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**VALWOOD® PROCESSING - A
PRELIMINARY INVESTIGATION**

L.R. Mathews

Department of Conservation and Land Management
W.U.R.C. Report No. 17 (1990)

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L. R. Mathews

SUMMARY

The VALWOOD® process developed at the Wood Utilisation Research Centre at Harvey produces value-added products for furniture or structural use by edge- and face-gluing 10 mm thick laminates of regrowth eucalypts.

This study assessed the recoveries from regrowth jarrah (*Eucalyptus marginata* Donn ex Sm.) logs with small end diameter over bark from 200 to 300 mm, and either 1.2 m or 2.4 m long. Boards of 13 or 16 mm thickness were sawn sap-to-sap, using a horizontal bandsaw with 3 mm kerf. The green recovery was 79.8 per cent (including wane). Boards at both thicknesses were air-dried during mid-summer ambient conditions to below fibre saturation point (about 25 per cent moisture content) in less than 12 days.

The boards were then high temperature dried to 8 per cent moisture content, and wane was removed by resawing for maximum recovery.

End splitting was the worst defect, with 68 per cent of boards affected. Face checking was less in boards with no juvenile wood, but cupping was more extensive. The cutting pattern was considered to be the major cause of end-splitting, and an alternative method is suggested.

The original 16 mm boards were dressed to 11 mm, and the 13 mm to 10 mm, to assess the potential to improve recovery by reducing sawing sizes.

Grading gave a recovery of 28.6 per cent of the original log volume. An improved sawing pattern, and less restrictive grading rules which were introduced later, will result in a substantial increase in recovery.

INTRODUCTION

Worldwide, the availability of cabinet grade hardwood timber is declining. Some mahogany-type timbers suitable for high-value products are native to Western Australia. The major commercial species are jarrah (*Eucalyptus marginata* Donn ex Sm.) and to a lesser extent karri (*E. diversicolor* F. Muell.). However, the areas of old growth forest available for timber production are decreasing, mainly because of past harvesting, mining operations, and provision of services. Large areas have been set aside for conservation, scientific, and recreation purposes in line with changing social attitudes towards the timber industry, and with increasing public awareness of conservation issues.

This decrease in available areas is coupled with industry problems such as the inevitable reduction in log size, poorer form and wood quality, and increasing environmental constraints. Sawmills may have inappropriate plant and technology for the changing resource, and the change from using green hardwoods to dry dressed softwoods in traditional construction markets is forcing the industry to change in order to survive.

As utilisation of the old growth forest decreases, a greater dependence on new growth (regrowth) forest will be required. In areas where the old forest was harvested, regrowth was only seriously considered as a resource in recent years, and little was known about its potential for sawn timber products.

Utilisation of these regrowth forests poses problems for growers, harvesters, processors, manufacturers and end users alike. Regrowth characteristics which differ considerably from old growth forests include:

- larger numbers of stems per hectare
- larger numbers of stems per volume unit
- smaller diameters (approx 20 - 40 cm)
- less productivity per unit volume
- lower recoveries of sawn wood, in smaller section and shorter lengths
- higher growth stresses causing splitting and distortion
- increased difficulty of seasoning
- more shrinkage and distortion
- appearance - different colour, grain pattern and other features
- lower extractives content and consequent likely reduction in durability
- higher proportions of sapwood and juvenile wood.

The challenge facing industry and researchers is to develop new strategies, processes and products for markets which best suit the future resource. To meet this challenge, a jointly funded research project involving the Commonwealth and State Governments and the Western Australian timber industry was initiated in 1986 by the Department of Conservation and Land Management, at its Wood Utilisation Research Centre (W.U.R.C) in Harvey.

The project recognized the approach of capitalising on the unique properties of Australian hardwoods, and maximizing timber into production for value added 'niche' markets would be appropriate to help meet a perceived demand for furniture-quality timber and reduce the problems faced by the timber industry.

This research study evaluated a different approach in utilisation of small diameter regrowth logs in the 200 - 300 mm small end diameter under bark range. The VALWOOD® process involves the sawmilling, seasoning and processing of regrowth eucalypt sawlogs to produce dressed boards suitable for glue-lamination into dimensioned furniture quality panels as well as structural panels

and products e.g. cross arms for power poles. The study of cutting logs into order lengths and thin sections for subsequent glue-lamination is on-going. During the course of this study the process and product were registered as VALWOOD®.

METHODS

Log Source and Preparation

Regrowth jarrah logs were harvested during October 1988 from the clear felling of a dam site on the Harris River, south-east of Harvey.

The logs were transported to a processing dump near Worsley and mechanically debarked using a modified Rosser head. They were then stored for several days before being transported to the W.U.R.C. Following measurement to determine volume, the logs were held under water sprays until December 1988, when preparation for sawmilling began.

From the stockpile a sample of 28 logs was randomly selected, then end-docked to produce a small end diameter under bark range of 200 to 290 mm in equal numbers of 2.4 m and 1.2 m lengths. Docking was also necessary to remove any end splitting, which could influence the trial results. Each log was then re-measured and identified in preparation for sawmilling. The volume processed was 2.20 m³.

Sawmilling

Sawmilling was carried out immediately after preparation, to minimise premature drying.

A 'Forestor 150' horizontal bandsaw milled the logs, using a sap-to-sap sawing pattern similar to that adopted by many European furniture wood sawmills and the saw-dry-rip process in the U.S.A. (Fig. 1). In this method all boards are produced with wane on both edges and resawing to width is performed after drying (Shedley¹ personal communication).

One half of each log was sawn into 16 mm thick slabs and the other half into 13 mm slabs in accordance with the cutting pattern set out in Figure 1. This method permitted valid comparisons of processing results as boards of each thickness were sawn from the same log.

Boards were regularly measured as they came off the saw to ensure that sizing was as accurate as the equipment would permit. A sizing allowance of 3 mm was made for kerf losses. Apart from sawdust the other residues produced were the roundback wing from the first cut from each side of the log and an occasional sawn section less than 13 mm which was left after the final cut (Fig. 1). As the boards were cut they were individually numbered and then transferred by roller skids to a stacking area to be bundled for drying.

1. Mr P. Shedley, Department of Conservation and Land Management, Como.

Drying

One bundle of each thickness (16 mm and 13 mm) was constructed in a conventional manner, using 10 mm x 20 mm dry jarrah stickers at 300 mm centres between each layer of boards. The two completed bundles were approximately 1 m wide x 2.4 m long x 800 mm high. Excessive drying during production breaks was prevented by covering the bundles with plastic sheeting.

Twelve sample boards were selected for determination of initial moisture content using the oven-dried method (Standards Association of Australia 1972). Board ends were not coated to reduce degrade, which would allow evaluation of any problems with thin boards. Construction of both bundles was completed within an hour of each other, after which they were individually weighed on platform scales. The bundles were then stacked side by side, approximately 1 m off the floor in an open-sided building, to air dry. A top weight of 806 kg (336 kg/m^2) was added to each bundle to reduce distortion during drying.

Air drying was considered appropriate for this trial, based on good results from previous tests using 10 mm and 20 mm boards which dried rapidly with minimal degrading under shelter during mid-summer ambient conditions (Mathews unpublished data). Each bundle was periodically re-weighed at two to 10 day intervals to determine average moisture content and drying rates, allowing for the static weight such as stickers and strapping. Re-weighing continued until samples indicated both bundles had dried to approximately 12 per cent or the equilibrium moisture content (e.m.c) of the surrounding air.

After the degrade assessment described below, the bundles were rebuilt in preparation for a high temperature final drying stage which ensured that all boards were below e.m.c. and in the 6-8 per cent moisture content range needed to provide stability and good glue bonds for laminated products (Newby² personal communication).

The high temperature drying was performed one bundle at a time. The schedule used was an initial steaming period of one half hour, followed by a one-hour drying period at 110°C , and a one half hour reconditioning steam cycle. Bundles were weighted as described previously during the final drying. At the end of each run the charge was allowed to cool overnight in the kiln.

Shrinkage was monitored on two boards in each stack. Moisture contents were again determined by taking oven-dried samples from the original sample boards.

The bundles were stored in a closed insulated shed for a minimum settling period of ten days, prior to the resawing process.

Degrade Assessment

Following air drying all boards were assessed for degrade on both faces. Severity ratings of 0 (nil) to 3 (major) were given for end splits and face checks, in addition to noting the occurrence of cup, twist, and boards containing juvenile core wood.

2. Mr P. Newby, Consultant, c/o Department of Conservation and Land Management, Harvey.

Resawing

Resawing the sap-to-sap boards was necessary to prepare their edges for subsequent dressing, using a panel saw to resaw the boards by ripping close to the sap and producing random width, parallel-edged boards.

The procedure used was as follows:

- taking each thickness at a time, boards were sorted into their original log number groups.
- boards containing juvenile core wood from each log were end marked and separated to determine the proportion of boards affected and to compare results. These were easily identified because they were the widest boards from each log, the closest to the pith, and mostly quarter sawn. Many contained long end splits in the mid-face.
- parcels of boards containing juvenile wood, and the remaining predominantly backsawn portion from each log, were weighed separately before resawing.
- boards from each portion of the log were then resawn taking care to separate the residue from the sapwood and heartwood.
- separate weight measurements of the sapwood residue, the heartwood residue, other off-cuts, and the rough sawn boards were recorded for each log.
- all boards were re-numbered with the juvenile core boards being distinguished by additional end marking to allow comparison of subsequent grading results.

Using the above procedure, the proportion by weight of each type of residue and products from each log was calculated, providing data for comparison with any subsequent trials of processing methods. Using initial and final weights to calculate a percentage dry recovery was considered more practical than measuring each individual random width board to calculate the volume recovered.

An important objective during resawing was to maximise recovery, and consequently little regard was given to the quality of the board produced. To achieve this aim the following guidelines were followed:

- the minimum board width to be recovered was set at 50 mm while no maximum width was specified
- up to 5 mm wane, in one position, and only on one edge, was permitted along the length of any board. (It was assumed that subsequent edge dressing would remove up to 5 mm from one side.)
- some 2.4 m boards with excessive spring or bends were docked into 1.2 m lengths

The only other docking carried out was to remove wood with rot or unstable portions which could be unsafe to handle or dress. Parcels of each thickness were then sorted into groups of boards in 5 mm width increments in preparation for dressing.

Dressing

Machining of the width-sorted boards to dressed sizes was carried out using two methods.

In the first method, boards up to 200 mm wide were dressed using a 'Guilliet' four-sider straightening planer. The wider remaining boards would not fit through the 'Guilliet' so a buzzer and thicknesser in combination were used. Machine settings for the four-sider were 2 mm each for top and bottom cutters, and on the edge cutters 5 mm on the fence and 3 mm on the other edge. Boards which showed skip on the edge were redressed (width only) to the next lower 5 mm increment size.

In the second method, the wider boards were first dressed on one edge to remove 3 mm, and then put through the thicknesser to remove 2 mm from each face. The individual board width was arrived at by measuring to the nearest 5 mm increment at the narrowest part of the board, allowing for up to 5 mm dressing on the rough edge. This method permitted the data from the wide boards to be combined with those from the narrower boards dressed using the first method.

Dressed sizes were 11 mm for the 16 mm sawn boards, and 10 mm for the 13 mm sawn boards (in the latter those showing skip were redressed to 8 mm). This indicated whether excessive dressing allowance was being made. The original parcels of boards of different thicknesses were kept separate for further comparisons during grading.

Grading and Recovery

Grading of the pre-dressed boards was done using draft standards prepared by the W.U.R.C., and designed to accommodate the basic requirements of face-and-edge-glued, laminated products for furniture manufacture.

All boards were graded into the following categories.

Grade 1

Face boards - Two faces and two edges suitable for constructing laminated products for further machining e.g. routing, profile cutting and turning.

Grade 2

Face boards - One face and one edge suitable for use in laminated panels where only the visible surface is of concern e.g. table tops.

Grade 3

Core boards - Generally solid wood (including stable pith) suitable for internal laminations of products or where the appearance of the surface is of lesser concern e.g. internal layers of table tops, cupboard backs.

Grade 4

Serviceable - Remaining wood not meeting the above grades e.g. with large voids, end splits, skip or other features unlikely to give good glue bonding.

The initial grading involved grading all boards following dressing. The objective was to determine the recovery in each grade and to identify any need for additional processing to improve those recoveries. The most obvious feature limiting each board from being upgraded was recorded, and these features were summarized for each grade.

The boards were then regraded using the 'phantom' grading technique to improve recoveries into higher grades while attempting to minimize waste and processing effort. In this method the person grading indicated by chalk marks where undesirable characteristics would be removed by docking to length or ripping in width. However, docking did not actually take place so the boards remained intact, thus the technique allowed subsequent review of the grading decisions.

To achieve the objective, ground rules for docking and ripping were established and applied to the following extent:

- Docking
 - permitted providing only a maximum of 20 per cent of board length is wasted (excessive end splits were ripped in most cases)
 - minimum length of 600 mm
 - length multiples of 100 mm.
- Ripping
 - permitted only on boards wider than 70 mm
 - maximum of 20 per cent of the board width
 - only once for each grade the board is upgraded
 - minimum width of 50 mm.

During the phantom grading exercise the original grade, the new grade, and dimensions of each new board were recorded.

Results were then analysed. Timber produced from this study was successfully laminated into various demonstration products as part of other ongoing trials.

RESULTS AND DISCUSSION

Log Source and Preparation

The regrowth jarrah logs from Harris River used in this trial were found to have more rot and gum deposits than other log sources processed. Some logs had been left in the forest for periods longer than intended, and some had been left for several days after debarking, prior to delivery and stockpile storage under water sprays. The effects which this premature drying had on the trial are unknown. Sampling of other log sources more representative of the regrowth forests, and delivered with less exposure to drying, is required for an objective assessment of the VALWOOD® process.

The log preparation method used in this instance was adequate, although it did not provide information on the log quality or length and diameter distribution expected from various regrowth forests using current regrowth log specifications. This information is needed if design of an adequate log handling and conversion plant for the VALWOOD® process is contemplated.

Sawmilling

In this trial a recovery of 79.8 per cent by volume of green boards resulted from sawing 2.20 m³ of logs. The recovery included some degree of inaccuracy, however, because all boards were produced with wane on their edges, making it difficult to judge where to measure their width. Future trials should incorporate weight measurement of the green-sawn boards to determine recoveries accurately, which is appropriate as this is the likely measure to be used for log purchases. Data on moisture content variation between logs would also be available to arrive at equitable log pricing by weight.

Sawing the 1.2 m length logs was easily achieved with the horizontal bandsaw equipment used, but lengths less than 2.1 m are impractical in most conventional equipment currently used in the local sawmilling industry.

Face cutting to remove a thin sawn section and correct log deflection caused by progressive tension release during sawing (Waugh 1986) was not necessary. Presumably this was because thin slices (13 mm and 16 mm) were progressively cut from short logs (1.2 - 2.4 m), and the combined effect was to minimise deflection.

The sawing pattern used (Fig. 1) resulted in an unacceptable level of end splitting of boards (which occurred as a result of growth stresses), sometimes immediately after sawing, and especially in boards sawn through the juvenile core.

Some recommended strategies (Krilov 1981) for relieving stress in regrowth logs are docking to shorter lengths, and simultaneous parallel sawing on opposing side of the log.

A suggested sawing pattern is given in Figure 2. This cutting pattern is expected to be of even greater benefit in reducing end splitting when longer lengths and more highly stressed regrowth hardwood species such as karri and Tasmanian blue gum (*E. globulus* Labill. subsp. *globulus*) are sawn.

Further evidence to support the adoption of alternative sawing strategies is presented later in the degrade assessment results. Sawmilling production rates using a horizontal bandsaw were adequate for research purposes, but the economic application for VALWOOD® is doubtful owing to the large number of logs and sawcuts required for commercial quantities to be produced. In addition, adoption of stress relieving sawing patterns (Machin 1981) is also impractical, owing to the frequent turning required to box out the pith.

Hardwood log conversion equipment suitable for a commercial process which incorporates sawing capacity for short (1.0 m/minute) small diameter logs, thin kerf sawing, high piece productivity, and low labour component and cost, needs to be evaluated.

Drying

Results of drying the thin boards were most encouraging. Degrade attributable to the drying method was negligible during the final grading exercise. Drying rates are compared in Figure 3, which shows little practical difference between the 16 mm and the 13 mm green sawn thickness when dried in ambient conditions.

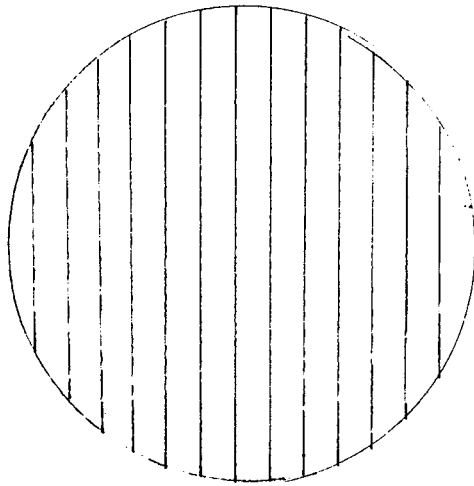


Figure 1. Through-and-through sawing pattern initially used for producing VALWOOD® boards

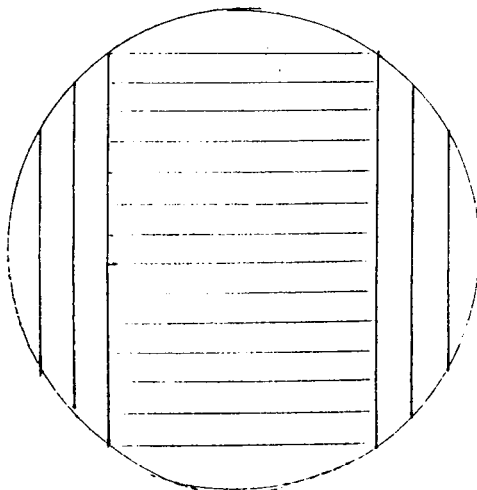


Figure 2. Sawing pattern to maximise the number of backsawn boards for VALWOOD® production.

The initial drying conditions for the bundles could be described as severe, considering the proposed end use as furniture wood. For the first 10 days, when moisture contents dropped from approximately 76 to 25 per cent, the maximum temperature averaged 28°C and the minimum relative humidity during the day averaged 35 per cent. In comparison, seasoning of 140 x 40 mm regrowth jarrah boards would require about 100 days to produce similar results in controlled kiln conditions of 30°C, 85 per cent relative humidity and 0.2 m/s air flow (Glossop³ personal communication). This demonstrates an important advantage of cutting thin boards.

Further drying trials will undoubtedly improve drying times based on the results of this study, but some caution is needed. The results showed that one log in particular produced boards of both thicknesses with many more drying checks than found in others, suggesting that the proportion of degrade would increase, regardless of the method used, as faster drying rates are pursued.

Observations made during the degrade assessment showed conventional methods of bundle construction, but with added weight restraint, gave good results. The boards dried with little evidence of distortion owing to twist or bow, but as mentioned later some spring resulted in the quarter sawn boards. A sticker spacing of 300 mm centres between layers of boards appears to be adequate as no corrugation was observed along boards.

The manual stacking method is labour intensive with the thin boards because twice as many layers and stickers are needed to make up a similar wood volume compared with a conventional board thickness of 28 mm using 20 mm thick stickers. Less wood is also dried with each kiln charge.

Some options to consider are:

- use automated stackers
- use wire mesh or similar layers
- use timber lattice panels
- use a drying system which eliminates layering (e.g. veneer jet dryer, microwave or some other progressive dryer)

The minimum requirements and the need for weight restraint during the drying process will need to be determined for some of these options to be considered.

This pilot study has demonstrated that a larger number of sawn pieces of various widths and grades can result from cutting small diameter, short logs into thin sections than from cutting larger logs in conventional sawmilling. To handle and season this large number of boards, it is critical that refinements or viable alternatives be developed to provide continuous supplies of timber for use in a commercial VALWOOD® process.

Mr B Glossop. Wood Utilisation Research Centre, Harvey.

Degrade Assessment

A total of 188 13 mm and 135 16 mm boards in the 10 - 15 per cent moisture content range were assessed for degrade prior to high temperature drying. The combined results showed that approximately 68.0 per cent of the boards contained end splits, and of these 33.7 per cent were longer than 200 mm (Table 1).

Other degrade results were:	31.0	per cent	face checked
	23.0	per cent	cupped
	0.0	per cent	twist
	40.0	per cent	affected by juvenile core wood.

Chi-squared tests showed neither board length (1.2 m or 2.4 m) nor thickness (16 mm or 13 mm) showed any significant effect on the occurrence or severity of end splitting. However, a trend was observed in the backsawn boards sawn adjacent to or containing juvenile core wood, which had a higher frequency and severity of end splitting.

A significant statistical relationship exists when the occurrence and severity of end splits is compared with the presence or absence of juvenile core wood in boards (Table 1). In boards containing juvenile core wood, over 95 per cent had some end splitting compared with 50 per cent of boards predominantly backsawn away from the corewood. There were 27.2 per cent of the total boards with the most severe end split rating of 3 occurring in juvenile core affected boards, compared with only 6.5 per cent in unaffected boards.

Table 2 shows a similar trend for face checking with 56.5 per cent of boards with juvenile core affected having face checks, compared with 13.6 per cent of the unaffected boards. Few of these checks were considered to be caused by the drying schedule used, and most appear related to the release of growth stresses as they are confined generally to the mid-face of quarter sawn boards.

The results of cupping when compared with the presence of juvenile core affected boards showed a reverse trend (Table 3). There is a negative relationship between the cupping and the presence of juvenile wood. Such distortion is to be expected when drying backsawn boards cut from small logs, owing to the differential radial and tangential shrinkages. This suggests that boards which are backsawn from the outer heartwood or sap zone have cupping rather than end splitting.

The above results support the conclusion that end splits are generally associated with quarter-sawn boards from close to the juvenile core zone. In the sap to sap sawing technique used for this trial approximately 40.0 per cent (Table 1) of all boards produced were recorded as being in this category. These are the widest boards, and were observed to split excessively at times for the full length along the pith, resulting in boards with excessive spring. This effect is well documented (Blair 1987). Observation by the author and other researchers (White 1989) has suggested the drying pattern used does little to compensate for growth stresses in small diameter regrowth alberta timber and supports the adoption of an alternative sawing pattern (Fig. 2).

Table 1
Effect of juvenile core wood on end splits

End split rating mm	Unaffected boards		Core-affected boards		Totals	
	No.	%	No.	%	No.	%
0 (No Split)	96	29.7	6	1.9	102	31.6
1 (0-200)	45	13.9	15	4.7	60	18.6
2 (100-200)	30	9.3	22	6.8	52	16.1
3 (200+)	21	6.5	88	27.2	109	33.7
TOTAL	192	59.4	131	40.6	332	100.0

Table 2
Effect of juvenile core wood on face checks

Face checking	Unaffected boards		Core-affected boards		Totals	
	No.	%	No.	%	No.	%
Nil	166	51.4	57	17.6	223	69.0
Minor	19	5.9	23	7.1	42	13.0
Mod	7	2.2	15	4.6	22	6.8
Major	0	0.0	36	11.2	136	11.2
TOTAL	92	59.5	131	40.5	323	100.0

Table 3
Effect of juvenile core wood on cup

Cupping	Unaffected boards		Core-affected boards		Totals	
	No.	%	No.	%	No.	%
Present	132	40.9	117	36.2	249	7.1
Absent	60	18.6	14	4.3	74	22.9
TOTAL	192	54.5	131	40.5	323	100.0

Other methods to reduce the stresses which cause end splitting e.g. end coating of logs or boards, resawing into narrower boards, sawing wane from boards before seasoning, need to be considered. The economic benefits of adopting any of these practices must be demonstrated if they are to be recommended for the VALWOOD® process.

Results of thickness measurements taken after final drying to 6 - 8 per cent moisture content shows approx 7 per cent shrinkage occurred. The 16 mm boards reduced to approx 15 mm while the 13 mm boards reduced to approx 12 mm. However, these measurements were taken on mostly backsawn boards, away from the juvenile core area where considerably greater shrinkage was observed. This differential shrinkage was not fully assessed although it had some effect on the dressing and grading results.

Resawing

The distribution of residues and recoveries resulting from resawing sap to sap boards with or without juvenile wood are compared in Table 4 which shows a final combined recovery of 84.2 per cent (by weight) after resawing the whole parcel into parallel edged boards.

It would be reasonable to assume that 84.2 per cent of the green sawn recovery of 79.8 per cent (i.e. 67.2 per cent) would equate with the nominal 33 per cent for conventional sawing. Actual recovery is of course lower owing to shrinkage.

The proportions of other wood residues produced were:

- 7.8 per cent wane wood
- 3.3 per cent pith-affected wood
- 0.3 per cent other wood.

The 4.4 per cent calculated difference, is assumed to be sawdust.

Although there was no significant difference in the overall recovery of resawn boards containing juvenile core wood compared with those backsawn from the outer log zone, there was a substantial difference in the proportion and type of residue which resulted in each zone.

Table 4
Effect of juvenile wood on dry resawn recovery

Resawing product category	Recovery - percentage by weight of original dry boards			
	Boards without juvenile wood (mostly back-sawn)	Boards with juvenile wood (mostly quarter-sawn)	Recovery average	Standard deviation
Wane wood	11.0	4.6	7.8	5.0
Juvenile wood	0.2	6.6	3.3	4.6
Other wood	0.3	0.3	0.3	-
Sawdust	4.1	4.6	4.3	-
Sawn boards	84.5	84.0	84.2	5.8
TOTAL Whole boards	100.0	100.0	100.0	.

As would be expected, outer boards had little or no juvenile wood removed compared with the centre boards, and the amount of wane-affected wood removed is appreciably more for sap-to-sap backsawn boards (11.0 per cent) than for sap-to-sap quarter-sawn boards containing juvenile core wood (4.6 per cent). Factors include:

- taper has a greater effect on the face and edges of outer backsawn boards, requiring more wood to be removed during resawing to produce wane-free parallel edged boards.
- for the outer backsawn boards the angle of the wane edge is also more acute to the board face, requiring a wider section to be removed to produce a wane free sawn edge. In contrast, boards quarter-sawn through the juvenile core area of the log have a wane edge angle closer to 90° to the face. This results in less wood being removed to achieve the desired parallel wane free board.

Adopting a taper resawing strategy, and cutting off wider wane sections and utilising them perhaps as mouldings, has potential to effectively improve the value of the processed board. In addition much of the otherwise wasted sapwood is recovered as a valuable product.

The method of resawing used was very time consuming. This is partly because in the sap-to-sap sawing technique all boards produced have wane on both edges. Other aspects which adversely affect production are:

- every board must be double handled, from the dry bundle for resawing and then restacked for storage, prior to dressing.
- additional rip sawing to remove excessive end splits is necessary to reduce the wastage otherwise resulting from docking ends.
- wide boards which split end to end require twice the number of rip cuts to produce a smaller volume of boards, compared with sound boards.

- the longer (2.4 m) half boards referred to above have excessive spring, and for efficient utilisation require two docking cuts to shorten their length. This produces four shorter (1.2 m) boards which then require a minimum of eight rip cuts to produce four parallel-edged boards.
- parallel sawing along the sap on one edge of a board results in loss of some wedge-shaped heartwood on the other, and the finished board has an uneven grain pattern. The uneven grain further complicates grain-matching during subsequent laying up for edge-joint laminating.
- a wide range of random widths resulted. This would necessitate sorting into width increments prior to dressing or using specialised dressing machines, resulting in slower production.

Changing the cutting pattern as recommended in Figure 2 would solve many of the above problems, offering greater flexibility in processing strategies and design. Some advantages envisaged for resawing are:

- approx 40 - 50 per cent of all boards from each log would be produced with four sawn surfaces, without the need for any edging cuts specifically to remove wane.
- end splitting would be significantly reduced because growth stresses would be relieved more during sawing.
- diametral boards containing pith and sap-wood in the same board would not be produced, therefore eliminating the additional crosscutting and subsequent rip cuts necessary to reduce excessive spring.
- the range and distribution of board widths would change considerably. With less resawing being required and more boards being produced at a standard 'centre cant' size, a wider average board width and a narrower range would result when (as expected) end splitting is reduced.
- the option of green resawing becomes more attractive because of the reduced number of 'wane on' boards which result using the alternative cutting pattern. Resawing green has advantages of less double handling, easier to stack, and less tension across boards, resulting in less distortion and splitting during drying. Less waste wood is dried in each pack compared with the sap-to-sap sawing pattern.
- the majority of boards will be backsawn. This will provide reduced and more uniform thickness shrinkage, eliminate spring and associated end splitting, and produce boards with improved grain features.

To permit effective planning of a commercial process, a thorough investigation of resawing strategies or options is warranted. Some suggestions are to:

- evaluate dry and green resawing and demonstrate the economic benefits.
- evaluate parallel and taper resawing in economic terms.
- evaluate the potential to recover high value products from wider sawn sections of wane edgings, rather than wasting the offcuts.
- investigate options for resawing equipment, and assess the feasibility and impact on other associated stages of the process.

Considering the wide range of dimensions and high number of boards to be processed, some compromise between utilisation, recovery and productivity will be inevitable in arriving at the optimum resawing strategy. In the final analysis, the range of products marketed will greatly influence the strategy adopted commercially.

Dressing

The parcel of 16 mm thick boards (15 mm dry) had 2 mm or 25 per cent of green size planed from each face, reducing the thickness to 11 mm. About 90 per cent of these boards were skip free on both faces after dressing.

For the 13 mm thick boards (12 mm dry) less planing allowance was applied, with only 1 mm or approximately 15 per cent of green size being removed during planing of each face, bringing the thickness down to 10 mm. Over 62 per cent of these boards were free of skip on both faces. It was unexpected to recover such a high proportion of the 13 mm boards free of skip by halving the planing allowance. Closer examination of the boards revealed that uneven shrinkage or collapse was responsible for two thirds of the skip, and that boards affected were mostly sawn from close to the juvenile core zone. The remaining one third of skip was due to undersize sawing.

These results and observations suggest that sawing or planing allowances may be excessive for some boards but insufficient for those sawn adjacent to the juvenile core zone. Alleviating this differential shrinkage would result in increased recovery. It is likely that a reconditioning cycle could recover the collapsed juvenile wood and an improved drying schedule should be developed. If this does not correct the problem, the alternative sawing pattern referred to previously (Fig. 2) gives the option to compensate for variations in shrinkage of boards from the pith zone by sawing to a greater thickness. Sawing allowances could be decreased by approximately 2 mm for outer zone boards and increased by a determined amount for juvenile core boards in each log. The sap-to-sap sawing pattern does not facilitate this as a viable option, because diametral boards contain juvenile wood and sapwood in the same piece.

It should be noted, however, that brittle heart would normally be rejected during conventional sawmilling, but in this trial all 'heart-in' material was retained for evaluation. Although this juvenile wood is inferior in strength properties to mature wood, the VALWOOD® system provides the necessary economic benefit for its use because it can be included in centre laminates.

Further evaluation of sawing and/or planing allowance and processing options is warranted to optimise the VALWOOD® process.

Grading and Recovery

To simplify the grading comparison and calculate recovered volumes, all boards in the 13 mm hick green sawn category were assumed to be 8 mm thick, with a dressing allowance of 4 mm applied to both the 13 mm and 16 mm sawn boards.

Table 5 shows a dry dressed total volume of 0.73 m³ for the full length grading and 0.66 m³ for phantom grading of the same parcel. When related to the original green log volume of 2.2 m³, the final recovery in dry dressed form is 33.4 per cent full length processed and 29.7 per cent phantom processed.

Table 5
Comparison of recoveries using two grading techniques on the sample parcel of boards (m³)

Full Length Grading					
Thickness (mm) (green - dry dressed)	1	2	Grade 3	4	Total
13 mm (8 mm)	Nil	0.02	0.15	0.23	0.40
16 mm (11mm)	0.03	0.02	0.18	0.11	0.34
Total	0.03	0.03	0.33	0.34	0.73
Percentage	4	4	45	46	100
Phantom Processing and Grading					
Thickness (mm) (green - dry dressed)	1	2	Grade 3	4	Total
3 mm (8 mm)	0.07	0.12	0.12	0.01	0.31
6 mm (11mm)	0.08	0.10	0.15	0.02	0.35
Total	0.15	0.22	0.26	0.03	0.66
Percentage	23	33	40	4	100

The loss of 3.7 per cent in recovery, resulting from docking and ripping out undesirable characteristics, is largely compensated for by the substantial increase in volume of the higher grades and a corresponding reduction in lower grades. The volume of wood in Grade 4 (Table 5) is unusable for VALWOOD® in its present form mostly because of end splits which would require docking. With docking to remove these defects, the overall recovery became 28.6 per cent of the green log volume.

Further improvements in quality and recovery are envisaged for VALWOOD® if some of the undesirable characteristics which affect utilisation can be overcome. A summary of the features which limited the grade and recovery of individual boards is presented in Table 6, which demonstrates that the major downgrading features (according to the rules applied) were end splits, excessive sapwood, voids, and kino (gum) deposits.

The most frequent downgrading feature was end splits. Presumably these splits have to be removed whether boards are used in full length or in shorter lengths, and processed to their maximum potential. End splitting in either case has an adverse effect on recovery and

Table 6

Summary of features limiting board upgrading

Fault	13 mm Thickness						16 mm Thickness						Combined thickness	
	Board grades		3 core	4 service	Total		1 (2+2)	2 (1+1)	3 core	4 service	Total		Total	Total
	1 (2+2)	2 (1+1)			No	%					No	%		
Sawn undersize	0	0	2	3	5	1.8	0	1	4	10	15	7.0	20	4.0
Uneven shrinkage	0	0	1	17	18	6.4	0	0	6	6	12	5.6	30	6.0
Stress spilt	0	0	0	16	16	5.7	0	0	2	4	6	2.8	22	4.4
End split	0	0	4	44	48	17.0	1	0	6	19	26	12.0	74	14.9
Surface check	0	0	1	0	1	0.4	0	0	0	1	1	0.5	2	0.4
Excessive sapwood	0	14	34	0	48	17.0	5	7	7	0	19	8.8	67	13.5
Wane	0	0	1	8	9	3.2	0	0	2	2	4	1.8	13	2.6
Unstable heart	0	0	1	4	5	1.8	0	0	2	4	6	2.8	11	2.2
Knot oversize	0	0	0	0	0	0.0	0	0	11	0	11	5.0	11	2.2
Knot frequency	0	0	16	0	16	5.7	0	0	10	0	10	4.6	26	5.2
Holes/voids	0	0	10	9	19	6.7	1	0	17	14	32	14.8	51	10.2
Gum veins	0	0	32	0	32	11.3	1	0	23	0	24	11.1	56	11.2
Gum pocket	0	0	4	16	20	7.1	0	0	7	7	14	6.5	34	6.8
Knot frequency	0	0	10	0	10	4	0	0	2	2	4	1.8	6	1.2
Birdseye	0	0	2	0	2	0.7	0	0	1	1	1	0.5	3	0.6
Decay	0	0	2	2	4	1.4	0	0	0	2	2	1.0	6	1.2
Multiple features	0	1	22	14	37	13.1	9	4	8	8	29	13.4	66	13.3
TOTAL	Nil	15	132	135	282	100%	17	12	108	79	216	100%	498	100%

productivity. There is strong evidence that this problem is attributed to the sap-to-sap cutting pattern used, which does little to relieve growth stresses and produces approximately 40 per cent of predominantly quarter-sawn boards.

It is possible that leaving wane on edges of boards creates additional drying stresses during seasoning, increasing the likelihood of distortion and end splits developing.

Excessive sapwood was another feature which prevented upgrading of many boards, but was not a problem in Grade 4. New industry grading rules introduced after this study accept a higher proportion of sapwood, which increases the recovery of higher grades. However, the final test is the choice of the buyer who may perceive sapwood as a detrimental feature. These grading rules relate to perceived markets which are yet to be realised and therefore the rules are open to conjecture. To make a thorough analysis of the VALWOOD® process, it will be necessary to identify the main markets and establish product specific grades for them. A review of the grade requirements is warranted. This will reduce the limitations on sapwood under existing grade rules, which are particularly hard on regrowth jarrah.

Results of the grading exercise demonstrated that to achieve a balance between maximum utilisation and producing the highest grade of boards, manufacturers may need to reprocess full lengths into variable grades, lengths, widths and species to match the resource to their products.

Should the upgrading result in a mismatch by producing too many shorts, then development of colour matching and end jointing technology for VALWOOD® could be considered. The question of optimum utilisation and efficient production depends on vigorous target marketing. This strategy should be achievable because of the flexibility to produce a range of products.

The width distribution for the whole parcel of boards following phantom ripping and docking is shown in Figure 4. The most frequent board size was 70 mm. This result was found to be consistent for boards of:

- different thickness (16 mm, 13 mm)
- different lengths (2.4 m, 1.2 m)
- different sawing zones (core or outer)
- different grades (G1, 2, 3 and 4).

The average board size of 70 mm is less than expected. It presumably results from resawing the diametral boards along the mid-face to eliminate excessive end splits or resaw boards which had split lengthwise into two sections.

The different cutting pattern suggested (Fig. 2) would have the effect of increasing the average board width distribution, therefore reducing the number of edge joints necessary to make up laminated panels.

In a commercial VALWOOD® grading operation a large number of boards are likely to be processed, and the species, dimensions, grades, and particular end uses will vary. It is envisaged that some form of optical scanning and sorting technology as part of the grading process will be necessary to maintain productivity, consistency and quality.

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