Natural and planted regeneration after harvesting of Huon pine (*Lagarostrobos franklinii*) at Traveller Creek, western Tasmania

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Abstract

A trial was established at Traveller Creek in western Tasmania in 1987 to compare three methods of regenerating Huon pine after selective harvesting. These methods were natural regeneration, planting of rooted cuttings, and planting of freshly gathered (on-site) cuttings.

Natural regeneration was often successful on disturbed sites where a Huon pine seed source existed within 50 m, although growth rates were extremely slow. Over the 16 years after harvesting, the mean annual height increment of natural seedlings on permanent plots was 2.3 cm/yr. Planting of rooted cuttings was also successful, with over 60% survival and mean annual height increment of 8 cm/yr over the 16-year period. Planting of unrooted cuttings was not successful. Both planting methods were adversely affected by late season planting, followed by a dry summer.

The results of this trial are consistent with current silvicultural prescriptions, which recommend that a combination of natural regeneration and rooted cuttings be used to ensure that regeneration of Huon pine is established by age five, when regeneration success is assessed for reporting purposes.

Introduction

Huon pine (*Lagarostrobos franklinii*)[1] is an endemic podocarp largely confined to the river systems of western and southern Tasmania (Peterson 1990; Gibson *et al.* 1991). It produces a unique timber, which was used historically for boat-building, window frames and other items which required a high level of durability. It is now used mainly for specialty furniture and smaller craft items. It is Tasmania's longest living softwood, often surviving for thousands of years (Francey *et al.* 1984).

Up to 500 m^3 of millable Huon pine, including salvage of dead and down timber, are selectively harvested each year from the Teepookana Plateau under the conditions of the management plan for the Teepookana State forest (Forestry Commission 1990). Regeneration of Huon pine is very slow, occurring via seedlings or vegetative reproduction (Gibson and Brown 1991; Shapcott 1991), so the harvested areas at Teepookana are regenerated using a combination of methods to ensure that regeneration is successful.

An operational trial was established in 1987 at Traveller Creek, some 15 km from Teepookana, to evaluate regeneration techniques for Huon pine (Kelly 1988). The trial is unreplicated and, ideally, a fully replicated trial would be established to confirm the observations reported in this paper. However, the current trial

[1] Scientific names for plants follow Buchanan (2005). Species' authorities are also given there.

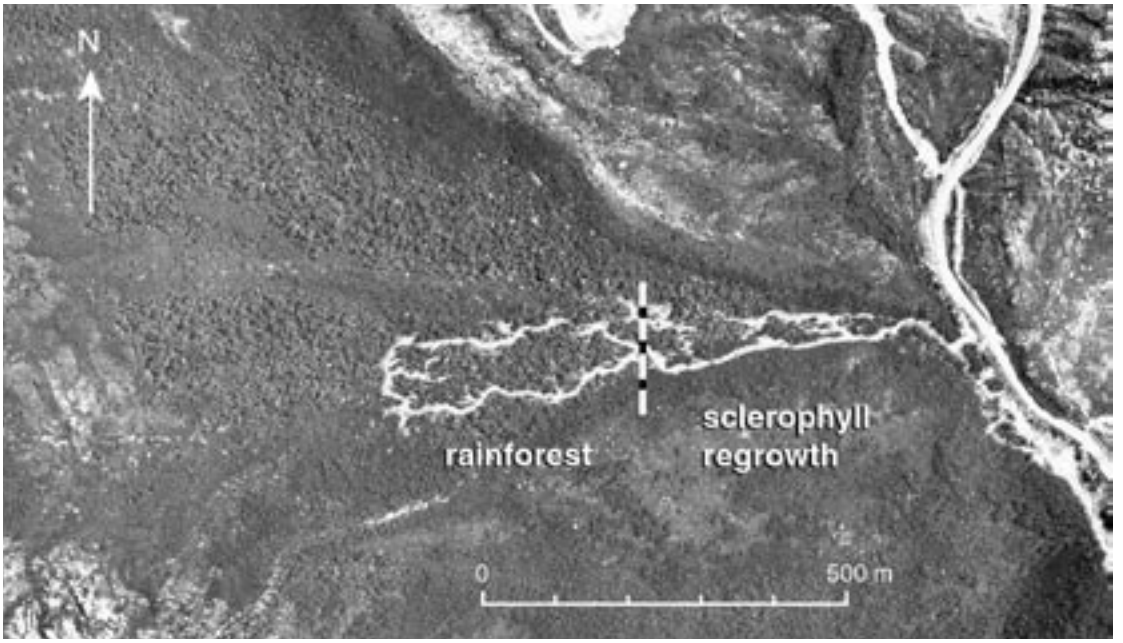

Photo 1. Aerial view of the Traveller Creek harvested area, photographed in 1991. (The dashed line marks rainforest to the west and sclerophyll regrowth to the east; continuous white lines are roads or tracks.)

is unique in that it represents the only formal assessment of natural and assisted regeneration methods for Huon pine after selective logging.

Methods

The site

The trial site is located on the eastern mid-slopes of Mount Jukes, approximately 10 km south of Queenstown at about 500 m a.s.l. (GDA: 384895E, 5329649N). Traveller Creek and a tributary drain the site in well-defined gullies. A thin, peaty soil lies over and amongst rocks and boulders of Ordovician siliceous conglomerate (Richley 1978). The mean annual rainfall is approximately 2500 mm.

The upper slopes of the site are covered by implicate rainforest with Huon pine, myrtle (*Nothofagus cunninghamii*), leatherwood (*Eucryphia lucida* and *E. milliganii*) and celery-top pine (*Phyllocladus aspleniifolius*) as dominant tree species. Occasional King Billy pines (*Athrotaxis selaginoides*) are also present. The lower slopes to the south-east are covered with wet sclerophyll forest dominated by *Eucalyptus nitida* with a thick understorey of *Banksia marginata* and *Leptospermum* species. The sclerophyll forest includes occasional dead Huon pines and downers (fallen trees) and appears to be regrowth following a fire. It seems likely that, prior to the fire, the sclerophyll forest of the lower slopes was formerly rainforest rich in Huon pine and similar to that which still exists on the upper slopes. There is also evidence of fire-scorch on some of the Huon pines in the rainforest on the upper slopes.

The forests in the area have been selectively logged several times for Huon pine and for a supply of wood fuel (mostly eucalypt) for smelting at nearby mines. Kerr and McDermott (1999) describe a steam-driven spot mill set up at Traveller Creek in 1935 by Cliff Bradshaw, and a track built from Mount Jukes to haul timber by a horse team to their mill. By 1940, the mill had been moved to the Princess River. The fire that regenerated the regrowth at the site probably occurred in the period from 1935 to 1940.

Photo 2. Searching for Huon pine seedlings on permanent plot 8. Sixteen years after harvesting, the Huon pine seedlings have been overgrown by the much faster growing seedlings of other rainforest trees and cutting grass (the sedge Gahnia grandis*).*

Harvesting

An area of 7 ha was selectively logged for Huon pine at Traveller Creek from June to September of 1987. The harvesting was confined to a narrow strip running west from the Mount Jukes Road (Photo 1). Dead Huon pine (logs) and trees in poor condition (i.e. with mostly dead crowns) were harvested. Some Huon pines in fair-to-good condition were left as part of the retained forest. The retention rate for Huon pine was not specified but was in the order of 10 trees per hectare. Huon pine is predominantly dioecious (with either male or female trees; Shapcott 1997), but no attempt has been made to identify the sex of the retained trees.

Regeneration types

Three modes of regeneration were assessed: natural regeneration, cuttings freshly gathered from the site (referred to as instant cuttings), and rooted cuttings.

Natural regeneration.—Regeneration of Huon pine by seed originating from the retained trees was monitored over time using 10 permanent 4 m^2 circular plots. The plots were subjectively located on prospective seedbed along the main snig track, at intervals of approximately 20 m. They were located to sample both disturbed and undisturbed seedbed and a range of crown covers. The numbers of Huon pine, myrtle, leatherwood, celery-top pine and sassafras (*Atherosperma moschatum*) seedlings on each plot were counted and the height of the tallest one of each species was recorded. Seedlings at the cotyledonary stage were not counted. The plots were monitored in 1988, 1992 and 2003 (i.e. at 1, 5 and 16 years after harvesting) (Photo 2).

During the 2003 measurement, a temporary regeneration transect of forty 16 m^2 circular plots was also established. The transect was located on the disturbed seedbed of the main snig track, starting at the top of the harvested area near the planting blocks and finishing before the creek crossing near Mount Jukes Road. Huon pine seedlings were counted and the height of the tallest one on each plot was measured. Plots were scored as stocked if at least one Huon pine seedling was present. Seedlings of

Table 1. Stocking and height of natural Huon pine seedlings, and stocking of other rainforest species, on a temporary regeneration transect 16 years after harvesting. Plots in rainforest are within 50 m of a live Huon pine; those in sclerophyll forest are greater than 50 m from a live Huon pine. (n = number of plots; S.E. = standard error; n/a = not applicable)

	Rainforest (n = 23)	Sclerophyll forest (n = 17)
Huon pine		
Plots stocked (%)	39	0
Seedlings		
Mean no./plot (S.E.)	2.1 (0.6)	0
Mean no./ha	1332	0
Mean height (cm) of the tallest seedling (S.E.)	15 (2.1)	n/a
Other rainforest species		
Plots stocked (%)		
Myrtle	74	12
Leatherwood (2 spp.)	100	6
Celery-top pine	9	0
Sassafras	13	0

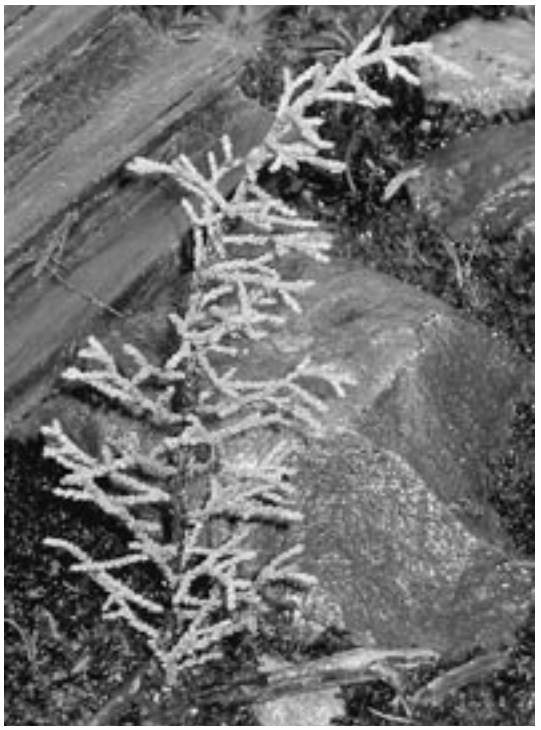

Photo 3. A natural Huon pine seedling, 16 years after the forest was harvested. Its height is 15 cm.

other rainforest species were recorded as present or absent only. The vegetation type and proximity of live Huon pine trees was noted at each plot. Of the 40 plots on the temporary regeneration transect, only the western 23 plots were within 50 m of a live Huon pine seed tree. The remaining 17 were in the sclerophyllous vegetation with fewer rainforest species, and were more than 50 m from a Huon pine seed tree.

Instant cuttings.—In October 1987, one hundred fresh tip-cuttings (about 15 cm long) from nearby Huon pine saplings and trees accessible from the ground were pushed 5 cm into disturbed soil. The cuttings were set out as a block on a grid of approximately 3 m spacing. No rooting hormone was used. The cuttings were measured at establishment and again in 1992 and 2003. The health of each cutting was assessed in late 1987 and winter 1988, using three categories: healthy, alive but unhealthy, and dead.

Rooted cuttings.—Ninety-five established Huon pine cuttings were obtained from the Forestry Tasmania nursery at Perth. The source location of the cuttings is not known. These were rooted and had been in the nursery for approximately two years. They were planted on site in August 1987, in two blocks in disturbed soil in rainforest, and measured four months later and again in 1992 and 2003. The health of rooted cuttings was also monitored in 1988, using the same categories as those used for the instant cuttings.

Results

Natural regeneration

Temporary regeneration transect.—The stocking and height of natural Huon pine regeneration along the temporary transect after 16 years are shown in Table 1. Plots within 50 m of a live Huon pine contained an average of 2.1 seedlings per plot, whereas no seedlings were found in plots greater

than 50 m from a live Huon pine. Height growth was slow, with the mean annual increment (MAI) of the tallest seedling in each plot averaging only 0.9 cm/yr across the 16 years of the trial. Most of the seedlings occurred in areas that had been heavily disturbed during the harvesting; for example, where rain-washed silt had built up behind small obstructions such as rocks and woody debris, and where exposed gravel was only slowly colonised by other species. Photo 3 shows a typical natural Huon pine seedling 16 years after harvesting.

Other rainforest tree species were also much more successful in regenerating on the western part of the transect (Table 1), where the surrounding vegetation had a much higher rainforest component. The most prolific was leatherwood, with 100% of the western 23 plots being stocked with either *Eucryphia lucida* or *E. milliganii* seedlings.

Permanent regeneration plots.—The seedling densities of the four most common rainforest tree species were measured over time in the permanent plots, and the results are shown in Figure 1. *Eucryphia lucida* and myrtle had the highest seedling densities. At five years, *E. lucida* was more than twice as abundant as myrtle but, within 16 years, high losses amongst the *Eucryphia* seedlings resulted in the two species having a similar abundance. Neither celery-top pine nor sassafras seedlings had established on the permanent plots, although some cotyledonary sassafras seedlings were present.

Low levels of natural Huon pine regeneration were found on the plots at each measurement, but recruitment of Huon pine is ongoing. All but one of the seedlings were established on plots with a disturbed seedbed. Several Huon pine seedlings disappeared from the permanent plots between measurements and were replaced by smaller recruits.

The height growth of the four most common rainforest tree species on the permanent plots is shown in Figure 2. *Eucryphia milliganii* was dominant, with growth rates of the tallest seedlings almost twice that of any other species. Myrtle height growth was very slow, with a MAI for the tallest seedlings over 16 years of less than 3 cm/yr. Huon pine height growth was also slow but steady, with a MAI of the tallest seedlings of 2.3 cm/yr. The tallest individual Huon pine seedling across all ten permanent plots showed a MAI (height) of 6 cm/yr.

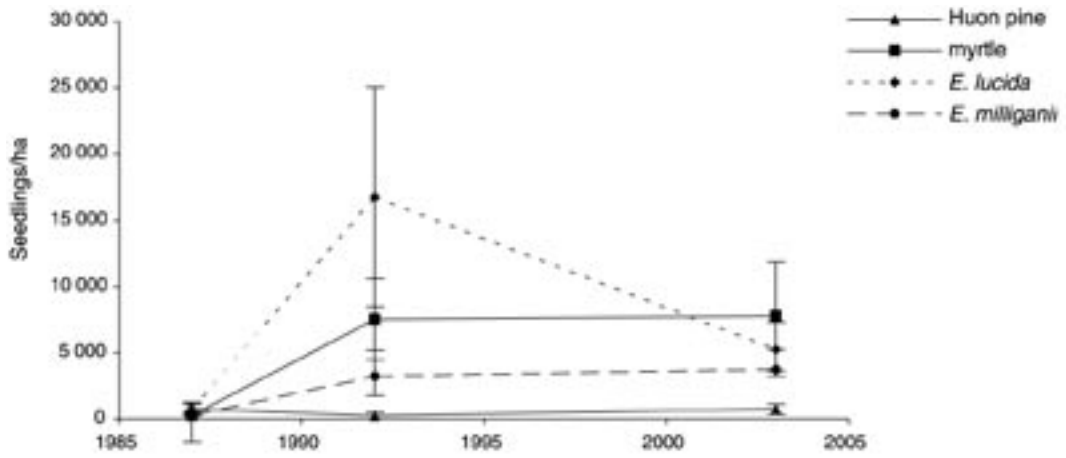

Figure 1. Seedling density over time for the four most common rainforest tree species in the permanent regeneration plots. (Error bars, S.E.)

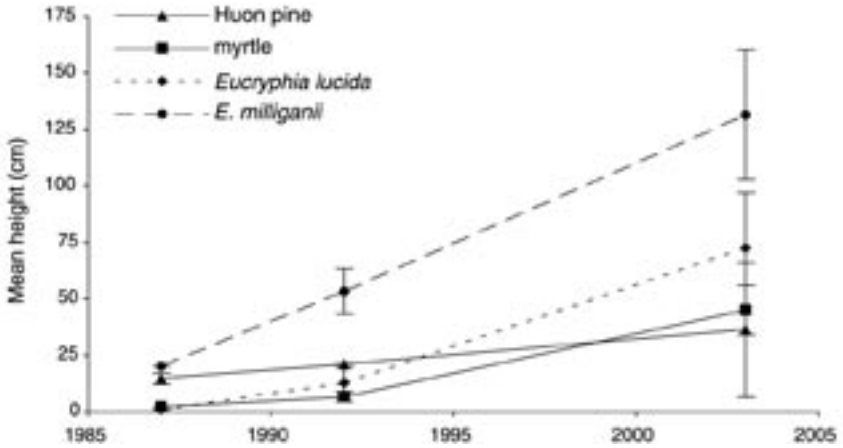

Figure 2. Heights (mean of the tallest individual in each plot) over time for the four most common rainforest species in the permanent regeneration plots. (Error bars, S.E.)

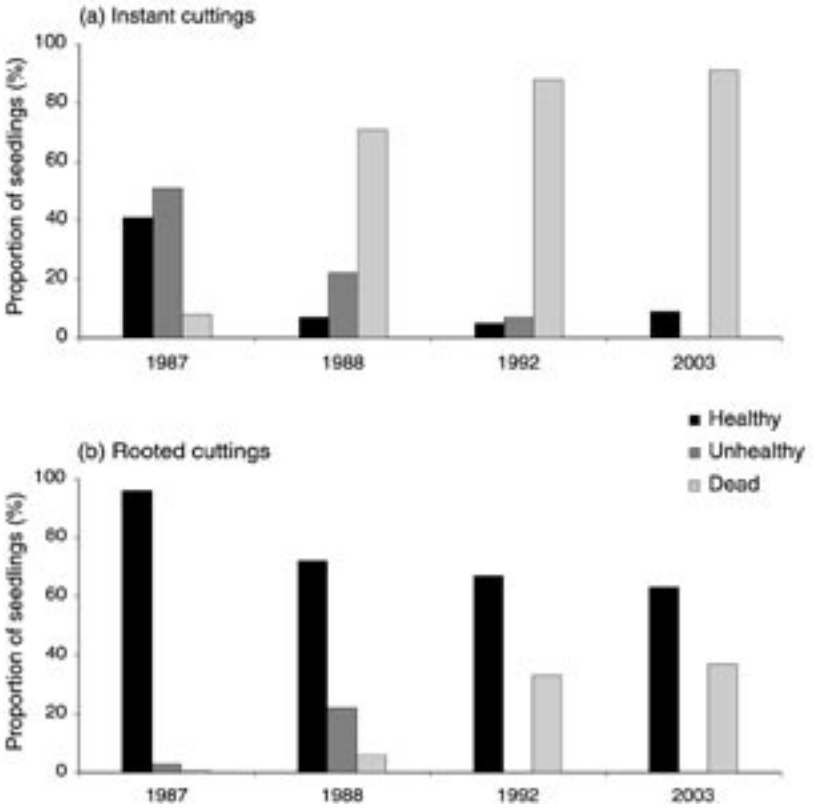

Figure 3. Health status of Huon pine cuttings over time for instant and rooted cuttings.

Instant cuttings

Health and survival.—The first health assessment of the instant cuttings took place in December 1987, two months after planting. At this time, 91% of the cuttings were still alive, but only 41% were healthy (Figure 3a).

Six months later, 70% of the cuttings were dead, with a further 22% unhealthy. The summer of 1987/88 was particularly dry, as shown by the soil dryness index (SDI)—a measure of how much moisture is required for soil saturation (Mount 1972). The SDI for Queenstown during January to April 1988 peaked regularly between 40 and 50 mm, while it varied between 10 and 20 mm, reaching 0 mm several times (Kelly 1988) during January to April in 1987 (a summer that was slightly wetter than normal).

The decline in health slowed over the next few years, with the number of live, healthy plants increasing slightly to 9% by the 2003 measurement.

Height growth.—The instant cuttings were very slow to become established, with high mortality and little height growth over the first five years. The plants that survived through that period then showed a periodic annual increment (PAI) of 1.5 cm/yr in height over the next 11 years (Figure 4).

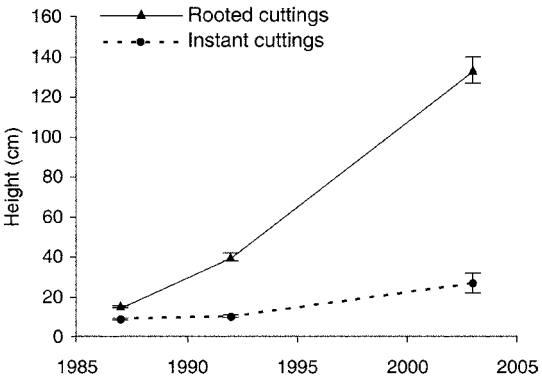

Figure 4. Height (mean of the tallest surviving individuals) of instant and rooted cuttings over time. (Error bars, S.E.)

Rooted cuttings

Health and survival.—In December 1987, four months after planting, 96% of the rooted cuttings were healthy (Figure 3b). This number declined to about 70% over the following dry summer and then stabilised over the next five years.

Height growth.—The rooted cuttings were slightly taller than the instant cuttings at planting and showed much faster growth (Figure 4). After the initial five-year period, their height growth increased further with a PAI (height) over the last 11 years of 8.2 cm/yr. A typical Huon pine grown from a cutting is shown in Photo 4.

Discussion

The results reported here are the first formal assessment of Huon pine regeneration success under different treatments. Although the trial is unreplicated, it is still relevant to developing regeneration guidelines for Huon pine.

Natural regeneration of Huon pine at Traveller Creek established very slowly, with most seedlings regenerating on areas of seedbed disturbed by harvesting. The mean height of the tallest seedlings in each plot on the temporary regeneration transect was only 15 cm after 16 years (0.9 cm/yr). Over the same period, seedlings on the permanent plots showed height growth of 2.3 cm/yr.

Shapcott (1991) suggests that years of heavy seeding (mast years) for Huon pine occur approximately every five to seven years. The timing of seedfall may also have contributed to slow early establishment. Observations at Teepookana (Leigh Clark, pers. comm.) indicate that it takes several years after harvesting on these gravelly sites for the build-up of pockets of silt suitable for seedling establishment.

Lateral seed dispersal in Huon pine is very limited (Shapcott 1991; Shapcott *et al.* 1995),

apart from seeds borne by rivers. Results from the temporary regeneration transect are consistent with this finding, since no seedlings were found in plots where live Huon pines were more than 50 m away. Notwithstanding these constraints, 39% of the plots on the temporary regeneration transect which had an available seed source were stocked with at least one Huon pine seedling. This is an acceptable standard for Huon pine regeneration (Forestry Tasmania 2003), given that the range 10–39% is classified as 'minimum ecological stocking' (Lutze 2003).

The rooted Huon pine cuttings were very successful, with over 60% survival over 16 years and a height growth of 8 cm/yr, which is much faster than that of the natural regeneration. The survival of the instant cuttings was low (9%) but could have been higher if the cuttings had been 'planted' several months earlier in the season. The rooted cuttings were planted at the end of winter, while the instant cuttings were not planted until spring of the same year. This put the instant cuttings at a disadvantage because they would have been establishing roots as the soils were drying out. The addition of rooting hormone might also have assisted in establishment.

Photo 4. A Huon pine rooted cutting, 16 years after planting. Its height is 130 cm.

The summer of 1987/88 was particularly dry and it is likely that both instant and rooted cuttings may have been more successful if planted prior to a summer of higher rainfall.

Height growth of other rainforest species, particularly myrtle, was also slow on the plots. Myrtle growth rates were less than one-tenth of those recorded by Hickey and Wilkinson (1999) for lowland rainforest on fertile sites. This can be attributed to the nutrient-poor site at Traveller Creek. Read and Hill (1988) showed that myrtle was the dominant species in callidendrous rainforests (high fertility sites) but not in implicate rainforests (low fertility sites), where species such as *Eucryphia* and celery-top pine were co-dominant with myrtle.

Current practice for regenerating Huon pine

The current recommendations for Huon pine regeneration are outlined in *Rainforest Silviculture* (Forestry Tasmania 1998) under 'Silviculture of rainforest dominated by Huon pine' (p. 25). The recommended silvicultural system uses both natural regeneration and planting to ensure that a harvested area has a satisfactory stocking of Huon pine regeneration of a reasonable size within a five-year time frame. This system was derived from operational and field experience. The results of the Traveller Creek logging and regeneration trial generally support these recommendations.

The recommendations, as listed in Forestry Tasmania (1998), include:

- Identification of seed trees (female trees) before harvesting;
- Retention of 10 healthy, well-crowned female seed trees per hectare;
- Collection of cutting material from the site before harvesting to provide rooted cuttings at the rate of 100 plants per hectare;
- Retention of advance growth seedlings during harvesting;
- Survey of natural regeneration after harvesting to identify understocked areas;
- Planting of rooted cuttings in understocked areas during winter;
- Protection from fire.

It is recognised that some of these points are difficult to achieve in an operational situation. It is particularly difficult, and not routine practice, to identify the sex of trees before harvest, although seed trees are retained. An alternative approach to ensure that trees of both sexes are retained may be to retain at least 20 live Huon pine trees per hectare where they are available, on the assumption that sufficient of these trees will be female. Note, however, that Shapcott *et al.* (1995) found that some Huon pine stands have quite skewed gender ratios and are dominated by one of the sexes.

Current practice is to plant rooted cuttings immediately after the completion of harvesting. This relies on collection of cutting material from an area at least 18 months prior to harvest, allowing time for the cuttings to develop roots in the nursery. Because of the slow colonisation of the gravelly seedbeds, it would be acceptable for the planting to be delayed by up to two years, allowing for the cutting material to be collected during the harvesting operation. Because of the unique genetic identity of different Huon pine stands (Shapcott 1997), it is very important that cutting material be collected from the site where it is to be planted out. Where there are not sufficient numbers of seed trees in the forest before harvesting, planted seedlings become a vital part of the regeneration strategy. In other areas, they are a safeguard against infrequent seed years and ensure that the areas are stocked within the required timeframe.

It is not currently recommended that instant cuttings be used as a method for regenerating harvested areas. However, the concept still has potential and could be tested again, using rooting hormone and winter establishment, as a cheaper option than rooted cuttings.

Acknowledgements

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