Productivity and economic implications of various silvicultural thinning regimes in Tasmanian regrowth eucalypt forests

A.V. LaSala*, J.K. Dawson and A.N. Goodwin
Forestry Tasmania, GPO Box 207, Hobart 7001

Abstract

Thinning of native eucalypt forests is employed in the densest even-aged regrowth stands. A series of simulated regimes involving different combinations of thinnings at ages of approximately 17, 32 and 47 years were applied to assessment data from high quality, young stands using growth and economic models. The objective was to evaluate the regimes on the basis of their ability to maximise sawlog volume and to determine their economic implications. Net Present Value (NPV) was calculated for each regime discounted back to the time of pre-commercial thinning (PCT) intervention using real discount rates of 5% and 10%. Regimes which ranked highest in terms of NPV did not rank highest in terms of sawlog volume, and vice versa. Sawlog yields in all thinned regimes exceeded those in the unthinned stands over a 65-year rotation, and consisted of larger sawlogs. A regime involving PCT plus one commercial thinning produced more sawlog volume at age 65 years than an unthinned regime at age 80 years. All regimes involving one or more commercial thinnings resulted in higher NPVs than allowing these stands to grow on without intervention until rotation ages of up to 80 years. The preferred thinning regime will vary according to the primary management objective.

* Corresponding author
e-mail: ann.lasala@forestrytas.com.au

Introduction

Forestry Tasmania is a Government Business Enterprise which manages approximately 1.5 million hectares of public land, of which 780 000 ha are native forests available for wood production. In 1997, the Tasmanian Regional Forest Agreement (RFA) was signed by the State and Federal Governments, significantly increasing the amount of forest protected by the reserve system and reducing the area of State forest available for wood production. The organisation needs to continue to meet existing wood-supply agreements, including a statutory requirement to supply 300 000 m^3 of high quality sawlog per year (Section 22AA, *Forestry Act 1920*, Tasmania).

Thinning has been identified as a way of enhancing regrowth forest productivity, and specifically of increasing sawlog yield given the reduced resource base. Commercial thinning has been practised on a small scale in Tasmania for many years, with a significant expansion in the early 1990s following the adoption of the Forests and Forest Industry Strategy (FFIS). Pre-commercial thinning commenced operationally in 1998 following the signing of the RFA.

Rawlins (1991), as part of the Young Eucalypt Program, analysed five management regimes for Australian regrowth eucalypt forests, representing increasing intensities of thinning. His results ascribed the highest

Net Present Value to a regime consisting of a non-commercial thinning at age five followed by a commercial thinning at age 20 and a clearfell at age 50. The application of his results to Tasmanian conditions has since been questioned, as they were considered to be 'based on a non-representative set of plantation growth data, run through an inappropriate growth model' (Public Land Use Commission 1996). A previous Forestry Tasmania study (Cunningham and Dawson 1995) found a regime involving a pre-commercial thinning at age 13, a commercial thinning at age 30 and a clearfell at age 65 would break even at a 4% discount rate based on the limited data available at that time. The current need for economic analyses which incorporate the effects on growth and yield of intensive silvicultural management has been highlighted at a national level (Raison *et al.* 2001).

The aim of this study was to evaluate several thinning strategies on the basis of their ability to maximise sawlog volume, while determining their economic implications. At present, all commercial thinning is done in previously untreated stands, as no stands which have been pre-commercially thinned are old enough for commercial thinning. The study did not seek to determine the economically optimal regime for individual sites.

Study sites and methods

Climate and forest type

Tasmania (146°E, 42°S) is an island located approximately 250 km south of the south-eastern tip of the Australian mainland. It has a temperate, maritime climate influenced by westerly weather patterns dominated by the Roaring Forties winds. Mean temperatures in summer range from 10°C to 23°C and in winter from –2°C to 14°C (Rogers 1997).

The majority of wood production occurs in wet sclerophyll forests, where thinning is concentrated in the higher quality areas. Wet sclerophyll forests are characterised by a dominant overstorey of *Eucalyptus* species of the subgenus *Monocalyptus.* The main commercial species are *E. delegatensis, E. obliqua* and *E. regnans,* collectively known as 'ash species'. These stands have a dense understorey of broadleaf trees or tall shrubs, and often a layer of ferns or sedges at ground level. Stands usually form even-aged cohorts, resulting from major disturbance events such as wildfire or a clearfell, burn and aerial sowing regime. These forests receive at least 1000 mm / yr of rainfall and are located between sea level and 600 m a.s.l. Soils are mostly fertile and acidic, with those of the better stands tending to be derived from dolerite and basalt parent materials (Wells and Hickey 1999).

Wet sclerophyll forests are typically managed using clearfelling, high intensity burning and aerial sowing. Typical rotation lengths are about 80–100 years, with mean annual increments (MAI, m^3 / ha / yr) of up to 10 on the most productive sites (Forestry Tasmania 2001).

Thinning techniques

Pre-commercial thinning (PCT) operations are carried out using manual stem injection of Glyphosate®. Stands are thinned to waste at about age 15 years, in preparation for a later commercial thinning. Commercial thinning (CT) operations in Tasmania are carried out using both mechanical, ground-based systems and cable harvesting. Commercial thinning is typically done in stands aged 25–40 years, with thinning yields consisting almost entirely of pulpwood.

Site characteristics

Ten coupes were chosen for inclusion in the study. All were vigorous stands on high quality sites, consisting of various proportions of the three ash species. All had been subjected to PCT at ages ranging from 14 to 21 years. Average coupe size was 36 ha. Basal area (BA, m^2 / ha) prior to PCT was closely related to tree density, with average tree size fairly constant across all coupes. Stand characteristics are given in Table 1.

The coupes had been pre-commercially thinned to an average retention rate of approximately 500 stems / ha of stems larger than 10 cm DBHOB (diameter at 1.3 m over bark). All prescriptions approximated a 50% BA removal, which is the operational standard. No commercial thinning operations had taken place at the time this study was done; therefore all references to commercial thinning results are based on modelled data only.

Data collection

The stand characterisation data used in the growth model were collected by contractors during each PCT operation as part of a mandatory self-assessment program reporting to Forestry Tasmania. Data were collected in circular 0.01 ha plots sampled at the rate of one per hectare, and consisted of tree tallies in 1 cm diameter classes. Injected and retained trees were counted separately, and all trees were classified as potential sawlog or pulpwood. The height of the tallest tree in each plot was measured and used to estimate height potential for the site (see Site Index explanation, Table 1).

Regime development

A series of notional thinning regimes was designed which incorporated various combinations of no thinning, pre-commercial thinning (PCT), commercial thinning (CT1), and a second commercial thinning (CT2). These regimes were simulated for each coupe using the growth and economic models described below.

The regimes were designed to meet current operational guidelines set by Forestry Tasmania (Forestry Tasmania 2001). All thinning treatments therefore retained approximately 50% of the pre-thinning basal area. In addition, the two commercial thinning treatments were required to retain

Table 1. Pre-thinning stand characteristics for coupes used in this study. (Abbreviations given in text.)

Parameter	Range	Average
Age at PCT (yr)	14–21	16.5
Site Index* (m)	31–47	36.8
Stems / ha†	939–1462	1209
BA (m^2 / ha)	20.5–34.2	27.4

* Site Index is defined as the mean height in metres of the tallest 30 eucalypts per hectare at age 50 years, and can be derived for any age from measured tree heights.

† Stems > 10 cm DBHOB.

at least 16 m^2 / ha basal area, and produce at least 70 m^3 / ha of removable pulpwood. Tree retention rates (stems / ha) were chosen to meet these goals in each of the regimes and therefore may vary between regimes. Basal area and stems per hectare refer to stems greater than 10 cm DBHOB at PCT age and to stems greater than 17 cm DBHOB at all other ages.

The age at which each coupe had been subjected to PCT was used as the base age for that coupe, and later treatments were applied at 15-year intervals from this base age. These intervals were designed to allow the stands to be thinned as soon as the basal area and volume criteria (above) were met.

Details of the regimes appear in Table 2. The standard forest management practice of clearfelling, high intensity burning, and aerial sowing is represented by the UT (unthinned) regime. The PRE regime, which involves a single pre-commercial thinning at age 15–25 years, is presented for comparison only. In practice, all PCT operations are performed to prepare the stand for a later commercial thinning. The CT1 regime approximates current practice for commercial thinning operations, with a single commercial thinning between ages 25 and 40 years. The PCT1 regime represents the planned management of stands treated with PCT at a young age, followed by a commercial thinning about 15 years later.

Table 2. *Thinning regimes utilised for modelling. (Abbreviations given in text.)*

Code	Description	Retention (stems / ha)	Average age (yr) at treatment
UT	No thinning	All stems	
PRE	PCT only	500	16.5
CT1	CT1 only	250	31.5
PCT1	PCT + CT1	500, 200	16.5, 31.5
CT12	CT1 + CT2	250, 100	31.5, 46.5
PCT12	PCT + CT1 + CT2	500, 200, 80	16.5, 31.5, 46.5

CT12 and PCT12 are notional extensions of regimes CT1 and PCT1, involving a second commercial thinning about 15 years after the first one. No second commercial thinning operations have been employed to date in eucalypt stands in Tasmania.

Growth model

The growth model used in this study is based on inventory and research plots located throughout Tasmania, and is based on the model (PFT 2004) routinely used for resource estimates by Forestry Tasmania. This model takes into account stand parameters such as age, site quality, and individual tree species when estimating future growth and yield.

The numbers and proportions of injected and retained trees in each diameter and product class in the study dataset were incorporated into the existing model, creating a generalised scenario of stem retention patterns in PCT operations. When regimes are applied, the thinning is executed probabilistically, preferentially retaining larger trees and trees of potential sawlog form until the prescriptions for stems per hectare are met.

Projected volume yields for each regime and coupe were generated and broken down into logs of different small-end diameter (SED) classes for each of the clearfell ages of 60, 65, 70, 75 and 80. These volume estimates were then processed using the economic model described below. In his explanation of the calculation of sustainable yield in Tasmanian State forests, Whiteley (1999) nominated 65 years as the rotation length for thinned stands and 90 years as the rotation length for extensively managed stands. Given the high site qualities of the coupes used in this study, and the inclusion of PCT as a management tool, particular emphasis has been paid to rotation ages of 65 and 80.

Economic model

A simple model was set up where thinning and harvest revenues, based on the log volume information generated in the growth model, were discounted back to the age of PCT intervention. This limits the analysis to a comparison among alternative treatments from PCT age onward. The model ignored all sunk and common costs, including the cost of native forest establishment and annual management costs. PCT costs were based on current practice. The same stumpages were used for all regimes, although in practice thinning operations may have slightly lower stumpages reflecting higher extraction costs. The net return after commercial thinning costs resulted in an interim revenue. Real discount rates of 5% and 10% were used to allow comparison with other forest management practices. Stumpage prices varied with small-end, under-bark diameter. Costs used were generalised; planners need to do their own analyses using real costs for their forest type and equipment configuration.

Pulpwood was defined in the growth model as having a minimum diameter over bark

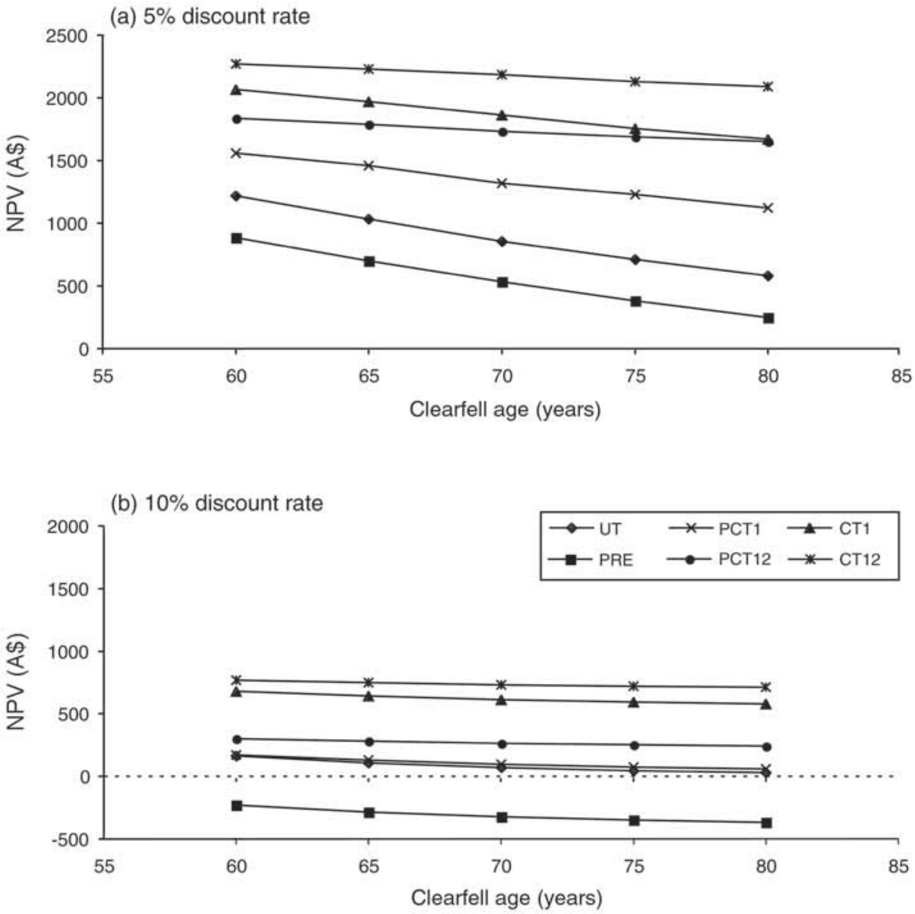

Figure 1. Net Present Values (A$) discounted back to the age of PCT intervention, by regime and five possible clearfell ages, at discount rates of (a) 5% and (b) 10%.

of 17 cm and a minimum SED of 10 cm. Minimum log lengths were defined as 2.4 m for sawlog and 3.6 m for pulpwood. Trees of potential sawlog form in the 20–30 cm SED category were identified by the growth model, but since they were assigned the same stumpage price by the economic model, they have been considered as pulpwood for discussion. Appearance grade, veneer-quality logs were included in the sawlog totals by the growth model, whereas structural-grade 'peeler' logs are included in the pulpwood totals.

The yields and economic returns for each coupe were examined individually and then averaged. Mean values for the ten coupes are presented and discussed, as trends in volume and economic return for each coupe followed the same patterns as the mean values.

Results

Modelled economic returns

Net Present Value (NPV) discounted back to the age of PCT intervention at rates of 5% and 10% is shown in Figure 1. Estimated values for each regime at five possible clearfell ages are shown. All NPVs decreased with increased rotation length, reflecting the relatively slow growth rates of native forests in Tasmania. At both discount rates, PRE was less worthwhile than UT, and actually represented a negative NPV at the 10% rate. All other regimes were more worthwhile than UT in these highly productive stands. Regimes CT1 and CT12 maximised NPV, as they provided pre-harvest revenues without incurring pre-harvest costs. The advantage gained in NPV between CT1 and PCT1, and between CT12 and PCT12 at any harvest age was roughly $500 / ha. This indicates that most of the difference can be accounted for by the cost of PCT, but that there is also some loss of volume due to PCT.

Table 3. Estimated yields of merchantable timber (m^3 / ha) at interim harvests and at clearfell for six thinnng regimes.

	Regime					
Harvest	UT	PRE	CT1	PCT1	CT12	PCT12
CLEARFELL AT AGE 65 YEARS						
First thinning						
pulpwood			152	117	152	121
sawlog			0	1	0	1
First thinning yield			152	118	152	122
Second thinning						
pulpwood					142	147
sawlog					19	53
Second thinning yield					161	200
Clearfell						
pulpwood	574	500	351	348	221	236
sawlog	150	249	225	298	145	140
Clearfell yield	724	749	576	646	366	376
Full rotation						
pulpwood	574	500	503	465	515	504
sawlog	150	249	225	299	164	194
Total yield	724	749	728	764	679	698
CLEARFELL AT AGE 80 YEARS						
First thinning						
pulpwood			152	117	152	121
sawlog			0	1	0	1
First thinning yield			152	118	152	122
Second thinning						
pulpwood					142	147
sawlog					19	53
Second thinning yield					161	200
Clearfell						
pulpwood	553	499	364	362	309	301
sawlog	275	386	384	480	229	244
Clearfell yield	828	885	748	842	538	545
Full rotation						
pulpwood	553	499	516	479	603	569
sawlog	275	386	384	481	248	298
Total yield	828	885	900	960	851	867

Estimated timber yields

Total volumes of merchantable timber (m^3/ha) estimated to be available at each harvest and at final clearfell ages of 65 and 80 are given in Table 3. Results given are modelled estimates only, represent mean values from the ten coupes in the study, and have not been subjected to statistical comparisons.

For both rotation lengths, harvested yields at clearfell were highest in the PRE regime with no interim harvest, and lowest in regimes with two commercial thinnings (CT12 and PCT12). Total yields over the life of a given rotation were comparable across regimes, again being lowest in regimes with multiple interim harvests (and in UT at age 80). PRE exceeded UT in volume at clearfell, as it had not suffered from the effects of natural suppression to the same extent. CT1 was able to yield more pulpwood at the time of its commercial thinning than PCT1, due to pulpwood which had been killed earlier being available for extraction. However, CT1 produced less volume at the time of clearfell and over the life of the rotation than PCT1.

Sawlog volumes at both clearfell ages for those regimes with one or no interim harvests decreased in the order PCT1→PRE→CT1→UT (Table 3). This reflects the beneficial effects of early and multiple treatments on sawlog production. Cumulative sawlog volumes for the UT regime were exceeded by those from all other regimes with a rotation length of 65 years, and by those from all other regimes except CT12 with a rotation length of 80 years.

Sawlog volumes for clearfells at age 65 and 80 were separated into small-end diameter (SED, cm) classes (Figure 2). A small amount of sawlog was also produced at the time of a second commercial thinning for the two regimes involved (not shown; see Table 4). Thinning increased the proportion of sawlog volume in the larger SED classes (> 50 cm SED). PCT1, CT12 and PCT12 all produced comparable amounts of sawlog volume in the SED 50–60 cm category. PCT12 produced the most sawlog volume in the SED 60–70 cm category.

Shorter rotations have been suggested as a possible outcome for thinning regimes

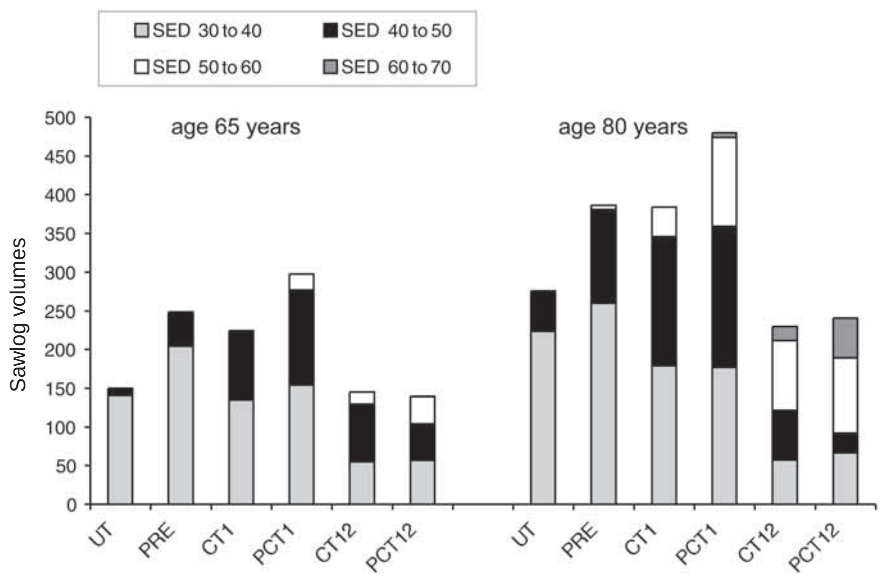

Figure 2. Mean sawlog volumes (m^3/ha) by small-end diameter classes (cm) at clearfell ages of 65 and 80 for six thinning regimes.

Table 4. Relative rankings of thinning regimes for different parameters for clearfells at ages 65 and 80. Rank 1 is the most profitable or productive for a given parameter.

	Clearfell at age 65				Clearfell at age 80			
Regime	NPV	Total volume	Sawlog volume	Summed rank	NPV	Total volume	Sawlog volume	Summed rank
UT	5	4	4	13	5	4	5	14
PRE	6	2	2	10	6	3	2	11
CT1	2	3	3	8	2	2	3	7
PCT1	4	1	1	6	4	1	1	6
CT12	1	6	6	13	1	6	6	13
PCT12	3	5	5	13	3	5	4	12

(Whiteley 1999). Therefore, the UT regime with a rotation length of 80 years has been compared with the other regimes with rotation lengths of 65 years (Table 3; Figure 2). At age 65 years, the PCT1 regime had more total sawlog than the UT regime had at 80 years, whereas the PRE and CT1 regimes at age 65 years were similar to UT at age 80 years in terms of total sawlog volume. Both CT1 and PCT1 had less sawlog in the SED 30–40 cm category but more in the SED 40–50 cm category at age 65 years than UT at age 80 years.

Economic and productivity ranking

The regimes have been ranked in terms of various economic and yield factors for clearfell ages of 65 and 80 years, with rank 1 being the most profitable or productive (Table 4). These rankings were then summed to give an overall ranking across the parameters for each regime. This system only allows comparison among regimes for a given clearfell age. Regimes which ranked most highly in terms of NPV did not rank most highly in terms of volume, and vice versa.

Discussion

Thinning can be performed for a variety of objectives; for example, producing a specific interim product, maximising NPV, or maximising yield of sawlog. This study aimed to identify the regime which would maximise sawlog yields; hence, PCT1 is the preferred option.

Factors affecting model results

Structural factors in both the growth and economic models have the potential to affect the results.

Fixed clearfell ages in the economic model mean that all coupes are evaluated at the same final age, regardless of the fact that their ages at the time of PCT varied. Subsequent thinnings were applied at set time periods from this PCT age, so the period from final treatment to final harvest may vary by up to seven years. This effect, however, is constant across regimes, and is mitigated further by the averaging of results across coupes.

Probabilistic thinning in the growth model removes trees from a stand using first principles at each application. Thus, yields at the first commercial thinning differ slightly for PCT1 and PCT12 (Table 3). This factor would become important if two regimes were extremely close in their predicted returns; for example, ± $50 / ha in NPV.

Sawlog classification was done at the time of PCT, at which time a tree is assessed as having sawlog potential if it contains one three-metre section of potential sawlog—otherwise, it is classified as pulpwood. At subsequent ages, the growth model classifies that entire section of these potential sawlog trees which meets sawlog size criteria as sawlog. Again, this bias is constant across regimes, and will not affect regime rankings or total merchantable volumes. It may, however, inflate sawlog volumes somewhat for all regimes.

Stumpages used in the economic model have the potential to affect model results and comparison of regimes, especially the use of identical stumpages for clearfell and thinning operations. A second series of stumpages was also set that reflected a much more rapid increase in prices with increasing log diameter (not reported here). The results obtained when using the 'ramped-up' stumpage prices resulted in no change to the relative economic rankings of the regimes. This is probably a result of the large diameter logs generally being available later in the rotation, when revenue affects NPV less.

Rotation length is another variable which will affect the comparison of regimes. One technique for setting appropriate endpoints for each regime would be to harvest at the age of peak MAI for a given forest product; for example, sawlog of a given size (Smith *et al.* 1997). Another approach would be to set the rotation length as the period of time until marginal costs equalled marginal revenue, which would most likely occur after peak MAI. Figure 2 indicates that by leaving stands until age 80 years before harvesting, sawlog volumes can be greatly increased for all regimes. Thinning can be seen as a means of periodically improving overall stand value by transferring productivity to the most valuable trees while liquidating others. With a management objective of sawlog production, thinning may actually enable longer rotations rather than shorter ones by lengthening the productive, value-adding period.

Operational damage which may occur during commercial thinning operations has not been incorporated in any modelled results. This type of damage causes sawlog trees to be downgraded to lower log classes or pulpwood. CT12 and PCT12 may be more subject to such damage than CT1 and PCT1, while UT and PRE incur no damage from this cause. The target for operational damage is no more than 10% (Forestry Tasmania 2001), which is generally met.

Background decay found in regrowth forests has been estimated to affect approximately 20% of total sawlog volume, as many logs do not meet allowable end-defect specifications (Wardlaw 2000). Sawlog volume estimates should therefore be reduced to account for this factor. Crop tree selection techniques which rely on external factors indicative of internal decay have proved to be effective in reducing the proportion of background decay retained in thinned stands. Therefore, this factor would affect the UT regime more than other regimes.

Fire may affect levels of stem decay during the life of the stand, particularly if fire occurs soon after thinning when slash fuels are still present in an undecomposed condition. Fire risk is therefore another variable to consider in the analysis.

Relative merits of the regimes

Based on the relative rankings in Table 4, UT scored relatively poorly for all parameters except total volume at clearfell, reflecting the fact that no volume had been removed prior to that time. PRE scored most poorly for NPV, due to the fact that there are early costs incurred for PCT, and no interim revenues. However, tree selection for potential sawlogs at the time of PCT seems to have been able to improve total and sawlog volumes at clearfell. CT1 scored in the middle range for all parameters, having a high NPV because of the interim harvest and no early costs, but lower clearfell volumes and values. This is because the stand was improved on only one occasion, and then left for a relatively long time during which it probably fully re-occupied the site. PCT1 scored poorly for NPV, reflecting the early costs of

PCT, but consistently well for all other parameters. This can be attributed to two treatments which improved stand quality followed by a relatively lengthy period in which the remaining trees were left to grow on. CT12 maximised NPV, by virtue of two interim revenues, but volumes and values at clearfell were low. PCT12 scores even more poorly than CT12, due to its early PCT costs and the associated reduction in available pulpwood.

Deciding on an optimal thinning regime for sawlog production comes down to a choice between UT, CT1 and PCT1. UT and CT1 reflect current practice. PCT1 has been started in many stands by doing PCT, with the expectation of a commercial thinning to follow. PRE has never been proposed as an end in itself. Second commercial thinnings (CT12 and PCT12) have not been employed to date in Tasmania. In any event, they are merely extensions of the regimes CT1 and PCT1, and the decision to do a second commercial thinning can always be made at a later stage.

Regimes CT1 and PCT1 both provide more revenue and will yield more timber than UT for a given clearfell age in this forest type. CT1 represents a higher NPV than PCT1 at all harvest ages, and is the regime of choice if only financial returns are considered. PCT1 will not bring a commercial thinning forward in time but will produce higher sawlog yields and higher overall wood yields over the life of the rotation. In dense, vigorous young stands, PCT1 is the regime of choice if the grower places a priority on sawlog production.

Acknowledgements

We thank John Cunningham for provision of data and John Hickey for support and comments on the draft manuscript.

References

Cunningham, J.K. and Dawson, J.K. (1995). Summary report on stem injection. Internal report, Forestry Tasmania, Hobart.

Forestry Tasmania (2001). *Thinning Regrowth Eucalypts.* Native Forest Silviculture Technical Bulletin No. 13. Forestry Tasmania, Hobart.

PFT (2004). FARM FORESTRY TOOLBOX V4.3. Private Forests Tasmania, Hobart.

Public Land Use Commission (1996). *Tasmanian – Commonwealth Regional Forest Agreement Background Report, Volume II, Part D: Social and Economic Report.* Tasmanian Public Land Use Commission in conjunction with Commonwealth Forests Taskforce, Hobart.

Raison, J., Rawson, R. and Connell, M. (2001). Intensive management of regrowth forests for wood production: a synthesis of workshop outcomes and requirements. In: *Intensive Management of Regrowth Forest for Wood Production Australia* (eds M. Connell, R. Raison and A. Brown), pp. 85–91. CSIRO Forestry and Forest Products, Canberra.

Rawlins, W.H.M. (1991). Economics of alternative management regimes. In: *The Young Eucalypt Report – Some Management Options for Australia's Regrowth Forests* (eds C.M. Kerruish and W.H.M. Rawlins), pp. 245–268. CSIRO, Australia.

Rogers, D.W. (1997). *Tasmanian Year Book 1998.* Australian Bureau of Statistics, Canberra.

Smith, D.M., Larson, B.C., Kelty, M.J. and Ashton, P.M.S. (1997). *The Practice of Silviculture: Applied Forest Ecology*. John Wiley & Sons, New York.

Wardlaw, T. (2000). Producing high quality eucalypt sawlogs – Not just a job done at the landing. In: *The Future of Eucalypts for Wood Products, IUFRO Conference,* pp. 365–373. March 2000, Launceston.

Wells, P. and Hickey, J.E. (1999). Wet sclerophyll, mixed and swamp forest. In: *Vegetation of Tasmania* (eds J.B. Reid, R.S. Hill, M.J. Brown and M. Hovenden), pp. 224–243. *Flora of Australia Supplementary Series* No. 8. Australian Biological Resources Study, Canberra.

Whiteley, S.B. (1999). Calculating the sustainable yield of Tasmania's State forests. *Tasforests* 11: 23–34.

Tasforests