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AN EXAMINATION OF THE BROWSING ANIMAL PROBLEM IN AUSTRALIAN EUCALYPT AND PINE PLANTATIONS.

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ABSTRACT: The severity and extent of browsing damage to pine and eucalypt plantations and possible solutions are examined. Twenty-six percent of all trees surviving 9 months after planting were browsed yet only six percent had more than 50% of foliage damaged. The most common form of damage was for the foliage to be browsed or the tree bitten off with browsing damage implicated in the mortality of the 24% of trees that died. No difference in the extent of damage between Pinus radiata and eucalypts was detected. Slight differences between three Eucalypt species and two ages of seedlings were detected; however, these differences in damage levels were insufficient to afford adequate protection through appropriate selection of species and type of nursery stock. Most of the damage was attributed to the Swamp Wallaby (Wallabia bicolor) and the European rabbit (Oryctolagus cuniculus). The use of electric or rotonet fencing and repellents containing chili or dog-urine extracts seem to offer the only nondestructive ways of minimising browsing damage. The development of less-palatable species and types of nursery stock is dependent on other considerations including general suitability, but warrants further research.

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INTRODUCTION

In recent times forest managers in southern Australia have used the poison 1080 (sodium monofluoroacetate) as the sole means of controlling damage caused by browsing animals to newly established forests. Prior to the advent of 1080 labour-intensive trapping, fumigation, shooting and fencing were used. The main targets are small macropods Wallabia bicolor, Macropus rufogreisus, Thylogale bilardieri, the European rabbit (Oryctolagus cuniculus) and feral domestic animals such as goats and sheep. Since 1988, however, due to public pressure, the industry in Victoria has been seeking to develop viable nondestructive techniques for the control of browsing animal damage.

In Australia, as in many other parts of the world, forestry plantations are most susceptible to browsing animal damage in the first year after planting. Consequently we have concentrated on addressing the problem of animal browsing in the first year after planting. The major lines of investigation were to answer the following questions: (1) How much damage is caused by these animals or, in other words, how much of a problem is the browsing? (2) What animals are causing the damage? (3) Can repellents, less palatable trees, barrier devices, alternative browse, or capture and relocation reduce browsing to acceptable levels? (4) How does forest establishment affect the behaviour and numbers of browsing animals especially in relation to the use of toxicants?

The first two questions were investigated as part of our browsing damage assessment project. The third was and still is being addressed by a series of experiments to be outlined below. The capture and relocation and the alternative browse options, however, are yet to be examined. Question four is currently under investigation and will be reported elsewhere. It essentially addresses the movements and home range of browsing animals before, during, and after forest establishment and the populations' response to 1080 baiting.

METHODS

Estimating the Extent of Damage

All plantations established by APM Forests are monitored for growth and survival using a grid system of plots 0.01-ha in size positioned every 4.5 ha. Each plot contains about 10 trees. Plots are checked routinely immediately after the plantation is established (to monitor stocking rates), 9 months after planting (to monitor survival), and at about five yearly intervals from age 11 to clearfelling at 27 years (to monitor volume growth).

In 1989 we began to monitor browsing damage in the stocking and survival plots in plantations established 9 months earlier (in 1988) and scored the damage using a semi-quantitative system. Undamaged trees were assigned a browsing score of "nil"; "tiny," approximately 10% damage to foliage and stem; "some," 25% damage; "half," 50% damage; "most," 75%; and "11," 100% damage. Types of browsing damage (i.e., "barkstripped," "pulled out," "bitten off," or "foliage browsed") were also scored. We plan to collect this information annually over several years to help characterise where the damage is most likely to occur. The information should also provide the basis for determining the long-term effect of browsing on trees and its associated cost.

Animals Causing the Damage

The basis for our knowledge on the animals causing the damage has been largely anecdotal although Hibbard (1976) and Waters (1985) noted that swamp wallabies and rabbits are responsible for most of the damage to plantations in Gippsland. To further clarify this question we surveyed some 148 compartments just prior to planting or in the first year after planting and noted the animals present. Evidence such as scats, foot prints, and actual sightings of animals likely to browse trees was recorded for each compartment along with topography and adjacent land use.

Browsing Prevention

Virtually all potential browsing prevention techniques were screened using captive animals in pen trials because of the proportionately higher cost of establishing field experiments. Pen trials were conducted at Monash University using nine captive swamp wallabies, (five females and four males). Throughout experiments animals were kept in three pens each measuring 20m × 15m in size.

Repellents

So as to avoid the screening of a multitude of chemicals as was done in the past by Schafer et al. (1983) and Schafer & Bowles (1985), potential repellents were selected using the following criteria:

1. The repellent must not be toxic, carcinogenic, or teratogenic for occupational health and safety, and animal ethics reasons.
2. There must be some reason to suspect that the formulation may work as a repellent.

Repellents were screened by planting 10 treated and 10 untreated trees (40 to 60cm E. regnans seedlings) in each pen in a Latin square arrangement. Treatment involved spraying trees (leaves and stems) with 3 to 5 ml of the repellent solutions listed in Table 1. On occasions when it was not possible to apply the repellent using a spray bottle, a paint brush was used. Based on data relating to rates of consumption of untreated trees, pens were checked at 2, 16, 24 and 48 hours after planting. Trees surviving longer than 48 hours were checked daily. The experiment was terminated when all trees were consumed. Experiments were repeated if it rained during the 48-hour observation period to avoid the possibility of results being confounded by the repellent being washed off part way through the experiment.

Table 1. Potential repellents screened on captive Swamp Wallabies.

Product name	Common chemical name active ingredient	Concentrations tested[a]	Comments
Egg and paint	---	5 eggs + 150 ml acrylic paint made up to 1 litre with water.	---
SFE	synthetic fermented egg see Bullard 19	undiluted.	phototoxic-trees wilted but still eaten.
Chicken manure	Dynamic Lifter (TM)	76 g sprinkled around each seedlings.	
Pulp mill liquor	various volatile sulphides and turpines	2 ml injected into plastic capillary tube and attached to each seedling.	---
Foxes urine volatiles	Iso pentynal methyl sulphide (IPMS)	50,100 mg/l in water.	[b]_
Dog urine	Active ingredient unknown	3 mls per tree.	to be fractionated
D-Ter	commercial preparation	as recommended	
Big Game Repellent	commercial preparation	as recommended	
Quazzia Chips and Paint	ground quazzia + paint	100 g quazzia chips	
Quazzia Chips and Acrylic Primal	ground quazzia + paint	boiled in 750 ml detergent and water and filtered. Extract mixed with 150 ml sticker.[d]	
Phytolacca + Primal	inkweed and sticker	100 g of homogonized phytolocca leaves + 1.0% acrylic sticker.	
HPA-23 Metallic base		1.0% w/w.	
Bitrex	denatonium benzoate	0.68% w/w.	
	denatonium saccharide	0.065% and 0.26% w/w[c]	
Chili paste	Sambai Olec		
Capsiane Oleoresin BPC 1923		0.1-1% capsaicin 1 g Oleoresin dissolved in 50 ml of 60% ethanol.	

[a]Mixed in water (or paint or primal as indicated) at concentration shown and sprayed on the trees after planting.
[b]Not sprayed on the trees but placed in plastic capillary tubes attached to the plants.
[c]Included dimethal sulphoxide at 90 ml/lit and Wilt proof to help stick repellents to the trees foliage.
[d]Primal and acrylic paint were used to adhere potential repellents to seedlings (referred to as stickers).

Trees were scored using the semi-quantitative technique described above. Trees were deemed to be "browsed" when greater than or equal to an estimated 50% of the leaves and/or stem were eaten, and "not browsed" when less than or equal to 25% of the tree was eaten. This semi-quantitative scoring technique minimised both operator error and the time it takes to score the damage. Results were analysed using a 2 × 2 chi square test and treatments were thought to have a significant repellent effect when $P<0.05$. Treatments providing a significant repellent effect were retested a further two times to confirm the result and then tested in the field.

Field Trials of Repellents

Potential repellents producing a significant repellent effect in pen trials were further tested by planting 50 treated and 50 untreated E. regnans seedling in a 0.4-ha area which had been completely denuded by browsing animals within weeks after planting. Trees were monitored weekly and damage recorded as in the pen trials. Similarly significance of results was tested using a 2 × 2 chi square analysis. Field trials were conducted between May and September as these are the months when trees are planted and most frequently browsed.

Seedling Palatability

Three species of eucalypt seedlings are commonly planted by APM Forests in Gippsland, these being Eucalyptus globulus. E. nitens and E. regnans. Generally these seedlings are 6 months old when planted although on occasions older seedlings (18 months old) may be planted. The two different ages will be referred to as young and old seedlings, respectively. This provided us with the opportunity to screen the relative palatability of two ages of the three species.

The following experimental design was used to minimise day/pen effects: on day one, 10 old and 10 young E. regnans were placed in pen 1, ditto for E. nitens in pen 2, and E. globulus in pen 3. On day two E. regnans was placed in pen 2, E. nitens in pen 3 and E. globulus in pen 1. On day three E. regnans was placed in pen 3, E. nitens in pen 1 and E. globulus in pen 2. Damage was scored as above at 2 and 16 hours. Results were pooled across days and pens.

Barrier Devices

Descriptions of barrier devices examined are listed in Table 2. So far Vexar tubing and stockings, and rotonet plastic mesh and electric fencing have been tested in pen trials, and all but electric fencing have been tested in field trials. Standard barbed-wire fencing was not tried in either pen or field trials because of its relatively high cost.

In pen trials Vexar tubes and stockings were placed over 10 of the 20 seedlings planted in each pen and, as with the repellent trials, damage was monitored at intervals of 2, 16, and 24 hours. For rotonet and electric fence pen trials, half the seedlings planted in each pen were fenced with rotonet and the damage monitored at the same intervals mentioned above. Success of treatments was analysed as for the repellents.

Field trials using Vexar tubes and stockings to protect E. regnans and P. radiata were established but browsing damage did not occur at sufficient levels for valid statistical comparisons to be made between treated and control seedlings.

Rotonet plastic fencing was trialed in the field by erecting 10 small fences around 10 groups of 10 trees and monthly comparing the damage of trees within fenced areas with 10 groups of 10 unprotected trees in the same area. Electric fencing designs trialed with penned wallabies are to be tested in the coming season.

Table 2. Barrier devices tested on captive Swamp Wallabies during pen trials.

Product name	Description	Supplier
Rotonet	Plastic mesh fencing 1.23 m high attached to steel pickets 10 m apart.	Maxlon Industries Melbourne
Vexar tubing	60 cm cylindrical tube of xx mm mesh tube supported by a 45 cm stake.	Dupont
Vexar stocking	60 cm stocking mesh placed over seedling.	Dupont
Electric fencing	3 strand, 10000V 2 amp, polypropylene wires, pickets placed 5 m apart.	Any agric. supplier

RESULTS

The Extent of Browsing Damage

Four hundred forty-seven 0.01-ha plots containing 3,628 trees were examined for browsing damage 9 months after planting. Twenty-four percent of trees examined showed some evidence of browsing, yet only 1.66% had 'most' or 'all' of their foliage and stem damaged (Tables 3 and 4). The significance of this will be discussed below. There was no detectable differences in the extent of damage to either eucalypt of P. radiata plantations. The most common form of damage was for the foliage to be browsed or for the young tree to be bitten off.

Table 3. The extent of browsing damage in P. radiata and Eucalypt plantations.

	P. radiata	Eucalypt
Number of 0.01 ha plots examined	357	90
Trees initially planted	3817	929
Trees dead at 9 months	53	1
Trees missing	858	260
Trees alive at 9 months	2906	668
Live trees with animal damage	741 (25)	131 (20)

() percent alive showing animal damage

Table 4. Severity of browsing damage to P. radiata and Eucalypt plantation 9 months after planting.

Damage score	P. radiata (%)	Eucalypt (%)
Nil	75	80
Tiny	6	2
Some	13	9
Half	4	6
Most	2	3
All	0	0

Differences not significant (Trend Chi-square $p>0.10$ (Maxwell 1961)

Browsing Prevention

Repellents

Only 2 of the 18 potential repellents screened in pen trials (see Table 1) significantly reduced browsing damage compared to that sustained by the untreated trees after 16 hours. These were dog urine and chili paste. Disappointingly, the commercial repellent preparations D-Ter and Big Game Repellent provided no protection nor did the two very bitter compounds bittrex (denotonium benzoate) and denotonium saccharide. No repellent provided significant protection for longer than 48 hours. Only the dog urine has been field tested, and results confirmed pen trial findings. Dog urine significantly reduced browsing by up to 50% over a 6-week period (Fig. 1).

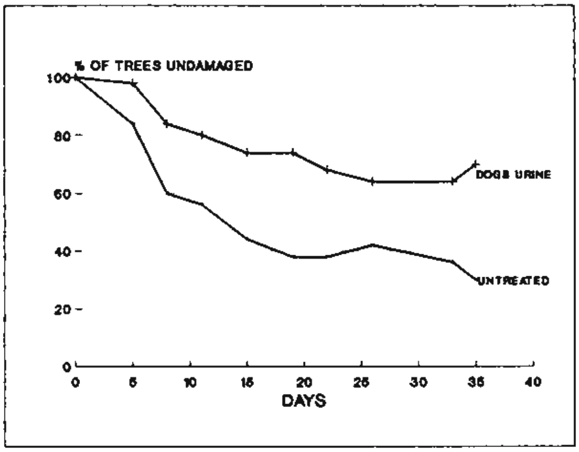

Figure 1. Survival of treated and untreated trees during a six week field trial of dog urine as a repellent to W. bicolor.

Seedling Palatability

There was no detectable difference in the extent of browsing damage to young E. regnans, E. nitens, and E. globulus seedlings. Old E. globulus seedlings, however, sustained significantly more damage than either E. nitens or E. globulus. Comparing the extent of damage to the different age seedlings of the same species, only E. globulus was significantly browsed as it got older. Looking at the trend of all species and age classes (Fig. 2), old E. globulus was the least palatable (more resistant to browsing), followed by old E. nitens, young E. globulus, and young E. nitens, then old E. regnans, and finally young E. regnans.

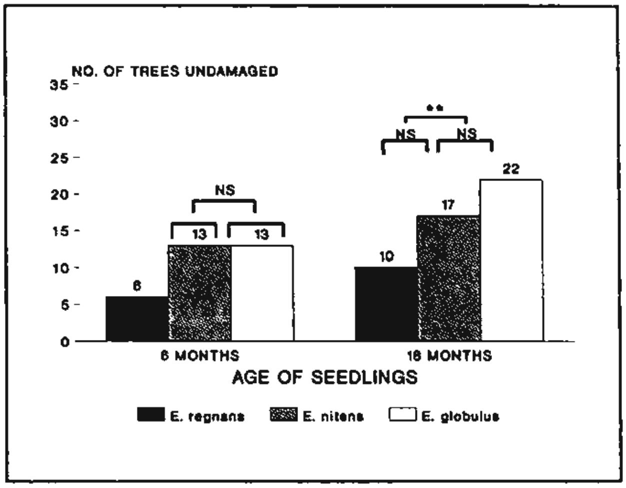

Figure 2. Relative palatability of 3 eucalypt species of 2 ages. Damage was recorded after trees were exposed to penned animals for 16 hours. Trees "undamaged" are defined as those with less than 25% of their foliage eaten.

Barrier Devices

The Vexar stockings and tubes tested in pen trials were unable to significantly reduce Swamp Wallaby browsing damage. Within 2 hours of commencing trials animals had removed most stockings and tubes and eaten the seedlings. Rotonet and electric fencing, on the other hand, both prevented browsing of trees within small fenced areas for up to 7 days. Field trials of rotonet over a 6-month period showed that 75% fewer trees were browsed in the fenced plots compared to the unfenced plots.

DISCUSSION

Unfortunately, it is difficult to accurately estimate the extent of the browsing problem. Yet when 24% of the trees surviving after 9 months show some evidence of browsing damage, it is reasonable to assume that browsing damage is a significant factor affecting the success of forest establishment. It should be noted that levels of browsing damage may even be higher as only 76% of all trees planted in 1988 were assessed at 9 months for browsing damage. A high proportion of the 24% of trees that did not survive were likely to have been browsed.

There was no significant difference in the extent of damage to eucalypts or pines assessed 9 months after planting (Table 4), but do similar damage levels produce similar losses? Probably not, according to Neilson (1981) and Cremer (1968). Neilson noted that only the most severe damage to pines 6- to 9-months after planting (usually Feb-May) is fatal, while Cremer (1968) reported that partial defoliation does not cause losses in eucalypts and that only complete defoliation between February and June affects survival. Thus both the timing and extent of damage are important when considering the effects of browsing damage.

Consequently it would seem that the best way to further refine browsing-damage estimates, develop browsing-prevention strategies, and an understanding of the problem, is to monitor survival at monthly or bimonthly intervals. As part of this process data could also be collected on other types of damage and losses so that browsing losses could then be contrasted against factors such as poor planting, weed control, and weather conditions.

Prior to the beginning of this study it was believed that rabbits and Swamp Wallabies were the animals causing most of the browsing damage to newly established plantations. However evidence was indirect (Hibbard 1976) and experimental work inconclusive (Waters 1975), no doubt because of the difficulties in directly observing the animals while they are damaging the trees.

So far we have not been able to overcome this problem. However, based on the relative frequency of occurrence of browsing animals in the 148 compartments (Table 5), reports from planters who have witnessed Swamp Wallabies eating newly planted seedlings, and our own examination of compartments damaged by browsing animals, we still believe that Swamp Wallabies and European Rabbits are the animals causing most of the damage. Our observation of the wallabies in pen trials corroborates this.

Table 5. The frequence of occurrence of large herbivores noted in surveys of 148 newly established compartments.

Species	Frequency No	(%)	Evidence seen	prints	scats	Dental morphology classification Sanson pers. comm.
Wallaby	125	(84)	3	81	108	B[a]
Rabbit	53	(36)	1	14	49	G[b]
Kangaroo	57	(38)	5	40	49	G
Wombat	41	(28)	0	21	40	G
Emu	36	(24)	8	17	21	B
Goat	10	(7)	7	3	4	B
Cow	8	(5)	1	4	6	G
Hare	6	(4)	0	0	6	G
Horse	4	(3)	0	1	3	G
Sheep	3	(2)	1	0	2	G

[a]B = Browsing animal.
[b]G = Grazing animal. Grazing animals rarely eat trees.

To date only 2 of the 18 potential repellents presented to Swamp Wallabies in pen trials have been able to significantly reduce browsing damage, these being chili paste and dog urine.

The success of chili paste is undoubtedly due to the active principal in hot peppers: capsaicin. Capsaicin (8-methyl-non(6)en-(1)oic acid -(1)-(4-oxym 3 methoxyl-benzyl-amide) has a chemical history going back 171 years (Walker 1968) and has been the subject of physiological studies at least since 1878 (Monsereenusorn et al 1982). Consequently its properties are fairly well known at least in its effects on humans, pigs, cats, dogs, rats, guinea-pigs, and rabbits. We are unaware of any tests on marsupials using capsaicin, but it does not seem unreasonable to assume that it works as a repellent because of its ability to produce pain by several mechanisms, neurogenic and humoral (Monsereenusorn et al. 1982). Future tests will involve screening various concentrations of capsaicin over various time spans to monitor possible desensitisation.

In contrast to our success with chili paste, we are presently unable to explain why dog urine acts as a Swamp Wallaby repellent, other than to suggest that dog urine induces a "fear" response in Swamp Wallabies presumably by olfactory means. The repellent nature of predator scents has been well enunciated by Sullivan et al. (1988); but until we can isolate the active or rather 'offensive' compounds within the dog urine and develop a slow release mechanism, this repellent option seems less attractive.

The relative palatability of eucalypt seedlings selected on the basis of age, species, or site appears to be a topic which has received little attention, especially considering trees can be so easily screened using penned animals. Of the three species and two age classes of eucalyptus screened here, 18- month-old E. globulus was the most browse-resistant. Two hours after planting, the number of old E. globulus damaged was one-third that of young E. regnans and only 75% that of the next-least palatable tree, old E. nitens (Fig. 2).

Such results are very encouraging; however, it is necessary to confirm them with field trials because of the unnaturally high densities of animals in the pens, the limited alternative browse, and the short time trees were exposed to the animals. It is also necessary to recognise that selection of species solely on their palatability is unlikely because of the overriding importance of other traits such as growth rate, form wood and pulping properties.

Barrier Devices

To date barrier devices appear to represent the only means of preventing browsing damage by wallabies to newly established forests. Both rotonet fences and electric fences proved successful at preventing swamp wallabies from eating seedlings during pen trials. However, both devices have limited application because of their high maintenance requirements and susceptibility to theft, in the case of electric fences, and damage by nontarget species, especially wombats, in the case of rotonet fencing. Both have been successfully used to protect small areas known to be inhabited by swamp wallabies but these were in remote, rather flat areas well away from any vegetation likely to damage or affect fences.

Overall we believe it is unlikely that any one of the lines of investigation outlined above represents a universal solution to the browsing problem. For example, it is very unlikely that any repellent or relatively less-palatable species such as E. globulus will provide total protection when animals are starving. Nor will planting less-palatable seedlings guarantee that they will not be browsed. Perhaps the best we can hope for is to reduce the browsing to what is considered an economically acceptable level while still maintaining a viable population of native animals in the area.

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LITERATURE CITED

CREMER, K. W. 1969. Browsing of mountain ash regeneration by wallabies and possums in Tasmania. Aust. For. 33:201-210

HIBBARD, S. J. 1976. Pest damage to Pinus radiata plantations in the Strzelecki ranges. Unpubl. rept., APM Forests, Morwell, Victoria, Australia.

MAXWELL, A. E. 1961. Analysing qualitative data. Metheun Press, London.

MONSEREENUSORN, Y., S. KONGSAMUT, and P. D. PEZALLA. 1982. Capsaicin - A Literature Survey. CRC Critical Reviews in Toxicology 10:321-339.

NEILSON, W. A. 1981. Effect of simulated browsing on survival and growth of Pinus radiata (D. Don) seedlings. Aust. For. Res. 11:47-53.

SCHAFER, E. W., W. A. BOWLES, and J. HURLBUT. 1983. The accurate oral toxicity, repellency and hazard potential of 998 chemicals to one or more species of wild and domestic birds. Arch. Environ. Contam. Toxicol. 12:355-382.

SCHAFER, E. W., and W. A. BOWLES. 1985. Acute oral toxicity and repellency of 933 chemicals to house and deer mice. Arch. Environ. Contam. Toxicol. 14:111-129.

SULLIVAN, T. P., D. S. SULLIVAN, D. R. CRUMP, H. WEISER, and E. A. DIXON. 1988. Predator odors and their potential role in managing pest rodents and rabbits. In: Proc. Vertebr. Pest Conf. 13:145-150. Univ. Calif., Davis.

WALKER, G. T. 1968. Capsaicin - properties, reactions and uses. Manuf. Chem. and Aerosol News 39:35-42.

WATERS, R. 1985. Aspects of the ecology of the Swamp Wallaby Wallabia bicolor (DESMAREST) in Eucalyptus regnans (F. Muell) and Pinus radiata (D. Don) plantations. MSc Thesis, Monash University, Australia.