

# Comparison of sawn timber recovery and defect levels in *Eucalyptus regnans* and *E. globulus* from thinned and unthinned stands at Balts Road, Tasman Peninsula

\*T.J. Wardlaw, B.S. Plumpton, A.M. Walsh and J.E. Hickey  
Forestry Tasmania, GPO Box 207, Hobart 7001

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## Abstract

*A sawmill study compared the green sawn timber recovery and defect levels in Eucalyptus globulus and E. regnans from adjacent thinned and unthinned stands in 56-year-old wildfire regenerated native forest. Thinning to waste at age 7 produced marked increases in log volume and, as a consequence, sawn timber recovery. The growth response to thinning was more marked in E. globulus. While thinning greatly increased the absolute volume of sawn timber containing defects, the relative volumes of most defects were comparable between trees from the thinned and unthinned stands. Holes from poorly shed, rotten branches were the only defect to increase significantly in response to thinning. Defect levels between species were different. Boards sawn from E. regnans had significantly more green knots, kino veins, discolouration and rot, and significantly less kino pockets and end splits than boards from E. globulus. The net benefit from thinning in terms of the volume production of clear, defect-free boards was substantial, and greatly exceeded the growth response to thinning in both species.*

## Introduction

Non-commercial (i.e. thinning to waste) and commercial thinning of eucalypts in native forest has been adopted as a strategy to increase sawlog yields in Tasmania, particularly from the more productive wet eucalypt forests (FFIC 1990; Forestry Tasmania 1998, 2002). Many studies have demonstrated the growth response of different eucalypt species retained following thinning (e.g. Goodwin 1990; Brown *et al.* 1998). Based on these studies, LaSala *et al.* (2004) predicted a near doubling of sawlog yields at age 65 (compared with unthinned forests) following pre-commercial thinning to 500 stems/ha at about age 15 years and commercial thinning to 250 stems/ha at about age 30 years.

As a silvicultural treatment, thinning is not without risk. Fungal stem decay is a major defect in eucalypts, reducing the recovery of high quality sawn timber (Waugh and Yang 1993). White and Kile (1994) have demonstrated that stem wounds inflicted to retained trees during thinning operations lead to the development of substantial volumes of stem decay at harvest. However, advances in thinning technologies used in wet eucalypt forests, combined with an increase in the experience of contractors conducting thinning operations, result in low levels of damage to retained stems (Cunningham 1997). Wardlaw (2003)

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\* Corresponding author  
e-mail: tim.wardlaw@forestrytas.com.au

showed that the high levels of stem decay that develop from natural origins have the potential to significantly discount future sawlog yields and largely negate the growth benefits of thinning. Those potential losses can be greatly reduced through careful tree selection during thinning (Wardlaw 2003).

Other defects such as knots, kino veins and stem splitting can also lead to a substantial reduction in the recovery of high quality sawn timber (Wardlaw 1998). However, the effect of thinning on the development of these defects in eucalypts is poorly understood. A thinning trial established in 1947 in regrowth forest regenerated in 1940 provided an opportunity to examine the effect of thinning on defect levels in sawn timber. In this study, we compare the amount of defect in boards sawn from a sample of trees harvested from thinned and unthinned plots in that thinning trial.

## Materials and methods

### Site and stand details

The sample area was located in a mixed *Eucalyptus regnans* (50–80%) – *E. globulus* (15–40%) – *E. obliqua* (5–10%) wet eucalypt forest on Balts Road (GDA94 co-ordinates: 5726100E, 5229190N), Tasman Peninsula (Figure 1). The stand regenerated naturally following a wildfire in 1940. Wheatfield regeneration occurred after the wildfire, with an estimated density of 114 000 seedlings/ha (Forestry Tasmania records). A small area of 0.2 ha (plot R025) was heavily thinned to waste in 1947, leaving 168 stems/ha. That plot was tended periodically to remove any coppice. An adjacent plot, R024, served as an unthinned control. By age 24, the density of eucalypt saplings in the unthinned plot had declined to 3024 stems/ha.

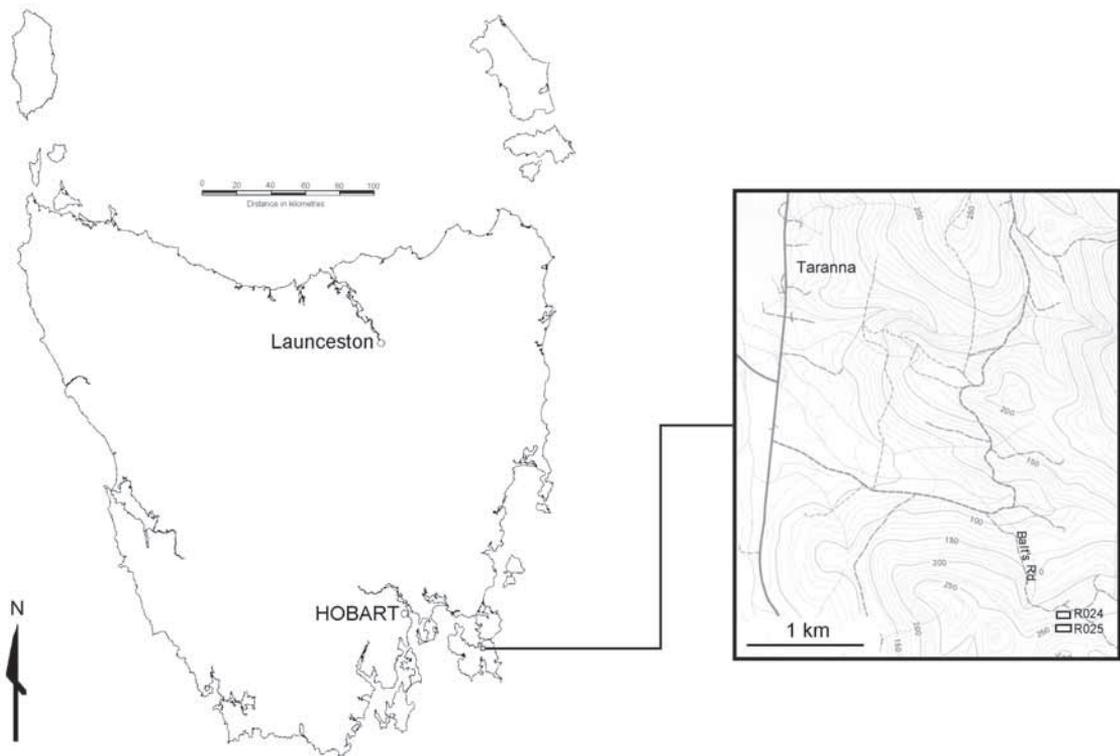


Figure 1. Location of the thinning trial at Balts Road, Tasman Peninsula.

A cable-thinning operation in the 56-year-old stand in November 1996 provided the opportunity to obtain a sample of the trees from the unthinned (R024) and previously thinned plot (R025) for an evaluation of sawn timber quality and recovery. At the time of harvest, the average height of the dominant trees was 41.7 m and 46.8 m in plots R024 and R025 respectively.

### *Selection of sample trees*

Sample trees were selected on the basis of size (diameter at breast height) and canopy class obtained from the 1996 remeasurement of the plots. Trees were randomly selected from among those trees that were in the dominant or co-dominant strata and had diameter at breast height over bark measurements (DBHOB) greater than 30 cm and 40 cm for the unthinned and thinned stands respectively. Eight and ten trees of *E. regnans* and *E. globulus* respectively were selected for sawing from the unthinned plot. In the thinned plot, nine *E. regnans* and five *E. globulus* were selected for sawing.

The selected trees were felled and docked into logs up to 11 m in length down to a small-end diameter of 30 cm (trees from the thinned stand) or 20 cm (trees from the unthinned stand). Prior to extracting the logs to the landing, the large end of each cut log was branded with its corresponding tree number and log section (starting from the butt log as 'A'). Each log-end was painted one of four colours to uniquely identify species and treatment. At the landing, the length of the log and diameters of the large, middle and small end were measured to enable the determination of log volume from log-volume tables (Forestry Commission 1974).

### *Sawing logs and measurement of recovered volumes and defects*

The logs were transported to a sawmill at Dunalley and stored under water spray until sawing commenced. Prior to sawing, logs were docked into lengths not exceeding

6 m and the freshly cut ends were painted and branded to match the identification markings on the parent logs. The logs were sawn into flitches using a circular saw coupled with a line bar carriage. Flitches were resawn into 30 mm or 40 mm thick boards of various widths using a breast bench saw coupled with a manual log carriage and sizing fence. The sawing pattern generally produced backsawn boards.

After sawing, each board was labelled with its corresponding tree/log number and a unique number identifying the individual board. The length, width and thickness of each board were measured. Each defect on the worst face of each board was identified and mapped diagrammatically (Figure 2). The defects were mapped by measuring their distance from the end of the board to the beginning and end of each defect using a measuring tape. The approximate proportion of the board width occupied by each defect was indicated diagrammatically. The following defects were recognised: galleries of insect borers, knots (green, dry, holes – rotten), discolouration, rot, kino (tight or loose vein, pocket), end split, wane, want (undersize), twist, bow and spring. These defects are the same as those recognised in AS2796.2 (Standards Australia 1999) for grading timber for appearance products, although the board grading rules themselves were not applied.

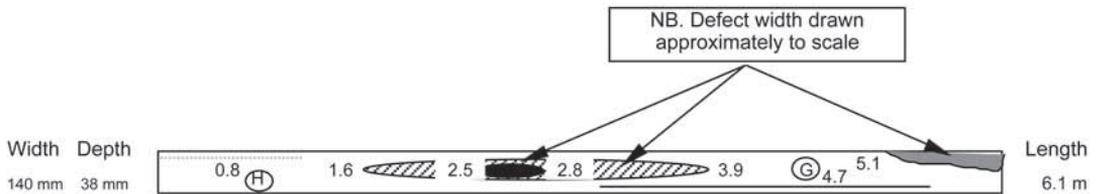
The volume of each board was calculated and the total volume of boards recovered from each log was summed. The volume occupied by each defect was calculated by multiplying the length of board occupied by the defect by the width and thickness of the board. This approach calculated the volume of board that would be lost if the defect was docked (crosscut) rather than the board being resawn (ripped) to a narrower width. The volume of boards lost by each type of defect was calculated for each log. In addition, the volume contained in defect-free boards longer than 1.8 m was calculated for each tree. The volume of defect-free boards provides a conservative measure

**BALTS ROAD THINNING TRIAL**  
**Milling study: thinned versus unthinned**

**Key for defect description on sawn boards**

Knots (green)	(G)	Borer holes	•••••
Knots (dry)	(D)	End split	
Knots, holes (rotten)	(H)	Want, wane	
Kino vein (tight)	—————	Twist	
Kino vein (loose)	- - - - -	Bow, spring	
Kino pocket			
Discolouration			
Rot			

**Example board description**



*Figure 2. Board diagram used to describe the position, size and type of defects in sawn boards. Numbers shown on the board in the example of a board description indicate the distance (m) of a defect from the starting end of the board.*

Table 1. Mean and standard errors (in brackets) of log volume, the volume/recovery of green sawn boards and the volume/recovery of clear, defect-free boards. Values of each of the parameters within treatment and species (main effects only), which have different subscripts, are significantly different ( $P < 0.05$ ).

	<i>Eucalyptus regnans</i>			<i>Eucalyptus globulus</i>			Treatment	
	Unthinned	Thinned	Overall	Unthinned	Thinned	Overall	Unthinned	Thinned
Sample size (trees)	8	9	17	10	5	15	18	14
Tree volume (m <sup>3</sup> )	0.83 (0.12)	1.82 (0.22)	1.35 <sub>a</sub> (0.18)	1.64 (0.29)	5.58 (0.93)	2.95 <sub>b</sub> (0.60)	1.28 <sub>a</sub> (0.19)	3.16 <sub>b</sub> (0.60)
Gross green-board volume (m <sup>3</sup> )	0.22 (0.04)	0.62 (0.09)	0.43 <sub>a</sub> (0.07)	0.49 (0.10)	2.31 (0.50)	1.10 <sub>b</sub> (0.28)	0.37 <sub>a</sub> (0.06)	1.23 <sub>b</sub> (0.29)
Recovery of green boards (% log volume)	26.00 (2.74)	35.00 (3.51)	31.00 <sub>a</sub> (2.47)	29.00 (1.69)	40.00 (2.54)	33.00 <sub>a</sub> (1.97)	28.00 <sub>a</sub> (1.53)	37.00 <sub>b</sub> (2.46)
Clear board <sup>1</sup> volume (m <sup>3</sup> )	0.05 (0.01)	0.17 (0.04)	0.11 <sub>a</sub> (0.03)	0.26 (0.06)	1.11 (0.17)	0.54 <sub>b</sub> (0.13)	0.16 <sub>a</sub> (0.04)	0.50 <sub>b</sub> (0.14)
Recovery of clear boards (% green-board volume)	22.00 (3.13)	26.00 (4.25)	24.00 <sub>a</sub> (2.65)	50.00 (3.78)	52.00 (6.58)	51.00 <sub>b</sub> (3.21)	38.00 <sub>a</sub> (4.17)	35.00 <sub>a</sub> (4.93)

<sup>1</sup> Boards that are at least 1.8 m long and are free of defects.

of the volume of boards that would meet AS2796.2 'select-grade'.

#### Data analysis

All analyses were done using data aggregated to the tree level. Analysis of variance (ANOVA) was used to test the significance of differences between species and treatments for the five sets of independent variables:

- (i) Sawlog volume;
- (ii) Ungraded green-board volume;
- (iii) Recovery of ungraded green boards (as a per cent of sawlog volume);
- (iv) Volume of defect-free boards (> 1.8 m long) = 'clear' boards;
- (v) Recovery of 'clear' boards (as a per cent of ungraded green-board volume);

Log transformation was used to stabilise variances of variables (i), (ii) and (iv).

Non-linear regression was used to model the relationship between the recovery of ungraded green boards and DBHOB. The

non-linear regression model was  $y = \alpha + \beta / \log x$ , where:

$y$  = green-board recovery (as a per cent of sawlog volume);

$x$  = DBHOB; and

$\alpha$  and  $\beta$  are parameters to be estimated.

Two-sample  $t$ -tests were used to test the significance of differences between species and between thinning treatments in the percentage of ungraded green-board volume occupied by each of the identified defect types.

#### Results

##### Sawlog yields and board recovery

The volume of sawlog (per tree) was significantly higher ( $P < 0.001$ ) in trees sampled from the thinned stand (Table 1, Figure 3). The difference between the thinned and unthinned stands was particularly pronounced in *E. globulus*. Trees of *E. globulus* sampled from the

thinned plot had 3.6 times greater sawlog volume than trees from the unthinned plot. By comparison, *E. regnans* trees sampled from the thinned plot had 2.1 times greater sawlog volume than trees from the unthinned plot.

The volume of ungraded sawn timber and the volume of clear, defect-free timber were both significantly greater ( $P < 0.001$  and  $P < 0.05$ , respectively) in trees sampled from the thinned stand (Table 1), mirroring the results for sawlog volumes. *Eucalyptus globulus* yielded significantly greater volumes of ungraded green boards ( $P < 0.05$ ) and clear, defect-free boards ( $P < 0.001$ ) than *E. regnans* in both the thinned and unthinned stands.

The recovery of ungraded green boards was significantly higher ( $P < 0.05$ ) in logs from the thinned stand. There was no significant difference in the recovery of ungraded green boards between the two species

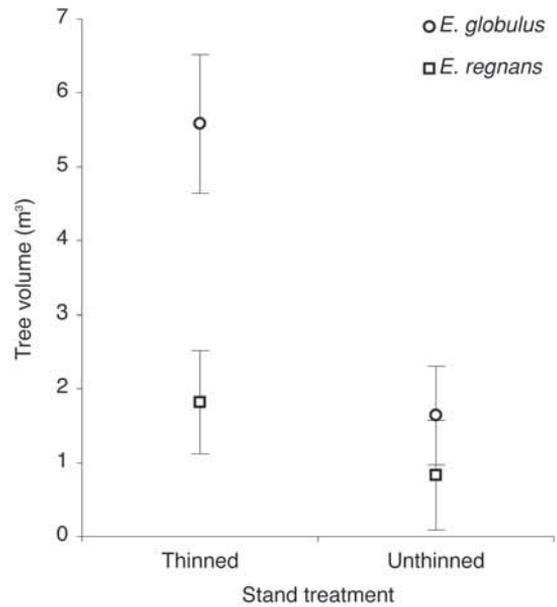


Figure 3. Average sawlog volume of *E. globulus* and *E. regnans* trees harvested from thinned and unthinned stands at Balts Road. Bars indicate 95% confidence limits.

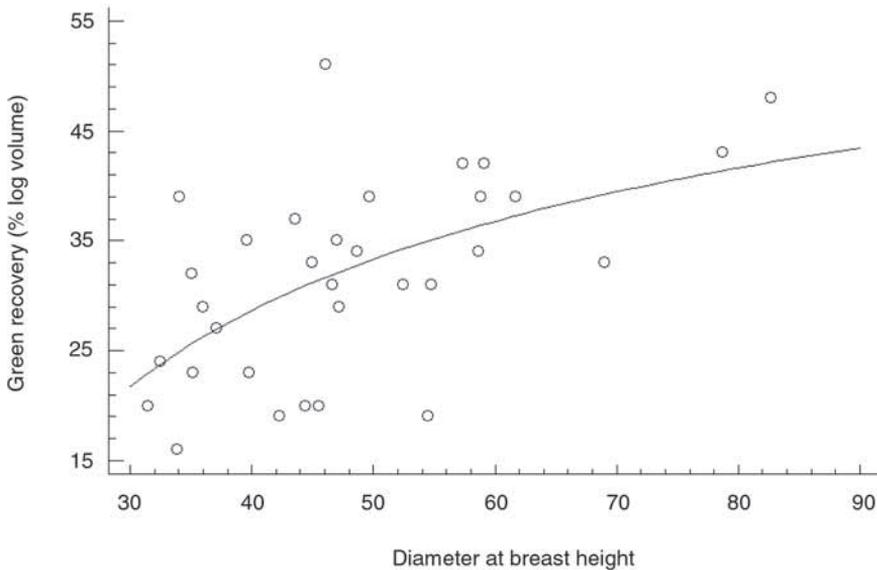


Figure 4. Plot of green-board recovery versus tree diameter (DBHOB) of all *E. globulus* and *E. regnans* sampled from thinned and unthinned plots. Superimposed on the plot is the fitted regression model:  $\text{Green recovery} = 110 - 302/\log \text{DBHOB}$ .

Table 2. Total board volume (in m<sup>3</sup>) containing various types of defect<sup>1</sup>.

	Treatment		Species	
	Thinned	Unthinned	<i>E. regnans</i>	<i>E. globulus</i>
Sample size	14	18	17	15
Kino (pockets)	0.611	0.172	0.659	0.124
Kino vein (loose)	0.320	0.160	0.040	0.440
Kino vein (tight)	1.122	0.263	0.298	1.086
Knots (hole)	1.042	0.408	0.550	0.900
Dry knots (tight)	0.279	0.166	0.218	0.227
Green knots	0.107	0.011	0.079	0.039
Discolouration	0.502	0.184	0.414	0.271
Rot	0.084	0.046	0.115	0.015
End splits	0.721	0.302	0.857	0.166
Want	0.176	0.066	0.173	0.070
Wane	0.398	0.195	0.425	0.169
<b>Total</b>	<b>5.362</b>	<b>1.973</b>	<b>3.828</b>	<b>3.507</b>

<sup>1</sup> Borer damage, twist, bow and spring were insignificant.

despite *E. globulus* sawlogs being significantly larger than sawlogs of *E. regnans* (Table 1). By contrast, the recovery of clear, defect-free boards (as a per cent of ungraded green-board volume) was significantly greater in *E. globulus* than in *E. regnans*, but did not differ significantly between the thinned and unthinned stands.

The recovery of green ungraded boards (as a percentage of sawlog volume) tended to increase with increasing tree size as measured by DBHOB (Figure 4). This relationship could be adequately explained ( $R^2 = 31.8\%$ ) by the non-linear regression model (standard errors in brackets):

$$\text{Green recovery} = 110 (\pm 21.1) - 302 (\pm 80.8) / \log \text{DBHOB.}$$

#### Defect levels

The total volume of sawn boards containing defects in trees sampled from the thinned stand was almost treble that of trees sampled from the unthinned stand (Table 2). However, there was little difference between the thinned and unthinned samples in the relative volume (as a percentage of total board volume) of sawn boards containing defects (Table 3). Holes from poorly shed, rotten branches occupied a significantly

higher proportion of the board volume in the logs sampled from the thinned stand compared with the unthinned stand (Table 3, Figure 5). None of the other defect types showed significant differences in the proportion of total board volume they occupied between the thinned and unthinned stands (Table 3, Figure 5).

The volume of sawn boards occupied by defects was comparable between *E. globulus* and *E. regnans* (Table 2). However, in *E. regnans*, the relative board volume containing defects (as a percentage of total board volume) was more than double that of *E. globulus* (Table 3). As a consequence, *E. globulus* yielded more than double the proportion of clear boards compared to *E. regnans* (Table 1). *Eucalyptus regnans* had significantly higher levels of kino veins (both loose and tight veins) and discolouration, and significantly lower levels of end splitting and kino pockets, than *E. globulus* (Table 3, Figure 6).

#### Discussion

Early and heavy waste thinning significantly increased sawlog volumes in both *E. globulus* and *E. regnans*. *Eucalyptus globulus*, which

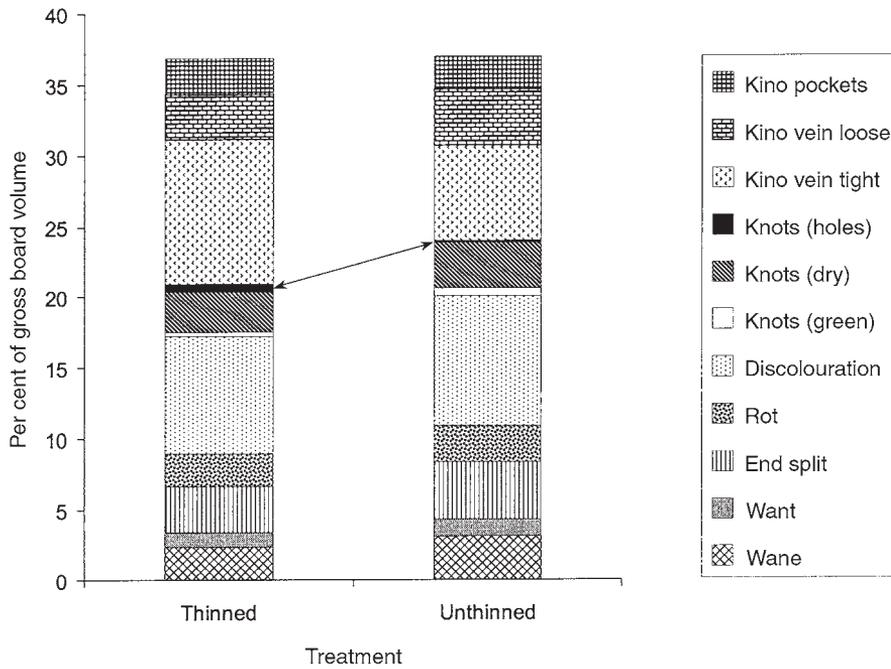


Figure 5. Comparison of the percentage of green-board volume containing various defects from thinned and unthinned stands. Defect groups joined by arrows are significantly different ( $P < 0.05$ ).

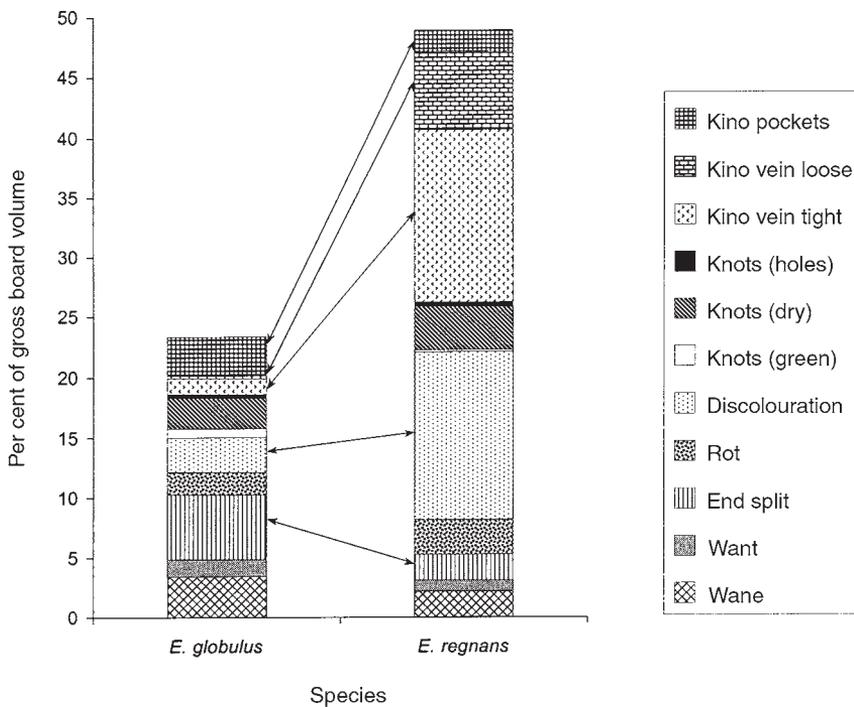


Figure 6. Comparison of the percentage of green-board volume containing various defects in *E. globulus* and *E. regnans* from thinned and unthinned stands. Defect groups connected by arrows are significantly different ( $P < 0.05$ ).

Table 3. Mean per cent (standard errors in brackets) of green-board volume containing various types of defect. Values for each type of defect within treatments and species that have different subscripts are significantly different ( $P < 0.05$ ) based on two-sample t-test (unequal variance) of untransformed data.

	Treatment		Species	
	Thinned	Unthinned	<i>E. regnans</i>	<i>E. globulus</i>
Sample size	14	18	17	15
Kino (pockets)	2.5 <sub>a</sub> (0.593)	2.3 <sub>a</sub> (0.389)	1.8 <sub>a</sub> (0.369)	3.1 <sub>b</sub> (0.529)
Kino vein (loose)	10.3 <sub>a</sub> (2.109)	6.8 <sub>a</sub> (2.378)	14.4 <sub>a</sub> (2.148)	1.3 <sub>b</sub> (0.224)
Kino vein (tight)	3.1 <sub>a</sub> (0.919)	3.9 <sub>a</sub> (1.847)	6.5 <sub>a</sub> (1.813)	0.3 <sub>b</sub> (0.111)
Knots (hole)	0.6 <sub>a</sub> (0.206)	0.2 <sub>b</sub> (0.039)	0.4 <sub>a</sub> (0.180)	0.3 <sub>a</sub> (0.064)
Dry knots	4.8 <sub>a</sub> (1.772)	3.9 <sub>a</sub> (0.896)	5.5 <sub>a</sub> (1.599)	3.0 <sub>b</sub> (0.608)
Green knots	0.30 <sub>a</sub> (0.082)	0.6 <sub>a</sub> (0.194)	0.2 <sub>a</sub> (0.049)	0.7 <sub>a</sub> (0.220)
Discolouration	8.3 <sub>a</sub> (1.903)	9.1 <sub>a</sub> (2.621)	13.9 <sub>a</sub> (2.523)	2.9 <sub>b</sub> (0.533)
Rot	2.3 <sub>a</sub> (0.831)	2.6 <sub>a</sub> (0.486)	2.9 <sub>a</sub> (0.788)	1.9 <sub>a</sub> (0.317)
End splits	3.3 <sub>a</sub> (0.645)	4.0 <sub>a</sub> (0.740)	2.2 <sub>a</sub> (0.392)	5.5 <sub>b</sub> (0.754)
Want	1.0 <sub>a</sub> (0.176)	1.1 <sub>a</sub> (0.423)	0.9 <sub>a</sub> (0.345)	1.2 <sub>a</sub> (0.361)
Wane	2.4 <sub>a</sub> (0.368)	3.1 <sub>a</sub> (0.616)	2.2 <sub>a</sub> (0.400)	3.4 <sub>a</sub> (0.648)
<b>Total</b>	<b>38.9</b>	<b>37.5</b>	<b>50.8</b>	<b>23.6</b>

has rapid early growth (West 1981), was particularly responsive to the thinning treatment: the average volume of *E. globulus* trees from the thinned stand was more than treble that from the unthinned stand. The increase in sawlog volume following thinning translated into comparable increases in the volume of green ungraded boards.

The heavy waste thinning treatment was done at a very early age before significant lifting of the green crown would have occurred. Such a silvicultural treatment

is not normally prescribed for native forests (Forestry Tasmania 2001) because of the risk of poor branch-size control (Goodwin 1990). Live branches that were present on the retained trees after thinning would be expected to persist longer (Goodwin 1990), grow to a larger size (Marks *et al.* 1986) and produce a wider defect core (Jacobs 1955) than in the unthinned stand. This is borne out by a more than trebling of the volume of sawn boards containing knots (green, dry and holes) in the trees from the thinned stand. The volume of other defects also increased by a similar amount in the trees

from the thinned stand. Some of these defects, particularly rot and discolouration, are associated with bigger branches (Wardlaw 2003).

Although thinning resulted in a substantial increase in the volume of defects, that increase was in proportion with the increases in volume of sawn timber so the relative amount of most defects was comparable with trees from the unthinned stand. As a consequence, the average volume of clear, defect-free boards sawn from trees sampled from the thinned stand was more than treble that of trees sampled from the unthinned stand. The only defect that significantly increased in relative volume following thinning was holes from poorly shed, rotten branches. This type of defect has been previously linked to impaired branch shedding due to rapid growth rates that typically occur in plantations (Jacobs 1955). Overall, however, this defect was a minor component of the board defects encountered.

Differences in defect levels between the two eucalypt species sampled were of far greater significance than differences due to stand treatment. The relative amount of defects in sawn boards from *E. regnans* was more than double that of *E. globulus*. *Eucalyptus regnans* boards had a significantly higher proportion of the sawn board volume occupied by rot, discolouration, knots and kino veins, but

less splitting and kino pockets than *E. globulus*. These results are consistent with the findings of Yang and Waugh (1996a, b) for plantation-grown trees of the same species. Because of faster growth rates coupled with lower levels of defect, *E. globulus* produced more than five times the volume of clear, defect-free boards compared to *E. regnans*, regardless of stand treatment.

Levels of defects, such as decay (discolouration and rot), which affect the recovery of high quality sawn timber, are known to vary widely among sites (Wardlaw 1996; Wardlaw *et al.* 1997). Therefore, a small study such as the one reported here, which samples a restricted forest area, will be of limited value informing the sawmilling sector on the quality of the future sawlog resource from regrowth forests in Tasmania. However, this study provides a measure of reassurance that the growth benefits accruing from thinning are not likely to be sacrificed by greater losses from defects.

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