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SAWLOGS FROM 13 YEAR OLD *EUCALYPTUS GLOBULUS* - MANAGEMENT, RECOVERY AND ECONOMICS.

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ABSTRACT

The development of forest industries in Australia based on young farm-grown eucalypts is becoming a distinct possibility. The climate for such a development includes, declining supplies of logs from traditional sources, increasing demand for wood particularly in parts of Asia, abundant agricultural land which requires trees both to protect the resource base and to improve agricultural productivity, and a greater understanding of how to mill and dry young eucalypt timbers.

In 1981 a trial was established near Busselton, Western Australia, to determine whether *E. globulus*, grown at wide-spacing, could produce high-grade sawlogs. Management involved heavy and early culling to 135 trees per hectare and high pruning to 8 m. A sample of trees was harvested at 13 years of age, producing 130 m^3 per ha of sawlogs and 48 m^3 per ha of pulpwood logs.

A peeling trial of butt logs (average diameter, 460 mm) found the product was unsuitable for plywood because sheets checked and buckled during drying using a standard regime. Pruned crown logs (average diameter, 330 mm) were milled into 25 mm, 38 mm and 50 mm thick boards, producing a recovery of green sawn timber of 34.7 per cent. Graded recoveries of 38 mm boards after drying in a batch kiln included 54 per cent prime and 19 per cent reject grade, indicating that 13-year-old blue gum can produce appearance grade timber. Economic analyses found that *E. globulus* for sawlog production can be a profitable tree cropping option for farmers and investors.

INTRODUCTION

The predominant sources of logs around the world are changing. The traditional supplies, from indigenous forests in North America and South East Asia for example, are declining steadily mainly as a result of conservation pressures while new supplies from plantations are increasing (Ferguson, 1995). At the same time demand for wood is increasing, particularly in developing regions such as parts of Asia. These changes are providing opportunities for Australia and other countries to capture a share of these growing markets.

However, to compete on the international market, Australia must be able to produce suitable quality logs at a competitive price. Some species of eucalypts appear to have the potential to meet these requirements. In terms of growth rates, the genus has species which are among the fastest growing hardwoods in the world (Hillis and Brown, 1984). Breeding programs are underway for several species (Eldridge *et al.*, 1993). In the case of *E. globulus*, one of the fastest growing species of the whole genus, tree improvement is well advanced. Butcher (1990) reports that average volume gains of 40 per cent are likely for *E. globulus* from clonal orchards.

Australia also has the conditions required to produce wood cheaply. Land is abundant and in fact vast areas of agricultural land require trees integrated with farming to provide landcare and productivity benefits (Bartle, 1991, Bird *et al.* 1992 and Moore, 1992). Indeed methods of integrating commercial tree crops with farming have been developed and are being practiced by innovative farmers (Reid and Stewart, 1994; Eckersley, 1995 and Washusen and Reid, 1996). Furthermore, Australian silvicultural practices are technically advanced and result in high growth rates of trees. Examples include controlling weeds during the second year after tree planting (Fremlin, 1995) and growing trees at very wide spacing (ie. < 150 trees per hectare) (Moore, 1991).

Techniques for milling and drying young eucalypts and our understanding of the properties and qualities of the timber produced have undergone significant advances in recent years. Research by Waugh and Rozsa (1991) showed that backsawn regrowth *E. regnans* in Victoria and Tasmania could be seasoned satisfactorily by controlled drying conditions in comparison with the low recoveries by air-drying quarter-sawn timber from mature trees. In Western Australia, research on plantation-grown *E. globulus* also showed that regrowth timber could be dried for appearance grades (Brennan *et al.* 1992), and considerable research was done on regrowth *E. marginata* (Thomson, 1989). James (1988), in his work with *E. regnans* in New Zealand, was optimistic about its potential to produce high grade sawlogs.

Given the international settings, local conditions and our technical know-how, Australia would appear to be in a strong position to develop industries based on eucalypts grown on farmland for sawlogs.

In 1981 a trial was established near Busselton in south west Western Australia to determine whether *E. globulus*, grown at wide spacing, could produce high grade sawlogs. Thirteen years later 55 trees were harvested for milling and veneering studies. This paper reports on the complete cycle of the study, from planting to milling:

- Tree management and costs
- Growth rates and wood yields
- Recoveries, properties and qualities of sawn timber and veneer and
- Economics of sawlog production.

MATERIALS AND METHODS

SITE

The study site is located approximately 20 km south west of Busselton, Western Australia. The climate is mild Mediterranean, with cool wet winters and warm to hot dry summers. The average rainfall is 900 mm per year, most of which falls between May and November.

GROWING

Site preparation and tree establishment

Low quality jarrah forest was cleared and the site prepared for planting during the year prior to establishing the experiment (Keene and Kelers, 1980). Soils were sands and sandy loams with depth varying from 80 cm to 200+ cm. Seedlings of *E. globulus* were planted by hand in June 1981 at a spacing of 3 m x 2 m in belts of 7 rows (1666 trees per ha within belts). The distance between belts was approximately 20 m. One hundred and fifty grams of Agras No. 1 was applied to each tree 2 months after planting.

Regenerating scrub and rushes were controlled by blade ploughing and poisoning (using glyphosate) during the second and third year after planting.

Pasture and grazing management

Subterranean clover was established in the same year as trees were planted by broadcasting seed at a rate of 10 kg per ha with Super Cu Zn Mo No.2 at a rate of 416 kg per ha. Pasture was improved by spreading additional clover seed with 480 kg per ha of Super Cu Zn B during the second year after planting. Approximately 200 kg per ha of Super was applied annually, including within the tree belts, from year 3 to 11. Grazing commenced 3 years after planting trees with the introduction of young cattle (less than 1 year old). Steers grazed the area each year after trees reached 5 years of age.

Tree management

The study involved thinning to three different densities; 85, 135 and 212 trees per hectare. Data on growth rates and timber yields presented in this paper are from the 135 trees per hectare plots only. Milling and veneering data were obtained by studying logs from all three stand densities.

Culling: Trees were culled to 540 per ha (2 out of 3 trees culled) at 3 years of age (mean height, 5 m). The second and final culling was carried out at 5 years of age to a density of 135 per ha (2 out of 3 trees culled).

Pruning: Trees were pruned to about 50 per cent of height (approximately 2.5 m) using hand shears after the first culling at 3 years of age. Pruned height at this age corresponded with a stem diameter of approximately 10 cm. Subsequent prunings were carried out using a mobile pruning platform at 5 years and at 8 years, to approximately 6 m and 8 m respectively (Table 1).

Table 1: Management regime applied to *E. globulus* for producing high grade sawlogs.

Age (yrs)	Year	Operation
0	1981	Planted seedlings at a spacing of 3 x 2 m. (1666 trees/ha within 7-row belt)
3	1984	Culled to 540 trees/ha Pruned to half tree height (about 2.5m)
5	1986	Culled to 135 trees/ha (final crop) Pruned to half height (about 6m)
8	1989	Pruned to half height (about 8m)
13	1994	Harvested 55 trees for milling and veneering studies

Costs of establishing and managing the trees have been calculated using contract rates where available; for example, ripping, mounding and planting. Cost of high pruning was estimated from measurements of time taken to carry out the job and applying them to the cost of hiring a mobile pruning platform with operator.

Tree measurement

Two measurement plots of 20 trees were established in each density at 5 years of age. Diameter at breast height over bark (DBHOB) and height were measured every 2 and 4 years respectively. Overbark volume was estimated for individual standing trees using the cone formula. Underbark volume was estimated for individual docked logs using length, mid-log diameter and measurements of bark thickness.

HARVESTING

A section of the trial was clearfelled in August 1994, when trees were 13.2 years old. Trees were docked into three log types; peeler logs, sawlogs and pulpwood logs.

One truck load of 22 m^3 of peeler logs was separated for a veneering study. Log specifications for peeler logs were length 2.7 m, minimum small end diameter (S.E.D.) of 350 mm, central pith and straight. The logs had metal plates driven into the ends to reduce splitting immediately after felling and docking.

Sawlogs were predominantly pruned crown logs, down to a minimum small end diameter of 250 mm. They were used to assess the potential for sawing and drying appearance grade timber from this resource.

The remaining parts of the stem, mainly the unpruned crown sections, were pulpwood logs.

Veneering

The 22 m^3 load of veneer logs in 5.4 m lengths, with some 2.7 m, was transported to WESFI's plywood factory at Victoria Park in Perth for a peeling trial. The logs were stockpiled and sprayed with water for six weeks before processing, to reduce end splitting and possible insect attack. Prior to peeling, the logs were stored in hot water at 70°C for two days, and docked to 2.6 m lengths immediately before peeling. Four logs were peeled without the hot water treatment.

The mean diameter of the logs at peeling was 420 mm (S.D. = 36 mm), with a range from 350 mm to 510 mm. The logs were peeled into 2.5 mm thick veneer, leaving a minimum 150 mm diameter core where the log was held by the dogs. The rolls of veneer produced were dried in a 'Hildebrand' veneer dryer, operating at 150°C and 2.7 m per min, where the veneer was dried to 6 to 10 per cent moisture content in about eight minutes. The veneers were then trimmed to the standard size of 2.4 m x 1.2 m and stacked under restraining weights.

Milling

Twenty-seven cubic metres of blue gum logs with an average diameter of 33.0 cm were delivered to the Wood Utilisation Research Centre at Harvey (now the Timber Utilisation Centre) for sawing and drying trials. The logs were stored under water sprays until processed to minimise end splitting and insect attack, similar to the storage at the plywood factory.

Sawing was carried out using a 'Forester 150' horizontal bandsaw for log breakdown, and a 'Jonsereds' vertical bandsaw for resawing. The objective was to produce one cubic metre each of 2.4 m length appearance grade timber, with 140 mm width and either 25 mm, 38 mm or 50 mm thickness. The remainder of the logs were milled into 100 mm x 18 mm boards for subsequent solid wood panel production.

Drying

The 18 mm thick boards were dried in a commercial CALM Solar-assisted Timber Drying Kiln, with no auxiliary heat used. One cubic metre each of 25 mm, 38 mm and 50 mm boards was used for batch kiln research for developing improved drying schedules, which will be reported separately in greater detail.

The drying schedule used in the Solar kiln commenced with mild conditions of 20°C and 90 per cent relative humidity, with progressive increases in temperature and corresponding decreases in humidity with final drying at 40°C and 55 per cent humidity. These boards, intended for panel production, dried from green to 10 per cent moisture content in five weeks.

Wood density assessments were made for three different measures - green, basic and air-dry density. The definitions of each parameter are as follows:

$$\text{Green density} = \frac{\text{green mass (kg)}}{\text{green volume (m3)}}$$

$$\text{Basic density} = \frac{\text{air-dry mass (kg)}}{\text{green volume (m3)}}$$

$$\text{Air-dry density} = \frac{\text{air-dry mass (kg)}}{\text{air-dry volume (m3)}}.$$

The method is defined in Australian Standard AS1080.3 - 1981 'Determination of density' (Standards Association of Australia, 1981).

Shrinkage in width and thickness was measured using sections cut from randomly selected boards to assess how much allowance is required for drying from green and subsequent dressing to achieve specific final dimensions. Shrinkage is expressed as a percentage based on initial (green) dimensions and air-dry measurements.

Thirty-six specimens (200 mm x 26 mm x 20 mm) were cut from randomly selected boards with widths of 150 mm, 100 mm or 75 mm, for assessment of the three density measures and shrinkage.

The boards, dried in the batch kiln, were graded to the Industry Standard (FIFWA, 1992), and the thin boards dried in the solar kiln to VALWOOD® specifications (Department of CALM, 1995).

RESULTS

TREE GROWTH AND WOOD YIELD

At 13 years of age the mean DBHOB of *E. globulus* growing at a stocking of 135 trees per hectare was 46.2 cm and height, 21.3 m. The mean annual increment in DBHOB was 3.5 cm per year and in height, 1.64 m per year. The basal area and total volume at 13 years were 22.7 m^2 per hectare and 163 m^3 per hectare respectively. Growth data are given in Table 2.

Table 2: Description of the *E. globulus* stand just prior to harvesting at 13 years of age.

Parameter	Value
Stand density	135 trees/ha
Mean DBHOB	46.2 cm
Mean height	21.3 m
Basal area	22.7 m^2/ha
Total volume over bark	162.7 m^3/ha
Mean annual increment of volume	12.5m^3/ha/yr

Merchantable volume (under-bark) of sawlogs and pulpwood logs is given in Table 3. It shows that approximately two thirds of the merchantable volume was sawlog and the other third was pulpwood logs.

Table 3: Actual merchantable volume (under-bark), by log type, from 13-year-old *E. globulus* at a stocking of 135 trees per hectare.

Log type	Volume	
	m^3/tree	m^3/ha
Pulpwood logs	0.36	48.6
Sawlogs (including veneer logs)	0.96	129.6
Total merchantable volume	**1.32**	**178.2**

The difference between total volume overbark (Table 2) and total merchantable volume underbark (Table 3) can be attributed to different methods of estimating volume - the cone formula was used to estimate volume of standing trees and Smalian's formula was used with docked logs.

PEELING

The peeling trial indicated that Tasmanian blue gum has considerable potential for peeling veneers, but as explained in the Discussion of this paper, it was not possible to quantify the recovery because of problems with log softening and then drying using a standard regime in the veneer dryer. The product was generally unsuitable for pressing into plywood sheets because of corrugation and splits which developed in the 2.5 mm thick sheets during drying.

The total volume of logs milled into sawn timber was 27.13 m^3. This produced 5.56 m^3 of green sawn appearance grade timber and 3.85 m^3 of thin boards for panel production, giving a total recovery of green sawn timber of 34.7 per cent (Table 4).

Table 4: Recovery of green sawn timber from 13-year-old *E. globulus* logs

Parameter	Value
Total volume of logs	27.13 m^3
Volume of appearance grade timber	5.56 m^3
Volume of thin boards	3.85 m^3
Total volume of sawn timber	9.41 m^3
Total recovery of green sawn timber	**34.7%**

In the 25 mm, 38 mm and 50 mm thick boards dried in the batch kiln, the percentages of Prime Grade material (FIFWA, 1992) were 51 per cent, 54 per cent and 32 per cent respectively, and of Standard Grade were 12 per cent, 6 per cent, and 22 per cent respectively.

Table 5: Graded recoveries of 25 mm, 38 mm and 50 mm thick boards from 13-year-old Tasmanian blue gums after drying in a batch kiln.

Grade	25 mm %	38 mm %	50 mm %
Prime	50.9	54.0	31.8
Standard	12.0	5.6	21.7
Merchantable	28.1	21.2	31.3
Reject	9.0	19.2	15.2

The average green moisture content was 93.6 per cent (S.D.= 4.1) with a range of 87.6 to 103.7 per cent. Mean green, basic and air-dry densities are given in Table 6.

Table 6: Mean green, basic and air-dry densities for 13 year old *E. globulus*.

Type	Density (kg/m^3)		
	Mean	S.D.	Range
Green	1041	25.9	991-1084
Basic	538	19.5	501-561
Air-dry	737	28.2	666-790

The mean width shrinkage in backsawn boards was 8.5 per cent (S.D. = 2.8) for blue gum and 7.5 per cent (S.D. = 2.5) for jarrah. Mean thickness shrinkage for blue gum and jarrah was 6.9 per cent (S.D. = 2.1) and 5.9 per cent (S.D. = 1.3) respectively (Table 7).

Table 7: Mean width and thickness shrinkage in backsawn boards as a percentage for 13-year-old *E. globulus* and regrowth jarrah (*E. marginata*).

Type	Shrinkage (%)		
	Mean	**S.D.**	**Range**
Width			
- blue gum	8.5	2.8	4.4 - 13
- jarrah	7.5	2.5	2.6 - 3.2
Thickness			
- blue gum	6.9	2.1	3.6 - 11.3
- jarrah*	5.9	1.3	2.6 - 7.6

* Reference: Thomson (1989)

ECONOMICS

The production of sawlogs from widely spaced eucalypts in a grazing enterprise can be evaluated in four quite distinct ways. These reflect the different perspectives of the timber industry, investors generally, farmers, and the regional community. A primary question for the timber industry would be - "can we produce a specific product at a competitive price?" Hence economic analysis could be used to calculate the total cost of producing sawlogs, expressed as a stumpage in dollars per cubic metre.

Alternatively the project could be evaluated as a discrete investment, separate from normal on-going farm costs and returns. In such an analysis, returns from the project relate solely to the extra costs incurred. Thirdly, a farmer might be more interested to know the annualised net returns per hectare for combined production of sawlogs and animal products. Finally, given the likely external benefits, such as improved catchment water balance, the regional community would wish to add those benefits to the net returns from commodities.

In this study the project was evaluated for the second and third purposes. Wood production costs used (see Table 8) apply to current silvicultural recommendations for growing 135 *E. globulus* crop trees per hectare on cleared farmland. A study established near Manjimup in 1989 showed that planting 400 seedlings of *E. globulus* per hectare provided adequate selection of crop trees (Moore, 1996). In addition to the costs and returns directly associated with sawlog production (see Table 8) this analysis took account of the changes in herd size and changes in livestock costs and returns (see Table 9). The project was viewed as a change in the use of a 50 hectare section of a 500 ha grazing enterprise producing mainly beef weaners.

Table 8. Costs and returns for 13-year-old *E. globulus* (135 trees/ha)

Year	Operation	Costs ($/ha)	Returns (at $30/m^3$ for sawlogs) ($/ha)	Returns (at $60/m^3$ for sawlogs) ($/ha)
1	Establish 400 trees/ha			
	- ripping & mounding	$10		
	- controlling weeds	$15		
	- seedlings (400 @ 30^c each)	$120		
	- planting	$50		
	- controlling rabbits and grasshoppers	$105		
3	Culling (to 200 trees/ha)	$60		
	Pruning (to 2.5 m approx.)	$130		
*	Heaping debris	$60		
	Poisoning coppice	$20		
5	Culling (to 135 trees/ha)	$50		
	Pruning (to 6 m approx.)	$180		
*	Heaping debris	$60		
	Poisoning coppice	$10		
8	Pruning (to 8 m approx.)	$240		
	Heaping debris	$60		
13	Clearfell (135 trees/ha)			
	- 97.6 m^3/ha of 1st grade sawlogs		$2 928	$5 856
	- 82 m^3/ha of pulpwood logs @ $20/$m^3$		$1 640	$1 640
	Total	**$1 170**	**$4 568**	**$7 496**

Findings with grazing sheep under widely spaced trees near Perth (Anderson *et al.*, 1988) indicate possible grazing levels under *E. globulus*. Carrying capacity with cattle under *E. globulus* is expected to average about 60% of open pasture over the first 13 years under the regime shown in Table 8. Carrying capacity levels are also based on simple observations at the study site itself.

Grazing cash flow in Year 1 of the project includes income from disposal of surplus breeders and payments for cleaning up the area to allow hay making between the trees in the first year or two.

Table 9 shows the effect of the project on farm cash flow. Using the difference between normal farm cash flow (column 5) and cash flow with 50 ha converted to agroforest (column 4), profitability is calculated by discounted cash flow analysis. A computer spreadsheet was used to calculate Internal Rate of Return (I.R.R.), a standard measure of profitability.

The annualised value of the net return from the project was calculated using an interest rate of 7 per cent.

Table 9: Cash flow for 50 hectare *E. globulus* sawlog project on a 500 hectare beef farm - stumpage $45/cubic metre and discount rate 7 per cent.

Year	Cash flow for trees ($/50 ha)	Cash flow for grazing between trees ($/50 ha)	Combined cash flow for trees & grazing ($/50 ha)	Cash flow for normal grazing ($/50 ha)	Difference between project & normal ($/50 ha)	Present value of difference ($/50 ha)
1	-16 000	17 403	1 403	12 922	-11 519	-11 519
2	0	6 259	6 259	12 922	-6 663	-6 227
3	-13 500	6 717	-6 783	12 922	-19 705	-17 211
4	0	8 246	8 246	12 922	-4 675	-3 816
5	-15 000	8 246	-6 754	12 922	-19 675	-15 010
6	0	8 246	8 246	12 922	-4 675	-3 333
7	0	8 246	8 246	12 922	-4 675	-3 115
8	-15 000	8 889	-6 111	12 922	-19 033	-11 853
9	0	8 614	8 614	12 922	-4 308	-2 507
10	0	8 339	8 339	12 922	-4 582	-2 493
11	0	8 064	8 064	12 922	-4 857	-2 469
12	0	7 790	7 790	12 922	-5 132	-2 438
13	301 556	1 517	303 073	12 922	290 151	128 830
			Net Present Value		**$46 839**	
			Internal rate of return		**13%**	
			Annuity equivalent		**$112/ha treated**	

At a sawlog stumpage of $45 per m^3 the I.R.R. was 13 per cent. Expressed as an annuity per project hectare (in year 0 dollars) this equates to $112/ha/year. This is the amount by which annualised returns from the 50 ha project area is <u>greater</u> than returns from normal grazing. The average gross margin for normal grazing was calculated to be $143/ha/yr after deducting those costs which vary in direct proportion to cattle number and hectares. In other words, the project increases the net returns by about 78 per cent to $255/ha/year for the project area.

If the project were to cover a substantial (rather than a small) proportion of the property, it could reduce the labour efficiency of the grazing enterprise but improve the economics of silvicultural and logging operations. It could also increase the likelihood of achieving any landcare objectives.

Sensitivity analysis

There is uncertainty about both the sawlog value and the effect of the trees on carrying capacity of the pasture. Table 10 shows that only if average carrying capacity were reduced to 40 per cent of normal and sawlog value reduced to $30 per cubic metre, would the project become unprofitable.

Table 10. Effects of sawlog price (stumpage) and carrying capacity of pasture under trees on project profitability.

	Average net benefit of project ($/ha/yr)		
	Stumpage price for sawlogs ($/m^3)		
Average carrying capacity of planted area (% of normal)	**$30/m^3**	**$45/m^3**	**$60/m^3**
80%	74	152	230
60%	34	112	190
40%	-5	72	150

Integrating trees into the farming enterprise

Although it is a convenient project for presenting the economic analysis, planting 50 ha in one year may not be the best option for the farmer. The area planted each year would need to be tailored to each farmer's labour and financial resources.

If the farmer is keen and able to do planting, thinning and pruning himself/herself, to save cash, profitability may be higher than in the example. However, this may mean spreading planting over a number of years. This could also reduce the borrowings needed for such a project and so improve the chances of funding it. The 50 ha project as shown requires outlays of more than $100,000, even without interest. This could well be beyond the financial resources of many graziers.

DISCUSSION

TREE GROWTH AND WOOD YIELD

The study showed that *E. globulus* can produce logs of millable size within 13 years when grown at a density of 135 trees per hectare (mean diameter of butt logs was 460 mm). The rapid growth of individual trees can be attributed to the lack of competition between widely spaced trees. Knowles (1991) in New Zealand and others in Australia (eg. Anderson *et al.*, 1988) described the rapid growth of individual *P. radiata* trees which can be achieved at the low end of the density range. It is reasonable to assume that eucalypts at low densities will respond in a similar way.

Heavy and early culling and high pruning was considered essential to achieve the goal of high quality sawlogs in as short a time as possible. Early culling also reduced the number of trees to be pruned - a considerable cost saving. Pruning was essential to produce clearwood (Nicholas, 1992 and Bird *et al.*, 1996). It is possible that pruning could have been completed in 2 rather than 3 prunings, at 4 and 7 years of age for example, thereby reducing pruning costs.

Culling and pruning work was found to be practical and cost effective. Culling with a light chainsaw was a straight forward operation. Pruning was time consuming, especially above 2.5 m, but economic analysis shows the costs can be justified (see Economics section). A range of equipment for pruning is available including low cost manual methods, such as hand shears, polesaws, and ladders and hand saws and more expensive mechanical methods, such as mobile platforms.

The silvicultural regime described may be particularly suited to small scale farm forestry. As the product is a high quality one, and should command high prices, relatively small areas (1-5 ha) are likely to be viable. In addition, the required management may be more easily carried out by individual landowners than industrial foresters.

The wide-spaced approach to growing eucalypts for sawlogs is applicable to any layout of trees. Where commercial tree crops are deliberately integrated with farming to provide productivity gains and soil and water repair, trees may be distributed across the landscape in various layouts, such as belts and blocks. Whatever layout is used, the trees themselves can be grown at wide-spacing to produce sawlogs in as short a time as possible.

The total volume of wood produced per hectare per year by *E. globulus* at 135 trees per ha was about half that of a typical plantation of *E. globulus* (1200 trees per ha); 12.5 m^3 per ha per year (Table 2) compared with about 25 m^3 per ha per year. This indicates that at 135 trees per ha, *E. globulus* was not fully utilising the site. Nevertheless the total volume of merchantable wood produced was substantial (178 m^3 per ha - Table 3). Even more importantly it was high quality wood and valued at between $4568 and $7496 per hectare (Table 8).

Some growers, especially those trying to develop a wood production component to their farming enterprise, may not wish to maximise wood production. For them, a more important need may be to obtain income from trees as soon as possible. To achieve this they may be prepared to forego some wood production in order to produce saleable logs more quickly. Wide-spaced regimes also enable growers to obtain income from the land while the trees are growing, especially during the first 15 years. Simple observations at this site and other similar trials indicate that pasture growth beneath eucalypts at wide-spacing can be substantial. For these reasons growing trees at wide-spacing could be an attractive option for some growers.

PEELING

The importance of applying metal plates immediately after felling and docking the peeler logs, to minimise the effects of end splitting resulting from growth stresses, was demonstrated during the harvesting phase. Logs left without plates for more than fifteen minutes were observed splitting. Logs should be transported to the mill as soon as possible after being docked. However, where logs cannot be processed immediately, storage under watersprays reduces endsplitting and insect attack, and can reduce growth stresses in the log.

The hot water treatment at 70^{0}C for two days prior to peeling was too severe, causing excessive softening of many logs. The result was shattering, crushing or splitting at the lathe dogs, which resulted in a large core and substantial loss of recovery.

The log ends that were freshly docked had fewer problems with splitting than the original log ends, and observations of the peeling process indicated that the four unsteamed logs had fewer end-splits than the steamed logs. Consequently, WESFI staff now consider that overnight soaking at 40^{0}C would be a more suitable treatment prior to peeling.

At the time of peeling, the veneer appeared to be mainly core grade quality and reject material, with no face grade material. Drying of the veneers confirmed this opinion. The major problem with the veneers was the corrugating effect resulting from drying, which presumably could be related back to growth stresses and variable moisture contents. Some buckling also occurred close to the heart. Veneer quality was also adversely affected by extensive splitting in the ends of the sheets. This is also likely to be caused by growth stresses in the young material.

MILLING AND DRYING

The results of the trial indicated that Tasmanian blue gum logs are more suitable for sawlog production than they are for veneer and plywood production at this age. Graded recoveries (Table 5) show that this young material has potential for appearance grade timber, with 51 per cent of 25 mm boards making prime grade. The percentage of prime grade from 38 mm and 50 mm boards was 54 per cent and 32 per cent respectively. About 10 per cent was rejected overall because of natural or drying-induced defects in the 25 mm and a greater percentage in 38 mm and 50 mm thick timber. There was some variation in recoveries in the mix of grades between the different thicknesses. These results are encouraging, especially as logs milled were predominantly pruned crown logs, the butt logs having been used for the peeling study. Future milling studies should include butt logs.

The basic density of 538 kg per m^3 and air-dry density of 737 kg per m^3 (Table 5) for this 13-year-old wood as expected were less than the 561 kg per m^3 and 790 kg per m^3 respectively for 17 to 23 year-old samples from Tasmania reported by Kingston and Risdon (1961). This is because mean wood density increases with age.

The shrinkage figure (Table 7) of 8.5 per cent in width was substantially less than the 14.4 per cent tangential shrinkage reported by Kingston and Risdon (1961), although the 6.9 per cent reduction in thickness was the same figure they reported for radial shrinkage.

Hillis and Brown (1984) suggest that both timber recovery and ease of milling are improved with larger log sizes, because growth stresses are less. Consequently it is possible to make recommendations about the silvicultural treatments and rotation lengths required to produce acceptable quality sawlogs and veneer logs. The logs could be considerably larger than the minimum 350 mm small end diameter limit used in this trial. For example, a log diameter of 700 to 800 mm for peeler logs was suggested by WESFI staff. The average log diameter peeled in this study was 420 mm, and on this basis a rotation length of 20 to 25 years would be required to produce peeler logs or slicing flitches. The advantages would be that the gradient in growth stress across logs would be much less in these larger logs, and that end splits and drying defects would consequently be greatly reduced.

ECONOMICS

Given the assumptions used, economic analysis shows that the project is profitable. The I.R.R. is in the range of 6.7 to 18 per cent and the annualised returns are likely to be substantially higher than returns from normal grazing. Preliminary analysis of this silvo-pastoral system using FARMTREE (Loane, 1994) suggests that the 13 year rotation length may be sub-optimal because the stand would produce a much greater volume of larger diameter logs if grown on beyond 20 years

As it is now believed that sustainable land management may require trees distributed across the agricultural landscape (George *et al.* 1994), farm forestry systems, such as widely-spaced eucalypts in belts with alleys for grazing and cropping, may offer significant external benefits. If these were quantified and included in the analysis the project would be even more profitable.

CONCLUSION

The study found:

- *E. globulus* produced marketable sawlogs in 13 years when grown at 135 per hectare.
- A high proportion of timber produced from the sawlogs was of appearance grade.
- The quality of veneers produced with a standard peeling regime was unsatisfactory.
- The project was profitable, with annualised returns being substantially higher than returns from normal grazing.

It is likely that wood recovery and quality would be further improved by:

- allowing logs to grow to 700 to 800 mm diameter (20 to 25 years)
- milling butt logs and
- gaining additional milling and drying experience.

The results add weight to the proposition that eucalypt sawlogs grown on farms can become a competitive source of sawlogs in the future.

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