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AN INTEGRATED PEST MANAGEMENT STRATEGY TO MANAGE MAMMAL BROWSING ON STATE FOREST IN TASMANIA

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ABSTRACT: Browsing of sown and planted tree seedlings by mammalian herbivores (wallabies, pademelons, possums and rabbits) is currently a significant biotic risk faced by production forestry in Tasmania. Use of the poison 1080 has historically been the principal method of managing mammal browsing. However it's use, particularly against native herbivores, is controversial and in 2004 the Premier of Tasmania announced that the use of 1080 on State Forest would cease from December 2005. New knowledge of the development of browsing-damage over space and time in young eucalypt plantations has now provided the framework to guide implementation of a suite of tactics to manage browsing, each to a particular level of browsing risk. In this paper we outline the strategy being adopted for the replacement of 1080-based management of mammal browsing in State Forest in Tasmania with integrated pest management.

INTRODUCTION

Forestry Tasmania is a Government Business Enterprise, responsible for managing 1.5 million hectares of State forest. In financial year 2003/04, 11300ha of native forests were regenerated, while 6100ha of eucalypt plantations and 2900 ha of pine plantations were established (Forestry Tasmania Annual Report 2003-04). Eucalypt plantations established under Forestry Tasmania's Intensive Forest Management Program, are managed for the production of sawlog and veneer through effective site selection and cost effective pruning, fertilising, thinning, and pest management techniques (Farmer and Smith 1997).

Native, and introduced, herbivorous mammals are significant pests in forest establishment in Tasmania (Statham 1983; Wardlaw and de Little 2000). The animals involved are the Bennett's wallaby (*Macropus rufogriseus*), brush-tail possum (*Trichosurus vulpecula*), Tasmanian pademelon (*Thylogale billardierii*), and occasionally the introduced European rabbit (*Oryctolagus cuniculus*).

If seedlings are less than one metre tall, and the browsing damage is repeated and severe, then browsing impacts on seedling survival and growth (Neilsen 1981, Wilkinson and Neilsen 1995). Left unmanaged, browsing can result in significant areas of seedlings failing to establish or be suitable for managing to produce sawlogs, thus devaluing the crop. For example, Neilsen and Wilkinson (1995) studied 586ha of unprotected *Eucalyptus nitens* and *E. regnans* plantations and found 63% of area failed due to browsing.

For many years the primary means to mitigate damage has been the use of the poison 1080 (sodium monofluoroacetate) to reduce local browser populations. The use of 1080 has been highly controversial in Tasmania (Fabian 2001). In 2001 a government sponsored community consultation process set a benchmark to phase out the use of 1080 by 2015 (Tasmania Together Government Activity Report 2002). Forestry Tasmania has a corporate objective to enjoy the broad support of the Tasmanian community for State forest management, and has made a commitment to reduce absolute use of 1080 by a minimum 25% between financial years 1999/2000-2004/2005. By financial year 2002/2003 Forestry Tasmania had exceeded this benchmark with a 38% reduction in the amount of 1080 used (Forestry Tasmania Sustainable Forest Management Report 2002/2003). In September 2004 the Tasmanian Premier Paul Lennon gave the commitment to parliament that the use of 1080 on State Forest would cease from December 2005. During the 2004 Federal Election campaign, the Howard Government made a commitment to fund research to help eliminate the use of 1080 on private lands in Tasmania, as well (Loghnane 2005).

The reduction in 1080 use by Forestry Tasmania has been largely due to an increase in the use of shooting. The leader of the Tasmanian Greens, a party that tabled a bill in State Parliament to ban 1080 (for all users except those involved with fox eradication) (Booth 2004), has advocated shooting as an alternative to 1080; “And of course, we mustn't forget good old-fashioned shooting. There are some times when that is the most appropriate method to be used as long as you have skilled people who are doing it.” (Putt 2003). Further, the leader of the Australian Greens, Bob Brown, has also suggested shooting as an alternative to 1080; “There is electric fencing, and ultimately it is better to shoot the animals. It's much better for the environment than the indiscriminate 1080. They're using 1080 because it's cheaper than bullets" (Harvey and Sexton 2004).

Despite tacit approval of the use of shooting from such high profile political leaders, is likely that replacing 1080 with a single lethal option will quickly lose broad community support. For example, an opinion survey of Melbourne and Sydney residents, commissioned by the government department Tourism Tasmania, found that approximately 10% of respondents agreed that it is acceptable to use 1080 protect seedlings, while only around 30% agreed that it is acceptable to use professional shooters to protect seedlings (Roy Morgan 2004). Further, it is likely that shooting will be uneconomical and ineffective in a number of situations. An approach that maximises the use of non-lethal options for managing browsing, in order to reduce the need for lethal control, would be a better option both in terms of economics and social acceptability.

In this paper we outline our approach for developing a way of managing browsing mammals using the principles of integrated pest management (IPM). In particular we describe how we have used a risk-based framework to design the elements of an IPM strategy against marsupial browsers.

Understanding browsing risk

Over the past four years, we have undertaken regular and intensive assessments of browsing damage in unprotected eucalypt plantations, during the first few months after planting. These surveys, which included mapping the damage using Global Positioning Satellites, have provided us with an objective basis for classifying plantations into categories of browsing risk based on the rate at which browsing increases over time. We are currently undertaking a similar survey approach in sown native forest coupes

As a result of the surveys, we could classify the plantations into browsing risk classes, i.e. low-risk (the initial rate of browsing was less than 0.5% of seedlings damaged per day); moderate-risk (between 0.5% and 2% of seedlings damaged per day); and high-risk (over 2% of seedlings damaged per day) (A. Walsh, unpublished data). The rate of damage is important because if it is slowed down sufficiently, the growth of seedlings can continue to a stage beyond which browsing has little impact. Bulinski (1999) found a strong correlation between the percentage of seedlings browsed and the mean severity of damage to individual seedlings. Thus, in plantations where the percentage of seedlings browsed is high, the severity of damage and the impact on survival and growth is high as well.

We also found spatial patterns in browsing damage within plantations. We have not yet completed analysis of the relationship between spatial patterns of damage and site factors. However severe damage is sometimes confined to small areas in a plantation, which we call hot-spots. These hot-spots can occur in low-risk as well as higher-risk plantations. For example, the plantation illustrated in Figure 1 was a low-risk plantation, except for the presence of hot-spots. In high-risk plantations the hot-spots have spread to cover most of the plantation.

Fig. 1. Aerial photo and map of a *Eucalyptus globulus* plantation, showing browsing damage 19 weeks after planting. Dots represent position of surveyed seedlings, with open circles representing unbrowsed seedlings and filled circles representing seedlings that suffered browsing at any time during the study. Damage is clustered in a "hot-spot" in the top right hand corner, which is probably related to pademelons sheltering in forest in daytime then moving through the plantation to graze on pasture in the adjacent farm land at night as indicated by the arrow (A. Walsh, unpublished data).

The risk-based IPM for browsing mammals

The aim of the spatio-temporal studies is to enable us to predict the coupe browsing-risk, and the location of hot spots before planting/sowing. This will allow for integrated pest management by planning appropriate threat-abatement measures before damage occurs. Table 1 presents a prototype IPM strategy in which various tactics for managing browsing in a new plantations are deployed on the basis of risk and timing (pre-, at or post-planting).

Table 1. Outline of the browsing IPM strategy and the tactics used for eucalypt plantations of various browsing risk profiles (note hot-spots can be found in each browsing risk profile).

Stage of deployment	Coupe browsing risk			
	Low	Moderate	High	Hot spots
Before planting	Nursery manipulation of seedlings			
		Shooting +/- trapping		
At planting		Repellents with diversionary feed		Tree guards or big seedlings
After planting		Monitoring +/- shooting or trapping		Tree guards

Nursery manipulation of seedlings
Research is planned to develop techniques to manipulate seedlings during nursery cultivation in order reduce the likelihood and impact of browsing damage to individual seedlings by;

- decreasing seedling palatability by exploiting the heritability of high levels of particular plant-secondary compounds in eucalypt leaves (O'Reilly 2000),
- decreasing palatability by toughening seedlings through a regime of regular flexing, which has been shown (in captive animal trials) to increase lignin production and confer a small but significant decrease in palatability (Burton 2003), and
- increasing growth rates after transplanting by applying high-nitrogen fertiliser during nursery development (Close *et al.* 2002). A particular focus of this approach will be to develop ways to manipulate the fertiliser regime so as to also reduce the palatability of nitrogen-rich seedlings.

Pre-plant shooting and/or trapping
In high-risk plantations, and some moderate-risk plantations, lethal methods to reduce browser populations will be required before planting. Diversionary feed, such as chopped carrot, will be used as bait in order to monitor the need for, and effectiveness, of shooting operations. Diversionary feed will also be used to attract the cryptic browsers into highly visible areas where they can be shot efficiently and humanely.

Trapping, where animals are caught and held alive in a cage overnight, before being shot the following morning, does not rely on establishing a line of sight to the targeted animal. We expect this method to be more effective than shooting in areas of reduced visibility due to vegetation, topography or harvest debris. While commonly used to manage possums, it is not an established method for managing pademelons. Two trap designs that may be suitable to capture pademelons already exist (Kinnear *et al.* 1988; Pollock and Montague 1991). However two other traps designs have recently been developed in Tasmania. Research and development is underway to test these latter designs to ensure they are humane, as well as to determine their effectiveness in reducing the rate of browsing.

Experience of US wildlife damage managers has shown that in order to maintain public trust when using lethal methods, an important consideration is to document that the animals taken are indeed the ones causing the damage (Dolbeer 2003). It may be possible to more confidently predict which species of browsing mammal is likely to be the most damaging in a particular situation by conducting animal tracking studies to try and detect associations between damage and site.

Repellents with diversionary feed

The repellents, WR-1® and PlantPlus® (known as PinePlus® in New Zealand) have been shown to reduce browsing damage (Marks *et al.* 1995, Delbridge and Lutze 1998, Johnston *et al.* 1998, Broekman and Wood 1999, Montague 2001, Witt 2002, A. Walsh unpublished data). Depending on the level of browsing risk, repellents slow the rate of browsing, which allows more time for seedlings to toughen and grow, as well as time to conduct lethal control operations if needed. These repellents are most cost-efficiently used by applying to seedlings whilst in the nursery just before dispatch. In the case of PlantPlus, this restricts the period of repellency to a narrow window of 2-3 weeks after planting (A. Walsh, unpublished data). The cost-effectiveness and practicality of re-applying repellent to planted seedlings in the field, and the species-specificity of the repellents (in order to deploy to correct areas) requires further investigation. Both WR-1 and PlantPlus require registration by the Australian Pesticides and Veterinary Medicines Authority.

Diversionary feed is required in order for repellents to be effective, as it provides animals an alternative to the seedlings treated with repellents (L. Clark pers comm, A. Walsh, unpublished data). The deployment of such crops in plantations could involve the use of existing vegetation growing on the site, sowing a decoy crop on site, or feeding out forage grown elsewhere. Further research is needed to select the most suitable crops/food for diversionary feed, develop cost-effective means for deployment, and evaluate the effect of diversionary feed on the behaviour of target animals (with respect to crop damage), as well as any non-target effects.

Tree guards or big seedlings

Traditionally, hot-spots of severe browsing damage in plantations could be found even where 1080 was used, and even after multiple poisoning operations. Where these hot-spots occupy only a small section of the plantation, it is likely to be more effective to use tactics tailored specifically for these areas. Tree guards or extra-tall seedlings have been identified as the most practical option to protect seedlings in hot-spots. Ideally, hot-spots will be identified prior to planting so that appropriate tactics can be deployed before damage occurs. Because of their greater cost, these options would be used on a reduced number of seedlings.

Tree guards that are currently available are unsuitable for industrial eucalypt plantations, and further research and development is required to provide an improved design. Extra-tall seedlings are grown in the nursery to the "browse-proof" height of 70-100 cm, and are coated with the repellent WR-1®. A field trial to evaluate the performance of tall seedlings is in progress. Fencing also remains an option that can be used in certain situations, particularly in suitable terrain where neighbouring vegetation communities harbour browsing mammals. However, the deployment of a physical barrier needs to be carefully considered due to the substantial costs ($AUD7000/km) and the potential for severe crop losses if the barrier fails.

Post-plant monitoring ± shooting or trapping

The non-lethal tactics just outlined may be sufficient to manage browsing in low risk plantations and hot-spots. In moderate and high-risk plantations, non-lethal tactics are not likely to provide sufficient protection. We have developed cost-effective monitoring method (A. Walsh, unpublished data) to detect when further controls are needed for protection. We plan that such monitoring, done regularly, would guide the use of post-plant shooting or trapping operations.

Sustainable management of browsing mammal populations
We have developed a strategy that aims to manage browsing during the relatively short time period that plantations are vulnerable, and spatially only at the coupe level. However the current forestry – agriculture interface favours high densities of the browsing mammals (Coleman *et al.* 1997, Efford 2000). In the longer term, this crop protection approach to managing browsing is not likely to be sustainable if used in isolation.

Another approach is to undertake landscape-scale management. Property based game management plans are being used increasingly in Tasmania to provide landscape-scale management (Game Management Services Unit 2004). The tools of property-based wildlife management plans are currently limited to culling. Further research is needed to expand the range of tactics available to manage populations at the landscape level. This should include research to better understand the response of browsers to the forestry – agriculture interface, as well as investigating the inter and intra-species interactions and their effect on browsing damage.

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