Fencing eucalypt coupes for blackwood regeneration

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Abstract

*Blackwood (*Acacia melanoxylon*) is a common understorey species in wet eucalypt forests in north-western Tasmania. It regenerates prolifically from ground-stored seed but the seedlings suffer severely from browsing by native mammals. Fencing of coupes with blackwood understoreys which are being regenerated to wet eucalypt forest results in a high stocking of blackwood seedlings in the regeneration. Fencing is undertaken within a few weeks of regeneration burning and sowing with eucalypt seed. A comparison of five unfenced regeneration coupes with seven similar fenced coupes aged from four to eleven years old has shown an increase in mean blackwood stocking from 70 seedlings/ha in unfenced areas to 2500 seedlings/ha in fenced coupes. Growth rates of blackwood and eucalypt regeneration are also significantly higher inside the fences.*

Average fencing costs are $4220/km. The area/perimeter ratio is very important to the economics of fencing, and a ratio of 15 ha fenced for each kilometre of fence line should be met. Costs of $4220/km are then equivalent to $280/ha. This can be partially offset by savings in seed requirements and poisoning costs.

Financial analysis indicates that if future blackwood volume estimates are reached, fencing will enhance the financial attractiveness of eucalypt regeneration. The mean internal rate of return for native forests with blackwood fencing (3.2%) is higher than the base rate of native forest silviculture (2.8%) in the area studied. If the rotation length can be reduced and sawlog volume increased by commercial thinning at age 30 years, this further increases the mean internal rate of return (3.5%). However, as a discrete investment, blackwood fencing does not compare with short rotation eucalypt plantations.

Introduction

Blackwood (*Acacia melanoxylon*) commonly occurs as an understorey species in wet eucalypt forests in north-western Tasmania. These forests are dominated by eucalypt species, commonly *Eucalyptus obliqua*, with a dense understorey of scrub species such as *Pomaderris apetala, Phebalium squameum, Acacia verticillata* and *Olearia argophylla*. Natural stands usually contain one or two classes of even-aged eucalypts originating from wildfires. Eucalypt seed, released from capsules in the crowns of standing trees, germinates at the same time as the ground-stored seed of understorey species such as blackwood.

Most of the wet eucalypt forest containing a significant blackwood understorey component lies north of the Arthur River and is within an area that has been selectively cut-over for eucalypt since the turn of the century. Much of this area has subsequently been burnt by wildfires, resulting in a mosaic of cut-over oldgrowth and well-stocked regrowth, with an understorey containing well-formed blackwood (Photo 1).

The usual harvesting method for these areas is clearfelling and removal of all commercial eucalypt and understorey species followed by a hot slash burn and aerial sowing of eucalypt seed (Forestry Tasmania 1998a). Blackwood germination is stimulated by both logging disturbance and fire, and massive numbers of seedlings can result. For example, field germinations of 70 000 seedlings/ha have been recorded in wet eucalypt forests following disturbance (Jennings 1998).

Photo 1. Blackwood regrowth with good form in E. obliqua *native forest.*

One of the major factors which limits blackwood regeneration is browsing. The red-bellied pademelon (*Thylogale billardierii*), is believed to be the most significant blackwood browser in wet forests in far north-western Tasmania (Statham 1983). Observations by one of the authors (SJ) over several years indicate that blackwood is also highly palatable to Bennetts wallaby (*Macropus rufogriseus*), other native mammals, European rabbits and domestic livestock. Without protection, nearly all young seedlings are browsed. They may be killed, or browsed seedlings may reshoot and recover, but repeated browsing damage affects form and reduces growth rates.

After almost a decade of enclosure of individual blackwood seedlings, the Circular Head Forest District trialled the fencing of entire coupes. In 1985, a 30 ha coupe was fenced with wire mesh to exclude browsing mammals. Fencing took place after the hot slash burn but before the first flush of germination was browsed. This treatment was successful, with 23 000 blackwood seedlings per hectare present two years after establishment. Since 1985, 13 coupes, totalling approximately 520 ha, have been fenced for blackwood regeneration, with the emphasis in recent years on developing a cheaper fence (Photo 2).

In 1996, seven coupes fenced for blackwood regeneration were monitored. The aim of monitoring was to:

(i) Measure the success of fencing as a means of browsing control;

(ii) Determine what levels of blackwood stocking had been achieved with fencing;

(iii) Estimate the volume of blackwood that would be produced from these areas in the future; and

(iv) Establish whether the cost of wire-netting fences could be justified for further coupes.

Methods

The analysis of fencing effectiveness considered regeneration success and predicted future yields, with and without future thinning. A financial analysis considered whether blackwood fencing improved the return from routine native forest silviculture and also whether blackwood fencing can compete as an attractive investment decision.

1. Regeneration success

Seven coupes between four and eleven years of age were recently compared with five nearby unfenced coupes with similar soil types, vegetation and altitude. Thirty 50 m^2 circular plots were established in each coupe. All eucalypts and blackwoods were counted in each plot. The heights of the tallest two eucalypts and the tallest two blackwoods in each plot were measured and the results expressed as the mean of 30 plots per coupe. A two-tailed *t*-test was used to compare means of blackwood and eucalypt density and height growth in fenced and unfenced areas.

2. Estimate of future yield

Initial estimates of yield.—The yields of blackwood and eucalypt from fenced areas predicted in this paper are estimates only, as the oldest fenced area is 11 years old and no such areas have yet been harvested. Initial estimates of future yield were calculated assuming an 85-year rotation with no stand improvement treatment.

Current harvesting of good quality natural regrowth forests in the Temma Forest Block is yielding an approximate sawlog to pulp-log ratio of 1:3, so it was assumed that the silvicultural regrowth forests of the future would be comparable.

Estimates of stocking and eucalypt volume were calculated using a sample of seven permanent Continuous Forest Inventory (CFI) plots (Forestry Commission 1985) from areas which contain *E. obliqua* and blackwood regrowth of a single age class. Information on individual blackwood trees within these plots provided an estimate of bole length for potential sawlog trees. Log volumes have been estimated using Forestry Tasmania's Log Volume Tables for Swamp Blackwood.

Estimates were compared with a review of eucalypt regrowth size and growth rates produced for Circular Head District (Tuson 1991), which examines a large area of 77-year-old regrowth within the area most suitable for blackwood fencing.

Yield estimates with future thinning.—As outlined in the Forests and Forest Industry

Photo 2. Newly erected blackwood fence at Togari Cpt 007C (1997).

Strategy (FFIC 1990), some areas of native forest silvicultural regeneration will be intensively managed. This may involve early age spacing and / or commercial thinning. However, development of good form in the blackwood stems is reliant on eucalypts and other scrub species suppressing the lower branches. These areas should not be spaced until after the development of a clear blackwood sawlog stem. For the purposes of this report, it has been assumed that early age spacing will not be done.

Commercial thinning in eucalypt stands is commonly done at age 25–45 years, depending on the growth of the stand (Forestry Tasmania 1998b). It is assumed that, with reduced competition in the commercially thinned stands, the blackwood diameter growth rates would increase from 0.5 cm / yr to 0.6 cm / yr and the same sawlog volume would still be reached during the shorter rotation lengths. It is also assumed that 10% of blackwood volume would be lost due to thinning damage because blackwoods form an understorey to the eucalypt canopy and are susceptible to damage where the larger, taller eucalypts are commercially felled.

3. Financial analysis

The financial analysis considered three factors: the cost of fencing; costs of regeneration establishment; and stumpages for sawlog and pulpwood.

Fencing costs.—The cost of fencing was determined from records of construction costs from five coupes established between 1991 and 1995. There are three major components of fencing costs: fence-line preparation, materials and erection.

Preparation of a fence line and construction of a fire line are performed together to reduce costs. However, clearing to the standard of a fence line does add to the cost of fire-line construction. The cost of fence-line preparation was calculated by subtracting the average 1996 fire-line cost from 20 coupes from the cost of fence-line / fire-line construction for another coupe fenced in 1997. A 35% overhead component was included in the fence-line preparation cost. A 10% overhead was included in the fencing materials and contract labour charge, which covers the costs involved in ordering materials and supervising the contractor.

Cost of fencing is presented per kilometre but, for the purposes of financial analysis, a cost per hectare is required. The cost per hectare is influenced by the size and shape of the coupe. A recommended ratio of area fenced to perimeter length of 15 ha / km was assumed, based on experience gained over the last few years and a desire to achieve the greatest area fenced for the minimum cost. This area / perimeter ratio can generally be achieved with coupes over 40 ha that have a broad-rectangular to square shape and reasonably straight boundaries. This allows calculation of a maximum cost per hectare for fencing, provided that the guidelines are observed. If the area is larger, with straighter boundaries, then fencing costs per hectare can be less than those used in this report.

Cost of regeneration establishment.—The cost of standard regeneration practices for wet eucalypt forest (i.e. clearfall, slash burn and then aerially sow with eucalypt seed) were compared with the additional cost of fencing blackwood regeneration. Establishment costs were assumed to fall between $350 / ha and $450 / ha, with a uniform distribution. This approximated the range of costs from 20 coupes established in the Circular Head District in 1996. The establishment cost and the cost of fencing were introduced in year one of the rotation. An annual overhead of $3–$5 / ha was charged for fire management and monitoring associated with a typical native forest area. No land rental was charged. The rotation length was assumed to be 85 years. A comparison was also made where a fenced blackwood coupe was thinned commercially at age 30 years. It was assumed that thinning reduced the rotation length by 15 years and increased the sawlog / pulpwood ratio at final harvest.

The cost of fencing was reduced for subsequent financial analysis by savings obtained from lower eucalypt seed rates. Adequate eucalypt stocking has been achieved in fenced coupes by reducing the sowing rate of *E. obliqua* seed from 0.5 kg / ha to 0.3 kg / ha where a good burn has been achieved, a saving of $30 / ha. Based on experience of browsing in the area, it was assumed that fencing would eliminate the need to poison (around $28 / ha) for about 25% of coupes but, in the remaining 75% of cases, there would be no savings associated with poisoning.

Stumpages.—Revenues were calculated using current sawlog stumpages of $62 / m^3 for blackwood Category 4 sawlog, $30 / m^3 for blackwood utility grade, $26 / m^3 for eucalypt sawlog and the current Circular Head pulpwood stumpage of $7.80 / t. Revenue produced by thinning is dependent on quantity, quality, age and distance from the market. A stumpage of $4–$5 / m^3 was deemed to be realistic.

Due to the level of uncertainty associated with key variables such as predicted blackwood sawlog volumes, the monte carlo modelling technique was used for the financial analysis. The internal rate of return (IRR) was used as the key economic indicator because this measures a project's ability to maximise the return on capital.

The marginal economic return for blackwood fencing and fencing with commercial thinning was also calculated to examine how these options performed as discrete marginal investment decisions.

The CRYSTAL BALL (1988–1996) monte carlo model was used to test the sensitivity of the results to the area / perimeter ratio of fencing, blackwood and eucalypt volumes and the other inputs assigned probability distributions.

In the primary analysis, a fixed cost of $4220 / km was used for fencing. Because reducing cost is seen as one of the primary ways of improving the viability of fencing, the sensitivity analysis was run with fencing costs varying between $3000 / km and $4500 / km with a normal distribution. This approximates a mean fencing cost of $250 / ha, with 98% of all values falling between $200–$300 / ha where an area / perimeter ratio of 15 hectares per kilometre is used.

Results

1. Regeneration success

All coupes were adequately stocked, although eucalypt stocking was variable both on fenced and unfenced coupes, ranging between 960 and 4260 eucalypt stems / ha. There was no significant difference between mean eucalypt stocking on fenced and unfenced areas ($P = 0.59$) (Figure 1).

Blackwood stocking within fenced areas was also highly variable. Stocking on fenced coupes averaged 2500 stems / ha (range 600–4700 stems / ha). Unfenced coupes averaged less than 5% of this level, with 70 stems / ha (range 20–100 stems / ha). The difference between mean blackwood stocking on fenced and unfenced coupes was highly significant ($P = 0.004$). As a method of controlling browsing by pademelons, the fences were very successful. Form of the young blackwoods is also very good, with *Pomaderris apetala* acting as a nurse crop (Photo 3).

Photo 3. Eight-year-old blackwood regeneration at Togari Cpt 021A, fenced in 1989.

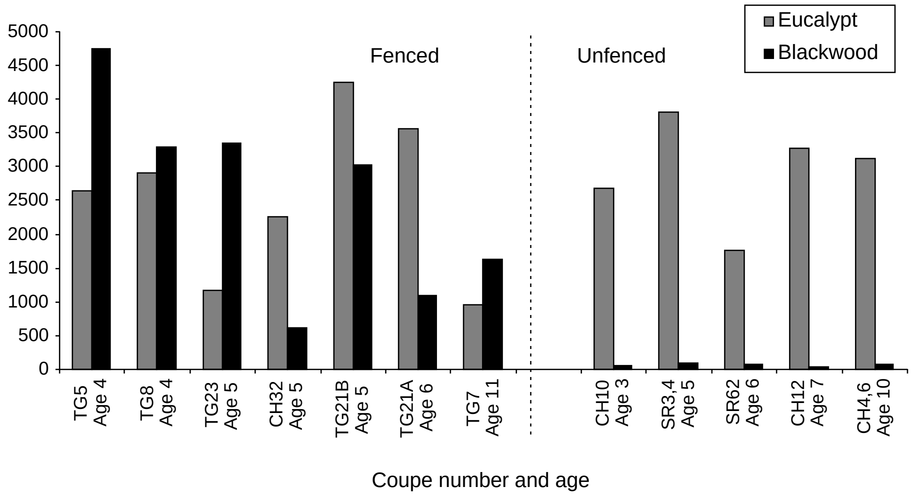

Figure 1. Eucalypt and blackwood stocking on fenced and unfenced coupes.

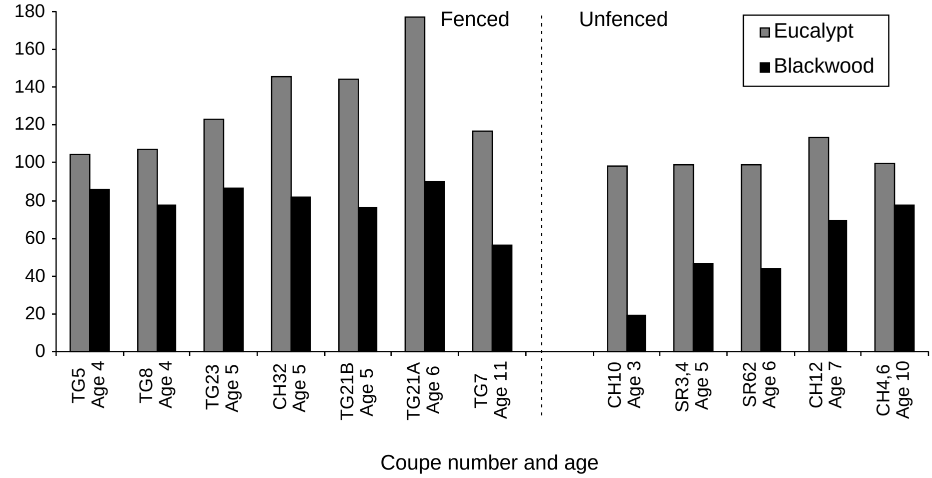

Figure 2. Eucalypt and blackwood height growth on fenced and unfenced coupes.

The mean annual increment (MAI height) for both eucalypts (P = 0.035) and blackwoods (P = 0.018) was significantly different between fenced and unfenced coupes (Figure 2).

2. Estimate of future yield

Initial estimates of yield.—Table 1 shows stocking and volume information summarised from CFI plot data. Bole height for most individual blackwood stems with sawlog potential on these CFI plots was in excess of 15 m.

Table 2 summarises information presented by Tuson (1991) which was collected from 2484 m of assessment stripline in *E. obliqua* regrowth forest.

Average blackwood sawlog length was 7.2 m, giving an average sawlog volume of 0.85 m^3/ tree.

Table 1. Growth data derived from seven permanent regrowth CFI plots. (DBH = diameter breast height, GBV = gross bole volume, MAI = mean annual increment)

		Eucalypt			Blackwood		
	Age	Stems/ha	DBH (cm)	GBV (m^3/ha)	Stems/ha	DBH (cm)	MAI (cm; diam.)
Mean of plots	59	205	49	379	76	33	0.58
Range	45–75	70–480	34–65	219–685	20–139	25–41	0.33–0.76

Table 2. Growth data derived from Tuson (1991). (GBV = gross bole volume)

		Eucalypt		Blackwood		
	Age	Stems/ha	GBV/ha	Stems/ha	Sawlog diameter	Sawlog/ha
Mean from strip assessment	77	90	330 m^3	11	43 cm	7 m^3

Using information from both these sources, the following estimates have been made:

- Eucalypt gross bole volume of 350–400 m^3 at age 85 years.
- Eucalypt sawlog to pulp ratio of 1:3, giving a yield of 100 m^3 sawlog and 250–300 t pulpwood/ha.
- Blackwood stocking at harvest of 150 stems/ha for fenced areas and 15 stems/ha in unfenced areas, of which two-thirds may have sawlog form.
- Blackwood sawlog length of 6–9 m Category 4, plus a 5 m utility log from the better trees and a 6–9 m utility log from the poorer formed trees.
- Average blackwood diameter MAI of 0.5 cm/yr, giving an average DBH of 42.5 cm at 85 years.
- Blackwood volume of 60–85 m^3 Category 4 sawlog, plus 50–70 m^3 utility log/ha for fenced areas and 8 m^3 Category 4 sawlog plus 6 m^3 utility log/ha for unfenced areas.

Yield estimates with future thinning.—The costs of commercial thinning were applied to the volume and revenue estimates for both fenced and unfenced eucalypt regeneration. Assuming stumpages of \$5/m^3, then returns from the commercial thinning operation are \$500/ha at age 30. Most of this revenue will be absorbed by the planning and supervision of the expensive thinning process (estimated at \$400/ha), giving a nett financial gain of \$100/ha.

The major benefit from thinning is the earlier supply of a better quality product. Total eucalypt volume at harvest did not change significantly, but estimated sawlog volume increased from 100 m^3 to 150 m^3, with a corresponding decrease in pulpwood volume. Rotation length was reduced to 70 years.

3. Financial analysis

Costs of fencing.—Table 3 shows the average materials and labour costs for two coupes in 1995 and fence-line preparation costing from one coupe in 1996. The average cost per kilometre of fence totalled \$4220. The District is still trying to reduce fencing costs so it is unlikely that these costs would be exceeded.

If an area/perimeter ratio of 15 hectares per kilometre is used, then \$4220/km equates to a cost of \$280/ha. A saving of \$30/ha in seed cost was then deducted, giving a marginal

Table 3. Average fencing costs for 1995/96 for Togari.

	Additional fence-line preparation	Fence materials	Contract labour	Total
Cost per km ($)	420	2060	1740	4220

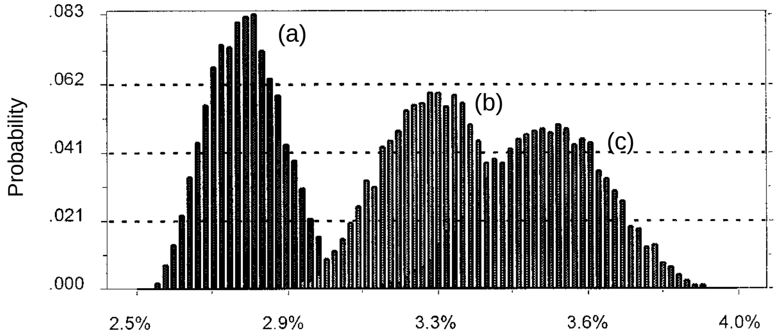

Figure 3. Internal rate of return for (a) native forest, (b) native forest with blackwood fencing and (c) native forest with blackwood fencing and thinning.

cost of blackwood fencing of $250/ha. Since control of browsing animals is not routinely carried out in all coupes in Togari Forest Block, a saving on animal control was not included in this base cost calculation.

Internal rate of return.—The standard 85-year native forest regime generated a mean internal rate of return (IRR) of 2.8% (range 2.5–3.0%). By fencing for blackwood, the mean IRR for this rotation was lifted to 3.2% (range 2.8–3.6%), demonstrating that the introduction of blackwood fencing increases the profitability for this type of extensive silvicultural regime. For blackwood fenced coupes where commercial thinning at age 30 years is possible, the mean IRR of the regime increases to 3.5% (range 3.0–4.0%). These results are shown in Figure 3.

As a discrete investment decision, fencing for blackwood has an IRR of 3.9% (range 2.9–5.0%). In combination with commercial thinning, this rises to 4.7% (range 3.4–6.0%).

Sensitivity analysis.—As a discrete investment decision, fencing for blackwood was overwhelmingly sensitive to the area/perimeter ratio. This model allowed area/perimeter ratios of between 10 ha/km and 20 ha/km, and produced 80.8% of the total variance (see Figure 4). This supports the suggestion that coupe size and shape is important and that the minimum 15-hectare-per-kilometre requirement should be met when selecting coupes for fencing.

Variations in the cost of fencing between $200/ha and $300/ha produced 7.7% of the

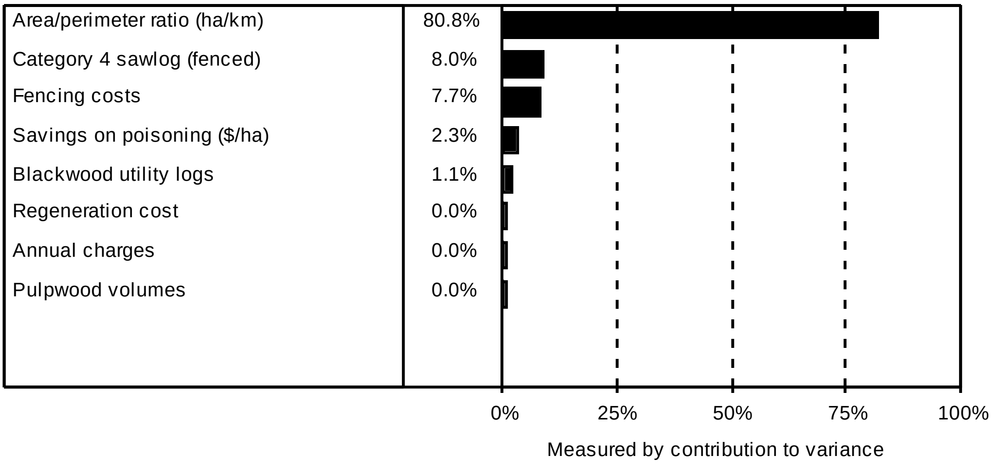

Figure 4. Major factors contributing to variance in the analysis of blackwood fencing.

total variance, indicating that reductions in fencing costs will have an influence, but not as important as coupe size and shape. The volume of Category 4 blackwood sawlog recovered at clearfell contributed 8.0% of variance.

Native forest regeneration costs, eucalypt pulpwood volumes and annual charges were not influenced by the decision to fence a blackwood area, and therefore had no impact on this discrete investment decision.

Discussion

The biggest asset for native forest blackwood establishment is the ground-stored seed resource originating from the previous forest. Regeneration procedures followed are identical to those for standard wet eucalypt forest, with the addition of a low quality netting fence to exclude browsing mammals. Fencing of these areas has proven to be an effective way of increasing the blackwood stocking, provided ground-stored seed is present. The regeneration produced can be patchy, which reflects the distribution of blackwood in the original stand. One of the additional benefits of fencing for blackwood regeneration is good early eucalypt growth due to the exclusion of browsing, with no requirement to reduce browsing animal populations by 1080 poisoning where fences are constructed.

It is not known whether the competition from a dense crop of blackwood will have an effect on the eucalypt overstorey volume. There may be a site limitation which prevents heavy stocking of both species, but this is considered unlikely because most wet eucalypt regrowth forests carry a heavy understorey of some species whether it be *Acacia* spp., *Pomaderris apetala, Phebalium squameum* or *Olearia argophylla.* If the estimated blackwood volumes can be achieved in the given rotation lengths, then the cost of the fence is more than covered by the increased revenue at harvest time, as long as the coupe size guidelines are used. Coupes which do not produce 15 ha fenced for each kilometre of fence line should not normally be fenced. The area / perimeter ratio is so influential because it combines the effects of both cost / ha spent and volume (revenue) received.

The financial success of fencing for blackwood in native forest is due to two things. Firstly, it is done opportunistically where the costs of eucalypt regeneration are already accepted and the only cost of this treatment is the marginal cost of fencing. Secondly, it produces a high value product which attracts a higher stumpage. Blackwood Category 4 sawlog will produce more than twice the revenue that the same volume of eucalypt Category 1 sawlog will produce.

This low ratio of expenditure to expected revenue gives a better return than standard eucalypt regeneration regardless of the rotation length or other treatment and therefore enhances the viability of native forest for wood production. In areas where growing native forest is a management objective, the construction of a fence increases the internal rate of return from 2.8% to 3.2%. In conjunction with commercial thinning, it achieves a mean IRR of 3.5%, which is considerably higher than that of standard native forest silviculture.

Even at its best, blackwood fencing only achieves a 5% return. By way of comparison, short rotation plantations usually achieve returns of between 5% and 12%, depending on the selected crop, rotation length and other factors.

There are other benefits from increasing blackwood production in conjunction with eucalypt regeneration which are not explored in this paper. They include an increase in the blackwood resource which allows flexibility with the blackwood sustained yield cut and a blackwood resource separate from the swamp blackwood resource, which increases wet weather harvesting flexibility. Fencing for blackwood also increases diversity in the silvicultural treatments used in the Circular Head District.

Recommendations

In order to ensure the operational success and financial viability of this treatment, the following guidelines should be followed:

- The areas selected for fencing must contain adequate ground-stored blackwood seed. This can be determined by assessment of the original forest or by soil sampling.
- The areas should be of a reasonable size (about 40 ha or larger), with a regular shape and reasonably straight boundaries (unsuitable corners can be excluded from fencing to improve the shape). A ratio of at least 15 ha fenced for each kilometre of fence line should be the target.
- The fence should be erected as cheaply as possible but to such a standard that little or no maintenance is required for the three- to four-year life of the fence.
- The fence should be erected within three weeks of the regeneration burn so that the flush of blackwood germination stimulated by the fire is protected.
- Early age spacing should not be carried out before a clear blackwood sawlog is achieved, or unless the understorey and scrub species are sufficiently thick to continue 'pruning' the blackwood stem to the required height.
- Commercial thinning prescriptions should specify that damage to blackwood stems is to be minimised. Supervision should be carried out so that this is achieved.

Acknowledgements

This paper is the result of many years of work by many people. Special thanks to Ross Lucas and Circular Head District staff who first trialled blackwood fencing at an operational level, Circular Head Management Branch for assistance with measuring and volume information, Bill Neilsen for help with statistics, Kevin Hortle for accessing CFI data, John Cunningham for thinning information, and John Hickey for direction and editing.

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