The Forestier silvicultural systems trial: Alternatives to clearfelling

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Abstract

The Forestier silvicultural systems trial was established over the period 1987 to 1989 and was designed to evaluate a variety of silvicultural systems in wet eucalypt forests. Treatments tested included clearfelling and sowing, with and without burning; harvesting of small gaps (group selection) of approximately 100 m diameter, with and without burning; and partial logging, which involved thinning of the overstorey. Successful regeneration was achieved only in the coupes that were clearfelled, burnt and sown. Stocking levels were adequate in the partially logged treatments shortly after sowing but declined in subsequent years and the result was poor by age five. Regeneration in all other treatments was unsuccessful. The ultimate failure of the regeneration within the alternative treatments is attributed to the intense browsing pressure which is thought to have followed the harvesting.

Partial logging resulted in a noticeable increase in the growth rate of the retained trees in those treatments where between three quarters and one half of the trees were removed. However, thinning also resulted in a major proliferation of epicormic shoot development on the boles of the retained stems.

The results of this trial have been compromised by the lack of browsing monitoring and subsequent control. The trial has clearly demonstrated that monitoring of browsing damage to regeneration, and control of browsing animals where damage levels are unacceptable, is an essential part of native forest silviculture.

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Introduction

The principal objective of this silvicultural systems trial was to evaluate the effectiveness of partial-logging and group selection silvicultural systems in wet forest types compared to the current standard technique for harvesting wet forests of clearfelling, burning and sowing. The trial was also designed to evaluate the effectiveness of burning versus non-burning treatments as ways of establishing regeneration, and to examine the response of trees retained under partial-logging systems to their release from competition. The relative effectiveness of each of the silvicultural systems evaluated in the trial was tested by assessing the adequacy of the stocking and growth of regeneration subsequent to each treatment.

Harvesting commenced in 1987 and was completed in January 1989. It proceeded quite slowly because the contractor had a relatively small operation, consisting of a tracked loader/hauler, a rubber-tyred skidder and a crab-grab tracked loader.

The site selected for the trial was chosen deliberately at the drier end of the wet forest range (rainfall of about 1000 mm per annum). It was considered that silvicultural systems which were known to be effective in dry forests would be more likely to be successful in such forests than in forests where the rainfall is in excess of 1500 mm per annum.

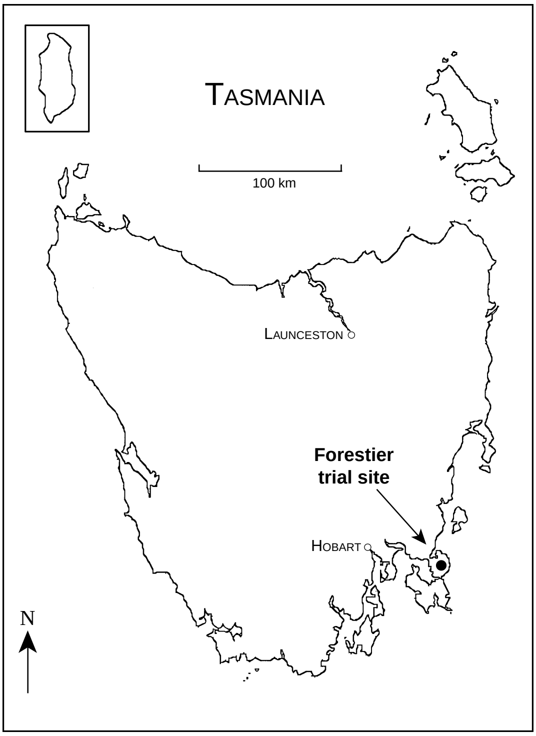

Figure 1. Location of the Forestier trial site in south-eastern Tasmania.

Silvicultural options

Clearfell, burn and sow

Clearfelling, followed by moderate to high intensity burning of the logging residues, and aerial sowing of seed has been demonstrated to be a very effective method of logging and regenerating wet eucalypt forests (Gilbert and Cunningham 1972; Wilkinson 1992). High intensity burning reduces the fuel load and hence the future risk of wildfire, and the ash-bed created by the fire enhances the early growth of the regeneration (Lockett and Candy 1984). The harvesting system is relatively safe compared with partial-logging systems (Mitchell 1993) and is the most cost-effective system (Forestry Commission 1994).

The disadvantages of the clearfell, burn and sow system include its high visual impact (Forestry Commission 1990), the loss of advance growth (Forestry Commission 1994), possible changes to the long-term species composition (Duncan 1996; Mueck and Peacock 1992; Murphy and Ough 1997; Peacock and Duncan 1995; Taylor and Haseler 1995) and, in high altitude forests or in areas susceptible to frosts, increased susceptibility to frost damage and the lack of an ongoing seed source (Battaglia and Wilson 1990).

Burning versus not burning

In wet eucalypt forests, burning of logging slash after harvesting has been shown to be more cost effective as a site-preparation technique than mechanical disturbance (King 1991). In dry eucalypt forests, it has been demonstrated that it is possible to harvest and regenerate the forest without burning by relying instead on mechanical disturbance to create sufficient seedbed (Forestry Commission 1993). It is possible to use mechanical disturbance in wet eucalypt forests but the much greater volume of logging slash and understorey debris raises additional problems. The voluminous debris reduces the area available as seedbed, increases the risk of uncontrollable wildfire for many years after the harvest (Forestry Commission 1994) and the seedlings do not get the benefit of the ashbed, which has been shown to stimulate healthy and vigorous growth of the eucalypts (Lockett and Candy 1984). Mechanical disturbance in areas of high rainfall may also result in substantial soil damage as soils are often too wet to achieve satisfactory effects from cultivation.

Partial-logging systems

Partial-logging systems were developed for forest types (notably dry grassy open forest and dry forests without established advance growth) where the clearfell, burn and sow regime was perceived to be unsuccessful, particularly in terms of adequately regenerating the site (Forestry Commission 1994). They have also been used in some mixed-age forest types as a means of allowing advance growth to develop further to sawlog size, rather than felling the poles for pulpwood at an earlier age. Retained trees of good quality can increase in size and value and achieve sawlog size much more quickly than can new regeneration.

Group selection

Group-selection logging systems (where small areas of trees are felled) can provide suitable conditions for regeneration and establishment of seedlings (Forestry Commission 1994). However, a number of problems arise simply because of the small size of the treatment. Roading, logging and burning costs are higher because of the small scale of the operation (Campbell 1997). It is more difficult to burn the area effectively and, even after a good burn, browsing pressures are high because the surrounding forest provides shelter for animals which browse the young regeneration. As the size of the coupe increases, and the area:perimeter ratio decreases, the impact of browsing animals has been shown to decrease (Mount 1976) and the regeneration burn is more manageable (Forestry Commission 1994).

The study area

Site description

The study area is located in wet eucalypt forest on the Forestier Peninsula, in south-eastern Tasmania (Figure 1). Before logging, the forest was predominantly even-aged *Eucalyptus regnans* regrowth between 60 and 80 years old, with some *E. obliqua* and *E. globulus* (also mostly regrowth) and very scattered oldgrowth trees approximately 250 years old. The regrowth forest was between 27 and 44 m tall, and its potential height at maturity of between 41 and 55 m indicated high site quality. The stand exhibited classic regrowth dieback symptoms, in that the subdominant trees, in particular, were observed to have considerable dieback of their crowns (T. Wardlaw, pers. comm.). In the unlogged areas, a number of the subdominant trees have died since 1989 whereas the dominant trees have since recovered and now show healthy growth rates. The understorey throughout was dominated by *Pomaderris apetala* (dogwood, native pear). The south-western portion of the study area is significantly drier than the rest and was dominated by *E. obliqua*.

The area was selectively logged early this century for sawlogs; subsequent wildfires between 1900 and 1920 removed the logging slash and undergrowth and created the conditions necessary for the establishment of the extant regrowth eucalypt forest.

Soils

Soils are brown/red ferrosols derived from dolerite. Moderately well-drained clay–loams lie over deep medium to heavy clays.

Climate

The long-term average rainfall of the trial area is approximately 900 mm per annum. It is relatively evenly distributed, with the driest months (January to March) receiving more than 50 mm per month. Cloud-stripping makes an important contribution to the effective rainfall on the site, as it does at many ridge-top sites on the east coast of Tasmania. Hence, the effective rainfall probably exceeds the stated figure. Average mean maximum and minimum temperatures respectively range from 11°C (July) to 22°C (February) and from 4°C (July) to 12°C (February). Frosts are common from May to September. The site lies within the humid warm/moist subhumid warm climatic zones as defined by Gentilli (1972).

Methods

Treatments

Four treatments were trialled in the study. The layout of the various coupes is shown in Figure 2. Harvesting commenced in December 1987 and was completed in January 1989. Burning treatments were applied in March and April of 1989 and the entire area was sown with eucalypt seed mixtures (at 0.6 kg/ha) in late April 1989.

1. *Group selection* (F, G, L and K, Figure 2)

   Two pairs of 100 m diameter gaps were felled. One of each pair was burnt and all were sown. In all the gaps (i.e. both burnt and unburnt), the fuel was mechanically heaped in the centre.

2. *Partial logging with two levels of retention* (E, H, I, J and M, Figure 2)

   (a) 'One in two' stems were retained, followed by top-disposal burning on part of each block, followed by sowing. (Three replicates: E, J and H)

   (b) 'One in four' stems were retained, then treated as above. (Two replicates: M and I)

   Area M was significantly drier than the rest of the partial-logging treatment area and is treated separately in the analysis of the regeneration surveys.

   The partial-logging treatments were applied to heterogenous stands and did not take into account the existing basal area of the stand being treated.

3. *Clearfell, burn and sow* (Areas A and N, Figure 2)

   The standard treatment as applied to wet forests over the past two decades was used as a 'control' for comparison with the other treatments applied to the site.

4. *Clearfell and sow* (Area A 'ub', Figure 2)

   A block was clearfelled and sown without burning. There was no subsequent heaping of fuel or additional mechanical disturbance of the block.

Monitoring methods

In order to monitor the relative success of each of the silvicultural systems, the characteristics of the seedbed, eucalypt seedling regeneration and the impacts of browsing were monitored in all of the coupes after harvest and subsequent treatments. The response of the retained trees to release from competition and the distribution of natural seedfall (both in time and space) were monitored in both the partially logged and unlogged areas.

Stocking (stems/ha) of eucalypt seedlings was measured one year and five years after completion of the harvest and subsequent treatments. The heights of the seedlings and of the understorey scrub were measured five years after completion.

Seedfall

Twenty-five seed traps were placed within the trial area. Nineteen traps were placed within the undisturbed forest adjacent to the trial. Six traps were placed within the partial-logging areas in two groups of three. Three were located beneath the crowns of retained trees that were heated (or scorched in some instances) by the top-disposal burning. Three more were located beneath the crowns of trees that were not heated. Observations were also made of the seed crop of felled trees.

Seedbed

The same set of plots that was established to survey the regeneration was used also to assess the nature of the seedbed. Each plot was scored as either burnt (high intensity burn); burnt (low intensity burn); highly disturbed (mechanically); partly disturbed (mechanically); or undisturbed. The relative proportion of each seedbed type in each coupe was then calculated. Correlation analysis was used to examine the relationship between the stocking of regeneration and the nature of the seedbed.

Regeneration

A 40 m x 40 m grid system of permanent plots (4 m^2) was established to monitor the germination, establishment and growth of eucalypt regeneration. The standard system (Forestry Commission 1991) was used to assess the stocking at each measurement. When there was no eucalypt seedling located on the 4 m^2 plot, a 16 m^2 plot centred on the

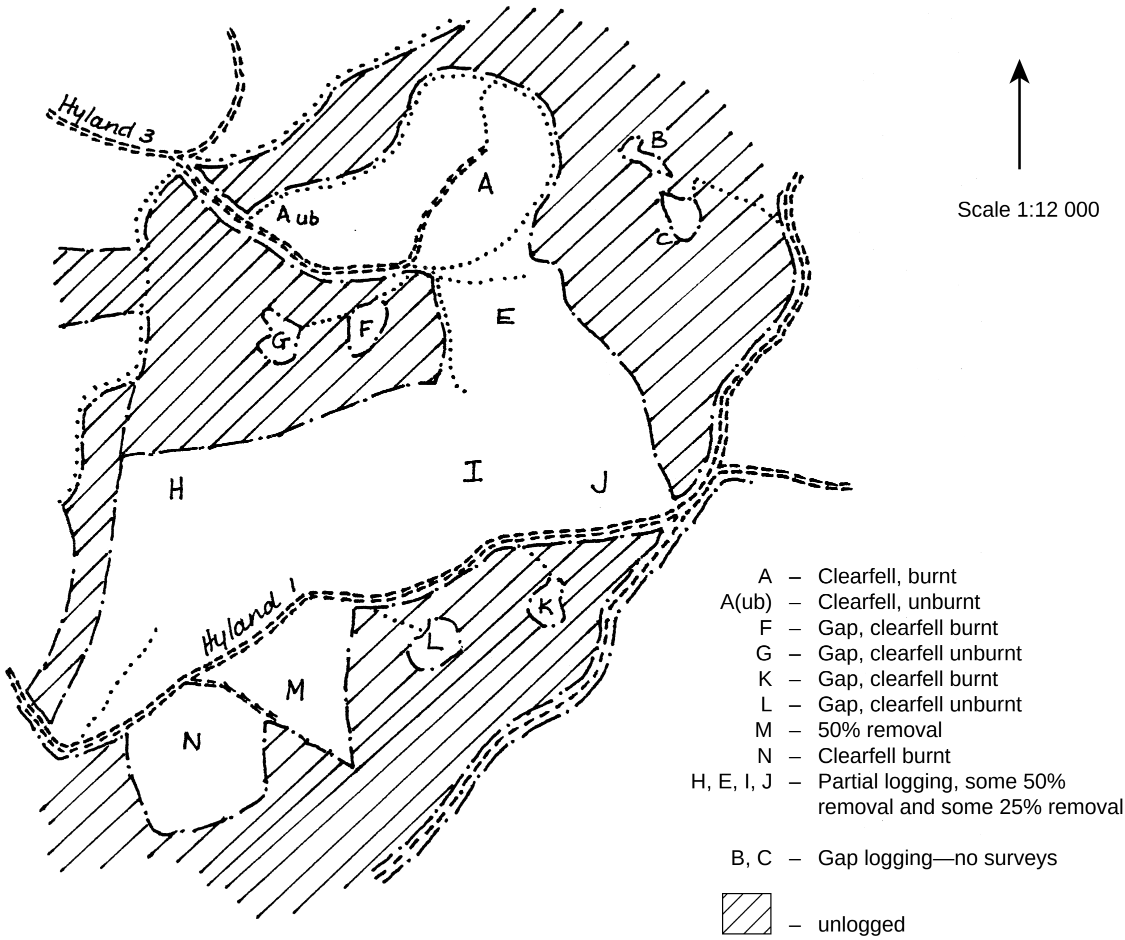

Figure 2. Layout of the Forestier trial.

same point was searched for seedlings (Forestry Commission 1991).

Height growth of the regeneration and the competing scrub

The mean dominant height of the eucalypts and the adjacent understorey scrub was assessed at five years. Within 10.3 m of each plot point of the regeneration survey, the height of the tallest eucalypt and the height of the tallest understorey species were recorded (equivalent to a rate of 30 trees/ha). The relative heights of the scrub and the eucalypts by treatment were compared using a range of statistical methods (analysis of means, *t*-tests, analysis of variance).

Browsing impacts

In order to monitor the effects of browsing, 15 fenced plots ranging in size from four to 10 m^2 were installed. The fences were constructed using steel star pickets and 80 cm high chicken wire mesh. They were erected after each coupe had been logged but before any post-logging burning had occurred.

Response of regrowth to partial release

Within the trial area, there were three planned levels of overstorey retention: 100%, 50% (i.e. one in two stems retained) and 25% (one in four). Within each treatment, five trees (all *E. regnans*) with

Table 1. Details of the seed mix used to aerially sow the site.

Species	Seed zone	Proportion (%)	Weight used (kg)
Eucalyptus regnans	L18 and M38	60	30
Eucalyptus obliqua	L13	35	18
Eucalyptus globulus	L13	5	3
			51

Seed zone	**Location**	**Rainfall**	**Temperature**
L13	Nugent, Forestier and Tasman Peninsula	moist	cool
L18	Geeveston, Southport and Sth Bruny Island	moist	cool
M38	Snow Hill, Mt Connection and Tooms	intermediate	cold

good or full crowns, medium crowns and small or poor crowns were selected before logging, for monitoring after logging. The diameter at breast height over bark (dbhob) of each tree was recorded at each measurement.

The growth response of the retained trees following the partial-logging treatment was analysed using multi-factor analysis of variance and multiple range tests.

Results

Seedfall

Virtually no viable seed was collected in the seed traps between establishment of the trial and completion of the harvest (i.e. between December 1987 and January 1989). Observations of the seed crop during harvest revealed that nearly all of the *Eucalyptus regnans* and most of the *E. obliqua* had virtually no seed in their crowns. The south-western corner of the block, which carried drier *E. obliqua* forest, had an adequate seed crop (McCormick and Edwards 1991). As a result of the poor seed crop, the entire trial was aerially sown with 51 kg of seed at a rate of 0.6 kg/ha. Details of the seed mix are shown in Table 1.

Seedbed

The proportions of each of the described seedbed types that were produced by each treatment are shown in Figure 3. It is apparent that the proportion of receptive (burnt or disturbed) seedbed is higher in the clearfelled and burnt coupes than in any of the other treatments. Correlation analysis of the overall stocking of regeneration and the nature of the seedbed showed that there was no statistically significant relationship between the two.

Regeneration

Table 2 shows the results of the regeneration surveys at ages one and five years. A coupe that has 30% of 4 m^2 plots stocked is considered to be adequately stocked if the seedlings are well distributed throughout the coupe (Lockett 1979). The table shows that two treatments achieved adequate stocking. The clearfelled, burnt and sown areas had 51% of the 4 m^2 plots stocked at the five-year remeasurement and the partial logging in the drier forest types had 35% of the 4 m^2 plots stocked at the same time. It is also clear that the stocking of all the other treatments was inadequate and decreased between the age one and age five measurements. The stocking of blackwood regeneration in the unburnt, clearfelled gap was significantly higher than in the burnt clearfelled gap.

Height growth of the regeneration and the competing scrub

Figure 4 shows the mean dominant heights of the eucalypts and the competing scrub for the four treatments at the five-year measurement. There are no significant differences between

Table 2. Results of the regeneration survey at age 1 year and age 5 years. (MDH = mean dominant height)

Treatment type	Eucalypt seedling stocking (%) age 1 year: 4 m² plots stocked	Eucalypt seedling stocking (%) age 1 year: 16 m² plots stocked	Eucalypt seedling stocking (%) age 5 years: 4 m² plots stocked	Eucalypt seedling stocking (%) age 5 years: 16 m² plots stocked	Heights (m) and basal areas (m²/ha) age 5 years: scrub height	Heights (m) and basal areas (m²/ha) age 5 years: eucalypt MDH	Heights (m) and basal areas (m²/ha) age 5 years: retained basal area	Blackwood seedling stocking (%) age 5 years: 4 m² plots stocked	Blackwood seedling stocking (%) age 5 years: 16 m² plots stocked
Clearfell, unburnt, sown	24	36	16	20	3.6	4.0	0	0	0
Clearfell, burnt, sown	38	69	51	78	1.8	4.4	0	0	0
Gap, clearfell, burnt	25	50	14	19	3.2	4.7	0	11	11
Gap, clearfell, unburnt	32	51	11	17	3.2	4.9	0	26	47
Partial logging (dry)	64	68	35	45	2.2	4.3	7.8	0	0
Partial logging (wet)	19	32	11	26	3.8	4.0	7.6	0	0
Partial logging (overall)	28	40	16	30	3.5	4.1	7.7	0	0

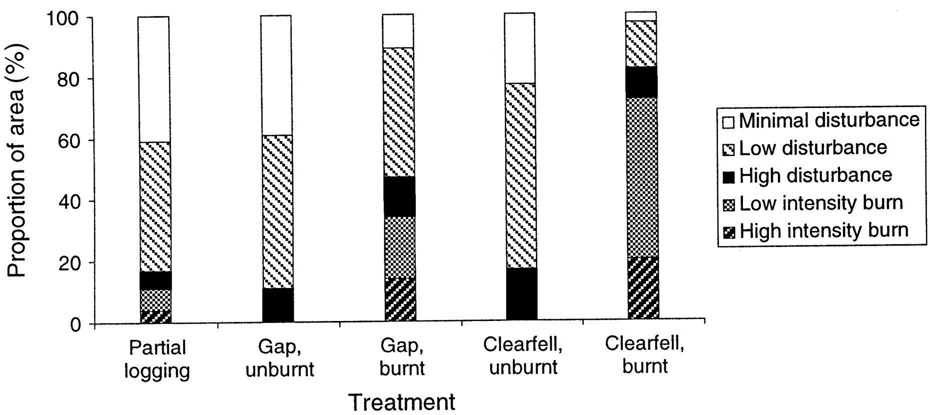

Figure 3. Proportions of various types of seedbed, by treatment, eight months after logging.

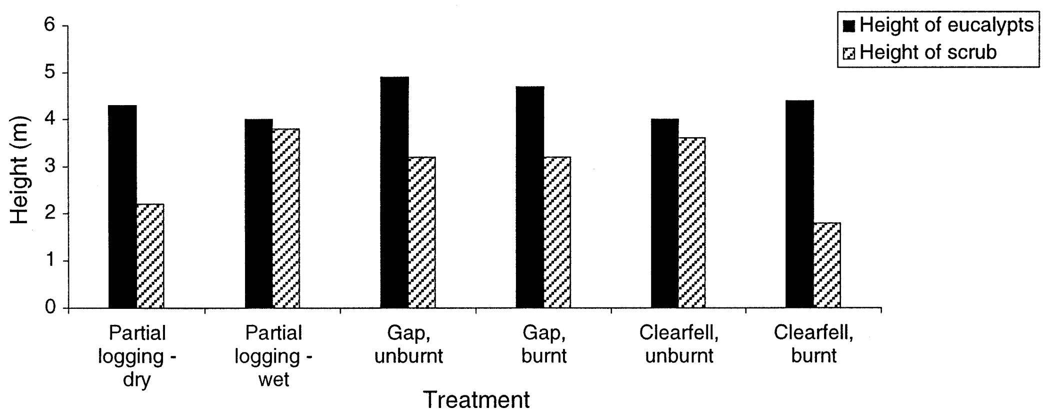

Figure 4. Height growth of eucalypt regeneration and competing scrub, five years after harvesting.

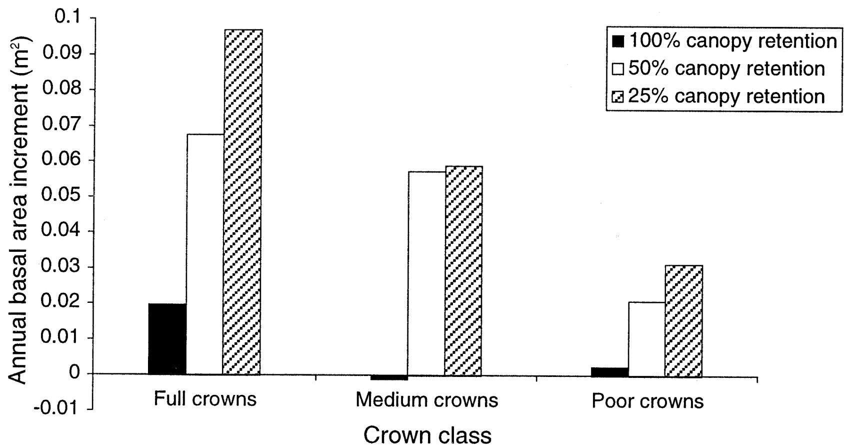

Figure 5. Average annual basal area increment of retained trees.

the heights of the eucalypts among the different treatments. There are no statistically significant differences between the height of the regeneration and the height of the scrub, either within or across treatments. Analysis of the scrub height by treatment showed that the distribution of the scrub heights was skewed and transformations of the data did not normalise the distribution. The skewness of the scrub heights is thought to be attributable to the fact that, in the partially logged areas, scrub from the pre-harvest stand persisted intact alongside post-harvesting germinants; thus the scrub heights tended to fall into one of two broad classes, ranging from one to four metres and from six to ten metres.

Browsing impacts

Fences from nine of the 15 fenced plots that were constructed were stolen before any data were collected. There were not sufficient plots remaining to draw any statistically valid conclusions regarding the impacts of browsing on the establishment of regeneration. However, it was clear from a visual assessment of the site that there were established seedlings within all the fenced plots, whereas, with the exception of the clearfelled, burnt and sown coupe, established seedlings were uncommon outside the fences (Photo 1). Observations recorded by officers working in the trial during establishment suggests that animal numbers in the area were high and that significant browsing was taking place.

Response of regrowth to partial release

Figure 5 shows the annual increment in basal area for the three levels of canopy retention and for the three canopy classes. Two trees with the poorest crowns died between the first and second measurements: these trees have been treated in the analysis as if they had stayed the same size.

Multi-factor analysis of variance showed that there was a significant response of the trees to release from competition. For the retention level, the result was highly significant at $P < 0.001$ and, for the crown class, the result was also significant at $P < 0.05$.

A multiple range test showed that there was a significant difference in growth between the trees in the 100% canopy retention group and those in both the 25% and 50% retention groups. The test also showed that there was no significant difference in response between the trees in the 25% and 50% classes.

Discussion

Seedbed

The proportion of receptive (burnt or disturbed) seedbed is higher in the burnt coupes than in the mechanically disturbed coupes. Correlation analysis between the apparent seedbed receptivity and its stocking with regeneration showed no significant relationship. Because of the excessive browsing damage that occurred within the trial, it is not possible to determine whether the amount of receptive seedbed that was created by mechanical disturbance would have been sufficient to allow adequate seedling establishment, nor is it possible to determine whether the seedbed created by a hot burn was more or less receptive than the seedbed prepared by mechanical disturbance.

Photo 1. Established seedlings in a fenced indicator plot. Note the browsing pressure outside the fence.

Regeneration

All the treatments had reasonable stockings one year after sowing but, with the exception of the clearfelled, burnt and sown treatment, stockings declined rapidly in the subsequent winter. The rapid reduction in the stocking of these coupes with time is attributed to the heavy levels of animal browsing that occurred, particularly in the winter of 1990, some 15 months after sowing, when the seedlings were becoming established. (See also the notes below on the assessment of browsing impacts.)

Blackwood regeneration was observed only in the 'gaps' coupe. The difference in stocking between the two coupes may be the result of the different treatments. In the burnt gap, it was observed that all the blackwood seedlings germinated immediately following the fire and were then browsed, whereas in the unburnt coupe, germination, which would have been triggered by mechanical disturbance, occurred over a longer period of time, and the seedlings were protected to some extent by the retained slash. Wilkinson and Jennings (1994) also found that high intensity burning resulted in a flush of germinations, which effectively exhausted the supply of ground-stored seed in the upper soil profile, whereas soil disturbance alone resulted in lower levels of germination, which left a supply of ground-stored seed in the upper soil profile that would be available following later disturbance. The protection to palatable young seedlings afforded by retained slash has been observed by a number of authors (Orr 1991) so that the assumption that seedlings survived better on the unburnt coupe appears reasonable.

Height growth of the regeneration and the competing scrub

The mean height of the eucalypts is not significantly different between treatments.

Stocking of the eucalypt regeneration is significantly different between treatments, and only the clearfelled, burnt and sown treatment was considered well stocked at the five-year measurement. (The partial-logging treatment on the driest site is considered adequately stocked, but barely.) The scrub height on the clearfelled, burnt and sown treatment appears (Figure 4) to be lower than that on the other treatments but the non-normality of the data invalidated statistical tests used to test that hypothesis (as explained above). There was no scrub left intact on the clearfelled, burnt and sown treatment, which may explain the apparent shortness of the scrub on this treatment.

The lack of variation in the height of the eucalypts by treatment suggests that the understorey scrub is not having a significant competitive effect on the height growth of the eucalypts at this stage. However, with some treatments, this is based on only a small number of trees, and longer term assessments of the productivity of each treatment would inform this question further.

Browsing

The dramatic drop in the stocking levels that occurred between the age one- and five-year assessments on all the coupes except the clearfelled, burnt and sown coupe is attributed to the effects of animal browsing, but there are insufficient data from the fenced plots to be able to quantify this accurately. The site is on a ridge at a relatively low altitude, close to the coast. Maximum/minimum thermometers maintained at the site between 1990 and 1993 showed no unusual or out-of-season frost, so that the chance that a particularly heavy frost killed the regeneration is considered to be low. There was no recorded exceptional snowfall in the period between the age one and age five measurements. Rainfall for the 1990 to 1993 period, as measured by a rain gauge maintained at the site, was close to the long-term average, so that drought was not a factor. Visual observation by one of us (LE) of the coupe in the years following sowing indicates that the most likely cause of the decline in stocking was browsing.

Partial logging/regrowth-release

The retained trees in both the 25% and 50% canopy retention treatments showed a positive response to release from competition. The response was most marked in those trees that had balanced, healthy crowns before treatment (Figure 5). However, the overall vigour of the crowns before harvest was poor. This was considered to be the result of regrowth dieback that arose possibly from an extended dry period during the 1980s (T. Wardlaw, pers. comm.). After harvest, many of the retained trees died, whilst others recovered, predominantly through extensive development of epicormic branches (Photo 2). This epicormic development may have been a factor in the increased growth rates of the trees following harvest, but their poor form means that few, if any, will be suitable as sawlogs in the future. Forestry Tasmania (1998) found that epicormic branch production in a 60-year-old stand of *Eucalyptus obliqua* was closely related to the size of the crown: the greater the crown volume, the lower the incidence of epicormic branch production following thinning. The generally poor crowns of the trees in this trial may similarly be related to the high levels of epicormic branch production following thinning.

In the partially logged areas, damage to the retained stems was minimal and the distribution of retained stems was good. The contractor experienced some difficulty when logging the wetter, steeper parts of the block and, in some cases, the disturbance to the understorey was not adequate to create suitable seedbed. In future operations, the contractor could be encouraged to create more seedbed and disturb the understorey to a greater degree. However, this would have to be weighed against the increased risk of soil damage resulting from compaction or mixing of soil horizons under wet conditions. Burning on the clearfelled areas created extensive receptive seedbed. The gaps burnt less readily but, since the contractor

Photo 2. Epicormic shoot development following harvesting in the canopy retention treatment.

had heaped much of the fuel, the resulting seedbed was good. The top-disposal burning was more difficult to carry out successfully. For most of the autumn following logging, the fuel was very dry and the risk of scorch and subsequent tree death was considered too high. Burning under *E. regnans* is problematic when compared to other eucalypt species because of its low resistance to scorch damage (Edwards and Wilkinson 1995). The top-disposal burns were eventually conducted on an ideal day, although it was only possible to get heaped fuels to burn and the lighter fuels scattered across the coupe would not burn.

Conclusions

Successful eucalypt regeneration is known to be dependent on the creation of a suitably receptive seedbed, either through burning or through mechanical disturbance, and on the control of browsing by mammals (when and where browsing is a problem) during the first two or three years after logging (Forestry

Commission 1999). The major reason for the failure of regeneration in this trial is thought to be heavy browsing pressure in the first and second winters after establishment. The early regeneration survey indicated that adequate stocking of the coupes was likely; later figures clearly show that regeneration declined to inadequate levels. These results clearly demonstrate the importance of monitoring regeneration for browsing damage during the first two years after regeneration is established. Early control of browsing damage in this trial would have resulted in higher stocking of established regeneration. This in turn would have allowed a more comprehensive assessment of the varying impacts of the different treatments on the success or otherwise of the regeneration.

It is very difficult to make statistically supported statements about the different treatments in the absence of adequate regeneration across the trial, but it is possible to make informed observations. The most successfully regenerated areas were those given the standard treatment of clearfell, burn and sow across a large area. The small gaps that were given the same treatment had less successful regeneration, which again is attributed to the heavy browsing pressure. As browsing mammals must be coming into the coupe from adjacent forest, it is logical to conclude that the smaller the area treated, the greater will be the browsing impact from adjacent forest, and vice versa (Mount 1976). In the unburnt coupes, the animals can find shelter within the unburnt logging slash and the consequent browsing damage in this case was such that very few seedlings became established after logging.

Partial logging of even-aged regrowth in this trial demonstrated that there is a growth response of the retained trees to the release from competition. Similar results from thinning regrowth forests have been obtained by a number of authors (see Forestry Tasmania 1998 for a review of recent research). Before partial logging can be routinely prescribed in wet forests, there are a number of problems to resolve. Where effective regeneration is required†, it is essential that the harvesting method create sufficient receptive seedbed. In this trial, this was difficult to achieve because of the large amount of logging slash and understorey, which was difficult to burn because of the constraints imposed by the heavy fuel load, by limited suitable weather conditions and by the high sensitivity of *E. regnans* to fire damage. On the one afternoon when the weather and the surrounding fuel conditions were suitable, the condition of the slash ranged from being too moist to burn, to being so dry that the level of scorch to the retained trees was unacceptable. It is also essential that the level of damage caused by browsing animals be monitored and that if, and when, browsing damage exceeds acceptable levels, some form of control of browsing animals is undertaken. Options for such control in wet forests are limited: fencing is difficult and expensive to establish and equally expensive to maintain; shooting where visibility is limited is unlikely to be effective; and poisoning with 1080 is effective and economic but socially unpopular.

With the benefit of the experience from this and other wet forest harvesting trials (Allen 1992), a range of alternative methods of harvesting wet eucalypt forests have been developed and will be tested at the Warra Long-Term Ecological Reseach site over the next five years (see http://www.warra.com).

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† In commercial thinning operations, regeneration is often not required because the stand remains well stocked following the thinning operation.

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