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# Alternatives to 1080 Poison for Control of Native Animals in Tasmania: A Response to Public Concerns

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**ABSTRACT:** Compound 1080 (sodium monofluoroacetate) has been used in Tasmania for control of introduced rabbits since the early 1950s and for the native Bennett's wallaby, Tasmanian pademelon, and brushtail possum for almost as long. Recently, public pressure has resulted in a target to phase out the use of 1080 by 2015. In 2005, the Australian and Tasmanian Governments announced funding for a program to assist in the development of alternatives to 1080. Following an initial independent review in 2006, research and demonstrations focussed on fencing and barriers; shooting, trapping and behavioural research; alternative toxins and delivery mechanisms; repellents; and damage / control relationships. The most positive outcomes from the program were increased understanding of the complexity of the Tasmanian browsing damage problem and the need to measure and address the damage, rather than count the numbers of animals culled. For those agricultural producers who had used it, wallaby-proof fencing was thought to be the most effective long-term control option, despite the increased costs of materials and maintenance. Fencing is not suitable for all situations, including most forest production areas; it is not a stand-alone control option, as it must be accompanied by culling at construction and over time. Shooting is the second-most-important method of control, and there is scope for improvements in effectiveness through better practices and equipment. Trapping can be useful in some areas but it is expensive, and current traps will not catch Bennett's wallabies. Repellents have not proven to be effective, and further developmental work is required before Feratox<sup>®</sup> can be recommended for safe use in Tasmania.

**KEY WORDS:** 1080, Australia, Bennett's wallaby, browsing damage, brushtail possum, control, fencing, *Macropus rufogriseus*, repellents, shooting, trapping, Tasmania, Tasmanian pademelon, *Thylogale billardierii*, toxicants, *Trichosurus vulpecula*

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## INTRODUCTION

In Tasmania, rocky slopes generally left as bush frequently abut improved pastures, crops, and forest coupes, providing a mosaic of vegetation types ideal for three native marsupial species: two wallabies, Bennett's wallaby (*Macropus rufogriseus rufogriseus*) and Tasmanian pademelon (*Thylogale billardierii*); and brushtail possum (*Trichosurus vulpecula*) (hereafter called Bennett's, pademelon, and possum). Individuals of these species mostly shelter in the bush by day and emerge in the evening to feed on pasture, crops, and newly planted or germinated tree seedlings.

Loss of agricultural production to browsing is considerable and ongoing, although most producers have only anecdotal records. Limited experimental information has reported between 11% and 100% pasture loss in areas accessible to wallabies at locations around the State of Tasmania, Australia (Statham 1994, 2000; Donaghy and Tegg 2001, Statham and Rayner 1995). Browsing damage in forest coupes is extensive and has been reported over the past 30 years (Cremer 1969, Coleman et al. 1997, Statham 1983). It mostly occurs at seedling stage and anecdotally has been thought to be concentrated in areas close to vegetation cover.

For several decades, poisoning with 1080 was the primary control method used to address browsing

damage. The amount of 1080 used has declined from around 30 kg per annum 20 - 30 years ago to less than 1 kg in 2009. As a direct response to this reduction, culling by shooting and trapping has increased in recent years to over 1,000,000 wallabies, and 350,000 possums, (J. Dawson, DPIPWE, pers. commun.). The numbers culled do not reflect the relative contribution of each species to the browsing damage but rather their relative abundance and ease with which they can be culled. Shooting in its various forms (recreational, hunting, professional, and commercial) is the primary method of control.

The 3-year 'Research into Alternatives to the Use of 1080 Program' was funded by a \$4 million grant from the Australian government. It was run through DPIPWE by a program manager, John Dawson, with a Stakeholder Advisory Group and Technical Committee. The objectives were to develop practical, effective, and financially-viable alternatives to 1080 in controlling Tasmanian browsing animals on private forest and agricultural land through implementing a coordinated research, field testing, and demonstration program.

Following an independent review of current practices recommending possible research areas, 19 different projects were funded as well as a cooperative program with the Tasmanian Institute of Agricultural Research (TIAR). Two project officers were employed specifically

for the Program, primarily to work with private landowners, demonstrating and trialing trapping, shooting, and fencing activities.

The findings from the Program, which finishes in June 2010, are considered here with information sourced from either published papers or unpublished reports to the Program.

## **LANDHOLDER DECISION MAKING REGARDING USE OF 1080**

A socio-economic study was carried out to identify how different landholders monitor and react to high levels of browsing damage and how they decide whether or not use 1080 (Mooney and Fulton 2008). The data were collected by means of a stakeholder workshop, mailout survey, and 90 interviews with landholders.

The majority of landholders regarded the management of browsing animals as 'very important,' the mean reported reduction in productivity was 15%, and costs of control were regarded significant. Many expressed frustration because they perceive that the problems of browsing animals are increasing, but their choice of controls is decreasing. Most had an ongoing shooting program, and many also used fencing or 1080. Many landholder families did the shooting themselves; others use recreational shooters or gun clubs.

A significant number of landholders were fencing to exclude browsing animals, mostly on small and medium sized properties such as horticultural, cropping, or intensive grazing operations. The most common reason for not fencing was 'construction costs'. However, of all the control methods, respondents reported fencing as the most effective.

Landholders said that 1080 was a more common control strategy in the past than it is now. The most common reason for not using 1080 recently was that it was 'too hard to get', followed by 'concern about health, safety and environment', then 'concern about neighbour issues, including farm dogs'.

Only a minority of landholders consistently used formal methods to measure browsing damage and effects of control methods; the majority used observational methods, generally unrecorded. Some counted the number of animals shot or poisoned.

## **FENCES AND BARRIERS**

### **Wallaby-Proof Fencing**

Work in this area focused on extension-based activities and the development of practical information handouts. A 44-page Wallaby Proof Fencing planning guide (Statham and Statham 2009) was prepared, combining information from 36 property owners across Tasmania with results from relevant Tasmanian and mainland Australian studies.

Generally, fencing ideas from innovative landowners have been adapted by small groups of farmers in pockets around the state, often seeded by government grants. Materials and construction are more expensive than traditional fencing, and a variety of different mesh types, fence designs, and construction techniques were found to have varying degrees of effectiveness. In most cases, it was not until the fences had been constructed that farmers

realised how much pasture they had been losing to wildlife. There was no 'best' wallaby fence identified, as the materials and design depend on the animal species involved, terrain, proportion of the population to be excluded, and finances available; and no single fence type is suitable in all situations.

Wallaby-proof fencing is a long-term option that requires careful planning and ongoing maintenance. It needs to be integrated with other control methods such as shooting, poisoning, or trapping at the time of construction, to reduce physical pressure on the fence, browsing pressure on the area into which the animals are restricted, and possible animal deaths due to starvation. Further lethal control is required over time as breaches occur, and shooting along the fenceline can be very effective.

Two major impediments to effective wallaby-proof fencing were holes dug under them by wombats (*Vombatus ursinus*) and where a public road goes through a property. A functioning wombat gate that allowed wombat thoroughfare but stopped wallabies was developed. Similarly, a modified cattle grid was found to reduce Bennett's traffic by 50%.

Some of the fences surveyed used electrified sheep mesh effectively, but in each case the material costs were similar to non-electrified fences, due to cost of insulators. An innovative fence system designed for domestic stock was tested. With specially designed insulated plastic sleeves for attaching wire mesh and lightweight posts, it is cheaper and quicker to construct than other electric fencing. However, it was found to be insufficiently robust to cope with pressure from Bennett's. Clips and plastic sleeving were broken, some posts were pulled out, and some animals forced the mesh open as they pushed their way through.

### **Individual Seedling Protection**

Individual tree guards, referred to as seedling stockings, are now used on eucalypt seedlings planted in peripheral rows of a forest plantation. Made of flexible polyethylene netting, they are applied in the nursery before planting and thought to prevent browsing damage. In a trial at 8 sites where stockings were applied to the outside row of seedlings, browsing was delayed, but after 48 weeks there was no difference between treatments (Miller et al. 2009).

## **SHOOTING**

### **Night Vision Rifle Scope**

In a study of the effectiveness of culling the three browsing species on farmland by shooting, which compared an infrared night vision rifle scope to standard spotlight shooting, 871 animals were shot and 1,114 seen. Pademelons were the most abundant species, followed by possums. For both wallaby species, 96% of animals seen when using the night vision scope were shot, compared with 52% of animals seen with a traditional white light spotlight. Spotlighting had some advantages in terms of familiarity, comparative comfort, and the area that could be covered; but the night vision technology enabled shooting in areas inaccessible to vehicles and selective shooting of animals with different habits. Establishment of food dumps was required pre-shooting to attract

animals, a technique already used by many professional shooters as part of their normal spotlighting activities (Tasmanian Plantation Management Services 2009).

### **Wallaby Response to Spotlight and Shooting Noise**

The response of wallabies to spotlight, and to vehicle and firearm noise, was observed in a paddock adjacent to bush where shooting from a vehicle had recently occurred, using a large multi-filter spotlight and video camera set on a high tower. Under a white spotlight, Bennett's generally remained stationary, but pademelons hopped off quickly. When shots were fired towards them, both species became more alert and hopped a small distance, and then stopped to graze; but when someone walked towards them letting off regular shots, both species hopped away. When a vehicle was started, up all pademelons fled out of site before the spotlight was turned on.

### **Firearm Noise Suppression**

The efficacy of shooting using a red light, firearm suppressor, and subsonic ammunition with a .22 rimfire rifle was investigated at two sites where pademelons were the most abundant species present. At the first site, the advantages of the sound suppression deteriorated quickly because animals moved to the edge of the light, too far away for a clean shot. At the second site, 417 pademelons and 49 Bennett's were shot. The dramatic decline in numbers shot, seen leaving, and observed out of range over time suggested most had been culled.

### **Thermal Imaging Scope**

In several trials, more than twice as many animals were seen with thermal imaging than with a white spotlight during fixed-point counting. However, it was not possible to differentiate between the wallaby species, as they both showed as black blobs. The use of a thermal imaging scope for locating animals also improved a professional shooter's efficiency in some circumstances.

### **Effectiveness of Commercial Harvesting for Browsing Control**

This study on King Island, Bass Strait, where Bennett's cause considerable loss of pasture, was carried out in two phases. The first, based on driven spotlight transects estimated numbers foraging on the island's pastures, and the second compared the amount of pasture loss with shooting for commercial harvesting, to traditional shooting that aims at killing as many wallabies as possible. A population of between 440,000 and 535,000 Bennett's was estimated to be grazing the 71,000 hectares of pastoral area (Branson 2008). Preliminary results from the second phase indicated that commercial harvesting did not significantly reduce pasture losses to wildlife, because shooters only took limited numbers of animals. More intensive shooting was more successful in reduce pasture losses.

### **TRAPPING**

Because possums are readily trapped, the aim of trapping was to maximize trapping efficiency of pademelons and Bennett's. At the start of the Program, there

were two traps approved for catching possums and pademelons in Tasmania: the Mersey box trap and Edwards tent trap. The Mersey box trap is a modified cage trap with a sheet metal hood that drops down when the trap is sprung, developed by Forestry Tasmania (FT) specifically for catching pademelons, which exhibit signs of stress when held in traditional mesh traps. The Edwards tent trap, designed by Dr. Ivo Edwards, is a collapsible trap comprised of a nylon fabric wool pack attached to a minimal steel framework, so that the trapped animal is contained by soft fabric. Edwards put considerable effort into improving his original trap design.

### **Targeted Culling by Trapping**

Trials prior to the Program found that possums had a stronger preference than pademelons for eating eucalypt foliage, both in captivity (McArthur et al. 2000, McArthur and Turner 1997) and on plantations (Bulinski and McArthur 2003). If possums were responsible for most eucalypt browsing damage, culling only by trapping them would reduce the killing of wallabies and the considerable cost it incurs. A trial in 5 plantations to test this hypothesis was abandoned when a steady increase in damage straight after planting was attributed to Bennett's, and shooting became necessary to save the crop.

### **Trapping Intensity**

By increasing the density of Mersey box traps (30, 60, and 120 traps / km) along 1-km trap lines, the number of pademelons trapped increased from 45 to 154 and then 180, but resulted in a decline in percentage capture rate from 50% through 34% to 8%. At the low density, catch was dominated by possums, to the detriment of wallaby catch.

### **Trap Comparison Trials**

Two groups did trap comparison trials between Mersey box traps and Edwards tent traps. In the first, by an operator unfamiliar with Edwards tent traps, 37 pademelons were caught in Mersey box traps and 3 in Edwards tent traps. In the second, Edwards compared these two traps and two of his later designs, Stubby Tent Trap 2 and Lay Flat Trap, both of which comprise soft fabric and a sprung metal framework. Pademelons and possums were caught in all four trap designs at several different locations, but more possums than pademelons were caught in all but the Lay Flat Trap. Comparisons between the traps were compounded by differences in numbers of traps used, nights trapped, and presentation of catch efficiency data in terms of numbers of total animals rather than by species.

### **BEHAVIOURAL RESEARCH**

A movement study of wallabies gained an understanding of how home ranges of wallabies change following a lethal control program and construction of a wallaby-proof fence (Wiggins et al. 2010). Thirteen pademelons and 17 Bennett's were trapped in pasture adjacent to bush on three properties and fitted with GPS collars. The collars were programmed to record 3 10-minute interval positions at 0200, 0600, and 2100 hours daily between mid December 2008 and early June 2009.

Lethal control by shooting removed 191 pademelons and 66 Bennett's from one property in February, and two sections of wallaby proof mesh fence with electrified outrigger were constructed on the boundary of the same property in March.

Tracking data 4 weeks pre- and post- both interventions were used to quantify animal movements. Immediately following the shooting, both species increased both their home range area and percentage of agricultural land used. The estimated home range areas were  $2.4 \pm 0.7$  ha for pademelons and  $10.3 \pm 1.9$  ha for Bennett's pre-shooting, and  $3.3 \pm 1.1$  ha and  $11.6 \pm 1.7$  ha, respectively post-shooting. Post-shooting, those animals of both species remaining spent significantly more of their time on the pasture. Estimated home range area for pademelons moving near one of the fenced areas decreased significantly from  $3.2 \pm 1.1$  ha to  $2.6 \pm 0.7$  ha, with individuals shifting their range around the ends of the fence to an adjacent unfenced paddock. At the other, longer, new fence, Bennett's decreased their range non-significantly from  $12.8 \pm 4.5$  ha to  $6.1 \pm 1.3$  ha. In the absence of adjacent unfenced pasture, they moved over the hill to a different property. The 6 females stayed out of the paddock after fencing: 3 of them went near the fence but scarcely changed their range in the adjacent bush, a fourth stayed in the bush without being recorded near the fence, and 2 extended their range away from the fence including spending time in a eucalypt plantation approximately 1.2 km from the fence. Of the 7 males, 2 moved around the southern end of the fence into the paddock. None of the others were recorded near the fence, but were recorded in their former range areas, 2 increased the time spent in the plantation 1.2 km away but not the actual area. There was little shift in home range location at the unfenced site for either species.

### REPELLENTS AND DETERRENTS

A study investigated whether populations of possums that have coexisted with two bluegum (*Eucalyptus globulus*) populations of genetic extremes in susceptibility to mammal browsers have different feeding responses to bluegum (Wiggins et al. 2008). No significant differences in possum feeding response were found, when possums from the two locations were offered foliage types from four different locations, and it was concluded that all possums should respond similarly to all seedlings, regardless of eucalypt genetic resistance to browsing.

Two trials found that SenTree™ Browsing Deterrent (Sure Gro, Dingley, Victoria, Australia), an egg-based repellent incorporating a sandy grit, was ineffective in preventing damage (Miller et al. 2009). A multi-agent repellent comprising egg powder, bitrex, oleoresin capsicum, skunk, and predator odour, developed in New Zealand (Shapiro et al. 2008), was used for trials in Tasmania together with dingo urine and Feralmone®, a spray pack dog and fox attractant containing synthetic fermented egg having anecdotal wallaby repellency. Only the multi-agent repellent was effective in preventing wallabies from eating commercial wallaby pellets; however, this formulation smelled so strongly it was difficult to use (Fowles 2009).

### ALTERNATIVE TOXINS AND DELIVERY MECHANISMS

Following a review of alternative toxins available, Feratox® (Connovation Ltd., Auckland, New Zealand), an encapsulated form of cyanide, was investigated by a collaborative New Zealand - Tasmanian study. Captive studies in New Zealand found that Bennett's died quickly and humanely from Feratox® (Statham et al. 2010). The Tasmanian research investigated a range of bait stations, in order to target browsing species and minimise nontarget poisoning, through nontoxic trials with a captive colony of wallabies and in field conditions, using still and video cameras to record animal behaviour. The smaller macropods (Tasmanian bettong, *Bettongia gaimardi* and long-nosed potoroo, *Potorous tridactylus*), common wombats (*Vombatus ursinus*), and birds were excluded by use of above-ground, box-style bait stations.

Mixed results were achieved in 4 field trials using Feratox® in agricultural areas. In the first trial targeting pademelons in August 2008, very few pademelons ate from bait stations and none were killed, despite observations of them in the area when spotlighting. In the second trial, also targeting pademelons in August 2008 at a different property, Feratox® was presented in a peanut butter-based bait mixture placed in Strikers (small rectangular potato starch dishes, Connovation Ltd., Auckland, New Zealand) stapled to posts. In this trial, 51 pademelons were killed, and spotlight counts before and after poisoning indicated an 83% reduction in the poisoned area and no change in the adjacent control area. Spillage of bait and Feratox® was a concern in both trials, and a potoroo was killed in the second trial, presumably from eating a spilt Feratox® pellet.

Following further work to improve Feratox® delivery, two more toxic trials were carried out. Trial 3, in September 2009, targeted both wallaby species using single-bite baits. Nine Bennett's and 41 pademelons were killed, but spotlight counts showed reductions of only a 10% in pademelon and 18% in Bennett's numbers after poisoning, and faecal pellet collections indicated a 53.7% and 22.2% reduction in numbers deposited, respectively. Also, a high proportion of Feratox® were spilt, attributed to animals detecting cyanide leaking from the capsules.

Trial 4, in January 2010, targeted both wallaby species using Strikers in a paddock near the Trial 2 site. Pademelons showed little interest in the baits; only 10 were killed, and average numbers seen spotlighting pre and post poisoning were 26.7 and 25.0, respectively. Although only 6 Bennett's were killed, all on the first night, these represented most of the population in the area, as average numbers seen dropped from 4.7 pre-poisoning to 1.0 post-poisoning. This trial was compromised by forest ravens (*Corvus tasmanicus*) attracted to the bait. Ravens had been present in variable numbers at all other trial sites, particularly during poisoning when they scavenged carcasses, but had not previously been attracted to bait. The lack of interest in baits by pademelons was unexpected, as there was a big reduction in numbers nearby earlier, in Trial 2 (Statham et al. 2010).

## DAMAGE/CONTROL RELATIONSHIPS

### Control Contract Systems

The suitability of adapting New Zealand “performance-based” possum control contract systems to Tasmanian conditions was reviewed (Warburton and Cowan 2008). These use either a defined trapping protocol or WaxTags® (Pest Control Research Ltd., Christchurch, New Zealand) post poisoning to assess the remaining possum population. WaxTags® are small blocks of wax mounted on a triangular piece of plastic that animals readily chew, leaving an impression of their teeth later used for species identification (Thomas et al. 1999). It was noted that successful pest control requires a clear understanding of

- the target species;
- the relationship between browsing pest density and impact that is usually non-linear;
- the reduction in density required to get the desired resource protection – a control operation will only be successful if it reduces the damage to the required level, regardless of the number of animals culled; and
- the fact that for production systems such as forestry and agriculture, the benefits must outweigh the costs.

The review found that there was little information on the relationship between pest densities and their impacts in the two Tasmanian production systems. This meant that performance measures could not be set and hence a performance-based contract system was not recommended. Instead, an input system within an adaptive management framework was recommended, with further validation of spotlight counting to monitor populations, and testing whether WaxTags® are species-specific and hence inexpensive and effective for monitoring control operations.

### Property Based Wildlife Management Plans

Property Based Wildlife Management Plans (PBWMPs) are agreements between landholders and groups of hunters involving management of native and non-native pest and game wildlife, aimed to achieve effective mitigation of damage caused by overabundant animals, improved hunter access to wildlife, and reduced conflict between hunters and landowners (Hart 2000). A review examining the strengths and weaknesses of PBWMPs found there was little real data on which to base an assessment (Mooney and Presnell 2008). It suggested that a PBWMP is probably only fit for the purpose for which it was originally intended, and in reality this generally meant landholders with deer on their property can negotiate with shooters to have ‘game’ shot for the privilege of shooting introduced fallow deer (*Dama dama*).

### Integrated Game Management at a Sub-Catchment Scale

The feasibility of implementing sub-catchment browsing control using the nil-tenure approach was investigated over a series of meetings with landowners at Pyengana, a relatively isolated farming area in the north east of Tasmania (Mooney 2010). This approach considers the

movement and behaviour of species that cover large distances across the landscape, and targets the best control options and areas irrespective of the land tenure. Maps showing natural features and landmarks, but not property boundaries, are used to plan control strategies.

Despite finding that the nil tenure approach was not suitable in Tasmanian browsing control, largely due to the restricted movement pattern of wallabies, there were a number of positive outcomes from the project, mostly in relation to increased understanding of the issues involved in the management of native browsing animals.

### Measurement of Browsing Damage

Work in this area focussed on the measurement of damage in agricultural areas, with two studies measuring production loss in pastures. A 12-month trial of 16 northern Tasmanian dairy pastures found loss of production to pademelons was greatest near the bush edge and declined with increasing distance into the paddock. Averaged over the first 100 m, there was a loss of 53% in irrigated areas and 63% in dryland sites. Loss would have extended out beyond 100 m, declining with increasing distance from the bush.

In a 2-year study from February 2008 of dryland grazing pastures at Ross, in the midlands, browsing damage declined with distance from native vegetation edge. Damage from Bennett’s, possums, Forester kangaroo (*Macropus giganteus*), and fallow deer was severe during winter 2008 and varied between 100% at 25 m and 68% at 800 m from native vegetation edge. Browsing wildlife had the least impact during spring 2009, and reductions varied between 64% at 25 m and 0% at 800 m from native vegetation edge. Feed availability was found to be a large determinant into the distance and direction wildlife would travel to browse. It was not possible to quantify browsing animal numbers from various methods of spotlighting and faecal pellet counts (Smith 2010). A computer model is being developed to enable individual landholders to predict pasture losses on their farms.

## DISCUSSION

Tasmanian landholders surveyed in the Program regarded the management of browsing animals as ‘very important’, estimating a mean productivity loss of 15% and significant control costs. Many expressed frustration with their perception that problems of browsing damage are increasing, but choices of control are decreasing. These perceptions correlate with the increases in wallaby numbers counted and culled in recent years (J. Dawson, DPIPWE, pers. commun.). Also, personal observations by the authors and anecdotal reports suggest that pademelons in particular have extended their range and habitat use, and they seem to be behaving like an invading species.

Most landowners had an ongoing shooting program, and many also used fencing or 1080. The most common reason for not using 1080 recently was that it was ‘too hard to get’, followed by ‘concern about health, safety and environment’, then ‘concern about neighbour issues, including farm dogs’.

Wallaby-proof fencing was considered to be the most effective form of browsing damage control by those

landowners who had used it, from both the socioeconomic surveys and fencing study. However, it is more expensive than conventional fencing and needs to be very carefully planned, constructed, and maintained to provide long-term value. It is not a stand-alone control, but needs to be accompanied by lethal control at construction time to reduce pressure on the fence, maintain biodiversity in the area where the animals are contained, prevent wallabies moving to a nearby pasture or property, and for humaneness. Wallaby-proof fencing is not suitable for all situations, including most forest production areas. In plantations, individual seedling stockings delayed browsing damage.

Shooting was the most common lethal control method used. Work in the Program found that shooting efficiency can be improved by using specialised equipment including a night vision rifle scope, noise suppression, and a thermal imaging scope. Where control is by professional shooters, it may be worthwhile for some of them to set themselves up with some of this technology. The increased efficiency may be economical as well as a safer option than landowners shooting at night, after a full day's work on the farm.

Damage control by commercial harvesting does not seem viable because it relies on shooting a set number of bigger animals. This is disappointing, because wallaby meat is lean and hence healthy, and wallabies leave a light ecological footprint; they do not produce greenhouse gasses or cause erosion.

Not surprisingly, both wallaby species were found to shift their home ranges in response to both a lethal control operation and wallaby-proof fence construction. The home range estimates reported in this study were smaller than those of previous studies (le Mar et al. 2003), presumably because only night time records were made, and due to the short time frames of both the study and the subsamples used.

Some progress has been made trapping pademelons in both Mersey box traps and in Edwards collapsible traps. The latter suffer from the fact that few operators have had experience with them. None of the traps developed so far have caught Bennett's.

The most effective repellent formulation found, from pen studies in NZ and in a captive population of wallabies in Tasmania, was the combination of egg powder, bitrex, oleoresin capsicum, skunk, and predator odour, but it was too repellent to humans to allow practical use. None of the other natural or synthetic materials tested provided repellency beyond a few days.

Work with Feratox<sup>®</sup> found that it killed both wallaby species humanely, and it was found that nontarget species could be excluded from bait stations, but there are still issues relating to variable bait take by pademelons and spillage of toxic pellets.

Survey work showed that PBWMPs are really only effective in controlling browsing damage where deer occur, and the nil tenure approach was also found to be inappropriate. Except where properties share a common boundary with bush or plantation, in general it has to be an individual property problem and solution.

One of the main positives to come out of the Program was the increased awareness of browsing damage,

especially in agricultural areas. It is now realised by many that the relationship between damage and both animal species and numbers is not linear, and that it is the control of damage that must be addressed, and not simply the culling of wallabies and possums. We still do not have a sound method of estimating wallaby and possum population size, as both spotlighting and faecal pellet counting have been found unreliable. To this end, it is vital for land managers to measure the damage loss accompanying control measures and to ensure that the control operations are cost effective.

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