SEASONING W.A. SHEOAK (*Allocasuarina fraseriana*) BY AIR DRYING, DEHUMIDIFIED KILN OR TUNNEL KILN DRYING

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SUMMARY

W.A. sheoak (*Allocasuarina fraseriana* (Miq. L. Johnson) timber from mature or regrowth logs was seasoned by air drying, dehumidified kiln or tunnel kiln drying at either Harvey or Perth, during spring/summer or winter/spring. A large proportion of the timber contained sapwood on either the face of backsawn boards or the edge of quartersawn boards. Drying in spring/summer at either Harvey or Perth resulted in severe checking, bow, spring, twist and cupping, particularly in the boards containing sapwood. Boards dried in the winter/spring at Harvey had minimal seasoning degrade.

Timber was graded with *Lyctus* susceptible sapwood either included or excluded from the higher furniture grades. Results quantified the advantages in recoveries when sapwood is included in the higher grades.

INTRODUCTION

W.A. sheoak (*Allocasuarina fraseriana* Miq. L. Johnson), grows in the south west of Western Australia. The timber has the broad medullary rays which are characteristic of the genus, and when quarter sawn shows an 'oak' figure. It is used for furniture, decorative hardware and turnery, roofing shingles, flooring, panelling, and also makes excellent fuelwood (Bootle 1983). Until the advent of the aluminium cask, it was a favoured species for beer barrels.

Low shrinkage (after reconditioning, tangential shrinkage is 1.7 per cent and radial shrinkage 1.0 per cent (Kingston and Risdon 1961) and pronounced cross banding, make the timber very stable and suitable for both high quality indoor and outdoor furniture.

Current sawmilling practice is to exclude all sapwood from sawn sheoak timber, because of its susceptibility to *Lyctus* attack, and to reduce the colour variation in the finished product. Samples of air dried and high temperature dried mature and regrowth sheoak have been attacked by *L. brunneus* Steph. under laboratory conditions (Creffield *et al*. 1987).

The present study was jointly conducted between a sawmiller (Mr G. Saunders of Collie), a furniture manufacturing company (Inglewood Products Group of Malaga), and the Department of Conservation and Land Management.

The aims of this study were to

i) Compare the overall drying behaviour (degrade, shrinkage and drying rate) of backsawn or quartersawn sheoak timber cut from mature or regrowth logs, when air-dried, dehumidified dried or tunnel kiln dried.

(ii) assess the seasoning properties of timber containing sapwood on the backsawn face or quartersawn edge in each treatment.

(iii) test the suitability of the W.A. furniture grading standard (Appearance Graded Western Australian Hardwoods For Furniture Use, TAS-G4 (1985)) and Timber - Seasoned Hardwood Milled Products AS 2796-1985 for grading sheoak, and compare graded recoveries of timber with or without sapwood in the higher grades.

A series of experiments were conducted in two parts. Part I was carried out in spring/summer at Harvey or Malaga and part II in winter/spring at Harvey.

PART I

MATERIALS AND METHOD

Part I was conducted under spring/summer drying conditions and consisted of the following treatments :

(i) air-drying at the Wood Utilisation Research Centre (W.U.R.C.) at Harvey,

(ii) tunnel kiln drying at the W.U.R.C.,

(iii) air-drying at Inglewood Products, followed by final drying in a dehumidified kiln, and

(iv) dehumidified kiln drying at Inglewood Products.

Bundles that were air-dried in winter/spring at W.U.R.C. were high temperature dried to final moisture content (10 to 12 per cent) in a experimental high temperature kiln.

Logging

Logs came from Bristol Block, Collie, and were extracted and milled by Mr G. Saunders. The logging area is located in the Collie Coal basin, on a mid-slope area, with grey sand and Havel site type 'J' (Havel 1975). This area was cut over for sheoak approximately 25 years previously and contained patches of smaller undamaged regrowth trees.

The regrowth logs were cut from trees with a diameter over bark at breast height (d.b.h.o.b.) of 25 cm or less, and having sapwood around the periphery of the tree. Mature logs were derived from trees with a d.b.h.o.b. of greater than 25 cm. The majority of these trees had fire scars, and hence interrupted sapwood.

Sawmilling

Logs were sawn fresh from the forest at Mr. Saunder's sawmill in Collie. Milling produced backsawn and quartersawn boards with sapwood retained on the boards cut from the outer portions of each log (as mentioned in the Introduction, the current practice is to discard all sapwood). This produced some backsawn boards with sapwood on the face and some quartersawn boards with sapwood on the edge. Boards 25 mm thick were cut with widthsof 50, 75, 100, 125 or 150 mm, and lengthsof 0.6, 0.7, 1.0, 1.2, 1.5, 1.8, 2.1 or 2.2 m. Timber was block stacked, wrapped in plastic and transported to W.U.R.C. and Inglewood Products for drying.

Drying

At W.U.R.C. the timber was stripped for air and tunnel kiln drying (using 25 mm strippers) on 26 September 1984, six days after milling. Alternate layers of timber from mature and regrowth logs were constructed. Air and tunnel kiln drying conditions at this time of the year were severe, with maximum ambient temperatures between 25°C and 30°C and relative humidities as low as 40 per cent. The air-dried bundle was placed in an open drying shed and the tunnel kiln bundle with 25 mm mature jarrah, which were used to test the tunnel kiln concept in Western Australia. Operating principles of a tunnel kiln and drying condition experienced by the sheoak are described in Brennan and Glossop (1989). In itial drying conditions at the green end of the kiln were mean temperature - 17.1°C, mean relative humidity - 73.2 per cent and air velocity - 1.0 m/s.

Boards were assessed for wood quality and sample boards were randomly selected to monitor moisture loss, degrade and shrinkage. The defects recorded were: surface checks, end splits, twist, spring, cupping, bow and the presence of sapwood. Seasoning defects were noted on every inspection. The tunnel kiln bundle was assessed at two week intervals for 10 weeks and the air-dried bundle was assessed at two week intervals until it reached fibre saturation point (f.s.p). Moisture contents were measured with a Bollman electrical resistance

moisture meter and shrinkage with vernier calipers (accuracy ± 0.1 mm). Above a moisture content of 35 per cent the Bollman meter is unreliable. Both air-dried and tunnel kiln bundles continued air drying in the drying shed to final moisture content. The shrinkage samples were measured in identical positions before and after drying. No re-conditioning treatment was used to recover any adverse shrinkage or collapse.

At Inglewood Products the timber was initially assessed on 3 October 1984, 12 days after milling. Timber for air-drying and dehumidified drying were strip stacked (using 19 mm strippers) for three days in the direct sunlight before the initial assessment. Many pieces in both treatments had surface checked (resulting from this initial exposure to direct sunlight). This affected the results for dehumidified drying because timber was exposed to air drying conditions for 22 days. Again timber from regrowth and mature logs was alternately layered, and the same assessment procedure as used for the timber dried at W.U.R.C. was used, except the number of samples measured for shrinkage increased. Following 22 days air drying the bundles for dehumidified drying were placed in the kiln and dried using the following schedule:

Treatment	Time period (days)	R.H. (%)	Air temp. (°C)
Heat-up phase	3		45
Drying phase (i)	9	20 to 40	45
Drying phase (ii)	2.5	20 to 30	ambient

Note: In the last 2.5 days (drying phase (ii)) the heater was turned off, allowing conditions to fluctuate according to ambient conditions.

The air-dried boards were dried in the open under severe drying conditions for 36 days (3 October to 8 November 1984), then placed in the dehumidified kiln for 9 days (9 to 18 November 1984) to dry the boards to a final moisture content between eight and 10 per cent. A similar kiln schedule to the schedule for the dehumidified bundle was used.

Planing and Grading

Timber dried at Inglewood Products was pre-dressed on all four sides to the following sizes:

100 x 25 mm pre-dressed to 86 x 21 mm,

75 x 25 mm pre-dressed to 65 x 21 mm,

50 x 25 mm pre-dressed to 43 x 21 mm.

This pre-dressing is heavier than the general practice at Inglewood Products, which is pre-dressing to 23 mm, because excessive shrinkage had occurred on the boards containing sapwood. At the W.U.R.C. less shrinkage occurred and all boards were pre-dressed on two faces to 23 mm.

Only timber dried at Inglewood Products was graded using the TAS-G4 (1985) into furniture grades 1, 2 and 3 or below furniture grade.

Grading was done in two parts, one to include the *Lyctus*-susceptible sapwood in the higher grades and the other excluding sapwood. The aim was to assess the increased recoveries in the higher grades if sapwood is treated and therefore an allowable imperfection.

Analysis

Chi-squared tests were used to test if there is a significant difference in surface checks, end splits and warp, between backsawn and quartersawn timber from mature and regrowth logs.

Mean shrinkage of the boards dried at Inglewood Products was computed, and tangential and radial shrinkage were estimated.

RESULTS AND DISCUSSION

Seasoning

A survey by McKay (1970) and recent studies by Brennan and Glossop (1989) showed that protection is needed in the early stages of drying to avoid surface checking in mature jarrah timber of Select or Joinery grade. Air drying under Western Australian summer conditions will result in surface checking which will downgrade timber from appearance grades to structural grades. Timber for value-added markets needs protection immmediately after sawing, and should be stored in a controlled environment room before being dried in a kiln. This can be achieved by enclosing and air conditioning the docking and timber stripping areas.

Sheoak timber containing sapwood, particularly on the backsawn face, will surface check when subjected to severe drying conditions. In this study, block stacking and wrapping in plastic immediately after sawing prevented boards from checking while being transported, however strip stacking for air drying in direct sunlight resulted in severe downgrade, especially at Malaga.

Tunnel kiln drying resulted in severe surface checking due to the severe initial drying conditions. Mature jarrah also experienced severe degrade drying under these conditions (Brennan and Glossop 1989).

Moisture loss

The following drying rates were achieved over the first two weeks and the drying cycle:

Treatment	First two week of drying (%/day)	Over the drying cycle (%/day)
Air-dried (W.U.R.C.)	0.6	0.4 (70 days)
Tunnel kiln dried (W.U.R.C.)	1.2	0.5 (70 days)
Air-dried (Inglewood Products)	0.9	0.5 (62 days)
Dehumidified kiln dried (Inglewood Products)	1.3	0.6 (62 days)

Slight differences in drying rates occurred between treatments, particularly over the kiln cycle. The tunnel kiln bundle had double the drying rate of the air-dried bundle at W.U.R.C. for the first two weeks, but over the kiln cycle drying rates were similar. The dehumidified kiln dried bundle was air dried for 22 days, therefore very little difference occurred between the air-dried and dehumidified kiln dried treatments.

Shrinkage

Table 1 lists width and thickness shrinkage for timber dried at Inglewood Products in spring/ summer 1984/85. Approximately 25 samples were in each category (i.e. mature and regrowth backsawn and quartersawn boards) and the combined treatments had approximately 50 samples in each category.

Mean radial and tangential shrinkages before reconditioning for the combined samples was 2.6 per cent and 5.2 per cent respectively.

Kingston and Risdon (1961) quoted very low shrinkage values after re-conditioning (1.7 per cent tangential and 1.0 per cent radial.) However, shrinkage before reconditioning is considerably higher (4.5 per cent), which is only 0.7 per cent less than the combined mean tangential shrinkage estimated in this trial (Table 1). It is presumed that the samples assessed by Kingston and Risdon were small heartwood sections. In this study some boards had sapwood on either the face or edge, and this made many backsawn boards cup and twist, affecting the overall shrinkage assessment. Many quartersawn boards with sapwood on the edge showed very high shrinkage on the sapwood compared to the adjacent heartwood, again affecting shrinkage measurements.

Table 1

Width and thickness shrinkage (per cent) before reconditioning of timber from mature and regrowth logs dried in spring/summer at Inglewood Products (standard deviations in brackets)

	Air-dried				Dehumidified kiln drying				Combined			
	MB	MQ	RB	RQ	MB	MQ	RB	RQ	MB	MQ	RB	RQ
Width	3.7 (1.7)	1.6 (0.6)	4.2 (1.3)	2.6 (1.7)	5.7 (2.3)	2.1 (0.9)	5.5 (2.1)	2.4 (1.3)	4.7 (2.0)	1.8 (0.8)	4.8 (1.7)	2.5 (1.5)
Thickness	3.5 (1.3)	5.7 (2.7)	3.7 (2.2)	4.9 (1.3)	3.2 (1.7)	5.6 (2.2)	2.6 (1.9)	5.1 (2.1)	3.4 (1.5)	5.6 (2.4)	3.2 (2.0)	5.0 (1.7)

Combined mean radial shrinkage = 2.6 %
Combined mean tangential shrinkage = 5.2 %

MB = mature backsawn
MQ = mature quartersawn
RB = regrowth backsawn
RQ = regrowth quartersawn

The radial and tangential shrinkage for the mature boards would be either truly backsawn or quartersawn and give a more accurate result than boards cut from regrowth sawlogs, which are not truly backsawn or quartersawn because of the curvature of the growth rings.

Degrade following air and tunnel kiln drying summer at W.U.R.C.

Table 2 lists the percentage of boards with degrade before and after drying and the factors that had a significant change during
Degrade following air and tunnel kiln drying summer at W.U.R.C.

Table 2 lists the percentage of boards with degrade before and after drying and the factors that had a significant change during drying. Surface checking had a significant increase in backsawn boards cut from regrowth logs and dried in the tunnel kiln. Mature backsawn boards dried in the tunnel kiln showed a non-significant increase in surface checking. All other categories had increases in checking but their frequencies were too low to determine if changes were significant. Combining the backsawn and quartersawn boards for the different board types indicated no significant difference in surface checking.

Table 2

Degrade before and after air and tunnel kiln drying at W.U.R.C. in spring/summer.
(percentage of boards degraded)

	Air-dried												Tunnel kiln dried											
	Surface checks		End splits		Twist		Spring		Cup		Bow		Surface checks		End splits		Twist		Spring		Cup		Bow	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
Regrowth quarter-sawn	0	19	16	25	11	0	5	6	0	19	5	0	0	28	12	20	4	36	8	4	0	0	28	24
Regrowth back-sawn	0	21	16	21	3	18	3	11	0	61	13	4	3	38	8	8	5	16	8	35	3	24	3	3
Mature quarter-sawn	0	]6	3	2	0	8	0	17	0	6	5	2	0	0	4	7	11	15	0	0	0	7	7	11
Mature back-sawn	0	12	2	0	4	9			4	9		2 21	6	6		0 17	0	6	11	17	0	22	0	28	17	0

B = before drying
A = after drying
* = significant change ($p<.05$)

Cupping was the most common form of warp. Backsawn boards produced more cupping than quartersawn boards. A significant increase occurred with cupping for air-dried backsawn regrowth boards. When data for backsawn and quartersawn boards were combined, bow did not change significantly in the air-dried regrowth boards.

Combining both treatments, 64 per cent of the regrowth boards had some warp, with twist and spring more common in quartersawn boards and spring and cupping more common in backsawn boards. Although Table 2 indicates a high percentage of quartersawn boards with bow and backsawn boards with spring, indications are that boards containing both sapwood and heartwood distort during drying.

End splitting was more of a degrading feature in the regrowth boards than the mature boards in both treatments.

Degrade following air and dehumidified kiln drying at Inglewood Products

Table 3 lists the percentage of boards with degrade at the time of initial assessment (ie. after 3 days exposure to direct sunlight) and after drying and shows the factors that had a significant change during drying. The de(humidified kiln drying bundle received 22 days of air-drying in direct sunlight before placing in the kiln, and the air dried bundle recieved final drying in the duhumidified kiln. Initial drying under these conditions severely degraded boards in both treatments.

Table 3

Degrade before and after air-drying and dehumidified kiln drying at Inglewood Products (percentage of boards degraded).

	Air-dried												Dehumidified kiln											
	Surface checks		End splits		Twist		Spring		Cup		Bow		Surface checks		End splits		Twist		Spring		Cup		Bow	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
Small quarter-sawn	3	0	0	0	3	10	6	6	0	0	0	0	7	4	7	0	7	11	18	26	7	30	4	48
Small back-sawn	50	0	13	0	20	20	-	-	17	37	10	7	29	4	11	4	4	25	7	14	18	43	14	18
	***				N.S				N.S.				*								N.S.			
Mature quarter-sawn	0	0	3	3	7	*3	0	0	3	0	0	3	12	0	8	12	8	32	12	28	0	8	20	40
																							N.S.	
Mature back-sawn	24	3	24	0	10	14	3	3	14	10	3	0	37	11	26	22	30	7	11	26	37	70	15	26
													*		N.S.		N.S.		N.S.		*		N.S.	

B = before drying A = after drying

NOTE: Both treatment received three days of air drying in direct sunlight before the initial assessment. The dehumidified dried bundles received 22 days of air-drying before placing in the kiln.

* = significant change ($p<0.05$)
*** = significant change ($p<0.001$)
NS = not significant

A number of checks closed during drying and were undetected at the time of final inspection, therefore significant reductions were observed. Backsawn boards had a higher frequency of surface checks than quartersawn boards at the initial assessment.

With cupping, there was a significant increase in the dehumidified dried mature backsawn boards. Both the air-dried and dehumidified dried backsawn boards from regrowth logs showed increased cupping although it was not significant. Cupping was more common in backsawn than quartersawn boards.

Warp in the air dried boards indicated very little change during drying. For the dehumidified kiln drying treatment there was a significant increase in bow for the quartersawn boards from the regrowth logs. Spring and twist did not show any significant changes but a number of categories indicated increases. Dehumidified dried boards had more bow, spring and twist than the air-dried boards. End splitting did not degrade the timber to any great extent in either treatment.

Most chi-squared tests were invalid due to the low frequency of a particular type of degrade, therefore data from backsawn and quartersawn boards were combined.

For dehumidified dried boards from regrowth logs, there was a significant increase in cupping and bow, and for mature boards a significant increase in cupping and a significant decrease in checking. For air-dried treatment, regrowth boards showed a significant decrease in surface checking.

Grading Exercise

According to TAS-G4, the sapwood of sheoak is listed as susceptible to *Lyctus* spp. attack and is a non-permissable imperfection in all three furniture grades. However, according to AS2796 - 1985, sapwood susceptible to Lyctid borers shall be permitted, provided that it has been immunised against such attack in accordance with AS 1604-1980 'Preservative treatment for sawn timber, veneer and plywood'.

Table 4 lists the percentage of boards that could be upgraded into furniture grades when sapwood is included. Including sapwood increases recoveries in the higher furniture grades. For example, 24 per cent of the timber in the air-dried treatment is available for upgrading into Furniture Grades 1, 2 and 3, and 39.2 per cent of the timber dehumidified kiln dried is available for upgrading (Table 4).

Table 4

Grading exercise using at Inglewood Products (using TAS-G4 (1985))
(recoveries are given in percentages)

Grade	Air-dried		Dehumidified kiln drying	
	M	R	M	R
Furniture Grade 1	18.6	9.9	10.7	5.7
Furniture Grade 2	6.0	6.6	7.2	2.6
Furniture Grade 3	-	-	0.9	-
Amount of sapwood that could be upgraded	12.9	11.1	15.4	23.8
Non-appearance	17.2	17.7	19.2	14.5

NOTE: M = boards from mature logs
R = boards from regrowth logs

In many cases sapwood is only part of the backsawn face or a narrow band along the edge of a quartersawn board, but because it is *Lyctus* susceptible it cannot be included in the higher grades. Whether *Lyctus* susceptible or not, according to TAS-G4 sapwood is not to exceed 20 per cent of an edge or 30 per cent of a face, even though it may not occur on the full length of a piece. AS 2796 has no limitation on non-susceptible, immunized or preservative-treated *Lyctus*-susceptible sapwood. Many boards with sapwood which were included in the higher grades were still downgraded owing to the sapwood on a face or edge.

A grading specification for regrowth eucalypts now being used at W.U.R.C. incorporates four grades; feature, clear, processing and merchantable grades (Appendix 1). Sapwood limits for feature grade are; no limit on one face or two edges, provided one face is clear of sapwood, for clear and processing grades no limit. At the time of grading this specification was still being tested. When grading to this specification a high proportion of boards with treated *Lyctus*-susceptible sapwood would be upgraded.

In addition to this trial, a small sample of 26 sheoak boards were dried in a progressive tunnel kiln under mild conditions (R.H. 88 per cent and Temperature 15°C) for 106 days at Great Southern Hardwood's factory in Jolimont. Final drying was in a high temperature kiln to a moisture content between 9.5 and 10.5 per cent. All boards contained a high proportion of sapwood (Brennan 1986). Timber was subsequently planed, then graded using the grading rules in TAS-G4, AS 2796 and the method described in this report. Results from that trial clearly indicated that timber containing sapwood can be seasoned without severe degrade.

When sapwood is included in the higher grades, the volume of furniture grade 1 is doubled, furniture grade 2 is increased approximately fivefold and select threefold, and non-appearance is reduced by a quarter.

Marketing

Until recently sheoak had a strong local market in outdoor furniture and still maintained markets overseas and interstate. If timber with treated sapwood is used in outdoor furniture, weathering tests are necessary. Machining, finishing and stability properties of sheoak sapwood need testing and in different locations of service before it is included in finished outdoor furniture.

PART II

MATERIALS AND METHODS

Seasoning results in part I (spring/summer drying) resulted in a high proportion of downgrade, therefore drying in winter/spring was tested. In part II sheoak timber was dried at the W.U.R.C. in winter/spring 1985.

Logging

Logs were extracted from Westralia Block, Collie by Mr Saunders. This area had been logged for sheoak approximately 40 years previously and had a similar site type and stand structure to the area in Bristol Block, where logs were extracted for part 1. Logs were stockpiled under continuous waterspray for approximately three weeks before milling at the Departmental sawmill.

Sawmilling

At the time of this experiment the W.U.R.C. sawmill was being equipped with specialised saws for cutting regrowth hardwoods, therefore the existing pine mill was used to convert the log into sawn timber. The pine mill consisted of a circular breakdown and resaw, and the same cutting method as used by Mr. Saunder in part I was used in part II.

Drying

The following treatments were used:

(i) air-drying in a drying shed with 440 kg/m2 weight restraint to prevent timber movement,

(ii) air-drying in a drying shed without weight restraint, and

(iii) tunnel kiln drying.

Drying conditions at the green end of the tunnel kiln during winter/spring are in Brennan and Glossop (1989). Initial drying conditions at the green end were mean temperature 13.8° C, mean relative humidity 82.1 per cent and air velocity 0.5 m/s.

The same methods of sampling, measuring moisture loss, shrinkage and assessment of timber defects as used in part I were used in part II.

The tunnel kiln bundle was air-dried to a final moisture content between 10 and 12 per cent, but both air-dried bundles were dried to a final moisture content between 10 and 12 per cent in an experimental high temperature kiln.

The drying schedule for the two high temperature kiln charges were:

Treatment	Time (hrs)	Dry bulb Temp. (°C)	Wet bulb Temp. (°C)
Heat-up phase	0.5		
Drying phase (i)	3.0	95	65
Heat-up phase	1.0		
Drying phase (ii)	8.0	106	65 to 55
Heat-up phase	1.0		
Drying phase (iii)	4.0	92	65

Planing and grading

Boards were pre-dressed on two faces to 23 mm, then graded using TAS-G4 into furniture grades 1, 2 and 3 and AS 2796-1985 to Select, Standard, non-appearance and reject. Non-appearance grade included boards that could be utilised for structural purposes and reject was for boards unsuitable for either appearance or structural uses. Assessment and grading were the same as in part 1.

RESULTS AND DISCUSSION

Moisture loss

The following drying rates were achieved over the first two weeks and the drying cycle

Treatment	First two weeks of drying (%/day)	Over drying cycle (%/day)
Air-dried W.U.R.C.	3.2	1.1
Tunnel kiln dried	3.4	1.1

Drying conditions were similar for air-drying and tunnel kiln drying, therefore similar drying rates were achieved. These rates were double those recorded in part I, due to the high initial moisture contents caused by storing logs under continuous water spray for three weeks and very little drying between milling and placing timber in the kiln. Despite this faster initial drying rate, degrade was considerably less than in part 1.

Degrade

Tables 5 and 6 show the degrade before and after drying for air-dried and tunnel kiln dried bundles in winter/spring. The air-dried bundle with weight restraint had more surface checking than the boards dried without weights, and backsawn boards had more surface checking than quartersawn boards. Boards dried under weights were not free to move while drying, resulting in drying stresses releasing and producing surface checks instead of warp (the opposite effect occurred in the unweighted treatment).

Table 5

Degrade before and after air drying at W.U.R.C. in winter/spring
(percentage of boards degraded)

	Air-dried with weights												Air-dried without weights											
	Surface checks		End splits		Twist		Spring		Cup		Bow		Surface checks		End splits		Twist		Spring		Cup		Bow	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
Regrowth quarter-sawn	0	0	0	0	0	0	50	0	0	0	0	0	0	6	0	0	0	0	35 N.S.	50	0	0	24	31
Regrowth back-sawn	0	10	0	0	0	0	0	10	0	30	50	5 **	0	9	0	0	0	5	7	32	0	50 ***	60	23 **
Mature quarter-sawn	0	0	0	0	0	7	0	13	0	0	8	20	0	0	0	0	0	5	21	5	0	5	29	10
Mature back-sawn	0	21	0	0	0	0	8	11	0	16	17	16	0	0	0	13	0	13	0	27	0	33	3	0

B = before drying
A = after drying
* = significant change (p <.05)
** = significant change (p<.01)
*** = significant change (p<.001)
NS = not significant

NOTE: Statistical analyses were not done when sample sizes were less than 5.

Tunnel kiln dried boards had a higher frequency of surface checks than either of the air-dried bundles. Regrowth backsawn boards had a significant increase in surface checking.

There was a significant decrease in bow for regrowth backsawn boards. Backsawn boards dried without weight restaint showed increased cupping, whereas quartersawn boards had virtually no cupping. This was due to the excessive shrinkage of the sapwood on the backsawn face causing timber movement.

Boards air-dried under weights had less spring than the bundle air-dried without weights and tunnel kiln dried treatments. Generally the frequency of spring increased during drying for all treatments.

The bundle air-dried with weight restraint had less twist than the bundle without weights, and the tunnel kiln dried bundle produced most twist. End splitting was not a problem in any of the three treatments.

Table 6
Degrade before and after tunnel kiln drying in winter/spring
(percentage of boards degraded)

	Surface		End checks		Twist splits		Spring		Cupping		Bow	
	B	A	B	A	B	A	B	A	B	A	B	A
Regrowth quarter-sawn	0	18	0	0	0	36	33	27	0	0	17	0
Regrowth back-sawn	0	35 **	0	0	0	13	5	7	0	22	18	13
Mature quarter-sawn	0	5	0	0	0	5	11	16	0	0	11	5
Mature backsawn	0	0	4	0	0	4	0	17	0	13	0	4

B = before drying
A = after drying
* = significant change ($p < .01$)

NOTE: Statistical tests were not carried out when sample size was less than 5.

Grading Exercise

The results of the grading exercises are in Table 7, which lists the graded recoveries achieved when sapwood is included or excluded from the grading rules.

When sapwood was included, 15 per cent of boards were upgraded into Furniture grades 1, 2 and 3 and Select, using air drying without weights; 7.3 per cent using air-dried with weights and 23.6 per cent using tunnel kiln dried. More mature boards were upgraded when sapwood was included in the grading rules (Table 7).

For mature boards Furniture grades 1 and 2 gave the highest recoveries in all treatments except the tunnel kiln dried timber, and boards from the regrowth logs, showed Furniture grade 1 and non-appearance having the greater recoveries.

Combined Analysis (Parts I and II)

Data from Parts I and II were combined to assess the effect of sawing pattern and log type on degrade. Backsawn boards had a significant increase in surface checking, spring and cupping and sawing pattern had no significant influence on end splits, twist and bow. Boards cut from the regrowth logs had significantly more surface checks, twist and cupping than mature boards, while end splits, spring and bow were not significantly influenced by log size. A higher proportion of sapwood in the boards from the regrowth logs compared to mature boards could have been a major contributing factor to the high amount of checking, twist and cupping.

Table 7

Grading exercise using both TAS-G4 (1985) and AS 2796-1985 (percentage recovery)

Grade	Air-dried without weight restraint				Air-dried with weight restraint				Tunnel kiln dried winter/spring			
	with sapwood upgraded		without sapwood upgraded		with sapwood upgraded		without sapwood upgraded		with sapwood upgraded		without sapwood upgraded	
	M	R	M	R	M	R	M	R	M	R	M	R
Furniture Grade 1	-	-	-	-	31.0	9.5	26.0	8.2	18.9	6.1	10.9	4.4
Furniture Grade 2	48.8	8.0	37.8	4.3	0.7	-	0.7	-	2.4	1.1	2.4	0.6
Grade 3	1.7	0.9	1.6	0.9	-	-	-	-	-	-	-	-
Select	2.5	-	2.3	-	1.1	2.4	1.0	1.5	15.8	11.0	9.8	3.6
Standard	2.2	1.6	1.5	1.5	4.1	2.3	3.7	1.1	7.4	3.4	6.4	3.4
Non-appearance	8.5	6.8	16.4	15.8	20.6	14.7	20.9	24.5	12.5	21.4	27.5	31.0
Reject	6.6	11.7	6.3	10.9	7.5	6.1	6.9	5.5	-	-	-	-

Note: M = boards from mature logs

R = boards from regrowth logs

The air-dried bundles at W.U.R.C. (parts I and II) were dried in an open drying shed, and this resulted in some protection from direct sunlight and prevailing winds. Timber dried in the spring/summer produced more degrade, particularly surface checking, than the material dried in the winter/spring.

Drying without weight restraint resulted in a large increase in cupping on the backsawn boards, particularly boards from regrowth logs. Generally bow decreased owing to the weight restraint within the stacks from either the weights or the stack itself. Again it was observed that the presence of sapwood on boards was distorting the timber during drying. Air drying even with weight restraint produced an increase in cupping, particularly backsawn boards, but this was not significant. Combining data from both treatments resulted in a significant increase in cupping. The other forms of warp still occurred when dried under weight restraint, but not to the same extent as the unweighted treatment.

Tunnel kilning in the winter/spring was under milder drying conditions than the spring/summer treatment. Results showed less overall degrade in the winter/spring treatment, despite significant increases for both treatments in surface checks, twist and cupping.

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Appendix 1

W.U.R.C. grading rules for boards milled from regrowth eucalypts

Draft 1

These grade rules are intended for use with regrowth eucalypts, particularly jarrah.

The intention is to produce dry pre-dressed boards in one of four grades.

The sizes are based on the optimum metric size taking account of moisture content, shrinkage, section and length requirements of the appearance grade markets.

The grades are:

Feature,
Clear,
Processing, and
Merchantable.

These grades will apply to sections dressed not more than 2 mm over the finished metric size of 10, 20, 30, 40, 60, 80, 100, 120, 150 or 180 mm.

Lengths will range from 0.6 m to 3.6 m, increasing in increments of 0.3 m.

Timber must be seasoned to between 8 and 10 per cent M.C.

Feature Grade - acceptable feature

Sapwood. No limit on 1 face or 2 edges providing one face is clear of sapwood.

Branch occlusions or birds eye. Sound intergrown with seasoning checks up to 1 mm wide and confined within the area of the feature.

Surface checks. Length of individual checks not exceeding 200 mm and width 1 mm. Only one check is allowed in every 50 mm across the face of a board.

Knots. Ingrown and sound knots not to exceed half the width of the face or 50 mm (measured at right angles to arris), whichever is the larger. They need to be separated by at least twice the width of the face.

Knot occlusions or holes. Holes are to be free of bark and decay, with any associated voids not to exceed more than 0.5 cm2. The same limits for knots apply to holes.

Gum veins. Gum veins must be tight and to the same limits as surface checks.

Pin holes. Clear of stain around the edges and less than 1 mm in diameter. Limit on the number of holes is 10 holes per 10 cm2.

Bow and spring. Maximum of 2 mm in any length less than 1.8 m.

Skip and machine damage. Less than 1 mm deep on any face or edge.

Grub holes. Clear of stain and less than 1cm2.

Clear grade

Clear grade will be clear of all imperfections excepting sapwood which will be accepted for the full length of the piece.

Processing grade - acceptable features

Sapwood. Unlimited.

Birds eye. Unlimited.

Surface checks. Length of individual checks not to exceed 300 mm long and 1 mm wide. Only one check is allowed in every 50 mm across the face of a board.

Knots. Knots must be ingrown and free from bark and decay, but may contain fractures or voids up to 1 cm^2.

Knot occlusions or holes. This feature must be free from bark and decay and not exceed 1 cm2.

Gum veins. Maximum 3 mm in width, maximum of 50 cm in length.

Gum pockets. As for knots and holes.

Bow. 5 mm in any length less than 1.8 m.

Skip or machine damage. If on one face, then not to exceed 2 mm deep. If on two faces, then not to exceed 1 mm deep.

Pin holes. Up to 2 mm in diameter, no more than 20 in any 10 cm^2.

Merchantable grade

May contain features in excess of the above grades.