tasmanian oak, Victorian Ash

### Wood Features and Properties<sup>B</sup>

Heartwood pale pink or pale yellowish brown. Sapwood not clearly distinguishable and about 25-50 mm wide. Texture moderately coarse. Grain usually straight but sometimes wavy, producing a fiddleback figure. Gum veins common. Growth rings made conspicuous by the darker latewood. Very similar in appearance to mountain ash.

**Table 0-1** General properties of Alpine ash (Values shown in brackets represent the 95% probability range for individual specimens)

General			
<b>Basic Density</b> - kg/m <sup>3</sup>	<b>511<sup>C</sup></b> (397-573)	<b>536<sup>D</sup></b>	
<b>Estimated Saturated Moisture Content</b> - %	<b>130</b> (109-187)	<b>121</b>	
<b>Air dry Density</b> (12% MC) - kg/m <sup>3</sup>	<b>663<sup>C</sup></b> (498-756)		
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>5.0 kN</b>	<b>5.0 kN</b>
	<b>Unseasoned</b>	<b>3.9 kN</b>	<b>4.1 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD4</b>	
	<b>Unseasoned</b>	<b>S4</b>	
<b>Lyctus susceptibility<sup>F,G</sup></b>	<b>Mainland = Resistant</b> <b>Tasmania = Susceptible</b>		

<b>Shrinkage (% of green dimension) <sup>C</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>8.5%</b> <b>(4.1-12.2)</b>	<b>5.2</b> <b>(1.1-7.7)</b>
<b>Collapse</b>	<b>2.2</b> <b>(0-3.4)</b>	<b>1.7%</b> <b>(0.6-2.9)</b>
<b>Unit</b>	<b>0.35%</b> <b>(0.27-0.43)</b>	<b>0.22%</b> <b>(0.13-0.33)</b>
<b>Dimensional Movement (mm)</b>	<b>2.5</b>	<b>1.6</b>

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Bootle K.R. (2004) Wood in Australia: Types, properties and uses, McGraw-Hill Australia Pty Ltd.

<sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.

<sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.

<sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia

<sup>F</sup> Cookson L.J., Carr J., Chew N. and Creffield J. (2007) Reassessment of lyctine susceptible sapwood. FWPRDC PN03.1313. URL: [www.fwpa.com.au/content/pdfs/new\\_pdfs/PN03.1313\\_lyctine-report.pdf](http://www.fwpa.com.au/content/pdfs/new_pdfs/PN03.1313_lyctine-report.pdf). Accessed October 2008.

<sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Blue gum

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus globulus</i>
<b>Standard trade name:</b>	Southern blue gum
<b>Local names:</b>	Blue gum, Tasmanian blue gum

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale brown, sometimes with a pinkish tinge. Sapwood to 50 mm wide, paler but not always sharply distinguished from the heartwood. Texture medium and relatively even. Grain often interlocked. Growth rings prominent on end-section.

**Table 2: General properties of blue gum (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>681<sup>C</sup></b>	<b>561<sup>C</sup></b> (484-634) 17-23 y.o.	<b>733<sup>D</sup></b>
<b>Estimated Saturated Moisture Content- %</b>	<b>82</b>	<b>113</b> (92-141)	<b>71</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>900<sup>C</sup></b>	<b>727<sup>C</sup></b> (599-851)	
<b>Hardness (Janka)<sup>E</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>11.5 kN</b>	<b>11.5 kN</b>
	<b>Unseasoned</b>	<b>7.2 kN</b>	<b>7.5 kN</b>
<b>Strength group<sup>F</sup></b>	<b>Seasoned</b>	<b>SD2</b>	
	<b>Unseasoned</b>	<b>S3</b>	
<b>Durability ratings<sup>G</sup></b>	<b>Decay</b>	<b>3</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>H</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>14.4%</b> (7.9-20.8)	<b>6.9%</b> (3.2-10.6)
<b>Collapse</b>		<b>5.0%</b>	<b>2.3%</b>
<b>Unit</b>		<b>0.39%</b> (0.27-0.51)	<b>0.26%</b> (0.19-0.33)
<b>Dimensional Movement (mm)</b>		<b>3.1</b>	<b>2.1</b>

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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (2004) Wood in Australia: Types, properties and uses, McGraw-Hill Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>F</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>G</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>H</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## Southern blue gum

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus bicostata</i>
<b>Standard trade name:</b>	Southern blue gum
<b>Local names:</b>	Blue gum, Tasmanian blue gum

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale brown, sometimes with a pinkish tinge. Sapwood to 50 mm wide, paler but not always sharply distinguished from the heartwood. Texture medium and relatively even. Grain often interlocked. Growth rings prominent on end-section.

**Table 3: General properties of southern blue gum (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>733<sup>C</sup></b>		
<b>Estimated Saturated Moisture Content - %</b>	<b>71</b>		
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>973<sup>C</sup></b>		
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>11.5 kN</b>	<b>11.5 kN</b>
	<b>Unseasoned</b>	<b>7.2 kN</b>	<b>7.5 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD2</b>	
	<b>Unseasoned</b>	<b>S3</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay</b>	<b>3</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)	
<b>Green to Air dry (12% MC)</b>	<b>12.7%</b> <b>(8.7-16.4)</b>	<b>5.2%</b> <b>(3.0-7.6)</b>	
<b>Collapse</b>	<b>4.6%</b>	<b>1.4%</b>	
<b>Unit</b>	<b>0.40%</b> <b>(0.30-0.49)</b>	<b>0.28%</b> <b>(0.21-0.36)</b>	
<b>Dimensional Movement (mm)</b>	<b>3.2</b>		<b>2.0</b>



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- <sup>B</sup> Bootle K.R. (2004) Wood in Australia: Types, properties and uses, McGraw-Hill Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## Maiden's gum

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus maidenii</i>
<b>Standard trade name:</b>	Maiden's gum
<b>Local names:</b>	Spotted blue gum

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale brown, sometimes with a pinkish tinge. Sapwood to 50 mm wide, paler but not always sharply distinguished from the heartwood. Texture medium and relatively even. Grain often interlocked. Growth rings prominent on end-section.

**Table 4: General properties of blue gum (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>		
<b>Basic Density - kg/m<sup>3</sup></b>	<b>750<sup>C</sup> (660-855)</b>	<b>746<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>68 (52-86)</b>	<b>69</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>992<sup>C</sup> (879-1126)</b>	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>
	<b>Seasoned</b>	<b>10.8 kN</b>
	<b>Unseasoned</b>	<b>7.4 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD2</b>
	<b>Unseasoned</b>	<b>S3</b>
<b>Durability ratings<sup>F</sup></b>	<b>Decay</b>	<b>3</b>
	<b>Decay plus termites</b>	<b>4</b>
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>	
<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential (Backsawn)</b>	<b>Radial (Quarter sawn)</b>
<b>Green to Air dry (12% MC)</b>	<b>11.2% (5.5-17.0)</b>	<b>5.2% (2.1-8.1)</b>
<b>Collapse</b>	<b>3.5%</b>	<b>1.4%</b>
<b>Unit</b>	<b>0.41% (0.30-0.52)</b>	<b>0.27% (0.21-0.33)</b>
<b>Dimensional Movement (mm)</b>	<b>3.3</b>	<b>2.2</b>

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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (2004) Wood in Australia: Types, properties and uses, McGraw-Hill Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## Shining gum

### *Nomenclature*<sup>A</sup>

**Botanical Name:** *Eucalyptus nitens*

**Standard trade name:** Shining Gum

### *Wood Features and Properties*<sup>B</sup>

Heartwood straw colour, with pink or yellow tints. Sapwood not always easy to distinguish. Grain straight.

**Table 0-1** General properties of shining gum (Values shown in brackets represent the 95% probability range for individual specimens)

<b>General</b>		
<b>Basic Density</b> - kg/m <sup>3</sup>	<b>524<sup>C</sup></b> (445-604)	<b>531<sup>D</sup></b>
<b>Estimated Saturated Moisture Content</b> - %	<b>126</b> (100-159)	<b>123</b>
<b>Air dry Density</b> (12% MC) - kg/m <sup>3</sup>	<b>639<sup>C</sup></b> (529-753)	
<b>Hardness (Janka)<sup>D</sup></b>	<b>Seasoned</b>	<b>6.0 kN</b>
	<b>Unseasoned</b>	<b>4.7 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD4</b>
	<b>Unseasoned</b>	<b>S4</b>
<b>Durability ratings<sup>F</sup></b>	<b>Decay</b>	<b>4</b>
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>	
<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quartersawn)
<b>Green to Air dry (12% MC)</b>	<b>9.4%</b> (3.5-12.8)	<b>4.9%</b> (1.6-7.8)
<b>Collapse</b>	<b>3.5%</b> (0.5-4.9)	<b>1.9%</b> (0.4-3.2)
<b>Unit</b>	<b>0.33</b>	<b>0.22</b>
<b>Dimensional Movement (mm)</b>	<b>2.6</b>	<b>1.8</b>

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Bootle K.R. (2004) Wood in Australia: Types, properties and uses, McGraw-Hill Australia Pty Ltd.

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- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Bootle K.R. (2004) Wood in Australia: Types, properties and uses, McGraw-Hill Australia Pty Ltd.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## **Errinundra shining gum**

### *Nomenclature*

**Botanical Name:** *Eucalyptus denticulata*

**Standard trade name:** Errinundra shining Gum

### *Wood Features and Properties*

Species only recently described and there is no information for this species. Closest available information is for shining gum (*E. nitens*)

## Mountain Ash

### 1. Nomenclature<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus regnans</i>
<b>Standard trade name:</b>	Mountain ash
<b>Local names:</b>	stringy gum, swamp gum, white mountain ash, Australian oak, Tasmanian oak, Victorian Ash

### Wood Features and Properties<sup>B</sup>

Sapwood indistinct to 2.5cm wide, rarely attacked by *Lyctus* borers. Heartwood is pale brown with open texture, straight grain, distinct growth rings and moderately strong and hard, but not durable.

**Table 0-1** General properties of mountain ash (Values shown in brackets represent the 95% probability range for individual specimens)

General			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>500<sup>C</sup></b> (418-581)	<b>424<sup>C</sup></b> (332-519) 35 y.o.	<b>525<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>135</b> (107-174)	<b>171</b> (127-236)	<b>125</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>631<sup>C</sup></b> (509-792)	<b>548<sup>C</sup></b> (420-670) 35 y.o.	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>4.9 kN</b>	<b>4.9 kN</b>
	<b>Unseasoned</b>	<b>3.4 kN</b>	<b>3.4 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD3</b>	
	<b>Unseasoned</b>	<b>S4</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Resistant</b>		

<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>15.2%</b> <b>(8.0-21.2)</b>	<b>7.2%</b> <b>(1.9-11.0)</b>
<b>Collapse</b>	<b>6.3%</b> <b>(3.5-9.3)</b>	<b>2.8%</b> <b>(0.4-4.2)</b>
<b>Unit</b>	<b>0.31%</b> <b>(0.20-0.41)</b>	<b>0.20%</b> <b>(0.09-0.30)</b>
<b>Dimensional Movement (mm)</b>	<b>2.5</b>	<b>1.6</b>

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Boland D.J., Brooker M.I., Chippendale G.M. Hall N., Hyland B.P.M., Johnston R.D., Kleinig and Turner J.D. (1984) Forest trees of Australia. Nelson-CSIR

<sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.

<sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.

<sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia

<sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.

<sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## Messmate

### *Nomenclature*<sup>AB</sup>

<b>Botanical Name:</b>	<i>Eucalyptus obliqua</i>
<b>Standard trade name:</b>	Messmate
<b>Local names:</b>	Messmate stringybark, stringybark, Tasmanian oak, Victorian Ash

### *Wood Features and Properties*<sup>B</sup>

Sapwood is pale, usually distinguishable from heartwood and is susceptible to *Lyctus* borer attack. Heartwood is light brown to brown, open textured, straight grain, fairly well defined growth rings, moderately hard and strong with low durability.

**Table 2: General properties of messmate (Values shown in brackets represent the 95% probability range for individual specimens)**

General			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>599<sup>C</sup></b> (487-719)	<b>543<sup>C</sup></b> (441-649) 15-20 y.o.	<b>662<sup>D</sup></b> (634-690)
<b>Estimated Saturated Moisture Content - %</b>	<b>102</b> (74-140)	<b>119</b> (89-161)	<b>86</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>769<sup>C</sup></b> (639-915)	<b>676<sup>C</sup></b> (533-822) 15-20 y.o.	<b>815<sup>D</sup></b> (774-856)
<b>Hardness (Janka)<sup>E</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>7.1 kN</b>	<b>7.4 kN</b>
	<b>Unseasoned</b>	<b>5.3 kN</b>	<b>5.4 kN</b>
<b>Strength group<sup>F</sup></b>	<b>Seasoned</b>	<b>SD3</b>	
	<b>Unseasoned</b>	<b>S3</b>	
<b>Durability ratings<sup>G</sup></b>	<b>Decay</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>H</sup></b>	<b>Susceptible</b>		

<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>10.9%</b> <b>(3.2-19.6)</b>	<b>4.9%</b> <b>(-0.11-10.7)</b>
<b>Collapse</b>	<b>4.3%</b>	<b>1.5%</b>
<b>Unit</b>	<b>0.32%</b> <b>(0.2-0.44)</b>	<b>0.2%</b> <b>(0.12-0.28)</b>
<b>Dimensional Movement (mm)</b>	<b>2.6</b>	<b>1.6</b>

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Boland D.J., Brooker M.I., Chippendale G.M. Hall N., Hyland B.P.M., Johnston R.D., Kleinig and Turner J.D. (1984) Forest trees of Australia. Nelson-CSIR

<sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.

<sup>D</sup> Ozarska B, Thompson R., Lee M., Northway R., Ilic J., Molenaar S. & Turville G. (1999) The use of Australian hardwoods for high value-added wood products. User manual: Messmate. CSIRO Australia-FFP Client Report: 556.

<sup>E</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.

<sup>F</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia.

<sup>G</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.

<sup>H</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia.



## Manna gum

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus viminalis</i>
<b>Standard trade name:</b>	Manna gum
<b>Local names:</b>	Ribbon gum, white gum

### *Wood Features and Properties*<sup>B</sup>

Sapwood is pale and easily distinguishable and is susceptible to *Lyctus* borer attack. Heartwood is light pink or pale yellow with straight grain, moderately coarse textured, not very strong or durable.

**Table 3: General properties of manna gum (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>559<sup>C</sup></b> (436-654)	<b>586<sup>C</sup></b> (481-694)	<b>555<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>114</b> (88-164)	<b>105</b> (79-143)	<b>115</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>710<sup>C</sup></b> (533-870)	<b>743<sup>C</sup></b> (602-802)	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>5.7 kN</b>	<b>5.8 kN</b>
	<b>Unseasoned</b>	<b>5.0 kN</b>	<b>5.3 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD4</b>	
	<b>Unseasoned</b>	<b>S4</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>15.9%</b> (4.2-26.6)	<b>7.6%</b> (3.8-11.7)
<b>Collapse</b>		<b>7.9%</b>	<b>3.5%</b>
<b>Unit</b>		<b>0.31%</b> (0.2-0.41)	<b>0.17%</b> (0.08-0.31)
<b>Dimensional Movement (mm)</b>		<b>2.5</b>	<b>1.4</b>

<b>Shrinkage (% of green dimension)<sup>H</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>12%</b> (-)	<b>6%</b> (-)
<b>Collapse</b>	<b>6.5%</b> (-)	<b>3%</b> (-)

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Boland D.J., Brooker M.I., Chippendale G.M. Hall N., Hyland B.P.M., Johnston R.D., Kleinig and Turner J.D. (1984) Forest trees of Australia. Nelson-CSIR

<sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.

<sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.

<sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia

<sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.

<sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

<sup>H</sup> Cuevas L.E. (1969) Shrinkage and collapse studies on *eucalyptus viminalis*. Journal. Inst. Wood Sci. Vol4 (23):29-38

## Mountain Grey gum

### Nomenclature<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus cypellocarpa</i>
<b>Standard trade name:</b>	Mountain grey gum
<b>Local names:</b>	Spotted mountain gum, small fruited mountain gum, monkey gum, mountain blue gum,

### Wood Features and Properties

Sapwood susceptible to *Lyctus* attack and occasionally sufficiently paler to be distinctive<sup>B</sup>. The heartwood is pale yellow to brown, of medium texture, straight grained, hard, heavy, moderately strong and moderately durable<sup>C</sup>

**Table 4: General properties of mountain grey gum (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>		<b>666<sup>D</sup></b> (567-782)	
<b>Estimated Saturated Moisture Content - %</b>		<b>85</b> (63-111)	
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>		<b>807<sup>D</sup></b> (657-998)	
<b>Hardness (Janka)<sup>E</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>9.6 kN</b>	<b>10.3 kN</b>
	<b>Unseasoned</b>	<b>6.4 kN</b>	<b>6.6 kN</b>
<b>Strength group<sup>F</sup></b>	<b>Seasoned</b>	<b>SD2</b>	
	<b>Unseasoned</b>	<b>S3</b>	
<b>Durability ratings<sup>G</sup></b>	<b>Decay only</b>	<b>3</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>H</sup></b>	<b>Susceptible</b>		

<b>Shrinkage (% of green dimension)<sup>D</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>11.9%</b> (7.8-16.1)	<b>5.3%</b> (2.9-7.9)
<b>Collapse</b>	<b>4.7%</b>	<b>1.7%</b>
<b>Unit</b>	<b>0.39%</b> (0.33-0.45)	<b>0.27%</b> (0.20-0.35)
<b>Dimensional Movement (mm)</b>	<b>3.1</b>	<b>2.2</b>

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.

<sup>C</sup> Boland D.J., Brooker M.I., Chippendale G.M. Hall N., Hyland B.P.M., Johnston R.D., Kleinig and Turner J.D. (1984) Forest trees of Australia. Nelson-CSIR

<sup>D</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.

<sup>E</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.

<sup>F</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia

<sup>G</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.

<sup>H</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Candlebark

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus rubida</i>
<b>Standard trade name:</b>	Brown stringybark
<b>Local names:</b>	Ribbon gum, white gum

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale pink. Sapwood often indistinguishable. Texture course. Grain straight.

**Table 5: General properties of candlebark (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>538<sup>C</sup></b> (449-599)	<b>545<sup>C</sup></b> (469-615) 18-28 y.o.	<b>610<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>121</b> (102-157)	<b>118</b> (97-148) 18-28 y.o.	<b>99</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>654<sup>C</sup></b> (549-737)	<b>681<sup>C</sup></b> (549-737) 18-28 y.o.	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>5.9 kN</b>	<b>5.9 kN</b>
	<b>Unseasoned</b>	<b>5.0 kN</b>	<b>5.1 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD5</b>	
	<b>Unseasoned</b>	<b>S5</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>		

<b>Shrinkage (% of green dimension) <sup>C</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>12.2%</b> (2.6-24.3)	<b>5.5%</b> (1.1-9.8)
<b>Collapse</b>	<b>6.0%</b>	<b>2.6%</b>
<b>Unit</b>	<b>0.34%</b> (0.26-0.41)	<b>0.22%</b> (0.15-0.27)
<b>Dimensional Movement (mm)</b>	<b>2.7</b>	<b>1.8</b>

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

<sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.

<sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.

<sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.

<sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia

<sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.

<sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Cut-tail

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus fastigata</i>
<b>Standard trade name:</b>	Brownbarrel
<b>Local names:</b>	Cut-tail

### *Wood Features and Properties*

Heartwood pale brown. Sapwood paler and usually easy to distinguish. Texture medium and even. Texture course. Grain straight.<sup>B</sup>

**Table 6: General properties of cut-tail (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>561<sup>C</sup></b>	<b>599<sup>D</sup></b> (474-660)	<b>577<sup>E</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>113</b>	<b>102</b> (86-146)	<b>108</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>692<sup>C</sup></b> (612-814)	<b>694<sup>D</sup></b> (585-820)	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>5.9 kN</b>	<b>5.9 kN</b>
	<b>Unseasoned</b>	<b>5.0 kN</b>	<b>5.1 kN</b>
<b>Strength group<sup>F</sup></b>	<b>Seasoned</b>	<b>SD5</b>	
	<b>Unseasoned</b>	<b>S5</b>	
<b>Durability ratings<sup>G</sup></b>	<b>Decay only</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>H</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>11.8%</b> (1.5-21.3)	<b>6.5%</b> (0.4-12.4)
<b>Collapse</b>		<b>5.4%</b>	<b>3.0%</b>
<b>Unit</b>		<b>0.34%</b> (0.28-0.39)	<b>0.24%</b> (0.17-0.32)
<b>Dimensional Movement (mm)</b>		<b>2.7</b>	<b>1.9</b>

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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Budgen B. (1981) Shrinkage and Density of some Australian and South-east Asian Timbers CSIRO Division of Building Research Technical Paper No. 38.
- <sup>E</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>F</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>G</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>H</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## Mountain gum

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus dalrympleana</i>
<b>Standard trade name:</b>	Mountain gum
<b>Local names:</b>	Kindlingbark, mountain white gum

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale pink or pinkish brown. Sapwood of similar color and not easily distinguishable. Growth rings prominent because of the darker latewood. Texture medium: fine in latewood but relatively coarse in earlywood. Grain usually straight.

**Table 7: General properties of mountain gum (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>532<sup>C</sup></b> <b>(421-644)</b>	<b>578<sup>D</sup></b>	
<b>Estimated Saturated Moisture Content - %</b>	<b>123</b> <b>(90-172)</b>	<b>108</b>	
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>630<sup>C</sup></b> <b>(482-777)</b>		
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>6.2 kN</b>	<b>5.3 kN</b>
	<b>Unseasoned</b>	<b>5.2 kN</b>	<b>5.2 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD5</b>	
	<b>Unseasoned</b>	<b>S4</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>		
	<b>Decay plus termites</b>		
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>11.5%</b> (2.3-20.7)	<b>5.4%</b> (1.2-12.0)
<b>Collapse</b>		<b>6.7%</b>	<b>2.5%</b>
<b>Unit</b>		<b>0.35%</b>	<b>0.22%</b>
<b>Dimensional Movement (mm)</b>		<b>2.8</b>	<b>1.8</b>

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- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Brown Stringybark

### *Nomenclature*<sup>A</sup>

**Botanical Name:** *Eucalyptus baxteri*

**Standard trade name:** Brown stringybark

**Local names:**

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale brown. Sapwood may not be clearly defined. Texture medium and even. Grain variable. Gum veins common.

**Table 8: General properties of brown stringybark (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>		
<b>Basic Density - kg/m<sup>3</sup></b>	<b>613<sup>C</sup> (491-714)</b>	<b>610<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>97 (75-138)</b>	<b>99</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>791<sup>C</sup> (571-935)</b>	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>
	<b>Seasoned</b>	<b>7.5 kN</b>
	<b>Unseasoned</b>	<b>5.3 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD3</b>
	<b>Unseasoned</b>	<b>S3</b>
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>3</b>
	<b>Decay plus termites</b>	<b>4</b>
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Resistant</b>	
<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential (Backsawn)</b>	<b>Radial (Quarter sawn)</b>
<b>Green to Air dry (12% MC)</b>	<b>10.4% (6.0-14.6)</b>	<b>5.1% (1.5-7.7)</b>
<b>Collapse</b>	<b>4.4%</b>	<b>1.9%</b>
<b>Unit</b>	<b>0.33% (0.27-0.40)</b>	<b>0.24% (0.15-0.28)</b>
<b>Dimensional Movement (mm)</b>	<b>2.6</b>	<b>1.9</b>

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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Red stringybark

### *Nomenclature*<sup>A</sup>

**Botanical Name:** *Eucalyptus macrorhyncha*

**Standard trade name:** Red stringybark

**Local names:**

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale reddish brown. Sapwood distinctly paler and to 50 mm wide. Texture medium and even. Grain often interlocked.

**Table 9: General properties of red stringybark (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>		
<b>Basic Density - kg/m<sup>3</sup></b>	<b>697<sup>C</sup> (612-780)</b>	
<b>Estimated Saturated Moisture Content - %</b>	<b>78 (63-98)</b>	
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>822<sup>C</sup> (708-961)</b>	
<b>Hardness (Janka)<sup>D</sup></b>	<b>Seasoned</b>	<b>Tangential 9.2 kN</b>
	<b>Unseasoned</b>	<b>Radial 8.6 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>6.5 kN</b>
	<b>Unseasoned</b>	<b>SD4</b>
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>S3</b>
	<b>Decay plus termites</b>	<b>2</b>
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>	
<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential (Backsawn)</b>	<b>Radial (Quarter sawn)</b>
<b>Green to Air dry (12% MC)</b>	<b>9.8% (5.4-15.7)</b>	<b>5.7% (3.0-8.8)</b>
<b>Collapse</b>	<b>5.0%</b>	<b>2.7%</b>
<b>Unit</b>	<b>0.37% (0.26-0.46)</b>	<b>0.23% (0.17-0.31)</b>
<b>Dimensional Movement (mm)</b>	<b>3.0</b>	<b>1.8</b>

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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Southern mahogany

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus botryoides</i>
<b>Standard trade name:</b>	Southern mahogany
<b>Local names:</b>	Bangalay, Gippsland mahogany

### *Wood Features and Properties*<sup>B</sup>

Heartwood reddish brown. Sapwood distinctly paler. Texture moderately coarse and even. Grain sometimes interlocked.

**Table 10: General properties of southern mahogany (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>708<sup>C</sup> (631-778)</b>		
<b>Estimated Saturated Moisture Content - %</b>	<b>76 (63-93)</b>		
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>875<sup>C</sup> (764-988)</b>		
<b>Hardness (Janka)<sup>D</sup></b>	<b>Seasoned</b>	<b>Tangential 7.0 kN</b>	<b>Radial 7.3 kN</b>
	<b>Unseasoned</b>	<b>6.6 kN</b>	<b>6.5 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD3</b>	
	<b>Unseasoned</b>	<b>S2</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>3/2</b>	
	<b>Decay plus termites</b>	<b>3/2</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
	<b>Tangential (Backsawn)</b>	<b>Radial (Quarter sawn)</b>	
<b>Green to Air dry (12% MC)</b>	<b>9.8% (6.8-13.0)</b>	<b>5.1% (2.2-8.0)</b>	
<b>Collapse</b>	<b>2.8%</b>	<b>1.1%</b>	
<b>Unit</b>	<b>0.37% (0.32-0.42)</b>	<b>0.28% (0.16-0.38)</b>	
<b>Dimensional Movement (mm)</b>	<b>3.0</b>	<b>2.2</b>	



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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Silvertop ash

### Nomenclature<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus sieberi</i>
<b>Standard trade name:</b>	Silvertop ash
<b>Local names:</b>	Silvertop

### Wood Features and Properties<sup>B</sup>

Heartwood pale brown, sometimes pinkish. Sapwood to 25 mm wide, not clearly distinguishable from the heartwood. Texture medium. Grain often interlocked. Growth rings noticeable but not prominent. Gum veins, pin-hole borer discoloration and 'pencil streak' are common.

**Table 11: General properties of silvertop ash (Values shown in brackets represent the 95% probability range for individual specimens)**

General			
Basic Density - kg/m <sup>3</sup>	668 <sup>C</sup> (586-751)		
Estimated Saturated Moisture Content - %	84 (68-105)		
Air dry Density (12% MC) - kg/m <sup>3</sup>	815 <sup>C</sup> (687-971)		
Hardness (Janka) <sup>D</sup>	Seasoned	Tangential 9.6 kN	Radial 9.8 kN
	Unseasoned	6.6 kN	6.9 kN
Strength group <sup>E</sup>	Seasoned	SD3	
	Unseasoned	S3	
Durability ratings <sup>F</sup>	Decay only	3/2	
	Decay plus termites	4	
<i>Lyctus</i> susceptibility <sup>G</sup>	Susceptible		
Shrinkage (% of green dimension) <sup>C</sup>			
	Tangential (Backsawn)	Radial (Quarter sawn)	
Green to Air dry (12% MC)	10.6% (7.1-14.3)	5.7% (2.3-8.9)	
Collapse	3.6%	1.9%	
Unit	0.36% (0.29-0.43)	0.25% (0.16-0.34)	
Dimensional Movement (mm)	2.9	2.0	

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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## White stringybark

### *Nomenclature*<sup>A</sup>

**Botanical Name:** *Eucalyptus globoidea*

**Standard trade name:** White stringybark

**Local names:**

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale brown with a pinkish tinge. Sapwood paler but not distinctly differentiated, usually narrow.. Texture medium and even. Grain often interlocked.

**Table 12: General properties of white stringybark (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
Basic Density - kg/m <sup>3</sup>	652 <sup>C</sup> (557-749)		
Estimated Saturated Moisture Content - %	88 (68-114)		
Air dry Density (12% MC) - kg/m <sup>3</sup>	802 <sup>C</sup> (712-920)		
Hardness (Janka) <sup>D</sup>		<b>Tangential</b>	<b>Radial</b>
	Seasoned	9.0 kN	9.0 kN
	Unseasoned	6.3 kN	6.4 kN
Strength group <sup>E</sup>	Seasoned	SD3	
	Unseasoned	S3	
Durability ratings <sup>F</sup>	Decay only	3	
	Decay plus termites	3	
<i>Lyctus</i> susceptibility <sup>G</sup>	Resistant		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)	
Green to Air dry (12% MC)	10.6% (4.8-17.1)	5.6% (1.8-9.8)	
Collapse	4.6%	2.6%	
Unit	0.36% (0.30-0.42)	0.25% (0.19-0.33)	
Dimensional Movement (mm)	2.9	2.0	



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- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
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## Yertchuk

### Nomenclature<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus consideriana</i>
<b>Standard trade name:</b>	Yertchuk,
<b>Local names:</b>	Prickly stringybark, prickly bark

### Wood Features and Properties<sup>B</sup>

Heartwood pale brown. Sapwood paler but not always sharply distinguished. Texture moderately coarse but even. Grain slightly interlocked. Gum veins common

**Table 13: General properties of yertchuk (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>		
<b>Basic Density - kg/m<sup>3</sup></b>	<b>710<sup>C</sup></b> <b>(633-795)</b>	
<b>Estimated Saturated Moisture Content - %</b>	<b>76</b> <b>(60-93)</b>	
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>883<sup>C</sup></b> <b>(758-1014)</b>	
<b>Hardness (Janka)<sup>D</sup></b>	<b>Seasoned</b>	<b>Tangential</b> <b>10.0 kN</b>
	<b>Unseasoned</b>	<b>7.1 kN</b>
<b>Strength group<sup>D</sup></b>	<b>Seasoned</b>	<b>Radial</b> <b>10.3 kN</b>
	<b>Unseasoned</b>	<b>7.2 kN</b>
<b>Durability ratings<sup>E</sup></b>	<b>Decay only</b>	<b>SD3</b>
	<b>Decay plus termites</b>	<b>S3</b>
<b>Lyctus susceptibility<sup>F</sup></b>	<b>Resistant</b>	
<b>Shrinkage (% of green dimension)<sup>C</sup></b>		
	<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>	<b>9.1%</b> <b>(6.5-11.8)</b>	<b>5.7%</b> <b>(3.2-8.0)</b>
<b>Collapse</b>	<b>3.1%</b>	<b>2.0%</b>
<b>Unit</b>	<b>0.38%</b> <b>(0.31-0.45)</b>	<b>0.28%</b> <b>(0.23-0.34)</b>
<b>Dimensional Movement (mm)</b>	<b>3.0</b>	<b>2.2</b>

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- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>E</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>F</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Yellow Stringybark

### *Nomenclature*<sup>A</sup>

**Botanical Name:** *Eucalyptus muelleriana*

**Standard trade name:** Yellow stringybark,

**Local names:**

### *Wood Features and Properties*<sup>B</sup>

Heartwood yellowish brown with a pink tinge. Sapwood usually sufficiently paler to be clearly distinguishable. Texture medium and even. Grain often interlocked.

**Table 14: General properties of yellow stringybark (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>697<sup>C</sup></b> <b>(613-780)</b>	<b>659<sup>D</sup></b>	
<b>Estimated Saturated Moisture Content - %</b>	<b>78</b> <b>(63-98)</b>		
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>851<sup>C</sup></b> <b>(730-976)</b>		
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>10.0 kN</b>	<b>10.3 kN</b>
	<b>Unseasoned</b>	<b>7.1 kN</b>	<b>7.2 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD3</b>	
	<b>Unseasoned</b>	<b>S3</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>2</b>	
	<b>Decay plus termites</b>	<b>3</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Resistant</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>9.1%</b> (6.5-11.8)	<b>5.7%</b> (3.2-8.0)
<b>Collapse</b>		<b>3.1%</b>	<b>2.0%</b>
<b>Unit</b>		<b>0.38%</b> (0.31-0.45)	<b>0.28%</b> (0.23-0.34)
<b>Dimensional Movement (mm)</b>		<b>3.0</b>	<b>2.2</b>



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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia



## Broad-leaved Peppermint

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus dives</i>
<b>Standard trade name:</b>	Broad-leaved peppermint
<b>Local names:</b>	

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale pinkish brown. Sapwood paler but not sharply differentiated. Texture medium and even. Grain often interlocked. Gum veins common.

**Table 15: General properties of broad-leaved peppermint (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>610<sup>C</sup></b> (522-711)	<b>557<sup>C</sup></b> (468-652) 17-25 y.o.	<b>644<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>99</b> (75-126)	<b>114</b>	<b>90</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>738<sup>C</sup></b> (639-854)	<b>703<sup>C</sup></b> (554-855)	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>8.5 kN</b>	<b>8.3 kN</b>
	<b>Unseasoned</b>	<b>6.3 kN</b>	<b>6.3 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD4</b>	
	<b>Unseasoned</b>	<b>S3</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>3</b>	
	<b>Decay plus termites</b>	<b>3</b>	
<b><i>Lyctus</i> susceptibility<sup>G</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>13.2%</b> (6.5-20.5)	<b>6.3%</b> (3.6-9.5)
<b>Collapse</b>		<b>7.0%</b>	<b>3.1%</b>
<b>Unit</b>		<b>0.36%</b> (0.10-0.39)	<b>0.22%</b> (0.16-0.30)
<b>Dimensional Movement (mm)</b>		<b>2.9</b>	<b>1.8</b>



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- <sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia
- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## Narrow-leaved Peppermint

### Nomenclature<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus radiata</i>
<b>Standard trade name:</b>	Narrow-leaved peppermint
<b>Local names:</b>	

### Wood Features and Properties<sup>B</sup>

Heartwood pale pinkish brown. Sapwood slightly paler but not sharply differentiated. Texture medium and even. Grain sometimes interlocked. Gum veins common.

**Table 16: General properties of narrow-leaved peppermint (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>593<sup>C</sup></b> (532-670)	<b>545<sup>C</sup></b> (439-650) 15-25 y.o.	<b>591<sup>D</sup></b>
<b>Estimated Saturated Moisture Content - %</b>	<b>103</b> (84-123)	<b>118</b> (75-126)	<b>104</b>
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>727<sup>C</sup></b> (625-852)	<b>678<sup>C</sup></b> (519-835)	
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	<b>Radial</b>
	<b>Seasoned</b>	<b>6.8 kN</b>	<b>7.5 kN</b>
	<b>Unseasoned</b>	<b>5.0 kN</b>	<b>5.3 kN</b>
<b>Strength group<sup>E</sup></b>	<b>Seasoned</b>	<b>SD4</b>	
	<b>Unseasoned</b>	<b>S4</b>	
<b>Durability ratings<sup>F</sup></b>	<b>Decay only</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b>Lyctus susceptibility<sup>G</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
		<b>Tangential</b> (Backsawn)	<b>Radial</b> (Quarter sawn)
<b>Green to Air dry (12% MC)</b>		<b>17.1%</b> (6.3-27.9)	<b>7.1%</b> (1.2-13.4)
<b>Collapse</b>		<b>10.3%</b>	<b>4.1%</b>
<b>Unit</b>		<b>0.36%</b> (-0.01-0.73)	<b>0.18%</b> (0.03-0.33)
<b>Dimensional Movement (mm)</b>		<b>2.9</b>	<b>1.4</b>

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- <sup>B</sup> Bootle K.R. (1985) Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> Bolza E. and Kloot N.H. (1963) The mechanical properties of 174 Australian timbers. CSIRO Australia – Division of Forest Products Technology Paper No. 25.
- <sup>E</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>F</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
- <sup>G</sup> AS 2082 (2000) Timber-Hardwood-Visually stress-graded for structural purposes. Standards Australia

## River Peppermint

### *Nomenclature*<sup>A</sup>

<b>Botanical Name:</b>	<i>Eucalyptus elata</i>
<b>Standard trade name:</b>	River peppermint
<b>Local names:</b>	

### *Wood Features and Properties*<sup>B</sup>

Heartwood pale brown, subject to gum veins, fissile.

**Table 17: General properties of river peppermint (Values shown in brackets represent the 95% probability range for individual specimens)**

<b>General</b>			
<b>Basic Density - kg/m<sup>3</sup></b>	<b>554<sup>C</sup></b>		
<b>Estimated Saturated Moisture Content - %</b>	<b>115</b>		
<b>Air dry Density (12% MC) - kg/m<sup>3</sup></b>	<b>705<sup>C</sup></b>		
<b>Hardness (Janka)<sup>D</sup></b>		<b>Tangential</b>	
	<b>Seasoned</b>		
	<b>Unseasoned</b>	<b>5.5 kN</b>	<b>5.3 kN</b>
<b>Strength group<sup>D</sup></b>	<b>Seasoned</b>	<b>SD4</b>	
	<b>Unseasoned</b>	<b>S4</b>	
<b>Durability ratings<sup>E</sup></b>	<b>Decay only</b>	<b>4</b>	
	<b>Decay plus termites</b>	<b>4</b>	
<b><i>Lyctus</i> susceptibility<sup>F</sup></b>	<b>Susceptible</b>		
<b>Shrinkage (% of green dimension)<sup>C</sup></b>			
	<b>Tangential (Backsawn)</b>	<b>Radial (Quarter sawn)</b>	
<b>Green to Air dry (12% MC)</b>	<b>15.8%</b>	<b>8.1%</b>	
<b>Collapse</b>	<b>8.0%</b>	<b>3.8%</b>	
<b>Unit</b>	<b>0.39%</b>	<b>0.26%</b>	
<b>Dimensional Movement (mm)</b>	<b>3.1</b>	<b>2.0</b>	

<sup>A</sup> AS 2543 (1983) Nomenclature of Australian Timbers. Standards Australia

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- <sup>B</sup> Boland D.J., Brooker M.I., Chippendale G.M. Hall N., Hyland B.P.M., Johnston R.D., Kleinig and Turner J.D. (1984) Forest trees of Australia. Nelson-CSIR
- <sup>C</sup> Kingston R.S.T. & Risdon C.J.E. (1961) Shrinkage and Density of Australian and other South-west Pacific Woods, CSIRO Australia.
- <sup>D</sup> AS/NZS 2878 (2000) Timber-Classification into strength groups. Standards Australia
- <sup>E</sup> Thornton J.D. and Johnston G.C. (1997) Revised CSIRO durability classification: In-ground durability for mature outer heartwood. CSIRO Forestry and Forest Products.
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## Notes on wood properties

### **Basic density:**

The mass of the oven dry specimen divided by the volume when green.

### **Air dry density:**

The density of the wood when equilibrated to 12% moisture content. Mostly figures quoted are for volume after steam reconditioning.

### **Strength group:**

Minimum values for modulus of rupture (MOR), modulus of elasticity (MOE) and maximum crushing strength are shown for strength groups for both green (Table 18) and seasoned timber (Table 19).

**Table 18: Minimum values for strength groups for green timber (MPa)**

Property	S1	S2	S3	S4	S5	S6	S7
Modulus of rupture	103	86	73	62	52	43	36
Modulus of elasticity	16,300	14,200	12,400	10,700	9,100	7,900	6,900
Maximum crushing strength	52	43	36	31	26	22	18

**Table 19: Minimum values for strength groups for seasoned timber (MPa)**

Property	SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8
Modulus of rupture	150	130	110	94	78	65	55	45
Modulus of elasticity	25,500	18,500	16,000	14,000	12,500	10,000	9,100	7,900
Maximum crushing strength	80	70	61	54	47	41	36	30

### **Dimensional movement:**

The average maximum change in dimension in mm of a 100mm wide board resulting from a typical moisture content change from 15% to 7%. (e.g. Relative humidity change from 75% to 35% at 20°C).

### **Collapse:**

Values shown are recovered collapse and are the difference between the before and after reconditioning shrinkage values.

### **Durability rating:**

Is based on a classification developed by CSIRO, Division of Forest Products, which incorporates the durability of heartwood in contact with soil and exposed to attack by

decay fungi and termites. **Class 1** – excess of 25 years expected, **Class 2** – 15- 25 years expected, **Class 3** – 8- 15 years expected; **Class 4** – 1- 8 years expected (non-durable).

