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FPC TIMBER TECHNOLOGY REPORT FOR GREENING AUSTRALIA

VALUE-ADDING POTENTIAL OF *Eucalyptus rudis x E.camaldulensis*

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SUMMARY

FPC Timber Technology assessed the properties of timber from a 40-50 year old tree of the hybrid, *Eucalyptus rudis x E. camaldulensis* and compared them with a range of other species tested previously using the same test methods and assessment criteria. The results indicated that the hybrid would have dried to a drying quality level suitable for added-value utilisation, had it not checked severely before or during the drying process. The air-dry density of the hybrid was 1005 kg/m^3 and the air-dry hardness measured using a modified Janka method was 11.9 kN, making it denser and harder than Western Australia's (WA's) main commercial species, jarrah (*E. marginata*), karri (*E. diversicolor*) and marri (*Corymbia calophylla*).

Fifteen per cent of the timber was graded as Prime, 40 per cent was Standard and 45 per cent was Reject using the FIFWA Industry Standard for Sawn and Skip-Dressed WA Hardwoods for a minimum 900 mm length board. Gum and borer holes were the main reasons for downgrade, indicating that the hybrid would produce mostly feature grade timber products. The timber was straight grained with a fine even texture and orange-brown to pinkish-brown colour. The quartersawn timber had prominent brown streaks and wavy figure while the backsawn timber was less interesting. Quartersawing may therefore be advisable.

The timber machined well in comparison to the other commercial WA species assessed by FPC Timber Technology. Gluing with a urea formaldehyde formulation produced an acceptable result for seven replicates with 74 per cent average wood failure and 30 per cent minimum failure. The machining test panel was finished to a high standard with minimal preparation using a sprayed lacquer finish. Notwithstanding that a very small sample was assessed, FPC Timber Technology concluded that timber from the hybrid appeared to offer considerable value-adding potential for uses in furniture, building fitments, flooring and woodcraft.

INTRODUCTION

FPC Timber Technology was requested by Greening Australia to evaluate the value-adding potential of timber from a tree of the hybrid *Eucalyptus rudis* x *E. camaldulensis* which naturally occurs where the distributions of the two closely related river gums merge in the upper reaches of south-west Western Australia.

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A range of properties including drying quality (moisture content, residual drying stress, checking and collapse), machining quality (ripping, cross-cutting, planing, sanding, routing and drilling), visual grade, gluing, finishing and physical and aesthetic properties (air-dry density, air-dry hardness, colour, texture, grain and figure) were assessed by FPC Timber Technology and used as a basis for commenting on the value-adding potential of the hybrid in comparison to the commercial species jarrah (*E. marginata*), karri (*E. diversicolor*), marri (*Corymbia calophylla*) and blue gum (*E. globulus*) previously assessed by the same methods.

METHODS

Greening Australia supplied 0.15 m^3 of dry sawn timber that was mixed sawn from a 40-50 year old tree located near a swamp in Bolgart, approximately 20 kms north of Toodyay in Western Australia. The timber was dried in a solar assisted kiln using a commercial schedule for jarrah, and delivered to FPC Timber Technology where it was stored under cover until the trial commenced. The timber was severely checked on arrival at Harvey.

Three backsawn and three quartersawn 3400 x 120 x 43 mm boards were selected from the parcel of timber and branded for identification throughout the trial. Each of the boards was assessed using AS/NZS 4787:2001 (Standards Australia/Standards New Zealand 2001) and a drying quality class was assigned on the basis of each assessment. The classes given in the standard are as follow:

Class A:	Applies when the final use and final environment can accept a product with a wide range of moisture contents and the drying quality requirements are not high.
Class B:	Applies when the final use environment is more clearly defined but again the drying quality requirements are not considered high.
Class C:	Applies where higher drying quality is required and the final use environment is clearly defined.
Class D:	Applies where tight control over drying quality is required to limit 'in-service' movement resulting from changes in equilibrium moisture content.
Class E:	Caters for specific end uses and very specific requirements for drying quality.

The air-dry density of a test piece cut from each board was then determined using the measurement method specified in AS 1080.3:1983 (Standards Association of Australia 1983) for prismatic test pieces. The method involves accurately measuring the dimensions and mass of a prismatic sample and then calculating density from the mass and volume measurements.

The hardness of the air-dry samples used for the density assessments were then measured using a modified Janka method. The Janka method given in ASTM D143 (American Society for Testing and Materials 1994) requires incremental measurement of the force required to embed a 0.444" steel hemisphere into the face, edge and end grain of a 2 x 2 x 6" test block at a strain rate of 0.25 inches per minute. In this trial, a vice with a modified screw was used to embed the 0.444" steel hemisphere into the samples. The maximum load required to embed the hemisphere was determined from the maximum torque applied at the screw using a torque wrench. The rate of indentation was controlled manually by the speed of rotation of the wrench handle to achieve approximately 0.25 inches per minute movement at the jaws. The depth of indentation was measured at the jaws using a Vernier calliper. The test was repeated five times on various thickness samples and the results were averaged.

The six 43 mm boards selected for the machining test panel were then planed to 40 mm using an SCM 'Superset 23' four-side planer and visually graded to Industry Standard for Seasoned Sawn and Skip-Dressed WA Hardwoods (FIFWA 1992) which describes Prime, Standard and Reject grades. The percentage of each board that was graded as Prime, Standard or Reject, together with the characteristics that caused downgrading from higher to lower grades were recorded. A minimum required length for Prime and Standard of 900 mm was applied during grading to ensure useable pieces could be obtained.

The colour of each board was then described in accordance with the colour features given in CSIRO's Macro Key for Hardwood Identification (Ilic 1990). The method involved matching the base colour and other colour features such as flecks with standard colours and descriptions given in the Macro Key. Other aspects of appearance were then described using CSIRO's Trade Circular No. 43 (CSIRO Division of Forest Products 1960). The circular contains standard descriptions for grain (referred to as the prevalent direction of the wood fibres along the length of each board), texture (referred to as the size and position of the wood elements), and figure (described as the patterns in each board due to structural features, including knots and growth rings).

Two of the six boards were then cut in half using an Omga 'RN 600' radial arm saw and ripped to 76.25 mm on a Wadkin 'CP 380' panel saw so that an eight board, 610 mm wide machining test panel could be constructed. The boards were edge dressed using a Hombak 'AFK 5' buzzer and within 24 hours Craftbond 'UF62' urea formaldehyde adhesive was prepared and applied to the edges of the boards in accordance with AS 1328.1:1998 (Standards Australia 1998). The eight boards were then positioned in the machining test panel so that they alternated between backsawn and quartersawn and clamped for 24 hours prior to machining.

The panel was then trimmed to 610 mm in length and the off-cut was used to assess glue strength in accordance with AS 1328.1:1998 (Standards Australia 1998). The glue test involved preparing notched samples that were split along the glue line using a bolster and masonry hammer. The separated surfaces were then visually assessed and the percentage of wood failure was determined and stated in 5 per cent increments on a scale ranging from 0 to 100 per cent. In accordance with the test method, 60 per cent average wood failure was considered acceptable unless any individual samples achieved less than 30 per cent wood failure.

The panel was then planed with, and against the grain using a Robinson 36 x 7 " thicknesser that was adjusted to remove 1 mm of thickness with each pass. The quality of the planed surfaces was graded using the FPC Timber Technology visual grading rules for assessing machining quality given in Appendix A. The grading rules rank the quality of the cut surface on a scale ranging from 1 (a high quality surface that is virtually free from any defect associated with the particular machining or finishing process) to 5 (a surface that would be rejected as unfit for use). The panel was then sanded with a Worldmax 'Sheng Feng A 376' belt sander fitted with a 120 grit belt sander, using the same methodology and grading system used for planing.

The 'grid' pattern of 5 mm deep saw cuts shown in Appendix B was then ripped or cross-cut into the best face of the panel using the Omga radial arm saw. The panel arrises were 'pencil' rounded using a Makita '361 2BR' 6 mm router fitted with a 5 mm radius rounding bit and the 12 mm wide by 5 mm deep 'cross' and 'circle' patterns also shown in Appendix B, were then routed into the same face of the panel using the router fitted with a 6 mm diameter bit. Both machining operations were graded using the FPC Timber Technology visual grading rules given in Appendix A.

The pattern of 5 mm deep holes shown in Appendix B was then bored into the panel using an F&R 'Tough' pedestal drill-press fitted with a 6 mm brad point bit, followed by a 12 mm brad point bit and 16 mm, 19 mm and 25 mm saw tooth bits. The quality of the bored surfaces were then assessed using the FPC Timber Technology visual grading rules given in Appendix A.

Finally, the panel was hand sanded with 240 grit paper to produce a clean, smooth surface and finished with Wattyl 'Stylwood' in accordance with the manufacturer's instructions, and the quality of the finished surface was also assessed using the FPC Timber Technology visual grading rules given in Appendix A.

RESULTS AND DISCUSSION

The drying quality classes for moisture content, residual drying stress, surface checking, internal checking and collapse are given in Table 1.

Table 1. Drying quality classes of timber assessed using AS/NZS 4787:2001

Replicate	1	2	3	4	5	6
Moisture content (%) *	D	D	D	D	D	D
Residual drying stress (%)	D	D	D	D	D	D
Surface checking (%)	-	-	-	-	-	-
Internal checking (%)	E	E	E	-	E	E
Collapse (mm)	E	E	E	E	E	E

Notes: * *Based on a target moisture content of 12%.*
- *Denotes the timber that did not meet the requirements for any of the drying quality classes.*

Aside from surface checking, the drying quality class of the timber was D or E, meaning it would be suitable for flooring, furniture and other value-added uses where movement in service should be controlled. While fine surface checking can be removed by planing, severe checking cannot be removed without the considerable loss of timber. The hybrid produced high density timber which, like other dense eucalypts, could have been expected to surface check if not handled carefully. Considerable care was needed to avoid moisture loss in the early stages of drying and it appears this level of control was not achieved. Keeping eucalypt timber wet until it can be placed in a high humidity environment is a critical but often missed step in the drying process.

The air-dry density and hardness figures of the six replicate boards given in Table 2 show that variability was not unusually high. Previous tests conducted at Timber Technology have shown the experimental precision of these tests to be high. The variability in the results can therefore be attributed largely to variability in wood properties.

Table 2. **Physical properties of timber assessed using AS 1080.3:1983 and the modified ASTM D143 Janka method**

Replicate	1	2	3	4	5	6	Average
Air-dry density (kg/m^3)	1039	994	1010	974	1022	992	1005
Air-dry hardness (kN)	12.6	10.4	13.1	11.8	11.8	-	11.9

Note: Air-dry hardness figures were averaged from five repeat measurements on each replicate.

Table 3 compares average air-dry density and air-dry hardness measurements from this assessment with data for the hybrid parents, as well as jarrah, marri and karri. The results show that the hybrid had the highest air-dry density and was one of the hardest of the timbers, which bodes well for its value-adding potential where strength and hardness are required.

Table 3. **Comparisons of air-dry density and air-dry hardness of** *Eucalyptus rudis x E.camaldulensis* **with other species**

Species	Air –dry density (Kg/m^3)	Air-dry hardness (kN)
*E. rudis x E. camaldulensis**	1005	11.8
*E. rud*is (Siemon 2001 (Unpublished))[3]	815	-
E. camaldulensis (Bootle 1983)	900	10.0
E. marginata (Bootle 1983)	820	8.5
Corymbia calophylla Bootle (1983)	850	7.1
E. diversicolor (Bootle 1983)	900	9.0

*Note: * Average figures from Table 2*

The percentage length of each board that was graded into each grade category using the FIFWA Industry Standard is presented in Table 4. The figures in Table 4 are similar to those from other native eucalypt species graded at Timber Technology , however it should be noted that the recovered pieces were comparatively short. Notwithstanding, it can be seen that nearly half of the timber was Reject and therefore unsuitable for traditional value-added utilisation; another 40 per cent of the timber was Standard grade that, as yet, has not found many value-added uses. Only 15 per cent of the timber therefore would be suitable for traditional added-value uses, which emphasises the need to find products and markets for the bulk of the timber, which is the lower grade material.

Table 4: **Percentage grade of timber using the FIFWA Industry Standard**

Replicate	1	2	3	4	5	6	Average
Prime (%)	41	48	0	0	0	0	15
Standard (%)	0	0	100	84	0	59	40
Reject (%)	59	52	0	16	100	41	45

[3] Siemon, G. (2001), Internal report, FPC Timber Technology, 64 Weir Road, Harvey.

The characteristics that caused downgrading from Prime to Standard or Reject grade using the FIFWA Industry Standard are presented in Table 5. It is evident that checks and gum were the major reasons for downgrade, while heart, wane and borer attack also exceeded permissible grade limits.

As explained previously, the checking may have been reduced by improved handling and drying practices. The occurrence of heart and wane, like checking, may also have been reduced, but in this case recovery would have suffered, because the heart and wane would have been removed during the sawing process with corresponding loss of volume. Recovery was not assessed, so whether an optimum sawing pattern was used is unknown. Gum and borer holes develop during tree growth in the forest, so unlike drying and sawing, this process cannot realistically be controlled and therefore these characteristics must be accepted in the final product. This is the case with most eucalypts, and underpins the current drive in Western Australia and other states to develop products and markets for feature grade timber.

Table 5: Characteristics that caused downgrading from Prime to Standard or Reject grade using the FIFWA Industry Standard for Sawn and Seasoned Skip-Dressed WA Hardwoods

Replicate	1	2	3	4	5	6
Knots	✗	✗	✗	✗	✗	✗
Checks	✓	✓	✓	✓	✓	✓
Gum	✓	✓	✓	✓	✗	✓
Skip	✗	✗	✗	✗	✗	✗
Heart	✗	✓	✗	✗	✗	✗
Borer	✓	✗	✗	✗	✗	✗
Wane	✗	✗	✓	✗	✗	✗
Cupping	✗	✗	✗	✗	✗	✗
Spring	✗	✗	✗	✗	✗	✗
Bow	✗	✗	✗	✗	✗	✗
Twist	✗	✗	✗	✗	✗	✗

Notes: ✗ = *did not exceed allowance*
✓ = *exceeded allowance*

The grain, texture, colour and figure of the timber are described in Table 6 using CSIRO's Macro Key for Hardwood Identification (Ilic. 1990) and CSIRO's Trade Circular (CSIRO Division of Forest Products 1960).

Table 6 **Aesthetic properties of timber assessed using CSIRO's Macro Key for Hardwood Identification and CSIRO's Trade Circular No. 43**

Characteristic	Description
Grain	Straight
Texture	Fine and even
Colour	Heartwood orange-brown to pinkish-brown
Figure	Quartersawn boards had prominent brown streaks and wavy figure while the backsawn was not as highly figured

The timber's combination of straight grain, high density (and therefore assumed strength) and fine/even texture is an asset for value-added utilisation where high strength coupled with good machining properties are required. Uses where strength is critical include chair backs and legs in furniture construction where joints are highly stressed. The orange-brown to pinkish-brown heartwood colour is unusual for a Western Australian native species, thus improving the colour diversity available from the State's timber resource. Contrary to expectation, the quartersawn boards were more highly figured than the backsawn boards, suggesting that quartersawing may be the preferred sawing pattern for this hybrid.

The machining properties of the timber assessed using the FPC Timber Technology visual grading rules are presented in Table 7. It is apparent from the information given that the timber machined well in all operations. Planing quality was lower than the other machining operations, but this was also the case with other species tested by FPC Timber Technology.

Table 7: **Machining quality assessed using FPC Timber Technology visual grading rules**

Replicate	1	2	3	4	5A	6A	5B	6B	Average
Ripping	1	1	1	1	1	1	1	1	1
Cross-cutting	1	1	1	1	1	1	1	1	1
Planing	1	1	2	2	2	2	3	3	2
Sanding	1	1	1	1	1	1	1	1	1
Routing	1	1	1	1	1	1	1	1	1
Drilling	1	1	1	1	1	1	1	1	1

The average machining quality for the six replicate boards for each operation are compared with the results from previous trials carried out at FPC Timber Technology on other species, assessed using the same equipment and grading methods[4].

[4] A machining trial on jarrah, karri, marri and blue gum is currently being prepared by the authors.

Table 8: **Comparison of machining properties of *Eucalyptus rudis x E.camaldulensis* with other species assessed using the FPC Timber Technology visual grading rules for assessing machining quality**

Species	Ripping	Cross-cutting	Planing	Sanding	Routing	Drilling	Finishing
E. rudis x E. camaldulensis *	1	1	2	1	1	1	1
E. marginata	1	2	2	1	2	1	-
C. calophylla	1	2	3	1	2	1	-
E. globulus	1	2	3	1	2	1	-
E. diversicolor	1	3	2	1	2	1	-

Notes: * *Average of figures from Table 7*

The results show that the timber machined extremely well, and produced better results than that of other species assessed at FPC Timber Technology using the same test methods. The results of the glue test assessed using AS 1328.1:1998 (Table 9) show that the average value for percentage wood failure was greater than 60 per cent, and that no individual value was less than 30 per cent. These results constitute a pass, however it is likely that improvements could be achieved using different glues and/or gluing methods. Unlike the density and hardness tests, the precision of the glue test is generally quite low and therefore a large sample is required to reduce uncertainty.

Table 9. Glue strength assessed using AS 1328.1:1998

Replicate	1	2	3	4	5	6	7	Average
Wood failure (%)	80	80	75	30	65	95	95	74

The finishing quality results in Table 10 indicate that the timber finished very well. The quality of the finish could not be formally compared to other species tested at FPC Timber Technology, because the latter were not assessed by the same method. However, it was apparent to the authors that the effort required to prepare the hybrid timber surface for finishing was less than the effort required for the other species, particularly karri, which is prone to fibre pick-up.

Table 10:. Finishing quality assessed using the FPC Timber Technology visual grading rules for assessing machining quality

Replicate	1	2	3	4	5	6	7	8
Finish grade	1	1	1	1	1	1	1	1

CONCLUSION

The timber from the *Eucalyptus rudis x E.camaldulensis* hybrid was dense and hard with an attractive colour and appearance, and apart from surface checking the timber dried to a quality level suited to high value-added uses. There were no problems with ripping, cross-cutting, planing, sanding, routing, drilling, gluing or finishing, and indeed the hybrid timber performed better than the other species assessed at FPC Timber Technology using the same methods of assessment. Timber from only one tree was assessed in the trial and the extent to which the tree represented the species population is not known. The results must therefore be interpreted with caution. However, notwithstanding the need to test timber from other trees, the data indicate that the hybrid offers considerable potential for value-added use in furniture, building fitment, flooring and woodcraft.

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APPENDIX A

FPC Timber Technology Visual Grade Rules for Assessing Machining Quality.

1 Purpose

The purpose of this procedure is to specify five grades for assessing the quality of machined and finished timber surfaces.

2 Basis

Grading will be carried out independently by two graders in daylight. Where the grades determined by the two graders vary, a third grader will be required to grade the samples. The consensus grade will be accepted.

3 Grade Descriptions

1 describes a high quality surface that is virtually free from any defect associated with the particular machining or finishing process.

2 describes a good quality surface that is free from most defects associated with the machining or finishing process.

3 describes a surface that is acceptable, but not good.

4 describes an unacceptable surface that would have to be reworked or a reduced value negotiated.

5 describes a surface that would be rejected as unfit for use. If reworking is possible it probably would not be warranted due to the extent of the work required.

4 Considerations

Although an effort will be made to achieve the best outcome from each species during the machining and finishing trial, some concessions will have to made for differences in timber character - both in and outside species groups. Dark coloured timber, for example, will hide shadow causing defects while light timber will not; timber with knots, grain deviations and gum inclusions will not machine as well as clear timber; and timber with interlocked grain will not machine the same way as timber with straight grain. Numerous other examples could also be given.

While it will not be possible to vary the visual grades, mitigating characteristics will be noted.

APPENDIX B

Diagram of Standard Machining Test Panel.