Effect of Simulated Browsing on Survival and Growth of *Eucalyptus nitens* and *E. regnans* Seedlings

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Abstract

Severe and lasting growth reductions were caused by simulated browsing damage to planted Eucalyptus nitens *and* E. regnans *open-root and paper-pot seedlings in this study in north-eastern Tasmania. Clipping of seedlings to simulate different levels of browsing was carried out either two months or seven months after completion of planting or on both occasions. The most severe 'browsing' treatment resulted in growth to age three years averaging 0.7 dm^3tree^{-1} compared with 7.7 dm^3tree^{-1} for the control seedlings. Effect on growth was similar on both occasions and for the repeated clipping but clipping at seven months after planting caused the death of more seedlings, with only 25 per cent surviving when severely 'browsed' at that age. Less severe 'browsing' also resulted in significant growth losses.*

Introduction

In regenerated native forest in Tasmania, native animal species have caused considerable damage to eucalypt seedlings, leading to reduced stocking and loss of growth (Mollison 1960; Gilbert 1961; Cremer 1969; Statham 1983). Severe browsing of eucalypt plantations by native and exotic animals is also common in Tasmania. It is important to know the intensity of browsing at which survival and growth of planted seedlings is unacceptable so that animal control can be used only when needed.

The effect of browsing at different levels of intensity on survival and growth of open-root and paper-pot stock types of *E. regnans* F. Mueller and *E. nitens* (Deane *et* Maiden) Maiden was studied in a trial in north-eastern Tasmania.

Methods

The trial was one of a series designed to test the effect of various silvicultural treatments on the establishment and early growth of planted eucalypt seedlings. To prevent browsing by animals, the entire area was fenced with a mesh and electric fence (Neilsen 1981). The planting site was located 27 km north-west of St Helens in the Goulds Country Forest Block in north-eastern Tasmania at 120 m altitude. It was situated on a well-drained broad ridge with a gentle north-west aspect and about five per cent slope.

The climate is temperate with mild to warm summers (mean January temperature 16°C) and cool to mild winters (mean July temperature 7°C). Annual precipitation is approximately 1000 mm with a winter peak and periods of summer moisture deficit.

The site formerly carried *E. regnans* forest of 34-41 m predominant mean height. The trial area was logged in 1985, broadcast burnt in early March 1986 with a very hot burn, and windrowed in March - April 1986. The soil was cultivated by discing with little-giant discs, and mound-ploughed with tandem off-set discs of 600 mm diameter, in May 1986. For weed control, the area was sprayed with a mixture of amitrole, 1.5 kg $a.i.ha^{-1}$, and atrazine, 3 kg $a.i.ha^{-1}$, in July 1986 using a boom spray mounted on a Mercedes 4x4 tractor.

Material used for the trial was routine open-root and paper-pot *E. nitens* and *E. regnans* seedlings from Perth Nursery. At time of planting, open-root seedlings averaged 34.5 cm in height and paper-pot seedlings 8.2 cm. Open-root stock was planted in early August 1986. Paper-pot stock was planted in late September 1986. Planting conditions were good, with overcast conditions and some showers. Spacing was 3.5 m between rows and 1 m along rows.

Browsing damage of eucalypts in the field consists of the removal of tops, the eating of various proportions of leaves and stems and in severe cases, the eating of the seedling to near ground level (Statham 1983). For the trial, three severities of treatments previously used in the study of *Pinus radiata* D.Don were used (Neilsen 1981). These treatments were tips removed (T), half of the shoot removed (H) and a severe treatment which was complete shoot removal to within 25 mm of the ground (S).

Three treatment times were used. Early 'browsing' (E) was carried out on both open-root and paper-pot seedlings two months after planting of the paper-pot stock. Late 'browsing' (L) was carried out seven months after planting and repeated 'browsing' (R) was carried out at both two and seven months after planting. Secateurs were used to remove foliage and stems.

All treatments were applied in factorial combination, making nine browsing treatments plus control by two stock types and two fertilizer treatments (nil and treated). There were two replicates of *E. regnans* and one of *E. nitens*. In total, there were 120 plots of five trees. Plots were measured at planting, at seven months (time of final treatment), and at one, one and a half, two and three years after planting.

Fertilizer was applied in November 1986 to the fertilized treatment at the rate of 235 g tree^{-1} of 11:5:0 applied as a lump 150 mm from each tree on the downhill side (Neilsen 1981).

Analysis of variance and regression analysis were used to determine the effect of treatments on growth. Tukey's cross classification was used for testing differences in survival.

Results

Survival

Severe 'browsing' (S) significantly reduced survival of both species and both stock types, with survival of *E. nitens* being 34 per cent and *E. regnans* 55 per cent. For both species, the late severe (LS) 'browsing' produced the highest mortality. Late and repeated severe 'browsing' (LS and RS) reduced survival to less than 50 per cent (Table 1). Lighter 'browsing' treatments [removal of leading shoots (T) or half of the plant (H)] had no significant effect on survival.

Table 1. Mean survival (%) of E. nitens *and* E. regnans *seedlings (combined) subjected to various browsing treatments, and significance as determined by Tukey's test.*

Treatment	Survival	
Control	100.0	a*
Early - Tips	96.3	a
Late - Tips	100.0	a
Repeated - Tips	100.0	a
Early - Half	96.6	a
Late - Half	98.3	a
Repeated - Half	100.0	a
Early - Severe	72.1	b
Late - Severe	25.4	d
Repeated - Severe	47.1	c

* Columns of identical letters indicate non-significant subsets at $P = 0.05$.

Growth

Removal of half or more of a eucalypt seedling (H and S) within six months of planting significantly reduced volume growth at age three years (Table 2).

Table 2. Total volume growth (dm^3tree^{-1}) to age three years. Results are the mean of E. nitens *and* E. regnans *seedlings subjected to various browsing treatments, and significance as determined by analysis of variance allowing for species and stocktype differences.*

Treatment	Volume	
Control	7.69	a*
Early - Tips	5.75	abc
Late - Tips	7.16	ab
Repeated - Tips	6.15	abc
Early - Half	5.21	bc
Late - Half	5.18	bc
Repeated - Half	4.28	c
Early - Severe	1.91	d
Late - Severe	0.09	d
Repeated - Severe	0.24	d

* Columns of identical letters indicate non-significant subsets at $P = 0.05$.

Both severity and time of 'browsing' and their interaction with all other trial factors had significant effects on height at age two years (Table 3). Increasing severity of browsing progressively reduced growth, with severe 'browsing' (S) reducing volume at age three years to between one and 30 per cent of that attained by lightly browsed seedlings (T). Browsing to half height (H) also significantly reduced volume at age three years (Table 2). Late and repeated 'browsing' (L and R) significantly reduced height growth for half shoot removed (H) or severe (S) treatments.

Severe 'browsing' (S) significantly reduced increment beyond 12 months while for seedlings with leading shoots (T) or half shoot (H) removed, growth rates recovered (Fig. 1).

For the five months following the final treatment at age seven months, the two treatments which had half of the top removed at that time (LH and RH) grew significantly more height increment (28 cm) than any other 'browsing' treatments (mean of 14 cm for LT and RT) (Table 4). Although

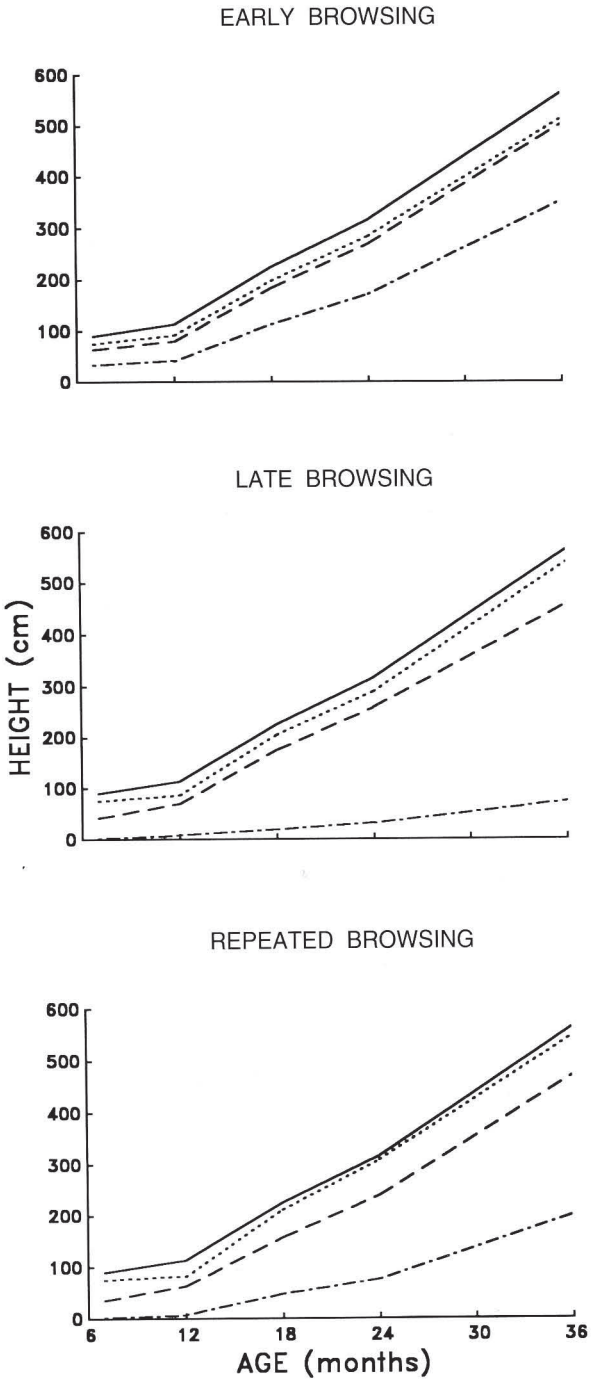

Figure 1. Height (cm) to age three years of E. nitens *and* E. regnans *seedlings subjected to various browsing treatments during three times. Browsing treatments were control ——, tips removed ·····, half tree removed --------, and severe – · – · –.*

Table 3. Analysis of variance table for mean height at age two years for fertilized and unfertilized, open-root and paper-pot E. regnans *and* E. nitens *seedlings, subjected to three levels of browsing during three browsing times.*

	SS	DF	MS	F-ratio	Sig.
Covariate					
Height at final treatment	1 319 616	1	1 319 616	725.96	0.0000
Main effects					
Severity of browsing	62 575	2	31 287	17.21	0.0000
Time of browsing	19 897	2	9 948	5.47	0.0059
Stocktype	4 438	1	4 438	2.44	0.1221
Species	1 058	1	1 058	0.58	0.4558
Fertilizer	8 665	1	8 665	4.76	0.0319
2-Factor Interactions					
Severity x Time	53 477	5	10 695	5.88	0.0001
Severity x Stocktype	28 620	3	9 540	5.24	0.0023
Time x Stocktype	31 319	3	10 439	5.74	0.0013
Severity x Species	26 742	3	8 914	4.90	0.0035
Time x Species	22 515	3	7 505	4.12	0.0089
Stocktype x Species	55 202	2	27 601	15.18	0.0000
Severity x Fertilizer	26 681	3	8 893	4.89	0.0036
Time x Fertilizer	23 803	3	7 934	4.36	0.0067
Stocktype x Fertilizer	23 436	2	11 718	6.44	0.0025
Species x Fertilizer	22 303	1	22 303	12.27	0.0008
Residual	145 420	80	1 817		
Total (Corr.)	1 673 738	107			

Table 4. Height growth increment (cm) for the five months immediately following various browsing treatments. Results are the mean of E. nitens *and* E. regnans *and significance as determined by least significant difference.*

Treatment	Height	Growth
Control	23.6	a*
Early - Tips	18.3	b
Late - Tips	10.8	cd
Repeated - Tips	7.6	de
Early - Half	15.6	bc
Late - Half	28.3	a
Repeated - Half	27.8	a
Early - Severe	7.3	de
Late - Severe	6.3	de
Repeated - Severe	4.1	e

* Columns of identical letters indicate non-significant subsets at $P = 0.05$.

not attaining the same total growth as those trees with the least severe removal (T), the difference was substantially reduced by age 12 months (Fig. 1). Removal of tips at age seven months (LT and RT) significantly reduced growth over the next five months (Table 4).

Species, stocktype and fertilizer differences all significantly contributed to differences in volume at age three years, either directly or through complex interactions (Table 3). However, for all of these different treatments, the effect of 'browsing' seriously restricted growth. There was also a significant difference between *E. regnans* and *E. nitens* in their relative response to different top removal treatments. Both open-root and paper-pot seedlings of both species were

equally affected by the treatments, allowing for the initial difference in height (covariate). Seedlings with severe late (SL) or repeated (R) browsing showed little response to fertilizer addition while all others showed a substantial response of over ten per cent.

Severe removal to 25 mm height resulted in growth to age three years averaging 0.7 dm^3tree^{-1} compared with 7.7 dm^3tree^{-1} for the control seedlings. Growth reductions were significant and lasted to at least age three years, the end of the study term (Fig. 1). The effect on growth was severe for all times of clipping but the later removal caused death of more seedlings, with only 25 per cent surviving when clipped to 25 mm at seven months. Less severe defoliation also resulted in significant growth losses.

Discussion

Seedling survival and growth were significantly reduced by 'browsing' damage simulated by partial removal of foliage and stem of planted *E. nitens* (subgenus *Symphyomyrtus*) and *E. regnans* (subgenus *Monocalyptus*) open-root and paper-pot seedlings. Because the effect of 'browsing' on eucalypts is long lasting (to at least three years), protection from animals is even more important than for *Pinus radiata* which has been shown to recover growth rates within a year of severe 'browsing' (Neilsen 1981).

Survival was lowest on seedlings which had been subjected to the highest relative rate of 'browsing', those first browsed to 25 mm at age seven months. At this stage, an average of 94 per cent of the shoot was removed. This agrees with results for *P. radiata* (Neilsen 1981). Cremer (1969) tied differences in the ability of *E. regnans* to survive browsing to different times of the year and to different sites. Complete defoliation in the autumn caused high mortality and severely reduced growth while defoliation in the spring reduced growth but did not substantially increase mortality. Whether variations in mortality are due to seasonal differences, perhaps in carbohydrate reserves (Cremer 1969), or to the relative degree of browsing at various times, is unclear. What is clear is that severe browsing has deleterious effects on survival and growth.

The inability of eucalypt seedlings to recover growth following severe browsing explains why some eucalypt plantations in Tasmania have been virtually destroyed. Protection of eucalypt seedlings at establishment from browsing by native and introduced animals is essential if eucalypt plantations are to be successful. Reduction in growth through browsing can negate any advantages of weed control and lead to continuing growth losses through suppression by weeds.

Browsing can be controlled by reducing animal populations, generally by poisoning with 1080. Poisoning often has to be started well in advance of planting and continued after planting to control animal populations to a level where satisfactory survival and growth of eucalypts are achieved. In cases of extreme browsing, fencing may be necessary. If poisoning is not environmentally acceptable, fencing, plus additional clearing to remove animal shelters within fenced areas, may be needed.

References

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