Comparison of the effects of spot and strip cultivation on the early growth of *Eucalyptus nitens* and *Pinus radiata* in Tasmania

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Abstract

The height and volume growth of Eucalyptus nitens *and* Pinus radiata *plots in northern and southern Tasmania were compared over a period of seven years following site preparation by spot cultivation (Ro-Tree cultivator) and conventional ripping and mounding. Four plots were located on poor quality soils at elevations below 450 m, and one plot was located on high quality soils at an elevation of 700 m in north-eastern Tasmania.*

Examination of tree height after two years shows that ripping and mounding have produced significantly better growth than spot cultivation at three low quality sites, whereas spot cultivation was significantly superior to ripping and mounding at the high quality site. However, after seven years, the only significant difference between treatments was at the high quality site, where spot cultivation exceeded ripping and mounding.

Comparison of stand volume (m^3/ha) after three years showed that ripping and mounding produced a trend to better growth at the four low quality sites but the results were not significant. However, after seven years, this trend was reversed, with higher stand volume occurring at all the spot-cultivated sites but, again, the results were not significantly different.

The three sites planted to E. nitens *showed marked age differences in growth related to elevation and soil quality. The site at highest elevation with high quality soils showed relatively poor early growth but then after four years surged ahead of all the other sites. Conversely, the site at lowest elevation (110 m) produced the greatest early height growth but, after seven years, has dropped to second lowest in terms of height and volume production.*

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Introduction

In Tasmania, conventional site preparation for plantations has concentrated on ripping and mounding, usually carried out simultaneously with a ripper-mounder unit mounted on a high-powered bulldozer. This system works well on logged areas that have been burnt and are largely clear of logging slash, and on farmland. With the current trend away from burning in order to conserve nutrients contained in slash, particularly on low quality sites, the trafficability and effectiveness of dozer-based ripper-mounder units have become restricted.

The use of excavators for site preparation has gained popularity over recent years. They can be used for windrowing heavy slash with minimal disturbance to the nutrient-rich topsoil layer (Turnbull *et al.* 1992) as an alternative to burning or line-

Table 1. Environmental characteristics of the sites.

	Blessington	Camden	Glengarry	Retreat	Plenty
Rainfall (mm / yr)	1000	1400	900	900	1200
Elevation (m)	400	700	110	130	450
Previous vegetation	dry eucalypt	wet eucalypt	dry eucalypt	radiata pine[1]	wet eucalypt
Parent material	Mathinna siltstone	Mathinna sandstone	Permian sandstone	Mathinna sandstone	Triassic sandstone
Soil profile class[2]	Lefroy	Sideling	unnamed[3]	Retreat	Sandspit
Soil drainage class	well drained	well drained	moderately well drained	moderately well drained	well drained
Soil-texture profile	gradational	gradational	texture-contrast	texture-contrast	texture-contrast
Nutrient levels	low	high	low	low	low–medium
Erodibility class	moderate	low	high	high and moderate[4]	moderate–high
Plantation species	*E. nitens*	*E. nitens*	*E. nitens*	*P. radiata*	*P. radiata*

[1] Previously dry eucalypt forest.
[2] Soil-profile class names follow Grant *et al*. (1995).
[3] Closest correlative is Buckland soil-profile class formed on Triassic sandstone (Grant *et al*. 1995).
[4] High where bleached sandy layers present; moderate where sandy layers have been eroded and clayey subsoils exposed on the surface.

raking with dozers. An excavator can also be used as a spot ripper-mounder without prior removal of slash. Other advantages of excavators are that they can operate safely on steeper slopes than dozers and, because they result in patchy disturbance to the soil surface rather than continuous lines of cultivation, excavators generally produce significantly less risk of soil movement. This feature is particularly important on sites where soils are highly erodible. However, the main disadvantage of spot cultivators is that because of slower ground coverage, unit costs are invariably much higher. Several different types of excavator-mounted spot cultivators are currently available in Tasmania, including the Wilco and Ro-Tree cultivators.

This paper compares the growth of young plantations of radiata pine (*Pinus radiata*) and hardwoods (*Eucalyptus nitens*) over seven years after preparing five contrasting sites in Tasmania using both the Ro-Tree cultivator and conventional ripping and mounding. It is assumed that any significant change in tree growth resulting from different site cultivation will occur within this time frame. As the sole objective of the trial was to investigate any effect of different site cultivation on tree growth, no attempt was made to compare costs of carrying out the two treatments, nor were uncultivated treatments included.

The study area

The five sites cover a wide range of environmental features (Table 1). Four of the sites occur in northern Tasmania between the West Tamar area and Diddleum Plains (Blessington, Camden, Glengarry and

Retreat), whereas the fifth is located in the middle Derwent Valley (Plenty) in southern Tasmania. Retreat and Plenty are planted to *P. radiata*; the other three sites to *E. nitens*. Topography ranges from undulating and easy rolling low hills with an elevation less than 150 m at Retreat and Glengarry to rolling hills with an elevation of 700 m at Camden. At Blessington and Plenty, the topography comprises undulating to rolling hills at elevations between 400 and 450 m.

The Blessington, Glengarry, Retreat and Plenty sites are generally classed as being of lower quality for plantations due to low levels of soil nutrients. Soils at these sites are correlated with the Lefroy, Buckland, Retreat and Sandspit soil-profile classes described in Grant *et al*. (1995). In the upper soil layer (0–10 cm), concentrations of total phosphorus and total nitrogen are typically less than 100 ppm and less than 0.15% respectively for representative soils (Grant *et al*. 1995). Laboratory analysis of surface soils near the Plenty trial site (Grant 1998) showed low total nitrogen (< 0.01%) and medium total phosphorus (100–250 ppm). Soils at the Glengarry, Retreat and Plenty sites have texture-contrast profiles characterised by thin, dark-coloured topsoils overlying bleached loamy sands that in turn overlie yellowish brown clays or clay loams. At Glengarry and Plenty, topsoils including bleached layers vary in thickness from about 25–45 cm, and subsoils are relatively soft and appear easily penetrable by tree roots. However, at the Retreat site, topsoils and bleached layers are relatively thin (< 20 cm) and occur sporadically due to the effects of previous topsoil degradation. Subsoils are generally heavy clays with poorly developed structure. Consequently, the Retreat soils have a soil physical limitation of restricted root penetration as well as low levels of nutrients. Soils at Blessington have gradational texture-profiles with thin loamy topsoils overlying well-structured clayey subsoils. Stone content varies from negligible at Glengarry to few at Retreat and common (< 30%) at Plenty and Blessington.

The Camden site has well-drained soils with gradational texture-profiles characterised by relatively thick (> 20 cm) loamy topsoils overlying relatively soft, well-structured clayey subsoils. They are correlated with the Sideling soil-profile class (Grant *et al*. 1995). Nutrient levels are relatively high, with concentrations of total P and N typically exceeding 350 ppm and 0.3% respectively in surface (0–10 cm) layers (Grant *et al*. 1995). The Camden site has better quality soils than the other four sites, but it occurs at higher elevation (700 m). Site characteristics are summarised in Table 1.

Methods

The sites were cultivated in the autumn of 1995 following windrowing and burning at the Blessington, Camden, Glengarry and Plenty sites. Windrowing was not carried out at the second rotation site (Retreat) and cultivation followed a light broadcast burn. Planting was completed at all sites in the spring of 1995. The Retreat site was ripped without being mounded, whereas all the other sites were both ripped and mounded by a single ripper-mounder unit. The sites selected for the trial had only one replicate of each treatment, generally located adjacent to each other so as to minimise any differences in soils and other environmental features.

At the Retreat site, no weed control was carried out, resulting in the prolific germination of wildling *P. radiata* seeds from the first rotation. These wildlings competed vigorously with the planted stock throughout the length of the trial. Weed control with residual herbicide was carried out at the Glengarry and Plenty sites, whereas, due to the short time lag between cultivation and planting, no weed control was deemed necessary at Camden and Blessington.

In each treatment, approximately 45 trees (3 rows x 15 trees) were initially measured in May 1996 for height growth. The surviving trees were measured over the period May–July for height and diameter (DBH) in the

Table 2. Tree survival after seven years at five sites in Tasmania.

	Survival (%)					
	1996		1997		2002	
Site	R / M[1]	R-T[1]	R / M	R-T	R / M	R-T
Blessington	96	100	96	100	96	98
Camden	98	94	88	80	88	80
Glengarry	100	84	100	84	98	80
Retreat[2]	98	96	95	88	91	86
Plenty	100	100	100	100	100	100

[1] R / M = rip and mound, R-T = spot cultivation with Ro-Tree cultivator.
[2] Ripped only, without mounding.

third, fourth, fifth and seventh years of the trial. Where the two different treatments were contiguous, a buffer zone of at least two rows was maintained between measured trees.

Tree volume was calculated using models developed for *Eucalyptus nitens* for the Boral Timber Tasmanian Estate (Confidential Report 2000) and for *Pinus radiata* (in Neilsen 1990). Due to the lack of replication, statistical analysis was carried out using a paired *t-test*, initially by analysing plot mean data and treating each site as a replicate, and then comparing the results at each site using individual tree data.

Results and discussion

Results of survival after one, two and seven years are shown in Table 2. Survival rates have been poorer under the Ro-Tree cultivation treatment at Camden, Glengarry and Retreat. Lowest survival for both treatments has occurred at the Camden site (elevation 700 m) where the climate is harshest in terms of lower mean annual temperature, colder winters and greater exposure to strong, cold winds. The reason for lower survival under spot cultivation at these three sites is unknown but may be related to poorer planting techniques and / or higher browsing pressure by pests, which is unrelated to treatment. No tree mortality was observed under either treatment at Plenty.

Table 3 shows results of mean tree height (m) over the seven years of measurement. Overall, significant differences between treatments mainly occur in years two and three, although the Camden site shows a significant difference in year seven. At Retreat, rip and mound has produced significantly higher growth after one year than spot cultivation but, from year two onwards, there are no significant differences in tree height between the two treatments at this site. In year two, significant differences show up at four sites: Blessington, Camden, Glengarry and Plenty. Apart from the Camden site, conventional rip and mound has produced better growth than spot cultivation, and this trend is continued after three years at the Blessington site. After seven years, only the Camden site shows a significant height difference between treatments, with spot cultivation out-performing ripping and mounding.

In Table 4, results for volume (m^3 / ha) at each site are presented for the years 1998, 1999, 2000 and 2002. These results demonstrate that there were no significant differences between treatments in any year when each site was treated as a replicate. When each site was compared individually, only the Camden site in 1998 showed a significant difference, with spot cultivation producing better growth than conventional ripping and mounding. At the other four sites there is no significant difference in volume between treatments for any year.

Table 3. Mean tree height over seven years (1996–2000, 2002) for spot cultivation versus rip and mound at five sites in Tasmania. (For abbreviations, see Table 2.)

	Mean tree height (m)											
	1996		1997		1998		1999		2000		2002	
Site	R/M	R-T	R/M	R-T	R/M	R-T	R/M	R-T	R/M	R-T	R/M	R-T
Blessington	0.38	0.34	1.36**	1.12**	2.79**	2.34**	4.49	4.03	5.58	5.36	7.81	7.61
Camden	0.43	0.45	1.31**	1.62**	3.02*	3.53*	5.79	6.31	8.19	8.70	12.42*	13.41*
Glengarry	1.18	1.18	2.28**	1.90**	3.46	3.15	4.30	4.20	4.86	4.83	6.56	5.89
Retreat[1]	0.50**	0.40**	0.96	0.97	1.46	1.55	2.22	2.23	2.99	3.07	5.04	5.59
Plenty	0.44	0.41	1.02*	0.92*	1.61	1.54	2.87	2.82	4.13	4.15	7.10	7.10

* Differences between treatments are significant at the 5% level, and ** at the 1% level.
[1] Ripped only.

Table 4. Volume at ages three, four, five years (1998–2000) and seven years (2002) for spot cultivation versus rip and mound at five sites in Tasmania. (For abbreviations, see Table 2.)

	Volume (m^3/ha)							
	1998		1999		2000		2002	
Site	R/M	R-T	R/M	R-T	R/M	R-T	R/M	R-T
Blessington	0.41	0.30	1.84	1.69	4.19	4.13	13.00	13.80
Camden	0.94*	1.51*	7.25	9.37	22.50	27.80	79.60	94.80
Glengarry	1.01	0.81	2.28	2.12	3.69	4.02	10.30	12.50
Retreat[1]	0.07	0.05	0.30	0.36	0.94	1.03	4.46	5.77
Plenty	0.07	0.06	0.95	0.94	3.59	3.71	18.80	19.60
Mean	**0.50**	**0.55**	**2.52**	**2.89**	**6.98**	**8.14**	**25.23**	**29.29**

[1] Ripped only.
* Differences between treatments significant at the 5% level.

Interestingly, after seven years, spot cultivation produces higher volume growth than ripping and mounding at all five sites, but none of the differences is significant. Comparison of *P*-values for the Camden site over the four years of volume measurements shows that *P* has increased every year due to increasing variation, and suggests that future differences between treatments are unlikely to be significant.

Tables 3 and 4 show some interesting differences in growth of *E. nitens* between sites on an annual basis. For example, after one year, tree height at Glengarry is about 2.5 times that at Blessington and Camden, and after three years Glengarry is still ahead, albeit by a much lower margin.

However, after four years, height and volume at the Camden site have surged ahead of the other sites and, after seven years, shows a seven-fold increase in volume over Glengarry and Blessington. The slow early growth at Camden is attributed to this site (elevation of 700 m) being much colder and more exposed than the relatively warm and sheltered Glengarry site at lower elevation (110 m). At Glengarry, the declining growth rates after three years appear to indicate that nutrient deficiencies are severely limiting, particularly since the foliage here shows clear signs of poor health. Likewise, similar signs of poor health and relatively slow growth at Blessington indicate that low levels of nutrients are a major limiting factor.

Secondary fertilisation is required at both Glengarry and Blessington to improve growth rates and productivity of the sites.

For the two sites planted to *P. radiata* there was little difference in growth rates at ages one and two. However, by age seven, the Plenty site was growing at a much faster rate than Retreat. This difference probably relates to both the lack of weed control with strong competition from wildling pines and to soils with poorer physical properties and restricted root penetration at the Retreat site.

Differences between the two treatments in relation to soil erosion were observed at the Glengarry site during measurement of tree height after the first year. Clear evidence of soil movement was noted along some furrows formed during the ripping and mounding operation where it had been carried out up and down slope. In many places, a thin (2–5 cm) veneer of quartz sand derived from erosion of the highly erodible bleached layer of the texture-contrast soils had been deposited on the surface of the furrow. In contrast, inspection of the Ro-Tree cultivated sites on sloping land revealed no obvious signs of soil movement between individual mounds, indicating that spot-cultivation is less hazardous than line ripping and mounding on highly erodible soils.

Summary and conclusions

The results of comparisons of tree height at five contrasting sites in Tasmania show that after two years the rip and mound treatment has produced significantly better growth at three low quality sites ($P < 0.01$ at Blessington and Glengarry; $P < 0.05$ at Plenty), whereas spot cultivation was significantly higher ($P < 0.01$) at the high quality site (Camden). However, after seven years, the only significant difference in tree height between treatments was at Camden ($P < 0.05$), where spot-cultivation was superior to ripping and mounding.

Comparison of stand volume (m^3/ha) shows that after three years, ripping and mounding has produced better growth at the four low quality sites (Blessington, Glengarry, Retreat, Plenty) but the results are not significant. After seven years, the Ro-Tree cultivator produced slightly better growth at all sites. However, the differences between treatments are not significant. Survival was also found to be lower in spot-cultivated sites at Camden, Glengarry and Retreat. As only one replicate at each site was included in the trial design, statistical differences between treatments were not demonstrated.

In many situations, the decision whether to use spot cultivation or line ripping and mounding will be based on rate of ground coverage and unit cost. However, on sites where soils are highly erodible or have steep slopes, spot cultivation is preferable. Likewise, on sites with thick covers of slash, spot cultivation may be preferable to ripping and mounding in order to minimise clearing costs and/or avoid burning.

Marked differences in growth at the three sites planted to *Eucalyptus nitens* is attributed to the effects of elevation and levels of soil nutrients. Relatively slow growth up to age three followed by fast growth in subsequent years at the high elevation Camden site is related to the effects of cool temperatures and exposure. Conversely, fast initial growth followed by declining growth rates at the low elevation Glengarry site is related to the effects of warmer temperatures and low levels of soil nutrients. Differences in growth at the two sites planted to *Pinus radiata* is considered to reflect the lack of weed control and poorer soil physical properties at the Retreat site compared to Plenty.

Acknowledgements

We thank Mr John Grant, soil consultant, for measuring the plots at Plenty Valley in

1997 and for carrying out statistical analysis of the data. Mr Peter Ryan, formerly of Boral Timber Ltd, assisted with the measurements under difficult weather conditions in 1998. The comments of two anonymous reviewers also helped to improve this manuscript.

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