Context Pest Control in New Zealand

Introduction

The early European settlers to New Zealand committed an enduring ecological blunder by introducing a great variety of their “replacement mammals” to environments that were often unable to cope with the subsequent impacts. For the previous 60 million years the only land mammals living here had been three species of bats (one is now extinct). No other large landmass on Earth has had such a history. Our native plants had co-evolved mainly with birds and insects, shaped by a dynamic climate. Consequently, many plants lack defences against browsing and grazing mammals, nor can they exploit mammals to disperse their seeds as do many continental plants. In this “heaven for herbivores” with plentiful food supplies, no predators, few diseases or competitors and mild winters, the founding populations of rabbits, rats, mice, possums, deer, goats, chamois and tahr increased rapidly. These population increases were made at considerable and sometimes devastating losses to native forests and other ecosystems. As rabbits decimated grazing lands, settlers compounded their first error with another by introducing the rabbit’s “natural enemies” – stoats, ferrets and weasels. Native birds and invertebrates then faced predation as well as competition pressure for food from the browsers. Many birds, such as the piopio and huia, did not survive this double onslaught that was exacerbated by the extensive habitat losses that accompanied colonisation.

The outcome of centuries of ecological upheavals has been one of the world’s highest rates of bird extinctions, about 1000 native species currently listed as threatened and a legacy of pest control obligations that continues today. Like other island countries that are remote from continental areas, a high percentage of New Zealand’s indigenous species are endemic (found nowhere else). This provides an additional global obligation for species conservation and further underlines the need to develop and apply effective pest control methods.

The pest status of a number of these introduced mammals - the possum in particular - has been compounded by the fact that they have become infected with bovine tuberculosis (subsequently referred to as “Tb”). Introduced species infected with Tb (possums, ferrets, deer, pigs, feral cats, stoats and hedgehogs) are now found in 16 separate geographical areas of New Zealand covering about 40% of the country’s land area. Feral cats, stoats and hedgehogs are ‘low risk’ species, however, in terms of transmitting and spreading Tb.

In contrast, possums can act as both a *maintenance host* (Tb can survive in possum populations without re-infection from any other source) and *spillover host* of Tb (contract Tb and infect other animals or species either directly or by scavenging infected carcasses.) A spillover host cannot cycle Tb through populations of its own species. While other wild animal species, such as ferrets and deer, can be important spillover hosts for Tb, possums are the major maintenance hosts for Tb. Ferrets are the other species that can be a maintenance host, but only at relatively high population densities. Hence contact with infected possum vectors is the main cause of Tb infection in farmed cattle and deer. The need to control wildlife infection thus adds a costly and complex dimension to the control and eradication of Tb from cattle and deer herds in New Zealand.

There has been steady development and refinement of pest control technologies and approaches over the past 50 years. These have been driven by the need for more specific targeting of pests, more humane methods, greater operational efficiencies and effectiveness. The desired outcomes have not focused on the number of pests killed, but on saving threatened species and ecosystems as well as improving the productivity and health of the primary production sectors, notably agriculture.

The poison referred to as ‘1080’ has been an important, indeed vital, toxin that has been applied and refined for use in pest control over most of this period. Its particular role as the only poison registered for aerial application throughout New Zealand, as well as for ground use, will be developed in more detail in subsequent sections. Central to its aerial use is the internationally unique circumstance that most of the mammals in New Zealand’s forests (especially rats) are usually regarded as pests and their losses following aerial 1080 operations are generally desirable or inconsequential with respect to the ecosystems they inhabit.

A. Vertebrate Pests in New Zealand

The primary use of 1080 in New Zealand is for the control of possums to meet a range of objectives and its use in the context of possum control will therefore be the major focus of this reassessment application. As the following brief summary explains, there are other important pest species in New Zealand that also threaten agriculture production and biodiversity values. For some of these 1080 is also an important management tool.

A.1 Possums

The Australian brushtail possum (*Trichosurus vulpecula*) was first released in New Zealand in 1858 near Riverton, Southland, but the major introductions and releases throughout New Zealand were in the 1890s. The original intentions of establishing a profitable trade in possum fur meant possums were legally protected for several decades through a restricted hunting season. Scientific evidence in the 1940s documented the negative impacts of possums on native forests. This led to an about-turn in Government policy in 1947 when all restrictions were lifted and the use of poisons was legalised for possum control. Possums continued to spread and now occupy the three main islands with the exception of coastal areas of south-west Fiordland. Possums have been successfully eradicated from at least 15 off-shore islands, including Kapiti, Rangitoto, Motutapu and Whenua Hou (Codfish), using poisons, traps and dogs. The resulting benefits for many native plant and animal species, particularly birds, have been documented.

Possums act as both maintenance and spillover hosts of Tb (definitions on previous page) and are the major source of Tb infection in livestock (cattle and deer). Possums were first implicated as Tb vectors in the late 1960s. The continued presence of Tb in New Zealand livestock herds has significant economic implications for New Zealand’s agriculture and primary produce sectors. The Animal Health Board (AHB) has the objective of achieving “Official Freedom” from bovine tuberculosis (no more than 0.2% of cattle and deer herds infected on a period prevalence basis) for New Zealand by 2013, through the implementation of a long-term pest management strategy. As proven vectors and maintenance hosts of Tb, possums are the primary target of AHB operations.

Possums are opportunistic feeders. Animals as well as plants are eaten by possums and they have both subtle as well as obvious effects on ecosystems.They cause major damage to native forests from ground level to the canopy by concentrating their feeding on particular species. Destruction of forest canopies has modified many areas; shrublands have replaced tall forests. Possums also have a significant impact on forest health and biodiversity by feeding on flowers, fruit and new shoots, thus competing for food with native bird and invertebrate species. They are now known to prey on eggs, chicks and even adult native birds on the nest, as well as young roosting bats. Invertebrates (including indigenous land snails and many insect species) are eaten by possums, especially in summer and autumn.

Possums also cause damage to seedlings and young trees in exotic plantations, and possum control during plantation establishment is a significant cost to the forestry sector. Possums also damage horticultural crops and gardens. At high densities they can reduce the availability of forage for grazing livestock.

A.2 Rabbits

Rabbits are the main vertebrate pest threatening grazing lands in New Zealand as well as being a significant conservation pest. Rabbits compete with livestock for feed, damage crops and young trees, and have detrimental effects by defoliating plants, modifying plant communities and destroying soil structure. While rabbits are no longer considered to be a problem throughout the country, (national extermination ceased as official government policy in 1971), they remain a significant regional problem, particularly in the South Island. Most regions in New Zealand have prepared Regional Pest Management Strategies that declare rabbits as pests and require some level of control to be undertaken.

Currently, rabbit haemorrhagic disease (RHD) is the main form of rabbit control in rabbit-affected areas. RHD was introduced (illegally) in 1997. Prior to the spread of RHD, 1080 was one of the important toxins in the battle to reduce rabbit numbers. As rabbits develop resistance and RHD loses its initial effectiveness, 1080 will re-emerge as an important option for controlling rabbit numbers.

A.3 Deer

Although there are nine species of introduced deer in New Zealand (including moose in Fiordland) the species causing the most widespread damage to forests and high country areas is the red deer (*Cervus elaphus*). Initially, colonising deer fed very selectively, causing spectacular local declines of the most palatable plants. Over time, they fed on less preferred plants and reduced the density and complexity of the forest understory. They continue, along with feral goats, to prevent or slow the re-establishment of the forest understory in many places and are considered a significant threat to normal forest dynamics. Feral deer may also play a role in the spread of Tb in the wild. So although deer are not specifically targeted in aerial 1080 operations, the (temporary) reduction in deer numbers through eating baits is considered beneficial from a conservation perspective. To recreational hunters deer are an important and valued species, however, and this has led to tensions between the pro-hunting and deer-as-pests advocates.

Research and trialling of deer repellents to prevent deer from eating toxic baits has been completed. Deer repellents are currently in operational use in some areas for aerial 1080 operations. The Department of Conservation's (DOC) policy on managing deer states that a deer repellent may be used by DOC or agencies undertaking possum control in gazetted recreational hunting areas (RHA) subject to the following criteria:

- Its use does not have negative consequences for indigenous biodiversity and the additional cost of repellent-treated bait does not jeopardise the efficacy of possum control in the RHA or adjoining areas.

- The use of the repellent is permitted by the statutory provisions under which the land is held and is in alignment with any operative General Policy, Conservation Management Strategy, Conservation Management Plan or regulations applying to the land.

These restrictions apply only to public conservation lands. On other lands the deer repellent can be used with the landowners consent or at their request. The major downturn of commercial aerial hunting of deer since 2002, which had previously removed the deer problem from many regions, has meant that wild deer populations are increasing, especially in montane areas and might, once again, threaten vulnerable ecosystems.

A.4 Other major vertebrate pests

Several introduced mammal species that have negative impacts on native plants and animals can be killed by 1080 operations that target possums. This can provide further benefits for native species. In this respect New Zealand is uniquely different from other countries where native mammals are usually valued and are well adapted to particular ecosystems. This is a major reason why 1080 aerial operations are possible in New Zealand, from an ecological perspective, providing there are no long-term negative impacts on native species.

Rodents (rats and mice) are significant conservation pests as predators and competitors with native fauna. Rats eat bird eggs, chicks and invertebrates, as well as fruits and seeds; mice eat mainly seeds and invertebrates. Predation by rodents is a significant threat to endangered and iconic bird species (e.g. kokako), especially when populations of mice and rats explode in years of prolific fruit or seed production, (notably in beech forests, the habitat of mohua or yellowhead).

Rats (particularly ship rats) and mice are generally targeted by DOC as part of wider intensive pest management in conservation areas, as well as more specifically on offshore islands and “mainland islands”. DOC currently uses a combination of aerial and ground based methods. In areas where aerial control of possums is carried out the by-kill of rats, around 90% reduction, is a valuable additional outcome if it is timed to benefit the breeding season of key bird species. Direct control of rats using 1080 cereal baits is also possible.

Mustelids (ferrets, stoats, and weasels) are significant conservation pests as predators and competitors of native fauna. Scientific studies have identified stoats as a major predator of bird eggs and chicks, including kiwi. Without predator control, only about 5% of kiwi chicks usually survive in the wild. But after an aerial 1080 operation in Tongariro Forest about 40% of kiwi chicks survived. In addition, ferrets are known carriers of Tb, primarily as spillover hosts (defined in Introduction).

Mustelids are not specifically controlled with 1080; trapping is the main control method. Secondary poisoning of ferrets and stoats occurs if they prey on or scavenge possums, rodents or rabbits poisoned directly by 1080. When this by-kill causes significant reductions of mustelid numbers, especially at nesting time, it is a valuable additional benefit of 1080 use.

Feral cats are significant conservation pests as predators of native birds. Although the use of 1080 for feral cats has been investigated it is not commonly used. Feral cats are commonly subjected to secondary poisoning from 1080 control for possums, but secondary poisoning of cats is too variable to be an effective control tool. (But note the case study in

Section I where 1080 is being deliberately and successfully used in the recovery of the endangered Southern New Zealand Dotterel).

Wallabies are considered a potential pastoral and environmental pest, grazing on grasses and on native vegetation. High numbers of the Dama wallaby (Rotorua lakes area) have caused considerable damage to native species, altering the composition of native forests by browsing forest understorey species. Wallabies, mostly the Bennett's wallaby (South Canterbury) can consume pastoral food resources equivalent to one third that of a grazing sheep. First used in 1960 against Bennett's wallaby, 1080 has proved effective in significantly reducing wallaby numbers and two 1080 baits are available for wallaby control.

Feral goats were first recognised as a threat to native vegetation in the 1890s and particularly on off-shore islands. By feeding on a wide range of plants they have reduced many forest understory associations to grass cover only. On Mt Taranaki, goats destroyed areas of sub-alpine scrub within 4 years. Feral goats are patchily distributed from Northland to Southland and are actively controlled in a number of parks. Together with deer, they continue to affect forest dynamics by browsing on seedlings and reducing the understory layer. Control of goats is largely by shooting, often from the air for sustained control on the mainland and for island eradications, but in special circumstances 1080 gel has been used and is applied to leaves.

B. Pest Control Methods

B.1 Traps

Commercial possum operators and some of the management agencies have used traps to catch possums for many decades. Lines of traps are set through an area; operators secure traps to trees in places where possums travel and on favoured food trees. Lures mixed into flour are used to attract possums to the trap location. There are two broad types of traps: leg-hold traps and kill traps. Leg-hold traps, such as the Victor No.1 trap, are most commonly used by commercial trapping operators. Leg-hold traps trap, but do not kill the possum; by legislation they must be checked within 12 hours of sunrise on the day after they are set and any trapped possums killed.

Kill traps, such as the Warrior, Sentinel and Set'n'Forget trap are less commonly used by commercial trapping operators. The 'Timms' trap is a kill trap that is useful in urban situations, but is not used commercially. Leg-hold traps, in particular, can kill or maim ground-dwelling birds (kiwi and weka) and must be used on elevated 'sets' in areas where these birds are present.

The bounty option for possum control

New Zealand operated a possum bounty scheme between 1951 and 1961. During that decade, 12.4 million possums were accounted for and a bounty payment was claimed for 8.2 million of them. The scheme was stopped as analysis showed that over 75% of the bounties were paid for possums that were taken from or near farms, picked off roads, or caught in other easily accessible places. These are not the places that need to be targeted for eliminating Tb or protecting high conservation values. For example, during the time the bounty was operating, the harvest of possums from Egmont National Park exceeded one possum per hectare in only one year. This level of harvest was always less than the normal productivity rate of the population. Therefore, possum losses to the bounty scheme were almost immediately replaced and there were no net conservation benefits.

B.2 Poisons

There are six poisons currently registered in New Zealand for possum control: 1080 (sodium fluoroacetate), cyanide, cholecalciferol (Vitamin D3), phosphorus, pindone and brodifacoum. Some are also registered for the control of other pests. Of these, 1080 is the only poison registered for aerial application on New Zealand's mainland. There are advantages and disadvantages associated with each poison and these are summarised in Table 1.The following paragraphs provide brief overviews of how each poison works, how it is used, and its main positive and negative aspects.

1080

1080 disrupts the complex metabolic pathway (known as the Krebs cycle) that provides energy for cells to function. After the animal's energy reserves are depleted, death occurs fairly quickly from heart or respiratory failure. Possums usually die within 6-18 hours from cardiac failure. Since it is an effective toxin for a range of mammalian pests 1080 has been used in several different formulations – cereal pellets, coated baits, pastes and gels. 1080 is extremely toxic to mammals, highly but less toxic to birds and invertebrates, and is of very low toxicity to fish, reptiles and amphibians. It is a highly effective and inexpensive way of achieving a rapid reduction in possum numbers and is the only poison registered for aerial application on New Zealand's mainland. As well as its effectiveness for controlling a range of pests (possums, wallabies, rodents, mustelids)it biodegrades quickly and completely in the environment. There is the risk of secondary-poisoning from animals eating possum carcases, with dogs being especially susceptible. Target animals that get a sub-lethal dose can develop bait shyness, making them more difficult to kill in subsequent 1080 operations. In contrast to brodifacoum, 1080 residues will not persist in animals that eat a sub-lethal dose of 1080. Poor quality (carrot) baits caused bird deaths in the past, but current best-practice has reduced these losses, usually of small insectivorous birds, to low levels.

Cyanide

Cyanide kills possums in 10-20 minutes by disrupting oxygen metabolism, leading to respiratory failure and death. Cyanide is an inexpensive, broad-spectrum toxin and has been used in New Zealand for several decades, especially by commercial hunters. Its instability is a potential risk, however, and it is considered too hazardous for use in pest control in a number of countries. A significant drawback of cyanide has been the aversion that some possums have to its smell, and the fact that some possums become cyanide-shy if they do not receive a fatal dose. Advances in the formulation of cyanide paste may overcome some or most of the cyanide shyness. Cyanide is now also used as a pellet (Feratox®), developed as a safer alternative to paste, which is less likely to lead to bait shyness. There is little known about the non-target impacts of cyanide although cyanide baits have been known to kill native birds including weka and kiwi. The risks of secondary poisoning are low.

Phosphorus

Phosphorus was first used for killing rabbits in the 1920s. It is used in paste form. The mode of action is unknown, but it causes damage to the vital organs as well as seriously disrupting their metabolic function. Possums die within a day, but other species may take longer. Animal welfare groups oppose its use as they consider that the mode of action of the poison is inhumane. It is still available to approved handlers as an acute poison for rabbit and possum control. While it is an effective poison there is little research data on its fate in the environment, or its persistence in carcasses. Phosphorus is a secondary poisoning risk to birds and dogs and the antidotes are of very limited value.

Cholecalciferol

Possums are particularly sensitive to cholecalciferol (Decal™, Feracol®), and usually die of heart failure within 4-7 days. It is licensed for use only in bait stations. A relatively new poison, introduced in New Zealand in 1995, cholecalciferol is very expensive relative to 1080 or cyanide. Not enough is known yet to be clear about its potential to cause secondary poisoning. Early tests show that cholecalciferol is less toxic to birds than 1080 or brodifacoum, although its non-target and environmental risks are not yet well understood. It will be toxic to all mammals that eat baits intended to kill possums or rodents.

Brodifacoum and pindone

Brodifacoum and pindone are both anticoagulant poisons, registered in New Zealand in 1991 and 1992 respectively. They act by disrupting blood clotting factors, causing extensive internal haemorrhaging, with death following after two to six weeks for possums. They are incorporated in cereal baits, and are currently only used in bait stations on the mainland. Pindone use has declined because of the large amounts of bait (over two kilograms) that possums can eat without being killed. It is considered more effective at controlling rats and rabbits, than possums. Both poisons are particularly useful in areas where possum populations are at low density, such as after aerial 1080 operations.

The major disadvantage of brodifacoum (which does not apply to pindone) is the persistence of residues after both primary and secondary poisoning. Trials with possums and captive pigs have shown that brodifacoum accumulates in the liver and, to a lesser extent, in muscle. While large amounts of brodifacoum-contaminated meat would need to be eaten to cause human fatalities, it is important to note that a much lower sub-lethal dose will produce significant clotting abnormalities and some haemorrhaging. Brodifacoum is known to have potentially lethal consequences for 16 non-target native bird species and another 12 bird species are considered at risk. DOC no longer uses brodifacoum widely on the mainland because of its concerns about residues accumulating in non-target species, particularly those that might be taken for human consumption.

However, brodifacoum has proved to be an effective poison in successful DOC campaigns to rid offshore islands of rodents through aerial operations.

Table 1 | **Advantages and disadvantages of different poisons**

Poison and formulations	Advantages	Disadvantages
1080 (pellets, coated baits (e.g. carrots), paste, gel)	- moderately rapid effects (4-12 hours) - very effective - low environmental persistence - only poison registered for aerial application on mainland - effective for multiple pest control (rats, stoats via secondary poisoning) - inexpensive	- secondary poisoning risks, especially to dogs which are very susceptible - currently no antidote
Cyanide (pellets, e.g.Feratox®, paste)	- rapid action (possums die in 10-20 minutes) - low environmental persistence - low secondary poisoning risk - inexpensive - effective for fur recovery	- hazardous in paste form - risk to humans if swallowed - cyanide aversion reduces effectiveness - no antidote, but a respiratory stimulant, if used immediately, can mitigate some effects
Phosphorus (paste)	- effective	- considered to be inhumane - causes secondary poisoning in birds and dogs - no antidote
Cholecalciferol (paste (Feracol®), cereal bait (Decal™)	- effective - low risk of secondary poisoning - no poison licence required	- expensive compared with 1080 or cyanide - long time to death, 4-7 days - possible risks to dogs
Brodifacoum (cereal pellets - Talon® or PESTOFF®)	- effective against low density numbers - effective against bait or poison-shy possums - antidote available - no poison licence required	- long time to death (1–4 weeks) - very persistent in the environment - high secondary poisoning risk - widespread contamination of other wildlife can occur - expensive compared with 1080 or cyanide - not acceptable for DOC areas where feral pigs, deer or other animals, taken for human consumption, are present, or in kiwi areas
Pindone (cereal bait)	- low secondary poison risk - antidote available	- need large amount before death occurs - possums take 2-4 weeks to die - not effective for possum control - moderate persistence in environment

B.3 Biotechnology for Possum Control

Research involving biotechnology is underway to develop new methods of possum control that could complement existing control methods. This research was accorded a high priority and two approaches are being pursued at present.

The first approach is to exploit differences in physiology (life processes) between possums and other animals in efforts to develop possum-specific toxins. These could ultimately reduce the use of non-specific toxins, and hence reduce risks to non-target species.

Methods of interfering with possum fertility are also being actively researched. Fertility control would suppress the recovery of possum numbers after conventional control, and offers potential advantages of humaneness, specificity and a reduction in the use of toxins.

New techniques are not likely to be available within the next ten years (the timeframe considered for this reassessment) and have a number of phases to go through before they can even be considered as a feasible option. Present estimates are that it will take another 4 years to complete the “proof of concept” stage. This requires the development of a prototype bait that meets the required specifications and would be ready for testing on captive possums. Assuming the “proof of concept” is successful, there would be a further period of about 4 years to then develop appropriate bait substrates, optimal delivery methods and techniques for mass production of baits. Moving to implementation would still be some years away after that.

Aside from the scientific aspects of this work, the use of bio-control methods is the subject of considerable public debate. A report by the Parliamentary Commissioner for the Environment, “Caught in the Headlights: New Zealander’s Reflections on Possums, Control Options and Genetic Engineering” (2000), showed that people are cautious about the use of genetic modification techniques to deliver fertility control for possum management. There would need to be public discussion and an application to ERMA that would take additional time. In short, the uncertainties and time lags around its long-term feasibility does not provide sufficient certainty for biotechnology approaches to be built into forward planning at this time.

C. 1080 Use in Aerial Operations

Section B outlined the main tools used to control possum numbers and other important vertebrate pest species that were briefly described in Section A. The important points that emerge are:

- A range of tools have been introduced and developed over several decades for pest control.
- The application of different tools has evolved, driven by the needs to reduce cost and environmental impacts and improve effectiveness.
- Different combinations of techniques and tools have been developed to manage each pest species.
- Poisons continue to play a major role in the control of most of the smaller vertebrate pests. Of the poisons currently in use 1080 is used against the largest number of species.

- Aerial control (1080 operations for possums/rodents) has been one of the key developments for management agencies and is a direct consequence of the extreme difficulty and cost of ground control of these pests over much of their range in New Zealand.

This section summarises the particular benefits of the use of 1080 in aerial operations. Although Section B referred to the use of 1080 in a range of formulations (pellets, pastes and gels) against several pest species for ground and aerial control, it is the use of 1080 in aerial operations on the New Zealand mainland that highlights its value in the control of pests, particularly possums.

C.1 Rationale for and importance of aerial 1080 operations

Aerial operations have been the key technique for controlling possums, both for Tb control and conservation objectives. Only aerial control of possums can achieve four objectives *simultaneously*.

1. The reduction of possum densities below a Residual Trap Catch Index (RTCI) measure of 5%.[1] (The RTCI is widely used as an indirect measure for possum density and uses a standard methodology which involves running a number of trap lines for a set number of nights and measuring capture rates.)
2. The reduction of several other pest populations at the same time (e.g. rats, mice and mustelids – by direct and secondary poisoning).
3. The reduction in density can be over very large areas in very short time frames. Achieving rapid reduction to low possum densities over large areas (>1000ha) is particularly important in stopping new outbreaks of Tb from spreading. Maintaining possum densities at a Residual Trap Catch Index level of below 2% is necessary to eradicate Tb from local possum populations.
4. Aerial control achieves a low possum density over all land, compared to patchy control achieved on the ground because of difficult topography. This is particularly important in the context of controlling for Tb.

Given that control budgets are limited, the relative cheapness of aerial 1080 operations is also an important consideration. As the case study of managing possums in Egmont National Park explains (see Section I) the money spent controlling possums via an aerial 1080 operation would only have covered one third of the Park area, at best, if it had been done by ground operators. Comparative costs of different methods vary according to a number of factors (see box later in section).

The effectiveness of aerial 1080 operations has increased over the past 15 years. During the 1990s, possum kills of 80% were the norm. This has improved to a norm of over 90% currently and some operations are achieving kill rates of over 95%.

A final and vital consideration is that, aside from the cost question, there are large areas of conservation and other lands that by reason of their remoteness or rugged terrain are extremely difficult to treat with ground control. Really difficult terrain, such as cliffs and steep gullies, or areas with impenetrable vegetation cover, can also occur close to farmland with

[1] An RCTI of 5% is the target for conservation purposes. Eradicating Tb from possum populations requires operators to achieve an RCTI of 2% or lower.

bovine Tb. If these areas are not treated effectively they become sources of possums that can quickly re-invade treated areas. Since possums can be a maintenance host for Tb (see Introduction for definition) the ability to target all possum populations in Tb areas is critical. If this is not possible, then Tb is likely to persist indefinitely in possum populations and perpetuate the Tb problem regardless of ongoing ground control efforts.

Eliminating tuberculous possums by aerial 1080 operations

Two particular aerial operations demonstrate the unique advantages of using 1080 for aerial control. The Hokonui Hills in Southland have had Tb-infected possums and possum control since the early 1970s. Repeated efforts by contractors using ground control had routinely failed to meet the performance targets (RTCI is 2% or less) needed to eliminate Tb from the possum population. This finally led AHB to fund the development of a new ‘enhanced aerial baiting strategy’ involving a new lure, an additional pre-feed and an increase in the aerial sowing rate. This strategy was tested in an aerial 1080 control operation over 13,000 ha in the Hokonui Hills in 2004. After the operation, no possums at all were caught in traps using the standard methodology that measures the RTCI score. This outstanding result was followed up by a second monitoring approach that covered the entire control area and confirmed that very few possums had survived the aerial operation. For the first time in the Hokonui Hills, a much lower RTCI than even 2% had been achieved.

In 2005, building on this success, a similar baiting strategy was trialled by the AHB and the Department of Conservation over about 83,000 ha of the Hauhungaroa Forest in the central North Island (see case study in Section I for details). Again, the operation achieved great success with only 6 possums caught in 16,170 trap nights after control. (This was an RTCI of 0.05%.) Both of these very successful operations allowed for an extended interval between successive aerial control operations thereby reducing the overall cost of possum control. This was in part due to the fact that successful control was achieved over a very large area at the same time thereby reducing the usual ‘edge effect’ of possums moving into the treated area that occurs when small areas are treated.

Following the 2004 Hokonui Hills operation, the number of infected herds in the Southland region has fallen from twenty to two. Consequently, Southland has attained the official status of being Tb-free on a regional basis. It is still too soon to fully ascertain the Tb control benefits from the 2005 Hauhungaroa operation.

Some communities have expressed concern about the aerial use of 1080. In Coromandel, for example, people asked for possum control using alternative techniques (biodynamic peppering and ground control) but when these methods failed to reduce the numbers sufficiently to conserve forests in difficult country the Department of Conservation reverted to 1080 aerial operations with subsequent success.

Costs of controlling pests

There are various references in this application to 'rugged terrain', 'inaccessible forests', 'remote areas', 'farmland', 'easy country' – all of which describe the wide diversity of landforms and locations over which possums and other vertebrate pests are controlled using 1080 and other methods. It is this diversity of country, and several other factors besides, that significantly affect the cost/hectare of pest control.

The costs/hectare vary more widely for ground control than for aerial operations since terrain and accessibility are significant factors for foot travellers carrying traps or poisons, but much less so for pilots. The other major cost factors that affect both ground and aerial control more equally are: consultations, transport, economies of scale and monitoring costs. These can all vary widely depending on: the number of affected landowners/communities/iwi that need to be consulted; transportation distances for moving large quantities of baits; size of treated area (large areas are more economic to treat/ha than small); and the amount of monitoring effort that agencies require before and after.

When all factors are considered over a range of different types of operations it is clear that, on average, ground control is more expensive than aerial 1080 operations. How much more expensive can range in extreme cases from 1 – 7 times if comparing control over easy farmland with minimum consultation and low base costs, to the costs of ground control on the rugged, incised slopes in Egmont National Park (see Case Studies, Section I). A more common range is 2 – 4 times more expensive for ground control while the value that occurs most frequently (median value) is x3. This is the multiplier used by DOC when estimating the costs of having to control pests without the use of 1080. The AHB estimates that a multiplier of x2 is appropriate for comparing aerial costs with more expensive ground control on 'easy country' for Tb control and a x4 multiplier applies for ground control on 'difficult country'.

C.2 Timing of 1080 operations

The steady improvements in kill rates over the past 15 years have been achieved through technical advances (improvements in baits and aerial distribution) combined with a good understanding of possum behaviour. Possums are more likely to take baits in winter when their preferred foods are less common. Also, research has shown that cold (winter) conditions (less than 9˚C) are significantly associated with kill rates of over 90% for aerial operations. Ship rats are also more likely to take bait in winter and spring operations than in autumn and summer. Research has shown the benefits of pre-feeding regimes in which the operational area is accurately sown with non-toxic bait to accustom the possums to a diet of cereal or carrot baits. Pre-feeding significantly increases the amount of bait eaten from bait stations, reduces bait avoidance by rats and reduces the likelihood of 1080 shyness occurring in possums. When the weather patterns are suitable, toxic baits are then distributed by helicopter or fixed-wing aircraft using GPS (Global Positioning System) navigation to ensure the area is completely covered. GPS navigation also ensures bait is applied only to the correct areas and waterways are avoided. Aerial operations are the only way to ensure an even distribution of bait, regardless of terrain, thereby exposing entire possum populations to the toxic baits.

The timing of aerial 1080 operations can also be tied into the nesting habits of native bird species to reduce the numbers of pests immediately prior to spring. This increases the chance of successful nesting without the unwanted attention of predators, particularly ship rats, stoats and possums. Operations that target ship rats can provide forest birds with at least one breeding season's protection. At Pureora, in the central North Island, robin fledging success has been shown to be far higher where aerial 1080 use reduced pest populations, by allowing robins to lay and hatch multiple clutches of eggs in a season. In the non- treatment areas, fewer robins survived to maturity and more adults were killed on the nest.

Aerial 1080 operations that are particularly successful extend the time period before further possum control is needed, as possum densities take much longer to reach levels at which they again threaten conservation values or risk the spread of Tb. Management agencies also benefit from the longer time intervals (about 5-7 years) which frees up funding for other priorities. By combining many of their operations AHB and DOC have made further gains in efficiencies in the costs of operations. Treating large areas also reduces the influence of possums moving in from the surrounding, untreated areas. This 'edge effect' can significantly reduce the effectiveness of control operations over small areas. (Refer also to Section F.7 'Conservation outcomes achieved collectively by agencies').

C.3 Outcome monitoring

Before possum control operations DOC often monitors the condition of vegetation to determine the detrimental effect that possums might be having on plant survival and condition. Possum densities are also measured and together this information helps determine the need for, and the timing of, the intervention. Research has shown that many palatable forest species are likely to recover if the possum density is below a Residual Trap Catch Index measure of 5%. Some species, such as native mistletoes, need even lower RTCI values, of about 2% or less, to survive browsing pressure by possums.

In Tb control, RTCI measurements are used both to trigger possum control operations and to measure the effectiveness of those operations in terms of the immediate reduction in possum density. The real measure of the success of Tb possum control operations, however, is in the reductions of Tb incidence in local cattle or farmed deer herds and, in the longer term, by eradicating Tb from local wildlife.

Conservation gains from aerial 1080 operations

In South Westland, where thousands of hectares are treated by aerial 1080 on a regular basis, possum control operations have been monitored to determine the outcomes of operations. Outcome monitoring measures the abundance or change in condition of key indicator species that are affected by possum browse or predation. The best species to monitor are those that are sensitive to increases or decreases in browse pressure and include fuchsia (*Fuchsia excorticata*), mistletoe (*Peraxilla* spp.) and land snails (*Powelliphanta* spp.). (A single possum can eat up to 60 snails over 1-2 nights.) Outcome monitoring in South Westland usually occurs 2-3 years after a control operation to provide a recovery period for the monitored species.

In general the story is the same throughout South Westland. Where possum control has been carried out, mostly using aerial 1080 over very large areas, the monitored species have recovered or remained intact as possums invade further south. Where there has been no treatment, the monitored species have deteriorated.

In the Tararua Ranges north of Wellington, tree fuchsia are highly susceptible to possum browse. Over 10 years (1994-2004), an experimental trial was carried out in four areas where steep rocky slopes with fuchsia were treated with aerial 1080 and another area at Kapakapanui was used as an untreated control site. Thirty percent of the monitored fuchsia died in the untreated area compared with only 7% in the treated areas combined. Many damaged fuchsia in the treated areas recovered and flourished in the absence of possum browse. These areas would have been impossible to treat by ground control methods because the terrain was mostly inaccessible and unsafe for ground control. Locally, the vegetation plays a key role in stabilising the upper slopes of the Waiohine River, as tree fuchsia stands do in other temperate forests, where they colonise and stabilise landslips and may help the succession of taller canopy species. Fuchsia trees also provide an invaluable nectar source for native birds and insects.