# Evaluating the use of 1080:
## Predators, poisons and silent forests

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Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

## Acknowledgements

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### Photography

Cover: West Coast, South Island, New Zealand.
Parliamentary Commissioner for the Environment archives.



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# Commissioner's overview



As I write this overview it is business as usual in the bush. This might conjure up images of tūī popping open mistletoe flowers, fantails flitting from tree to tree behind trampers and the calm of a grove of tree ferns. But in much of our great forests, the reality is far less halcyon. Sadly business as usual is more likely to mean stoats patrolling kiwi nests waiting for chicks to hatch, rats hunting down frogs, geckos and insects, and possums stripping mistletoe, fuchsia and rātā.

Last summer while on holiday I mentioned to a friend that I was investigating the use of the pesticide known in New Zealand as 1080. She responded "*That will be very difficult; there are such good arguments on both sides.*" What I have discovered through this investigation is that this is not so. While I respect the sincerity of those who oppose the use of 1080, without it our ability to protect many of our native plants and animals would be lost. And without 1080, keeping bovine tuberculosis at bay to protect dairy herds, and protecting young trees in plantation forests would be much more difficult and expensive.

In New Zealand, 3,500,000 kilograms of pesticide is used every year, and the amount of 1080 used is less than one-thousandth of this - about 3000 kilograms. Yet despite this, despite years of research, exhaustive reviews and the setting of many controls governing its use, 1080 remains controversial, and the call for a moratorium on 1080 from some Members of Parliament was a major impetus for this investigation.

Along with a number of other poisons, 1080 is used in bait stations on the ground, but it is the dropping of it from helicopters that elicits the greatest concerns. And this is understandable; scattering poison from the skies just feels like a really bad thing to do. So why is it done?

The great majority of our native plants and animals occur naturally nowhere else in the world. This makes them especially vulnerable to invaders from other countries, since there was no need to evolve defences against them. Birds did not need to fly if there were no ground predators to hunt them down.

This investigation is focused on three pests that do immense damage to our great native forests, as well as to other ecosystems and to the economy more generally – possums, rats and stoats. Most of us still think of possums as the major enemy, but over the last 15 years or so, scientists have developed a much deeper understanding of the destruction caused by rats and stoats. Increasingly, stoats, not possums, are spoken of by conservationists as 'enemy number one'.

The interaction between rats and stoats is particularly important. When there is plenty of food, rodent populations boom, providing meat for the carnivorous stoats. So-called 'mast events' are particularly tragic. In the very years when certain tree species flower profusely, when millions of seeds drop to the ground to enable birds to lay more eggs than usual, the rat and stoat populations irrupt and the chicks are doomed.

It was a surprise in this investigation to discover that possums, rats and stoats are only controlled on one eighth of Department of Conservation land. We may well be looking at a future where many of our special plants and animals can be found only on offshore islands with extremely limited access to the public and in sanctuaries behind big fences. Without active pest management, kiwi chicks have a one-in-twenty chance of making it to adulthood.

1080 is a substance that occurs naturally in many plants in Western Australia and other countries. That it exists naturally is no argument in its favour – so does hemlock. Plants that contain 1080 evolved it as a defence against browsing animals. Consequently, possums and other native animals in Western Australia have become immune over eons of evolutionary time. This has made it possible for 1080 to be aerially dropped over millions of hectares in Western Australia to kill foxes, feral cats and wild dogs.



An ideal method for controlling possums, rats and stoats would kill them effectively and enable native trees and animals to flourish, it could be used tactically to rapidly knock down irrupting populations of rats and stoats during mast events, and it could be used cost-effectively over large remote rugged areas as well as on small accessible reserves.

Such an ideal method would also have no unwanted effects. It would not kill or harm native birds, fish, lizards and insects, and it would not kill introduced animals that are not pests. It would not leave long-lasting residues in water and soil or endanger public safety. And it would kill possums, rats and stoats humanely as well as effectively.

In this investigation, 1080 and its alternatives (to the extent possible) are compared with this imaginary ideal, and 1080 scored surprisingly well. It is not perfect, but given how controversial it remains, I for one expected that it would not be as effective and safe as it is. In large part this is due to the many improvements in practice and controls that have been put on its use over the years.

In order to fully understand the concerns about 1080, my staff and I have had lengthy discussions with a variety of people at the forefront of the opposition to its use. We have striven to understand the nature of their concerns and studied the written material they have produced. Certainly some operations have not been well done; there is always room for improvement and there is always the possibility of human error, intentional or otherwise.

It must be extremely upsetting to lose a cherished dog to 1080, but only eight dogs have died this way in the last four years. The sad reality is that many many more will die on roads each year and no one is proposing a moratorium on traffic. It is important to keep risks in perspective.

The Department of Conservation often refers to 1080 as "one of the tools in the toolbox". This may give the impression there are alternatives that can do the same job, but this is not the case.

Indisputably trapping has a role to play, particularly in bush margins and reserves, along with a number of other poisons besides 1080. But ground operations can never be as effective or as cost-effective as aerial operations in large rugged remote areas.

One commonly used poison is cyanide. It has the advantages of killing humanely and breaking down quickly in the environment, including in the carcasses of poisoned animals. But because of this it cannot kill stoats; because stoats are carnivores, the only way to kill them in large numbers is secondary poisoning, that is, feeding on poisoned possums and rodents.

Another commonly used poison is brodifacoum, but brodifacoum has a higher risk of by-kill than 1080 because it persists in the environment for a long time, and it is particularly inhumane.

There are other alternative poisons to 1080 under development, but while they have some advantages over 1080, they cannot replace it. Biological control options held promise for a time, but research funding has stopped due to lack of progress, and probably also because most of the options involved genetic engineering.

The Prime Minister's Chief Science Adviser Sir Peter Gluckman frequently calls for policy decisions to be based on evidence. A solid body of evidence supporting the continued use of 1080 has been built up over the years; the large number of notes and references at the back of this report are testament to this.

It is my view based on careful analysis of the evidence that not only should the use of 1080 continue (including in aerial operations) to protect our forests, but that we should use more of it. And it is not as if much is being used now. Currently there is more Crown funding given to the Animal Health Board to kill carriers of bovine TB than the Department of Conservation spends on controlling possums, rats and stoats over the entire conservation estate.

It is seldom that I come to such a strong conclusion at the end of an investigation. But the possums, rats and stoats that have invaded our country will not leave of their own accord. Much of our identity as New Zealanders, along with the clean green brand with which we market our country to the world, is based on the ecosystems these pests are bent on destroying. We cannot allow our forests to die.

Dr Jan Wright
**Parliamentary Commissioner for the Environment**

# 1 Introduction

For around 65 million years New Zealand was surrounded by ocean separated from other major land masses – a small country of islands at the edge of the world. It is that remoteness which has shaped the unique, primeval landscape that New Zealanders know and love. And it is that isolation that provided a unique set of conditions creating plants, birds and other animals unlike anywhere else in the world. Birds and insects evolved without the threat of predatory land mammals. Wētā scurried across the bush floor instead of mice, while the giant Haast's eagle as top predator was New Zealand’s flying version of wolves and tigers.

This distinctiveness is well recognised internationally. The OECD has stated that *“In a global context, New Zealand has a special responsibility for biodiversity conservation, since a high percentage of its 90,000 native species are endemic and unique.”*[1]

While New Zealand is not alone in facing a challenge to protect its native species, we cannot afford to underestimate the size of the problem. Around 90 percent of our birds and insects are found nowhere else in the world, along with 80 percent of our plants and all of our 60 reptiles, 4 frogs and 3 bats. In contrast, Great Britain has only one unique native animal – a small bird known as the Scottish crossbill.[2] And in a recent study of 179 countries, New Zealand was ranked as having the highest proportion of threatened species.[3]

The threat to our biodiversity takes several forms. Historically, land clearance and modification had huge impacts on native species and ecosystems, although those days are largely behind us and around 30 percent of the country is now reserved in the public conservation estate. But every day, imports cross our borders with the potential for biosecurity breaches. And climate change is likely to threaten the survival of some of our plants and animals.

However, the biggest and most immediate risk lies at the feet of just a few introduced species. Possums, rats and stoats in particular continue to devastate our forests and the creatures that live within them. These predators are widespread throughout the country and are the greatest threat to the continued survival of many of our native birds.[4]

We do not have the luxury of time. Only one eighth of the conservation estate has any pest control at all, and without active management many of our iconic species are in danger of extinction.

Without much greater action we are heading towards a future where our most iconic bird, the kiwi, may only be found in fenced sanctuaries and offshore islands.[5] Already the dawn chorus has disappeared on much of the mainland.

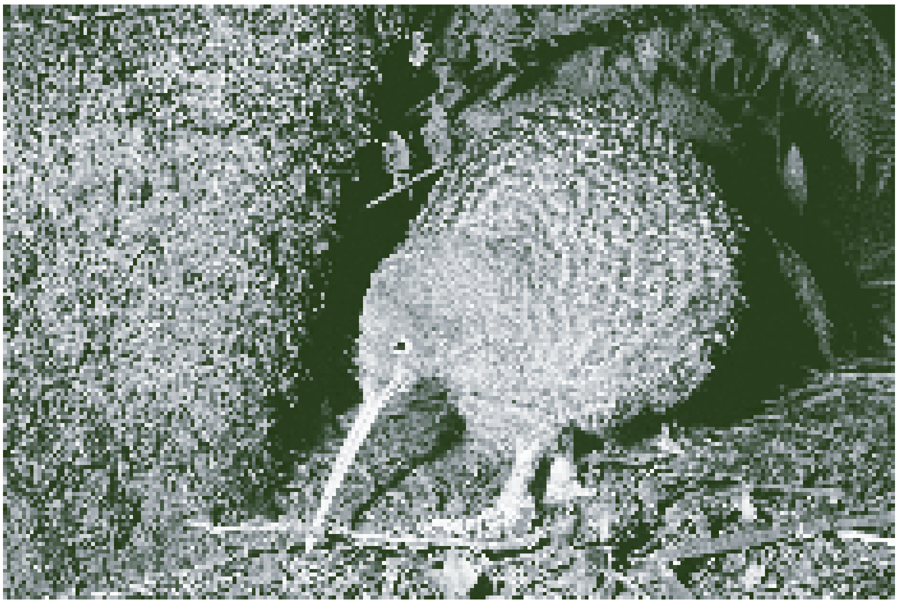
This is the context for the discussion of the use of 1080.

The active component of the poison known as 1080 occurs naturally in many plants found in Western Australia and parts of Africa. These plants evolved the poison as a defence against browsing animals.[6] The poison was patented in Germany – as a mothproofing agent in the 1920s and as a rat poison in the 1930s[7] – and in time came to be used for controlling rats, coyotes and rabbits, primarily in the United States and Australia. The name '1080' originates from the invoice number given to a batch submitted for testing, and the manufacturer adopted 1080 as the brand name.[8]

New Zealand has been using 1080 as a tool for the control of pests for over 60 years although it remains highly contentious. In 1994 the first Parliamentary Commissioner for the Environment, Helen Hughes, reviewed the use of 1080, and most of her recommendations for tighter control were adopted.[9] In 2007 the Environmental Risk Management Authority (ERMA) undertook a thorough review of 1080 in order to determine if the controls on its use should be changed or strengthened.[10]

Despite these reviews and a very large body of research about the effectiveness and risks of 1080, opposition to and public concern about 1080 has not abated; indeed it appears to be stronger than ever.

This was illustrated by statements from various political parties ahead of the 2008 election. Among Members of Parliament there is disagreement over how 1080 should be regarded, with a range of opinion from outright banning to questions over effective management and communication to strong advocacy. The use of 1080 is also vigorously debated at the local council level, particularly in the Westland and Taupō districts.



Source: Department of Conservation

**Figure 1.1: The roroa (great spotted kiwi) is one of five kiwi species. Like all kiwi species, roroa are threatened by introduced predators, particularly stoats who can eat over half of the chicks produced in a season.**

## 1.1 Purpose

The Parliamentary Commissioner for the Environment is an independent Officer of Parliament, with functions and powers granted through the Environment Act 1986. Her role allows a unique opportunity to provide Members of Parliament with independent advice in their consideration of matters that may have impacts on the environment.



Given the ongoing controversy regarding 1080, this investigation has been undertaken to provide Members of Parliament, members of the public and other interested groups with an independent assessment of 1080 that is not overly technical and is accessible to the general reader. It is an exploration of the ecological threat facing New Zealand and the physical tools and techniques of how to deal with that threat. Those interested in the detail that sits behind the assessment will find it in the many pages of notes and references that follow the body of the report.

The report is focused on the use of 1080 for killing possums, rats and stoats to protect native forests and the animals in them, not on its use to protect agriculture and forestry.

This report has been produced pursuant to subsections 16(1)(a) to (c) of the Environment Act 1986.

## 1.2 Structure

The remainder of this report is structured as follows:

Chapter 2 describes the vulnerability of our native species to introduced predators and why possums, rats and stoats in particular are such a great threat to biodiversity.

Chapter 3 examines how pests are controlled in New Zealand, who the main agencies are, and the legislative framework under which they operate.

Chapter 4 introduces the analytic framework that is used in the following three chapters to assess 1080 and alternatives.

Chapter 5 evaluates how well 1080 works by answering a series of questions related to its effectiveness.

Chapter 6 investigates concerns about 1080 by answering a series of questions related to its safety and humaneness.

Chapter 7 examines how well the alternatives to 1080 – trapping, other poisons and biological control – stack up.

Chapter 8 contains the conclusions of the investigation and six recommendations from the Commissioner.

## 1.3 What this report does not cover



This report does not cover:

- The state and effectiveness of the whole national pest management system.
- The conduct or outcomes of specific operations, except occasionally as examples.
- Detailed analysis of community perceptions and attitudes towards the use of 1080.
- The Animal Health Board's actions in controlling bovine tuberculosis (TB) in any detail.
- Concerns held by some Māori regarding the physical, cultural and spiritual impact of using 1080.
- The controls and regulations around the registration and use of 1080 in detail.

Source: Damian Davalos

**Figure 1.2: Hihi (stitchbirds) are the smallest of the three native honeyeaters - the other two are tui and bellbirds. Hihi nest in tree holes, so are very vulnerable to predation by possums, rats and stoats.**

# 2 Our forests under attack

New Zealand has one of the highest extinction rates of native species in the world, largely due to predation by introduced mammals. Introduced mammals are costly to our economy as well as our environment. Rabbits and hares can badly damage pasture and seedlings in plantation forests. Possums, wild deer and stoats can carry bovine TB and infect cattle and farmed deer.

This chapter explains why our native plants and animals are so unusual and why they are so vulnerable to predators that have come from other countries. The focus is on our remarkable native forests, as this is where the impacts of mammals are so great and where the use of the pesticide 1080 remains so controversial.

**"Most of New Zealand's birds have still not learned that mammals can be dangerous."[11]**

## 2.1 Our extraordinary environment

*"[New Zealand] shows us what the world might have looked like if mammals as well as dinosaurs had become extinct 65 million years ago, leaving the birds to inherit the globe."*[12]

New Zealand's native plants and animals are unlike any others in the world.

Sixty-five million years ago 'proto-New Zealand' separated from the ancient supercontinent Gondwanaland and took a group of existing plants and animals with it.[13] The animals included insects, amphibians, reptiles and birds, but crucially this separation of landmasses occurred before the main evolution of mammals. Consequently, except for three species of bats, there were no land mammals in New Zealand before humans arrived.[14]

Because there were no land mammals, our plants and animals have not developed defence mechanisms to deal with them, or have lost mechanisms they once had.[15] For instance, the leaves of our plants do not contain poisons to deter browsing mammals, while many of our birds and insects have lost the ability to fly. And while this 'predator naivety' served our species well for a long time, it left them ill-equipped to deal with the arrival of humans and their mammalian companions.

## 2.2 Mammals arrive and many prosper

Over the last 700 years, humans have introduced over 50 species of mammals into New Zealand. Some arrived by accident as stowaways. Some were introduced intentionally – for food, for fur, and for recreational hunting. Others were introduced to deal to earlier arrivals; for instance, stoats were brought in to control rabbits. Almost three quarters of the arrivals are now well established and thriving.[16]

The first mammals came in the ancestral waka (canoes) of the Māori in the thirteenth century – kurī (dogs) and kiore (rats). Kurī were used for hunting and food, but became extinct as a recognisable breed after the arrival of European settlers and interbreeding with European dogs.[17] Kiore were also an important source of protein. Indeed some tribes set restrictions on killing and created forest reserves for kiore to breed.[18]

When European settlers arrived they brought a wide range of other mammals. Governor Grey's zebras were short-lived, but the descendants of his wallabies remain a pest in some parts of the country.[19] Others such as sheep and cattle became an integral part of our economy. However, some introduced mammals have become serious pests, threatening our native plants and animals and the productivity of much of our economy.

**Introduced pests are the greatest threat by far to New Zealand's native plants and animals**

Pest mammals are now found almost everywhere in New Zealand, from the coast to well above the treeline. Possums browse among tree tops feeding on leaves and fruits, and also prey on invertebrates and the eggs and young of native birds. At least 19 species of native forest birds, including kiwi, whio (blue duck), kererū, kākāpō, kākā, kākāriki, mōhua (yellowhead), hihi (stitchbird), tīeke (saddleback) and kōkako are under attack from introduced mammals.[20] Predation by rats and mice has been responsible for declines or extinctions of many of our insects and lizards, including wētā, beetles, skinks and geckos. Rats and mice may also alter or stop forest regeneration through eating seeds and seedlings.[21]

Introduced predatory mammals do not only threaten the survival of individual species. Their actions can also disrupt or destroy the functioning of whole systems. For example, tūī and korimako (bellbirds) are major pollinators of native mistletoes,[22] while native trees like tawa, miro and pūriri rely on kererū and other native birds for the dispersal and germination of their fruit.[23] Therefore, lower numbers of these birds will affect how well the forest functions as a whole, with the potential to place forests at risk of collapse.

Predation by introduced pests has become by far the greatest threat to New Zealand's native plants and animals, although loss of habitat and disease also play a role.[24]

## 2.3 The biggest threats to our forests

There are a number of mammals that threaten our native ecosystems – possums, deer, wild pigs, rats, feral cats and stoats to name a few. However, in terms of forests there are three that consistently feature on the 'most wanted' list – possums, rats and stoats.



### Possums

Brushtail possums were brought to New Zealand over 150 years ago from Australia to establish an export fur trade.[25] The total number originally imported was 200 to 300 and most were introduced into the lower South Island and around Auckland. These first introductions were followed by an active period of breeding possums in captivity in New Zealand and releasing animals throughout the country. However, during the early 1920s the damaging effects of possums on native forest became an increasing concern. It culminated in the late 1940s when all protections for possums were removed and limited poisoning was made legal. Recently, the development of blends of merino wool and possum fur has once again made the fur valuable.

Possums are found almost everywhere in New Zealand, and there can be as many as 25 per hectare in preferred habitats.[26] A recent study estimated there are around 30 million possums in New Zealand.[27] They are the major cause of the decline of trees such as pōhutukawa, rewarewa, kāmahi, māhoe, tawa and rātā and can change the composition and structure of native forests.[28] They destroy the nests of kererū,[29] and North Island kōkako.[30] Possums have also been recorded killing adults or young of tītī (sooty shearwaters or muttonbirds), kāhu (harrier hawks), pīwakawaka (fantails) and tāiko (Westland black petrels).[31]

In their native Australia, possums are a natural part of the environment, are not a conservation threat, and are legally protected under Australian law.

Source: Nga Manu Images

**Figure 2.1: Since their arrival in New Zealand, brushtail possums have spread throughout the country. They have a varied diet, feeding on many native trees, birds and invertebrates.**

## Rats

Four species of rodents have been introduced into New Zealand. These are the kiore or Polynesian rat, the house mouse, the Norway or brown rat, and the ship or black rat.

*Kiore* have been almost completely displaced by European rodents and are now found only in a few parts of New Zealand.[32]

*Mice* are plentiful in native forests. Importantly for this report, mice populations will boom (or irrupt) in response to the abundance of food produced in 'mast events', and along with rats provide plentiful food allowing stoats to thrive. (Mast events are described in Section 2.4.)

*Norway rats* prefer wetland habitats and are much less common than ship rats in forests.

*Ship rats* are the most prevalent of the three rat species and the greatest rodent threat to our native forests and the creatures that live in them.

### Box 2.1: Kiore and European settlers

The first Polynesian explorers brought the kiore with them, as a stowaway or deliberately as a food resource. The kiore, about a third of the size of other rats, was widespread by the time of European settlement.

Kiore underwent periodic population irruptions in years when beech trees produced exceptionally large amounts of seed. In 1890 the impact of what is now known as a 'mast event' on the town of Picton was eloquently described:

*"…the whole town was pervaded with the odour of dead rats. It took the place of pastille in the drawing-rooms, and overpowered that of sanctity, even, in the churches."*[33]

Ship rats live in all types of native and exotic forests from the coast to the treeline.[34] They are very agile climbers and can spend a large proportion of their time up in the tree canopy. This, along with being nocturnal, means that they are not easily seen. They are generalists when it comes to food, and will eat both plants and animals all year around.

Ship rats are most abundant in lower elevation mixed podocarp-broadleaf forests that contain species like tawa, lemonwood, rimu, rātā and miro, where there is plenty of food and places to nest. They are generally less common in pure beech forests, except after heavy beech tree seeding in mast events.

The devastating impacts of these rats on native birds can be clearly seen on Big South Cape Island near Stewart Island, which was invaded by ship rats in 1962. Rat numbers exploded to high levels, and within three years, nine species of birds had declined or disappeared from the island, including South Island saddlebacks, Stead's bush wren and the Stewart Island snipe.[35] On the mainland, rats are known to contribute to declines in populations of forest birds such as North Island kōkako, kererū, kākāriki, mōhua, and brown creeper.[36]

## Stoats

Stoats, ferrets and weasels all belong to a family of carnivorous mammals known as mustelids. First released in the South Island towards the end of the nineteenth century, they were brought in as 'natural enemies' of the rabbits, which were causing such damage to the pastures and thus the economy of the colony. This introduction occurred despite the protests of scientists at the time.[37] Stoats and ferrets in particular are now well established.

Weasels are patchily distributed throughout New Zealand, preferring overgrown areas with thick ground cover. They remain relatively rare in New Zealand.[38]

Ferrets are most common in native grasslands and farmland, but can also be found in scrub, wetlands, along waterways, and on the edges of forests. They can be major predators of birds, particularly birds that live in the sorts of habitats that ferrets favour. They are known to have killed penguins, black stilts, wrybills, variable oystercatchers, New Zealand dotterels and weka, as well as lizards and insects.[39] In addition, they are a major carrier of bovine TB, particularly in the South Island. However, in comparison with stoats their impact on native forests is not large.

Stoats can live anywhere they can find prey, from the coast to the treeline and beyond, and in farmland, scrub, native and exotic forests, and tussock grasslands. Populations of stoats undergo periods of explosive growth as a result of huge increases in mice and rat numbers following mast events.

Stoats produce one litter of young per year in the spring, and anywhere from 2 to 20 young can be born. Male stoats will visit the nest when the young are only a few weeks old and mate with both the mother and the female babies – even though they are still blind, deaf and hairless and about one twentieth the size of the male. The young females will leave the nest in mid-summer already pregnant, although their own young will not develop until the next spring.[40] It is because female stoats come 'pre-loaded' with young that the presence of even one individual stoat can establish a population on predator-free islands and in fenced reserves. In 2011, $75,000 was spent to catch a single stoat on Kapiti Island.[41]

Source: Nga Manu Images

**Figure 2.2: Ship rats prey on insects and some birds, including kōkako, kākāriki and mōhua. Rats form a major part of the diet of stoats.**

Stoats can be described as the 'perfect predator'; birds that nest on the ground or in holes on trees have no escape. Up to 60 percent of kiwi chicks are eaten by stoats.[42] Stoats are territorial animals and intimately know the locations of nests and roosts within their territory. Researchers filming kiwi nests have observed stoats repeatedly visiting burrows while the eggs were being incubated, waiting for the chicks to hatch. Kākāpō and hihi are now only found on islands or sanctuaries completely free of predators and it is believed they cannot survive where stoats are present.[43]

### Why focus on the big three?

Possums, rats, and stoats all eat eggs and young birds. All are widespread and well-established throughout New Zealand and difficult to control. Stoats are carnivores so do not browse on plants, but rats and possums have a huge effect on plant life. And the combination of all three together at the same time is particularly devastating. Between them, they damage not only plants and animals, but affect all aspects of forest functions, from birdlife to seed propagation.

It is comparatively recently, only within the last 15 years or so, that scientists have learned how these three predators interact with each other. This is especially so for rats and stoats. And it is only within the last 10 years at most that tactical approaches to the control of all three have been developed.

**Boom years are now times of population collapse for native birds**

## 2.4 Death in a time of plenty - the masting cycle

It is a tragic irony of the New Zealand bush that in the very years when many birds have evolved to breed most successfully, rodent and stoat populations boom and cause tremendous damage. The cause is what are known as 'mast events'.[44]

Approximately every four to six years, some trees flower abundantly and produce much larger numbers of fruit and seeds than usual. The phenomenon is greatest in beech forests, but trees such as rimu will also undergo mast seeding.

Before mammals arrived in New Zealand, these mast years of abundant food allowed birds to raise many more chicks than in normal years. Kākāpō will only breed in a mast year,[45] while other species like mōhua and kākāriki will successfully raise more chicks in mast years due to the greater availability of food.[46]

Tragically, these boom years have now turned into times of population collapse for native birds in forests where mast events occur. The sudden abundance of food leads to huge population irruptions of mice, rats and (crucially) stoats, which feed on the mice and rats (see Figure 2.3). Hole-nesting birds such as mōhua, kākāriki and kākā are particularly at risk in these situations, since predators not only eat eggs and chicks, but also nesting females who cannot escape.

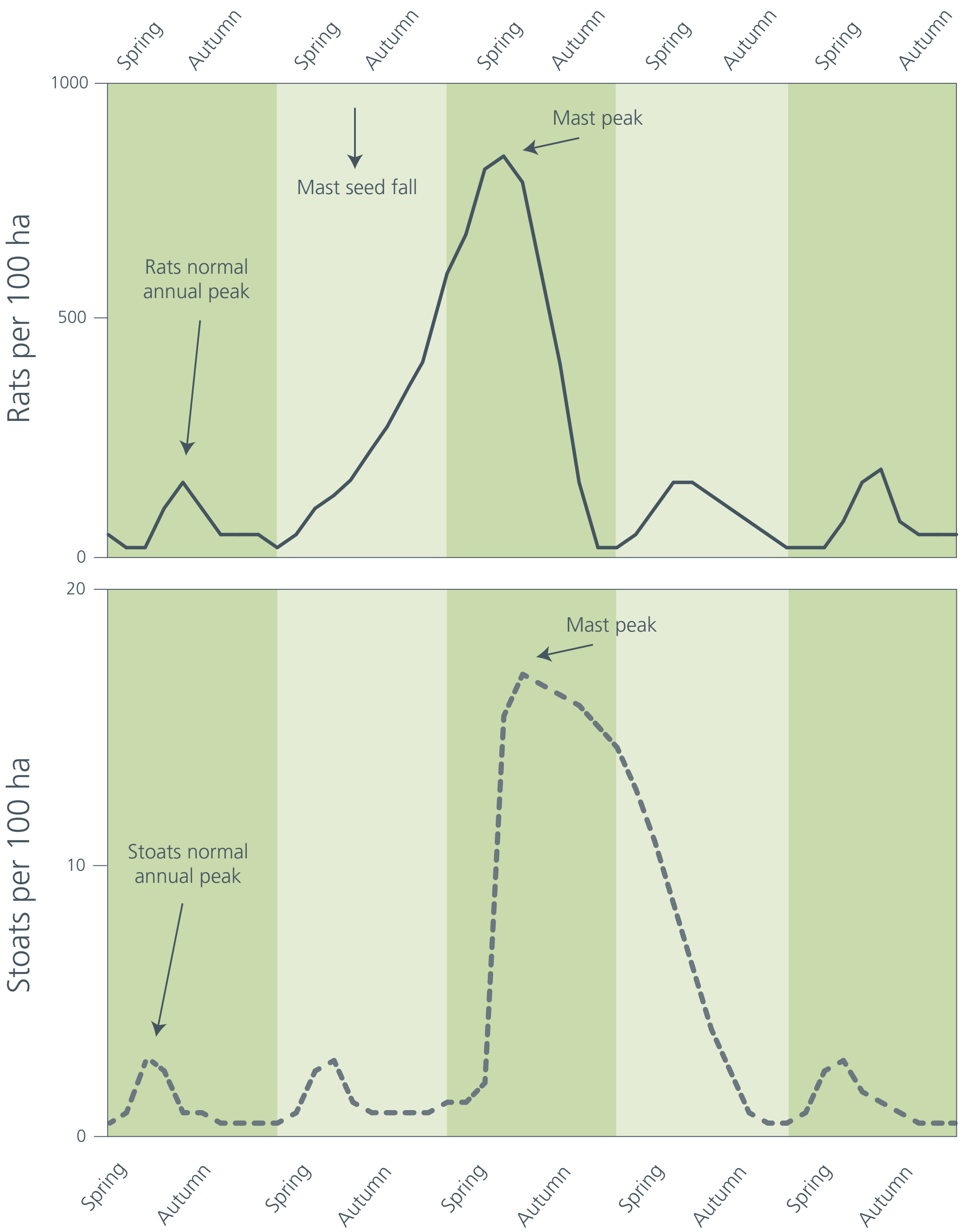



**Figure 2.3: A schematic diagram of a mast event showing the effect on populations of rats and stoats.**[47]

## 2.5 We do not have the luxury of time



The damage done to our native species and forests by possums, rats and stoats is a huge and accelerating problem. The situation with our iconic national bird shows that all is far from well. In areas with no pest control, kiwi populations are declining at between 2 and 6 percent per year.[48] This may not sound serious, but a population declining at 6 percent will be virtually gone within a generation.

The situation is just as bad for many other native animals and plants. The extremely high numbers of rats and stoats that follow a mast seeding is a critical and dangerous time for many forest birds. Kiwi, kākā, kōkako, kākāriki, mōhua and whio will almost certainly disappear from forests without effective pest control.

Other native birds (e.g. kererū, korimako, tūī) are also vulnerable to predation and competition for food from introduced mammals and will decline further without effective pest control. The loss or decline of such species, which are important seed dispersers and pollinators of native plants, will lead to other cascading ecological changes in native forests. Some of the bird-dependent native plants, such as mistletoes, are also very vulnerable to browsing damage by possums. Several other native plants and many animals, including insects, frogs, lizards and at least one bat, also face further decline and potential extinction on the New Zealand mainland as a result of the relentless impact of introduced mammals.

Extermination of these mammalian pests from the New Zealand mainland is currently not – and may never be – a realistic possibility. The largest island cleared of mammalian predators so far is uninhabited Campbell Island in the sub-Antarctic, which is only one fifteenth of the size of Stewart Island. For the foreseeable future we are faced with ongoing control of these pests if we wish to protect our native animals, plants and unique ecosystems.

**Kiwi on the mainland may be gone within a generation**

Yet there remains room for hope. Many government and non-government agencies, as well as private groups and individuals are engaged in tackling this task. For some, conservation of our native species is the primary aim, while for others it is the threat to pastoral agriculture. There is, however, a common enemy. One example of these different sectors working in conjunction with one another is illustrated by the Pest Control Education Trust – a joint initiative between the Royal Forest and Bird Protection Society and Federated Farmers. The aim of the Trust is "*to help educate the public about the importance of controlling introduced mammalian pests in New Zealand*".[49]

As discussed in the next chapter, there are many different techniques used to manage pests, and many different agencies involved. And all are controlled under a detailed framework of legislation and regulation.


# Controlling possums, rats and stoats

It is ironic that two of the 'big three' pests – possums and stoats – were deliberately introduced into New Zealand by those seeking an economic benefit. In contrast, rats are expansionists extraordinaire and there are very few places on the planet that they have not invaded.

Having arrived in this small country of islands populated with native species unable to fight back, these pests have run rampant. Attitudes towards them and methods for controlling them have undergone considerable changes over time.

This chapter describes the methods currently used to kill possums, rats and stoats, the agencies involved, and the laws that govern their activities.

## 3.1 How are possums, rats and stoats controlled?

There are various methods used for controlling pests. Each method is discussed below with a particular focus on possums, (ship) rats and stoats, although they will also often be used for other pest species as well.

### Trapping

There are three main types of traps used to kill possums, rats and stoats. Kill traps are designed to kill the target animal rapidly when the trap is triggered. Leg-hold traps are designed to capture the animal by the leg but not kill it directly. Cage traps are designed to capture the animal alive and unharmed. Both leg-hold traps and cage traps must be checked regularly and trapped animals then killed humanely.[50]

The design and use of traps has changed markedly over time. Steel-jawed leg-hold traps for possums must now comply with standards designed to limit injury to the captured animals. Larger leg-hold traps are required to have padded jaws.[51] On the conservation estate trappers must not set traps on the ground in areas with flightless birds such as kiwi and weka or where domestic or companion animals may be at risk.

A number of new traps that more effectively kill specific pests have been designed. DOC has developed traps designed specifically for rats and stoats. And recently a private group has developed self-resetting traps for possums, rats, and stoats that can kill as many as 12 animals before needing to be recharged.[52]

## Poisons

Fifteen poisons are registered and approved for use against mammal pests in New Zealand.[53] 1080 is one of the eleven used by the Department of Conservation (DOC) to control possums, rats and stoats. These poisons are not used in their 'raw form' but are incorporated into different baits. Poison baits can be placed in bait stations, stapled to trees in biodegradable 'bait bags' or dropped aerially from aircraft. Having a range of poisons available to use in ground operations is important for avoiding bait shyness or the build-up of resistance. The following are the main poisons used.

***1080 (sodium fluoroacetate)*** is approved for controlling possums and rats, and can also be used for controlling other pests such as rabbits and wallabies. 1080 is not used in its raw chemical form, but is incorporated into a range of different baits, including cereal baits, carrot baits, and less commonly, paste and gel baits.

Because stoats are carnivores they do not eat cereal and carrot 1080 baits, but can be killed if they eat possums or rats that have eaten the poison. This process is known as 'secondary poisoning'.

Most 1080 is used in ground operations to control possums to prevent the spread of bovine TB. The baits may be placed in bait stations (that allow the target pest in but are designed to exclude other animals), or applied directly to the ground.[54]

1080 is also used aerially to control possums, rats and stoats. 1080 is the only poison that is used aerially to control these species on public conservation land on the mainland, with the exception of brodifacoum in a very small number of cases. Almost all aerial 1080 operations use cereal baits, dropping about two kilograms of bait per hectare.

Source: Department of Conservation

**Figure 3.1: Bait stations keep the baits dry and prevent non-target animals from eating them.**

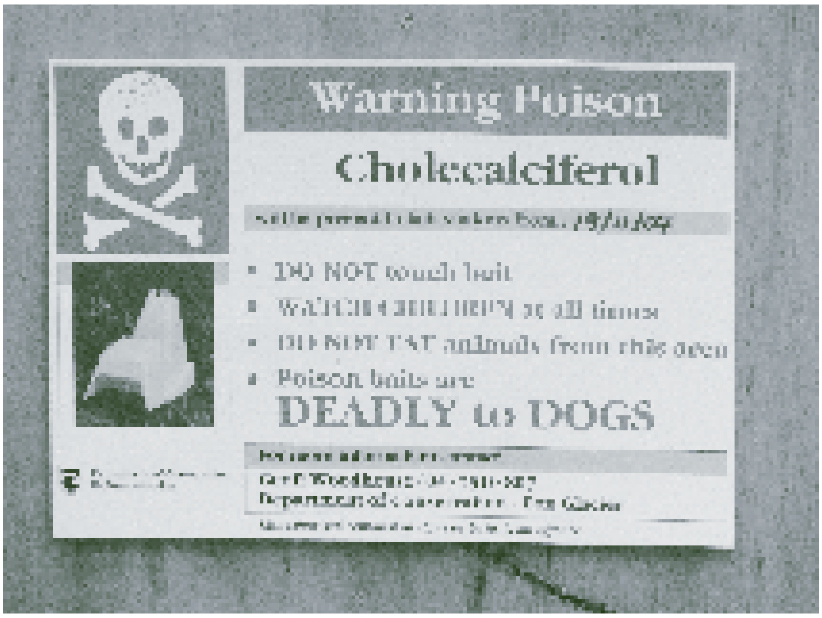
***Brodifacoum*** is used to control possums and rats, although it will kill predators such as stoats through secondary poisoning. It is mixed into cereal or wax-based baits for use in the field and is generally used in bait stations.[55] Brodifacoum is one of the three poisons that can be used aerially, although it is rarely used in this way. DOC will use brodifacoum aerially on offshore islands where the total eradication of rats or mice is possible. On the mainland DOC only uses brodifacoum aerially in reserves with predator-proof fences, where total eradication of rats and possums is possible and where there is little or no risk of by-kill. Some regional councils use brodifacoum aerially to control rats, although they also restrict its use to areas with predator-proof fences.[56]

***Pindone*** is broadly similar to brodifacoum, and is used to control rats although DOC rarely uses pindone because it is less effective. Pindone can be used aerially to control rabbits (the greatest users are private landowners), but this is in open habitats such as tussock grasslands, not in forests.

***Diphacinone, coumatetralyl*** and ***bromadiolone*** are three other poisons used by DOC to control rats. All three work in a similar way to pindone and brodifacoum.[57]

***Cyanide*** is used mainly to control possums and is used on both private land and public conservation land.[58] It is incorporated into a range of baits, including gel-coated capsules and pastes. Cyanide is only approved for use with ground methods, and is placed in bait stations, in bait bags, or laid by hand as a paste. DOC places restrictions on the way cyanide paste can be used, such as requiring it to be placed up off the ground in areas where flightless birds such as kiwi and weka live.

***Cholecalciferol*** is used by DOC to control rats and possums. It is incorporated into a range of baits, including cereal baits, gel blocks and pastes. It is only approved for ground applications and is used in bait stations or bait bags.




Source: Department of Conservation

**Figure 3.2: All operations that use a poison for pest control must place warning signs on their boundaries that inform people what poison is being used, what risks it poses, and when the area will be safe to enter.**

## Shooting

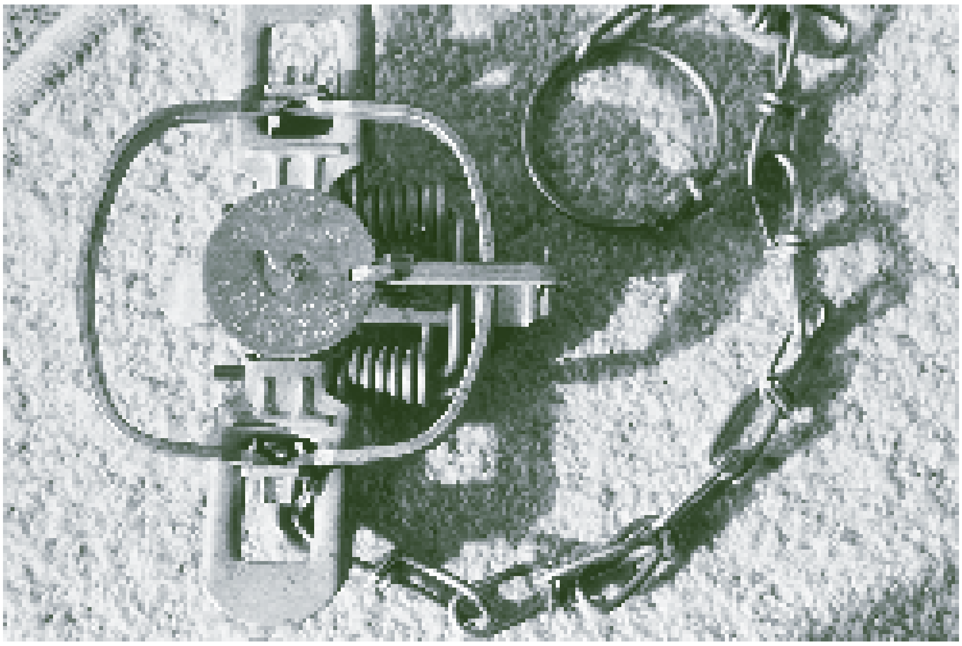
Rifles and shotguns are also used to kill some pests – although these tend to be larger animal such as deer and goats. Shooting possums at night on farmland or on the bush edge is a popular activity, although it is not used as a control method for possums, rats or stoats in forests. Therefore, it is not discussed further in this report.

## Biodynamic 'peppering'

Biodynamic 'peppering' is advocated by some as a control method for possums. It involves preparing ash from burnt possum skins, and applying homeopathic solutions made from the ash to the soil under specific astrological conditions. Scientific trials have shown no evidence of effectiveness.[59] Moreover, there is no mechanism known to science whereby biodynamic 'peppering' could work. Therefore, it is not discussed further in this report.

## Predator-proof fencing

Another approach to pest control on the mainland is the exclusion of pest mammals by fencing, creating fenced 'sanctuaries' such as Zealandia in Wellington and Maungatautari in the Waikato. These fences can be very effective at protecting native species, although they are expensive to build and require the removal of pests from within the fenced area by poisoning or trapping. They also require ongoing monitoring to ensure pests have not re-invaded the reserve, and maintenance of the fence. The ability of predator-proof fences to protect large areas is limited, and they are not discussed further in this report.



Source: Department of Conservation

**Figure 3.3: Leg-hold traps must now be set in a way that does not endanger birds and they must be checked regularly to minimise the suffering of captured animals.**

## 3.2 Who controls pests?

The big players in controlling possums, rats and stoats are the Department of Conservation (DOC), the Animal Health Board (AHB) and local government. Private land owners also use 1080 and other pest control methods to protect the productivity of farms and forests.



**Department of Conservation**

DOC has identified over 2,700 native species that are at risk of extinction, but actively manages only about 10 percent of these.[60] Management techniques include habitat protection, captive breeding programmes, relocation of threatened species and predator-proof fences. For many native species however, DOC's management is focused on direct control of possums, rats, stoats and other pest mammals.

**Over 2,700 native species that are at risk of extinction**

DOC targets a wide range of pests, in rugged and remote areas, as well as in small accessible reserves. DOC's use of aerial 1080 varies each year, depending on the management goals for the year. In 2009, DOC applied aerial 1080 to 174,000 hectares to control possums and rats. In that same year, DOC managed possums, rats and stoats on about 1.3 million hectares – just over one eighth of the public conservation estate.[61] About $22 million was spent killing possums, rats and stoats in 2009/10. This is about 8 percent of DOC's total budget under Vote Conservation.[62]

DOC provides a great deal of information about pest control on the conservation estate. This includes public consultation, printed material, and web-based communication including videos and maps of operations, although style and details on maps do vary in quality across conservancies. Summaries of pest control operations for each region are provided, along with information on location, method and poisons used, and which agency is undertaking the operation.[63] The pesticide summaries are technical in nature and use scientific terminology.

### Animal Health Board

The AHB is an incorporated society, made up of representatives from the farming sector and local government and has responsibilities to the Minister of Agriculture. Its goal is to eradicate bovine TB from New Zealand, and most of its work is focused on controlling TB spread from possums and other wild animal hosts. The AHB does not target rats since they are not carriers of TB, nor stoats as few live where the AHB is engaged in active eradication.[64]

Much of the AHB's pest control is done using ground techniques on private farmland or on forest edges. Work is also done within forests to knock possum numbers down and slow the rate of re-invasion back on to farmland, or to achieve the eradication of TB from wildlife. Aerial application of 1080 is sometimes used in these situations.[65]

In 2009 the AHB controlled possums and other carriers of TB over 3.4 million hectares. Of this, about 3 million hectares was controlled using trapping and ground poisoning, with the remainder controlled using aerial 1080.[66]

The AHB has a total budget of around $80 million – about $30 million from the Crown, $6 million from local government, and the remainder from industry levies.[67]

At the time of writing, a legislative amendment was before Parliament which would apply to the AHB. Under the proposed Biosecurity Law Reform Bill the AHB would, in relation to its role under pest management plans, be subject to the Ombudsmen Act 1975, which it currently is not.[68]

### Local Government

Regional councils and territorial authorities control a number of pest mammals, mainly targeting possums and rabbits.[69] Under the Resource Management Act 1991, regional councils are responsible for maintaining native biological diversity and councils are specifically required to manage pests under the Biosecurity Act 1993. Around 2 million hectares are managed for these pests by councils, although only a proportion of this area will receive pest control in any one year. While councils use a combination of ground control methods and aerial application of 1080, the latter was used on only a small proportion (1.4%) of the total area covered in 2009.[70]

### Other pest controllers

Private landowners use 1080 and other pest control methods to protect the productivity of farms and forests. The possum fur industry also kills approximately 1.8 million possums per year using traps and cyanide.

The recently announced Game Animal Council is to be responsible for the management of deer and other game species for hunting over much of the conservation estate.[71] It will not be responsible for the management of possums, rats and stoats, although some of their responsibilities around the management of game may impact on the control of possums, rats and stoats by other agencies.

In particular, it is proposed that the Game Animal Council will be responsible for the management of deer, pigs, chamois and tahr over the entire conservation estate, except for specific areas where DOC identifies that these species are having major conservation impacts. DOC will continue to be responsible for the management of possums, rats, stoats and other pests in the conservation estate. It is not clear what happens if, for instance, DOC wanted to carry out an aerial 1080 operation to kill possums, stoats and rats in an area where there would be a risk of killing deer.



### Application of aerial 1080

Figures 3.4 and 3.5 show the areas where aerial 1080 was applied in the 2008/2009 financial year.[72] Operations by DOC were carried out as part of its pest control activities to protect native species. AHB operations were carried out to knock down possum numbers in order to control bovine TB. Data available for mapping aerial 1080 operations in this way has only been available since the ERMA reassessment in 2007.

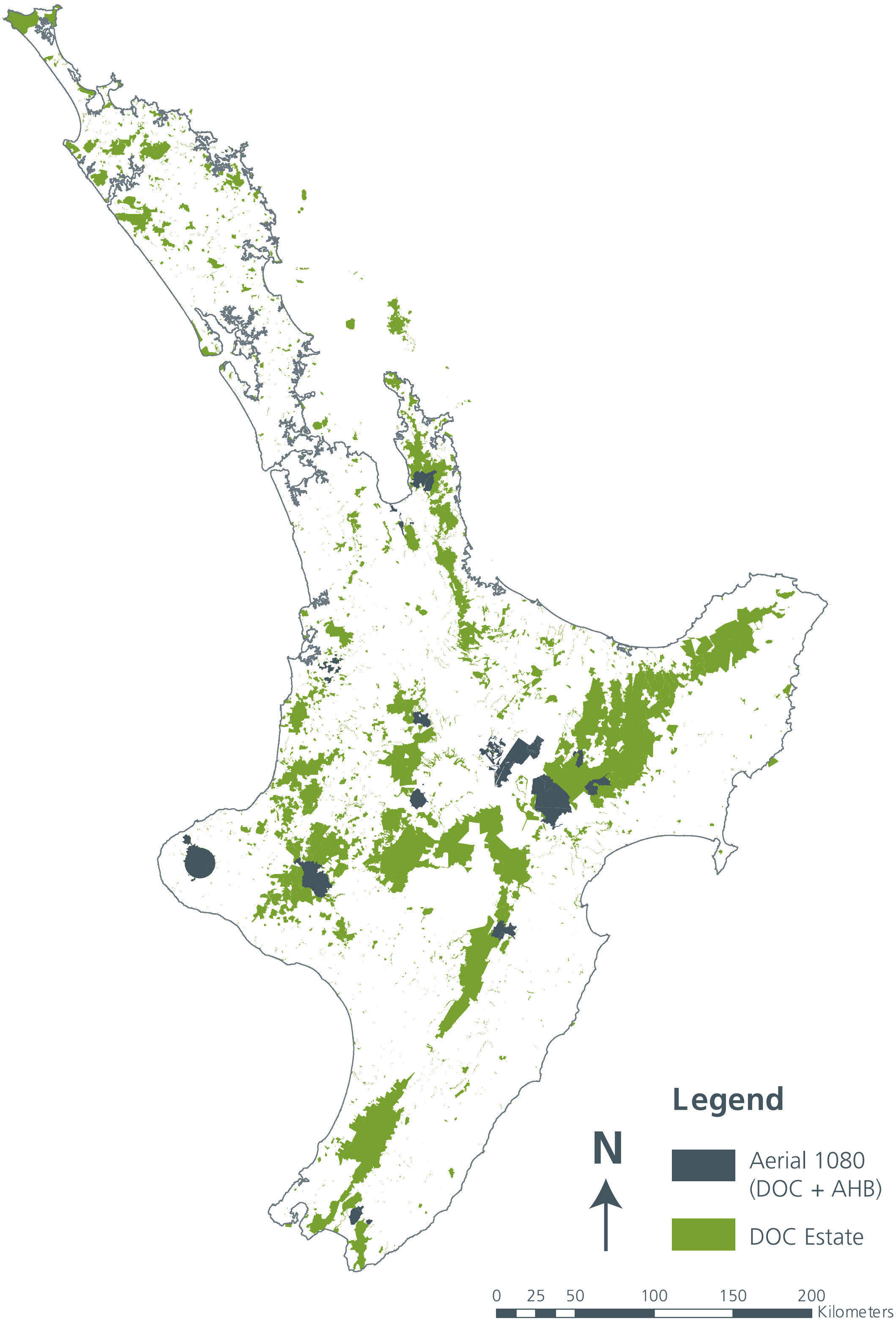



**Figure 3.4: Areas over which 1080 was dropped aerially from July 2008 to June 2009 in the North Island by the Department of Conservation and the Animal Health Board.**

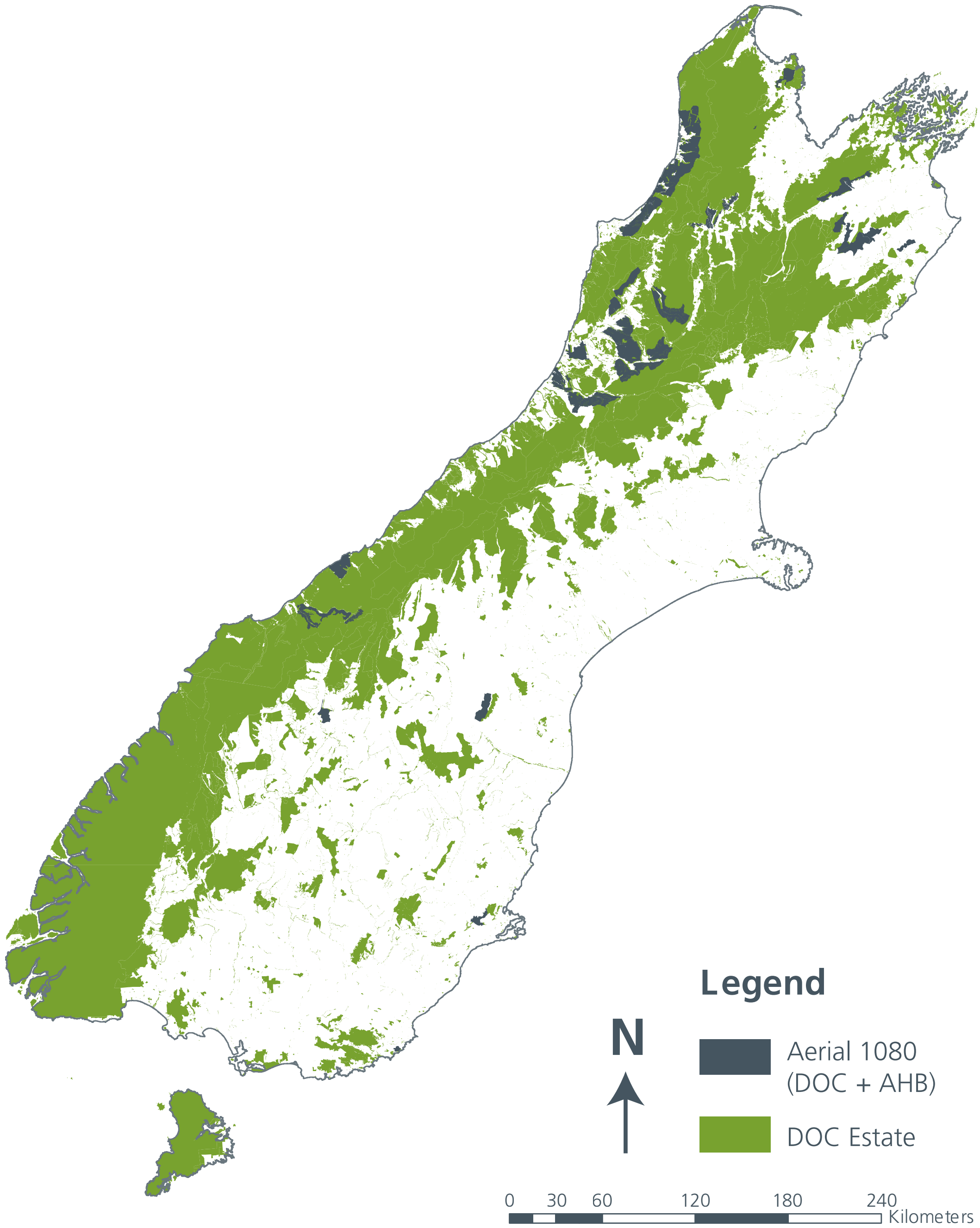



**Figure 3.5: Areas over which 1080 was dropped aerially from July 2008 to June 2009 in the South Island by the Department of Conservation and the Animal Health Board.**

## 3.3 Controlling the pest controllers

A labyrinth of legislation governs pest control. Some legislation is common to all operations – health and safety, fire safety and trespass legislation. Additional legislation applies to different pest control methods. For example, shooting of pests is covered by the Arms Act 1983, while the use of traps is covered by the Animal Welfare Act 1999. The controversy over 1080 has led to confusing doubling-up of regulations governing its use. For example, essentially identical requirements for protective clothing and equipment when using 1080 are set under the Hazardous Substances and New Organisms Act, the Agricultural Compounds and Veterinary Medicines Act and the Resource Management Act.

The use of 1080 and other poisons in New Zealand is mainly administered under four laws discussed below. At the absolute minimum, a poison must be registered under the Agricultural Compounds and Veterinary Medicines Act and be approved for use under the Hazardous Substances and New Organisms Act. Depending on the poison and the way it is to be used, other legislation may also apply. The aerial use of 1080 is controlled under 15 different laws.

**Aerial 1080 is controlled under 15 different laws**

**The Agricultural Compounds and Veterinary Medicines Act 1997**

Under this Act, poisons for the control of pests are defined as 'agricultural compounds'. The New Zealand Food Safety Authority administers the Act, and can register poisons, setting conditions on their use that must be followed by all operators.

**The Hazardous Substances and New Organisms Act 1996**

Under this Act, poisons need to be approved for use as hazardous substances. The Environmental Risk Management Authority (ERMA) administers the Act, and can set conditions and restrictions on the use of poisons to protect public health and the environment.

ERMA can also reassess the conditions placed on any poison. In 2007, the registration and use of 1080 was reassessed by ERMA.[73] The Authority approved the continued use of 1080 but strengthened the suite of controls on its use including the requirement that the details of all aerial 1080 operations be reported. Three recommendations were made for improved practice and communication, including consultation with all potentially affected parties before the operation takes place. This includes local iwi, hunting groups, commercial operators, and adjoining landholders.

Increased protections were placed around drinking water supplies. Any pest control operation that uses 1080 must obtain permission from the Medical Officer of Health, who can set restrictions on the operation to protect drinking water and public safety. The applicant must also consult with other regulators and demonstrate that they have complied with all other public health requirements.

Applicants must also get permission from DOC if the 1080 operation will occur on the DOC estate, in order to ensure biodiversity and conservation values are protected.

Anyone carrying out a 1080 operation is also required to notify all landowners and neighbours about an operation before it occurs. ERMA also publishes an annual report on the aerial use of 1080.

### The Resource Management Act 1991

Pest control operations that use 1080 and other poisons must comply with the Resource Management Act (RMA) and council plans. Territorial local authorities are responsible for the management of any adverse effects from the use of hazardous substances, and the protection of the surfaces of lakes and rivers.

Regional councils treat poisons as contaminants under the RMA.[74] Use of 1080 and other poisons used in ground operations is generally classed by regional councils as a permitted activity, meaning resource consents are not required, as long as the operations comply with RMA requirements and plans. Seven councils also class aerial 1080 operations as permitted activities.[75]



Six regional councils class aerial use of 1080 as a controlled activity, meaning that the Council can impose additional conditions on operations provided they are in the Council's plan. Provided these conditions are met, the consent will be granted automatically.[76] Another five regional councils class aerial use of 1080 as a discretionary activity, meaning the councils may or may not grant the consent and can impose any conditions.[77] Councils generally apply the same activity status to the aerial discharge of poisons other than 1080.[78]

One of the conditions put on DOC's resource consent for the use of aerial 1080 by the West Coast Regional Council is a specified number of operations during the five-year time frame of the consent. Any additional 1080 operations above this number require a dispensation from the Council.

**ERMA publishes an annual report on the aerial use of 1080**

Under the pre-2007 Operative Regional Plan, the Manawatu-Wanganui Regional Council classed the aerial use of 1080 as a permitted activity. The plan explains that a simple rule, with few conditions, "*has been adopted to reduce unnecessary regulation of an activity that is adequately and properly controlled by other agencies.*"

The only opportunity for public input into the conditions for permitted and controlled activities is during the public consultation phase of the plan development. For a discretionary activity, public notification of an application for a consent may be required, although recent changes to the RMA have altered the conditions under which public consultation may be required.[79]

### The Health Act 1956

Restrictions on the use of poisons to protect public health can be set under the Health Act.[80] These restrictions can be set by local authorities, and generally include measures to protect public drinking water supplies, such as establishing buffer zones around poisoning operations. They can also set requirements for the removal of any carcasses that may contain poison residues.

## 3.4 Are we losing the battle?

The AHB aims to eradicate bovine TB from New Zealand, through control of vector populations. It is achieving this by greatly reducing possum numbers in key areas, mostly through ground baiting and trapping on farms and forest margins.

DOC faces a much greater challenge. It must try to kill rats and stoats as well as possums, along with other pests such as cats. It must deal with a much greater range of terrain from small reserves near where people live to remote rugged back country.

Thirty percent of New Zealand lies within the conservation estate and only one eighth of it has any pest control at all. For example, almost no pest control is done within the spectacular Kahurangi National Park, yet much of it is beech forest and vulnerable to the destruction of mast events. There are some great biodiversity success stories on small intensively managed reserves, on remote offshore islands and behind predator-proof fences. But on the vast bulk of our conservation land, the battle is not being won.

This does not need to remain the case however. In the next chapter, a set of criteria are developed that can be used to judge how well different methods can control possums, rats, and stoats, particularly in our great native forests.

Source: Department of Conservation

**Figure 3.6: Possums have not yet invaded the Copland Valley on the West Coast of the South Island, and southern rātā are still healthy and flower profusely. In comparison, possums have been present for 30 years in the nearby Karangarua Valley and most of the rātā trees are dead or dying.**

# 4 Evaluating 1080 and its alternatives

In this chapter, a framework for evaluating 1080 and its alternatives is presented. This framework consists of nine criteria for judging how well a pest control method (or combination of methods) can deal with the enormous problem of controlling possums, rats and stoats on conservation land.

The nine criteria are presented in the form of questions about the effectiveness of, and concerns about, pest control methods. These questions are then used to evaluate 1080 and its alternatives in the following three chapters.

## 4.1 Assessing effectiveness

Five questions for assessing the effectiveness of a pest control method (by itself or used in combination with other methods) are presented in this section.

### *1. Can the method decrease populations of possums, rats and stoats?*

The problem of pests on conservation land is not just a possum problem. Lowering a possum population often means more food for rats and stoats. In order to arrest the rapid decline of our special birds and other unique species, possums, rats and stoats all need to be controlled. An effective pest control method would decrease populations of all three predators.

### *2. Can the method increase populations of native species?*

Killing predators does not necessarily lead to increases in populations of native species. A pest control method may accidentally kill individual members of species it is intended to protect. And a population of predators might rebound at a time when native species are particularly vulnerable – when fledglings are still in the nest, for instance. An effective pest control method will deliver a clear net increase in the populations of birds and other animals it is intended to protect.

### *3. Can the method rapidly knock down irrupting populations of pests?*

A huge amount of damage is done to native birds and other animals in mast years when populations of rats and stoats irrupt. The problem is especially acute in beech forests. An effective pest method would ideally be able to be used fast and tactically to deal with these sudden increases in predators.

*4. Can the method be used on a large scale in remote areas?*

Possums, rats and stoats are damaging our natural heritage almost everywhere, from the coast to above the treeline and from small reserves to vast areas of remote rugged backcountry. The big challenge is the vast areas of remote rugged backcountry, where very little pest control is done now. A pest control method that is effective at meeting this challenge is needed if we are to win the battle on the mainland.

*5: Is the method sufficiently cost-effective?*

The effectiveness of a method cannot be considered without thinking about its cost-effectiveness. A pest control method might be 100% effective and safe but be so expensive that it could only be used on a few hectares. Only one eighth of the conservation estate has any form of possum, rat or stoat control on it. Greater protection of our native species must be viable in terms of costs.

## 4.2 Assessing safety and other concerns

Four questions for assessing concerns about pest control methods are presented in this section.

*1. Does the method leave residues in the environment?*

A pest control method should not leave any long-lived damage behind in the ecosystems it is aimed at protecting. It should leave no significant residues in water, in soil, in plants and in animals.

*2. Can by-kill from the method be minimised?*

As well as sometimes killing individual members of native species, a pest control method may kill individual members of non-target species such as dogs. A safe pest control method would be able to be managed so as to prevent such by-kill, or at least reduce it to very low levels.

*3. Does the method endanger people?*

People need to be protected as well as animals. A safe pest control method would be able to be managed to protect the health of those who apply the method, those who live near treated areas, and those who use treated areas for water, food or recreation.

*4. Does the method kill humanely?*

Although the aim of pest control methods generally is to cause death, the death should not be lingering and painful. A pest control method should kill possums, rats and stoats humanely. And while by-kill should be avoided or minimised, any by-kill should also be killed humanely.

## 4.3 Applying the framework

While a variety of methods are used to protect conservation land from pests, DOC sees the use of 1080 as an essential option for controlling possums, rats and stoats on much of the conservation estate.

The nine questions presented in this chapter are used in Chapters 5 and 6 to assess the effectiveness and safety of 1080. Alternatives – current and prospective – are assessed in Chapter 7.

5

# Effectiveness of 1080

On much of the conservation estate, possums, rats and stoats are completely uncontrolled and are literally chewing the life out of our unique forests. This chapter assesses the effectiveness of 1080 in dealing with this problem by answering the five questions in Section 4.1, namely:

1. Can the method decrease populations of possums, rats and stoats?
2. Can the method increase populations of native species?
3. Can the method knock down rapidly irrupting populations of pests?
4. Can the method be used on a large scale in remote areas?
5. Is the method sufficiently cost-effective?

## 5.1 Can 1080 decrease populations of possums, rats and stoats?

Possums, rats and stoats are all very susceptible to poisoning by 1080. Possums and rats will eat cereal or carrot baits directly. Rats are more difficult than possums to lure into eating baits because they are wary of anything new, but this can be overcome through pre-feeding with non-toxic baits and other techniques. Stoats can be killed by 1080 if they eat poisoned rats and mice, which are a major part of their diet.

And when populations of rats and mice are knocked down, there is not enough food around for a stoat population to increase, which keeps stoat numbers down for longer. Thus 1080 dropped aerially can be used to decrease populations of all three pests in the same operation.

Kill rates for *possums* using 1080 generally range between 75 and 100 percent of the population, although they are now usually above 90 percent.[81]

Kill rates for rats using 1080 are often close to 100 percent.[82] But because of their high breeding rate, populations of rats can rebound relatively quickly.[83]

There is less information on kill rates for *stoats* using 1080 than for possums or rats. This is because the understanding that 1080 can kill stoats through secondary poisoning has developed relatively recently. Nevertheless, there is evidence that 1080 operations can kill most or all of a stoat population. In three different studies, individual stoats were fitted with radio-transmitters and monitored after 1080 operations. All the stoats monitored through these operations died, with 1080 residues found in all but one.[84]

Since the reassessment in 2007, details of all pest control operations that include the use of aerial 1080 are reported to ERMA. Since 2008, 233 individual applications of aerial 1080 (sometimes several applications make up one operation) have been reported to ERMA.[85] Of the 66 applications of aerial 1080 by DOC, 80 percent were monitored and of these 96 percent met their pest reduction targets.[86]

In most instances the AHB does not monitor the reduction in possum numbers after an aerial 1080 operation. Instead, the AHB monitors TB infection rates in cattle herds as the indicator of success.

Without massive ongoing effort and expense, eradication of pests is only feasible on offshore islands and within fenced sanctuaries. Even in these situations constant vigilance is required in case pests re-invade. The success of any 1080 operation on the mainland is only temporary – populations of pests can only be knocked down for a time.

How frequently aerial 1080 operations are repeated in an area depends on the pest that is being controlled. For possums, control is generally done every 5 to 10 years,[87] while for rats, the intervals are likely to be shorter – generally every 2 to 4 years. Ground control of pests using 1080 is often ongoing, with bait stations refilled with poison several times per year.

Source: Sid Mosdell

**Figure 5.1: Kākāriki nest in tree holes, making them very vulnerable to rats and stoats who will eat mother birds, eggs and chicks. The impact is particularly bad in mast years when the huge increase in seed fuels an explosion of rat and stoat numbers. The years that should be boom years for kākāriki are instead the time of the greatest population decline.**

A concern with any poison is the development of resistance in the few survivors, so care must be taken not to apply the same poison too often in the same area. To overcome this, different poisons may be alternated in the same operation. For example, in a ground operation 1080 may be used for several years and then a different poison like brodifacoum may be used for a year, before switching back to 1080. Resistance is less likely to be a problem after aerial 1080 operations because the poison is only in the environment for a short period of time and animals cannot be exposed to the repeated doses required to build up resistance.



## 5.2 Can 1080 increase populations of native species?

1080 operations can decrease populations of possums, rats and stoats, but what matters most is whether populations of native species subsequently increase as a result.

There is a solid and growing body of evidence that, when used well, 1080 leads to increases in a variety of native species. Gathering such evidence out in the field is challenging; a controlled experiment in the bush can never reach the gold standard of a double-blind randomised controlled trial. Nevertheless, over the years the evidence for increases in populations of native species and benefits to native ecosystems has steadily grown.

This evidence is based on a variety of different measurement techniques. For instance, to assess whether a particular bird population has increased, several techniques will be used to compare the birds in the area where the 1080 has been used with a nearby area where it has not been used. These techniques usually include monitoring specific nests to see how many chicks survive, tracking tagged adult birds, counting numbers of breeding pairs, and counting the total numbers of birds.

Many native bird populations have been successfully protected by reducing predator numbers through aerial 1080 operations. Whio, kererū, kiwi, tomtits, robins, kākāriki and mōhua have all responded well to pest control programmes using aerial 1080 operations, with increased chick and adult survival, and increases in population size.[88] Recent field trials have shown that aerial 1080 operations are likely to be able to protect kiwi populations from stoats far more effectively than the current labour-intensive methods of trapping and hand rearing of chicks (see Box 5.1).

Data on seedling survival, tree growth rates and foliage cover may all be used to work out if trees are responding to possum control. Studies have shown significantly better growth and survival for kāmahi, māhoe and tawa,[89] and tree fuchsia,[90] lasting for up to five years after an aerial 1080 operation. As possum populations rebound in the years following control, damage to trees will increase again.

Aerial 1080 has been particularly successful in the management of kōkako in the central North Island. Kōkako suffer heavy predation from introduced predators. Possums and rats eat nesting females, eggs and chicks, and very few kōkako pairs will successfully raise young in areas with no predator control. This predation also leads to a critical shortage of females, so that in unmanaged areas many ‘breeding pairs’ actually end up being male-male pairings.[91]

The kōkako 'rescue' took eight years. Populations of possums and rats were controlled using aerial 1080 for the first three years to initially knock down pests, followed by ground baiting with brodifacoum and 1080 to keep them at low levels.

The aerial 1080 operations reduced predators to low enough levels for nearly 50 percent of nests of kōkako to successfully produce young. In comparison, in areas with no predator control, only 14 percent of nests successfully produced young. In turn this meant that in areas with predator control, there were now young female kōkako that could replace the male-male pairs and create viable breeding pairs, increasing the population further.

Predator control reversed the population decline within three years and, by the end of the study, the population in areas with predator control had increased eight-fold. In two other areas in the study without pest control, populations of kōkako did not increase over the course of the study.

### Box 5.1: Using 1080 to help kiwi

The greatest threat facing mainland kiwi populations is the killing of kiwi by predators. Kiwi chicks are especially vulnerable to stoat predation during the first six months of their lives. After this time, the chick is too big – at about one kilogram in weight – for a stoat to kill and it has a high chance of survival.[92]

Over the last two decades, this threat has been managed by removing kiwi eggs from the wild, hatching the chicks in captivity and raising them to a size where they will be able to fight off a stoat attack, before releasing them back into the wild. This technique can be very effective, but it is very expensive and labour-intensive and can only protect kiwi over relatively small areas.

However, recent trials by DOC in the Tongariro Forest in the central North Island have shown that aerial 1080 operations can protect kiwi populations, as well as other threatened species such as whio and pīwakawaka (fantails), over large areas. Before the 1080 operation, kiwi chicks in the forest had less than a 25 percent chance of surviving to six months of age. 1080 was dropped in the study site in September 2006 and rat and stoat numbers were reduced to very low levels. For the next two years, kiwi chick survival was more than twice as high as before the operation, and above levels required to keep the population stable. After two years, stoat numbers had increased again and chick survival dropped back to pre-control levels. Crucially however, the short-term increase in chick survival the 1080 operation provided was high enough to turn the population decline into an increase.[93]

DOC has another aerial 1080 operation planned for the area later in 2011, and will monitor chick survival again in the seasons following the operation.

Not all 1080 operations have been successful in increasing populations of native species. Some operations may simply have failed to kill enough pests. Others may have been mistimed so that predator populations were not low enough in spring when nesting birds and fledglings are especially vulnerable. In other cases, factors other than predation may limit growth in native bird populations, such as very low numbers of birds, making it hard for birds to find breeding mates.



For instance, low bird numbers affected the outcome of a 1080 operation in spring of 2006 in the Hawdon Valley in Arthur's Pass National Park. The goal of the operation was to protect populations of kākāriki karaka (orange-fronted parakeets). The aerial 1080 operation successfully reduced rat numbers to zero and follow up control with brodifacoum on bait stations kept numbers at that level over the following summer. The rat control was essential in protecting kākāriki karaka in the valley but the bird numbers were so low that no increases in their populations were seen. The researchers concluded that the populations of kākāriki karaka would require continued effective pest control as well as the reintroduction of captive-bred birds back into the study site to help increase numbers and opportunities for breeding.[94]

Source: Lee Thangyin

**Figure 5.2: Kōkako have benefitted greatly from the use of aerial 1080. Without predator control, most female kōkako are killed while sitting on the nest.**

## 5.3 Can 1080 rapidly knock down irrupting populations of pests?

A fast, tactical knockdown of possums, rats and stoats is often needed in the late winter or early spring to protect birds during the nesting season. The most difficult challenge occurs in mast years as described in Section 2.4. The sudden abundance of fruit and seeds in a mast year is followed by a sudden abundance of rats and mice which is then followed by a sudden abundance of stoats.

With modern techniques – such as pre-feeding with non-toxic baits, and using helicopters with GPS systems – aerial 1080 can knock down possum, rat and stoat numbers in areas of any size in two to three weeks, even during a population irruption.[95] Although rats breed up again relatively rapidly, the key is to time the use of 1080 so that vulnerable fledglings can leave the nest before rat, mouse and therefore stoat numbers increase again.

An example of the successful use of aerial 1080 in combination with ground baiting was the operation to protect mōhua in beech forest in the Dart and Caples Valleys in Otago.[96] The mast began in autumn of 2006. Brodifacoum was placed in bait stations in winter 2006, but it did not stop the rat population from increasing. To control the rat explosion, aerial 1080 was applied the following spring. As a result, rat numbers were dramatically reduced, and then were able to be kept at low levels by continued application of brodifacoum in bait stations. Mōhua were able to successfully breed and maintain their population size in this area.

Source: Department of Conservation

**Figure 5.3: Helicopters are used to drop aerial 1080 in rugged areas that are difficult to access. A single helicopter, using a GPS system and mechanised loading, can cover thousands of hectares in one day and control possums, rats and stoats in the same operation.**

In contrast, for the area not treated with poison, rat numbers doubled. In these areas mōhua survival was low and the population continued to decline.[97]

Possum populations do not respond in the same way as rats during a mast seeding because their breeding cycles are much longer – about one year – and generally only one young is produced at a time. This means that possum populations do not increase at the same high rates as rats, mice and stoats following mast seeding.



## 5.4 Can 1080 be used on a large scale in remote areas?

Much of the conservation estate consists of vast areas of steep hills and mountains that are difficult to access. For many of these areas the only options are to drop a poison from a helicopter, or a biocontrol method which will spread itself through predator populations.

1080 is the only poison currently licensed for aerial operations against both possums and rats on the mainland. The larger the area over which pests can be controlled, the longer it takes for their numbers to build up back to levels that threaten native species. The average size of aerial 1080 operations in 2009 was about 8,000 hectares, with the largest just over 46,000 hectares.[98]

In contrast, ground operations carried out by DOC typically cover areas of at most 4,000 hectares.[99] In larger areas, cost-effectiveness, terrain, and access mean that aerial 1080 is the only realistic option.

## 5.5 Is 1080 sufficiently cost-effective?

Budgets are always limited and the cost-effectiveness of different pest control options must always be considered.

The cost per hectare of aerial 1080 operations is relatively constant because it is mainly made up of the cost of the bait and the helicopter. Over recent years the cost has been dropping, and an aerial 1080 operation including pre-feeding can now cost $12 to $16 per hectare.[100] The ability of aerial 1080 to control possums and rats (and therefore stoats) in the same operation gives it a real cost advantage over ground control.

**Costs rise when targeting possums, rats, stoats**

In comparison, ground-baiting operations using 1080 (often in combination with other methods) vary greatly in cost. One important variable is terrain. Ground control of possums alone (not including rats and stoats) in easily accessible farmland can cost as little as $4 per hectare, but be as much as $40 per hectare on the bush-pasture edge. Costs will rise significantly if tracks, bridges and huts are needed for access; in rugged country or in areas with difficult vegetation cover, possum control can cost $80 per hectare or more.[101] Costs will also be much greater if rats and stoats are targeted as well as possums because additional traps or other control methods will be required.

In particularly rugged or difficult terrain, there may be areas that people just cannot get into and so predators in these 'pockets' will not be controlled. Predator populations will then recover more quickly and so ground control may be required more frequently than aerial control – for possums this may mean control every 2 to 3 years rather than every 4 to 7 years – pushing costs up further.[102]

DOC controlled possums over 29,000 hectares using aerial 1080 in the Cascade River region of South Westland in June 2010 to protect mistletoe and native bird populations. The operation used cereal baits and cost just over $12 per hectare to apply pre-feed and toxic baits over the area. Monitoring of possum populations after the operation cost a further $1 per hectare. The quoted cost to achieve the same level of control using ground 1080 was $44 per hectare with a further $4 per hectare to monitor the effectiveness of the operation.[103]



## 5.6 Conclusions

Over the years there have been many changes to the way in which 1080 is used to protect the conservation estate. A more tactical approach to its use, based on the greater understanding of the devastation played by rats and stoats as well as possums, is proving effective, not just in killing these predators but also in increasing the populations of native birds and other animals.

The case for the use of 1080 is very strong. 1080:

- can kill possums, rats and stoats in one operation
- can knock back predators for a time allowing populations of native species to increase
- can be used quickly to protect birds and other animals at vulnerable times, including during the particularly destructive beech masts
- can be used aerially so it can be applied over large remote rugged areas
- is more cost-effective than ground methods in the majority of the conservation estate.

As a pest control method targeting possums, rats and stoats, 1080 is particularly effective. However, like any pest control method there are downsides to 1080 as well as upsides, and there is considerable public concern about its use, especially when used aerially. In the next chapter the safety of 1080 and other concerns about it are examined.

# 6 Concerns about 1080

Ideally a pest control method would have no unwanted effects, but the reality is that all current pest control methods may cause problems. This chapter assesses the safety and other concerns about 1080 by answering the four questions in Section 4.2, namely:

1. Does the method leave residues in the environment?
2. Can by-kill from the method be minimised?
3. Does the method endanger people?
4. Does the method kill humanely?

In each section, the concern about 1080 is assessed. Examples of the many controls that have been put in place around the use of this poison are also presented.

## 6.1 Does 1080 leave residues in the environment?

Some poisons leave residues in water or soil or bioaccumulate[104] in plants or animals. 1080 is not one of these poisons in that it naturally breaks down in the environment and does not leave permanent residues in water, soil, plants or animals.

### Water

1080 baits can enter waterways during aerial application. Once in water, 1080 is biodegraded into non-toxic by-products[105] within two to six days,[106] although the breakdown rate is slower in colder conditions.[107] However, under field conditions, dilution will usually reduce 1080 quickly to very low concentrations in water.[108] A field trial looking at leaching rates of 1080 from baits placed in streams found that 50 percent of the 1080 was leached from cereal baits within 2 hours, and 90 percent was leached within 24 hours.[109] Unlike the biological breakdown process, the leaching and dilution rate does not depend on the temperature of the water.

After aerial 1080 operations, water samples from both drinking water supplies and natural waterways are tested by Landcare Research for the presence of 1080. Most sampling takes place within 24 hours of the aerial drops.[110] From September 1990 to February 2011, 2,537 water samples have been tested,[111] with traces of 1080 found in 86 of the samples. None of these 86 samples had been taken from a drinking water supply.

Concentrations of 1080 in the 86 samples ranged from 0.1 to 9 parts per billion, with only six of these at or above the Ministry of Health trigger value of 2 parts per billion. None of the six had been taken from human or stock drinking water supplies, and four were likely to be 'false positives' due to accidental contamination.[112]



## Soil

In soil 1080 undergoes the same two processes – biodegradation by micro-organisms and dilution following leaching from baits.

The rate at which 1080 biodegrades in soil depends on the temperature of the soil, the levels of bacteria and other micro-organisms present, and the amount of rain that falls. 1080 will be significantly broken down in one to two weeks under favourable conditions – that is, soil temperature between 11°C and 23°C and soil moisture between 8 and 15 percent.[113] In extremely dry and cold conditions, 1080 may remain in baits for several months.[114]

Rainfall will leach 1080 from baits left lying on soil and then dilute it down to undetectable levels – often faster than bacterial breakdown will.

Concentrations of 1080 in soil and leaf litter following three aerial 1080 operations were measured in a field study. Very low concentrations of 1080 were recorded in 6 out of 118 soil samples, at an average concentration of 0.01 mg/kg of soil.[115] Low concentrations of 1080 were found in leaf litter in two of the three study sites, with the highest level recorded being 0.19 mg/kg of leaf litter.[116] This concentration is between 200 to 500 times lower than that required to kill native insects such as ants and wētā.[117]

Source: Parliamentary Commissioner for the Environment archives

**Figure 6.1: The 1080 in any baits dropped in water leaches out of the baits very quickly and is rapidly diluted to extremely low levels.**

### Plants

Plants can take up 1080 from the soil through their roots, and 1080 has been recorded in very low concentrations in a number of New Zealand plants including kāpuka (New Zealand broadleaf), kāramuramu, pūhā, and watercress.[118] Any 1080 that is taken up does not remain in the plants; rather the compound is broken down by the plants and is undetectable within one to two months.

In one trial 1080 baits were put at the base of kāramuramu plants.[119] The highest level of 1080 measured seven days later was 0.005 mg/kg of plant material. 1080 was undetectable after 28 days.[120]

In a similar field trial, 1080 baits were placed at the base of pūhā plants and nine of the ten plants took up some 1080. The highest level of 1080 recorded was 0.002 mg/kg of plant material, found three days after the 1080 was added. 1080 was undetectable in the pūhā 38 days later.[121]

### Animals

Poisons used for pest control can also persist in the environment in the bodies of poisoned animals.

Animals that eat non-lethal doses of 1080 retain it in their body tissues and blood for a period of time. In general, concentrations of 1080 will peak and then drop over a matter of hours or days as it is broken down and excreted from the body. The time this process takes will depend on the species and the dose of 1080.

**1080 does not leave permanent residues in the environment**

It will take up to a week for all traces of 1080 to be eliminated from the bodies of poisoned possums.[122] There is no data available on how long deer or dogs take to eliminate 1080 following sub-lethal doses, although it is likely to be broadly similar to other mammals studied. Wētā, native ants and kōura excrete 1080 within one to two weeks.[123]

Although 1080 does not leave permanent residues in the environment, it does leave residues for a limited time. A number of the controls on 1080 exist specifically to reduce the risk of environmental contamination, particularly during aerial operations (see Section 6.3).

## 6.2 Can by-kill from 1080 be minimised?

By-kill is almost inevitable with any pest control method. 1080 is a broad spectrum poison and can kill native animals including birds, reptiles, frogs, fish and insects. It can also kill dogs, deer, pigs and other introduced animals.

By-kill is generally easier to limit for ground use of 1080 than aerial use. Bait stations containing 1080 (and other poisons) are attached to trees and have openings designed so that animals such as dogs and deer are not able to reach the bait inside.

## Birds

Birds may be killed by eating baits directly and predatory birds, such as falcons, Australasian harriers, ruru and weka could be killed if they eat an animal that has eaten poisoned bait.[124] Individuals from 19 species of native birds and 13 species of introduced birds have been found dead after aerial 1080 drops. Most of these recorded bird deaths were associated with only four operations 35 years ago that used poor quality carrot baits with many small fragments.[125] Overall, far more bird deaths have been associated with the use of carrot baits rather than cereal baits.[126]

Although it is now infrequent, individual aerial 1080 operations can still sometimes affect local bird populations if not carried out with sufficient care. One relatively recent case is the death of 7 out of 17 monitored kea from 1080 poisoning following an aerial operation by the AHB in May 2008 in South Westland, where the helicopter dropped some of the 1080 above the bushline in kea habitat.[127]

## Reptiles, frogs and fish

Reptiles, frogs and fish are all susceptible to 1080, although much less sensitive to it than mammals. A dose of 1080 equivalent to about three fully dissolved baits per litre would be required to kill a trout.[128]

## Aquatic life

A field study to investigate the impacts of an aerial 1080 operation on native fish and stream insects was conducted on the West Coast in 2004.[129] Cereal 1080 baits were added to five different streams. Populations of longfin eels, kōura and upland bullies, and stream invertebrates were sampled before and after the 1080 was added. Enough 1080 was added to replicate the highest numbers of baits found previously in small streams following aerial 1080 operations. 1080 was recorded in all five streams at very low concentrations for up to 12 hours after the baits were added. No effect on any of the fish or insects in the study was found.

## Insects

Insects are susceptible to 1080 poisoning. Some insects are attracted to baits, especially cereal baits, and will die if they consume them.[130] Some field trials have shown that insect numbers can be temporarily reduced within 20 cm of toxic baits, but numbers return to normal levels within six days of the bait being removed.[131] Other trials have found no evidence that insect communities are negatively affected.[132]

## Dogs

Some people are particularly concerned about accidental deaths of dogs from 1080. Being natural scavengers, dogs are generally the most common pet to die after eating a poison.[133] The two most common poisonings in dogs are from anticoagulant rat poison and slug poison from domestic use.[134]

Since its re-assessment of 1080, ERMA's annual reports on the use of aerial 1080 contain lists of all incidents and complaints. Eight dogs have been reported to have died from 1080 poisoning since 2007. Two of those died where the operation was not adequately notified – a breach of standard operating procedures. There may be more incidents that have not been reported.

Considerable research is directed at developing poisons or bait types that will limit the secondary poisoning risks to dogs.[135]

## Deer and pigs

Wild deer may eat baits directly, and pigs may eat baits or the carcasses of animals that have eaten baits. The proportion of the deer population that is killed in any operation depends on a number of factors, including the type of bait that is used, whether pre-feeding with non-toxic baits is carried out, and at what time of year the operation occurs.[136]



DOC has established eight designated recreational hunting areas where deer repellent may be added to the bait if 1080 is used.[137] 1080 is not used over the vast majority of the country where deer and other game species live. The way deer, pigs, chamois and tahr are managed on the conservation estate is expected to change with the establishment of the Game Animal Council (see Box 6.1).

### Box 6.1: The proposed role of the Game Animal Council

The management of deer and other game animals is proposed to be split between DOC and the Game Animal Council. DOC would continue to manage game animals in areas where they have been identified as having major conservation impacts. The Game Animal Council would be responsible for the management of game animals for the remainder of the conservation estate.

The discussion paper on the Game Animal Council suggested that DOC and the council work together to identify priority areas *'where animals need to be actively controlled for conservation purposes'*. Outside these areas, the paper suggests the Council should be responsible for issuing permits for any activities that may kill or harm game species.

Because of the risk of by-kill that 1080 poses to deer, it is not clear what would happen if an agency wishes to use 1080 to control possums, rats and stoats in areas managed by the Council.

## Responding to concerns

Public concerns about the risk of by-kill have been one of the main drivers of improvements in the way aerial 1080 is used.

Average sowing rates of 1080 cereal baits have steadily fallen from over 30 kg of bait per hectare in the 1950s to under 2 kg of bait per hectare today – equivalent to about four baits in an area the size of a tennis court (see Figure 6.2). Baits are now dyed green or blue to make them less attractive to birds, and deer repellent can also be added.[138]

Bait design and delivery has also been improved. Small pieces of carrot bait ('chaff') are easy for a bird to eat. The 2007 ERMA reassessment introduced specific controls on the use of carrot baits to reduce the risk of by-kill, including a minimum size for carrot baits and requirements for the removal of chaff. DOC now rarely uses carrot baits in aerial 1080 operations in native forests, although the AHB may, and carrot baits are still used for the control of rabbits in open country.[139]

The average sowing rate of carrot baits from operations targeting possums in forests is now around 3.5 kg per hectare.[140]

Research is currently underway to develop protocols and methods to reduce the risks of 1080 operations to native species. For example, protocols to protect kea during aerial 1080 operations are being developed by DOC. To date, 23 individual kea have been monitored through aerial 1080 operations since the new protocols have been introduced and no kea have been poisoned.[141]




**Figure 6.2: The average amount of bait containing 1080 dropped aerially on forests has fallen steadily over the last four decades.[142]**

Landcare Research, along with DOC and the AHB, is also conducting trials looking at reducing sowing rates to just 250 grams of 1080 baits per hectare – an eighth of the current sowing rates.

Many of the controls on the use of 1080 are aimed at limiting by-kill, and serious cases of by-kill such as those that occurred with native birds in the 1970s are now rare. But as with any regulations, human error and non-compliance mean that all 1080 operations will not be carried out exactly as specified in regulations, and so the risk of by-kill as with any poison cannot be completely eliminated.

## 6.3 Does 1080 endanger people?

1080 will kill people if they consume enough of it, either by eating 1080 baits directly or by consuming contaminated food or water that contains 1080. At the highest concentrations of 1080 in baits, eating about seven baits could kill an adult and one bait could seriously harm a child.[143]



However, in the 60 years of use of 1080 in New Zealand, there are no known records of any deaths from people consuming baits from the field use of 1080.[144] There is one case from New Zealand in the 1960s where it appears a possum hunter died after eating 1080-laced jam bait – a bait that is now banned[145] – that was present in his home.[146]

### Risk of death from environmental contamination

There are no records of any deaths associated with drinking water or eating wild food after a 1080 operation.

1080 residues have never been recorded in public drinking water supplies. And the highest recorded concentration in any other water sample following a 1080 operation is 9 parts per billion (see Section 6.2). At this concentration an adult would need to drink thousands of litres of water at one time to risk death.[147]

In one trial, eels were fed possum meat contaminated with 1080 to simulate an eel eating a poisoned possum carcass that had fallen into water. The recorded concentrations of 1080 in the eel tissue mean that an adult would have to eat about five tonnes of eel in one meal to risk death.[148] Similarly, an adult would need to eat at least 100 kg of venison from poisoned deer or 30 kg of kōura tails in one meal to risk death.[149]

**1080 residues have never been recorded in public drinking water supplies**

For plants at the highest recorded concentrations of 1080, an adult would need to eat 28 tonnes of kāramuramu, or 9 tonnes of pūhā or 2 tonnes of watercress at one meal to risk death.[150]

### Risk of illness from environmental contamination

With current management practices, the risk of people becoming sick from drinking water or eating food containing 1080 is very small. For instance, to risk illness from non-lethal doses of 1080, an adult would have to eat about half a kilogram of eel containing the 1080 concentrations in the trial cited above every day for 90 days.[151] However, 1080 eaten by live eels is broken down and excreted in two to three weeks.

Many laboratory trials have been conducted to determine if 1080 can cause non-lethal effects.

Trials with mice and rats have found that non-lethal doses of 1080 do not cause DNA mutations in individuals or their offspring, and do not cause cancer.[152] Trials have also determined that 1080 does not disrupt the hormone systems of fish and mammals, including humans.[153]

Studies of the effect of 1080 on rats, ferrets, ducks, starlings, lizards, and invertebrates have shown that repeated non-lethal doses of 1080 can damage organs such as the heart, muscles and testes.[154] Studies with rats have also shown that prolonged exposure to high doses of 1080 may affect the development of unborn young.

The same types of effects could potentially occur in people if they were exposed to high enough doses of 1080 over a long enough period of time. However, it is important to note that these results all come from laboratory studies where animals were dosed with 1080 over long periods.

Source: Parliamentary Commissioner for the Environment archives

**Figure 6.3: A cereal bait containing 1080. After an aerial drop there are about four of these baits on an area the size of a tennis court. They are dyed green to make them less palatable to birds, and a deer repellent can also be added.**

## Controls on 1080 to protect people

Overall, the presence of 1080 baits in the environment poses very little risk to people. This low risk is due to a combination of the properties of 1080 and the way it is managed. Very small amounts of 1080 are applied in pest control operations. Any residues remain in the environment for a short length of time. The series of controls on the use of 1080 virtually eliminate the chance of the public accidentally coming into contact with 1080 baits or residues.



Nevertheless 1080 is a poison, and there are many controls on its use to protect people during and after aerial 1080 operations. For instance:

- The Health Act specifically prohibits the contamination of any drinking water supply, and regional councils place restrictions over the application of 1080 around water bodies. Aerial operations must avoid water supplies – including restrictions on flights near water supplies by aircraft transporting 1080. Depending on the situation, intakes to drinking water supplies may need to be closed and monitored for the poison during aerial 1080 operations, and an alternative drinking water supply provided. Water cannot be taken from a water supply until monitoring has shown that 1080 is not present.[155]

- There are controls on how long after an aerial 1080 operation that people should not commercially harvest food from an area and this period must be clearly stated on signs and public notices. The withholding period for aerial 1080 is based on a minimum period of six months plus an additional period based on the length of time baits and poisoned possum carcasses take to break down at the site.[156] The agency carrying out the operation must monitor the breakdown of baits and carcasses in the operational area to determine if the withholding period needs to be modified. The warning signs cannot be removed until monitoring has shown no 1080 is still present.[157]

- Under the Hazardous Substances and New Organisms Act 1996 and the Health and Safety Act 1992 there are controls in place to protect those who prepare baits and carry out 1080 operations. Anyone handling 1080 must be properly trained and wear suitable protective clothing. 1080 must be packaged and transported in clearly labelled secure containers. Exposure limits for contact with 1080 have been set,[158] and the health of all workers must be monitored regularly.

## 6.4 Does 1080 kill humanely?

Determining the humaneness of different pest control techniques is not an absolute science. Humaneness is a relative measure that is based both on the time it takes a poisoned animal to lose consciousness and on the nature and severity of symptoms it experiences. Humaneness is also a somewhat subjective measure, and different people may have different opinions on how humane a particular pest control method is.

A recent report commissioned by the National Animal Welfare Advisory Committee (NAWAC) rated the relative humaneness of 1080 and other pest control techniques used in New Zealand.[159] The results of the NAWAC report form the basis of the humaneness assessments in this report. The NAWAC report rated 1080 as moderately humane.

1080 works by interrupting the body's energy production systems: an animal's cells are starved of energy and subsequently vital functions in the body stop. 1080 acts on different animals in different ways. Herbivores usually die of heart failure, whereas carnivores are more likely to suffer convulsions and respiratory failure.

**National Animal Welfare Advisory Committee report rated 1080 as moderately humane**

The symptoms poisoned animals display also differ. Possums stop eating within an hour of consuming 1080, become lethargic and die between 5 and 40 hours later, depending on the dose consumed.[160] Rats can show pain-related behaviours such as increased grooming and stomach scratching, altered breathing, un-coordination and convulsions.

Deer have been recorded as becoming lethargic and lying down quietly without convulsions or leg-thrashing.  However, researchers have noted that behavioural responses in deer to poisoning must be interpreted cautiously.  This is because deer are known to frequently show no symptoms when in pain.[161]

Dogs, stoats, and ferrets have all been observed to go through states of fitting and uncoordinated movement to difficulty in breathing, lethargy, and paralysis. Vomiting can also occur.[162] It is not clear how much carnivores suffer during poisoning, as there is some evidence that they lose consciousness well before death occurs.[163]

The suffering of animals killed by 1080 can be reduced in two ways. First, baits can be designed to contain enough 1080 to ensure that they eat enough to die as quickly as possible. Second, painkillers may be added to baits.[164] Currently baits contain doses at levels that increase the likelihood of a fatal dose, but painkillers are not added to them.

There is no known antidote to 1080 poisoning, although veterinary treatment can reduce suffering in poisoned animals.[165]

## 6.5 Conclusions



1080 is a poison and like any poison has risks associated with its use. Many people are concerned about its safety and humaneness, although it is the most regulated pest control poison used in New Zealand. 1080:

- leaves residues for very short times in the environment, with one exception – it can linger in carcasses of poisoned animals under very cold and dry conditions for some months
- can still cause by-kill of both native and introduced animals, and although techniques are increasingly being used to reduce this risk, there is no way to protect uncontrolled dogs
- does not endanger people provided it is used as prescribed in regulations
- kills different animals in different ways, but is not the most inhumane pest control poison as will be seen in the next chapter.

# 7 How do the alternatives stack up?

Many of those concerned about 1080 believe or hope that there are alternatives to its use, and millions of dollars of funding has gone into research on potential alternatives. One common view is that it is the best we have until alternatives become available.

But what is the real prospect of alternatives? The Department of Conservation often refers to 1080 as *"one of the tools in the toolbox"*. This is certainly the case for ground control of pests where 1080 is alternated with other poisons in bait stations. But 1080 is the only poison that is used in aerial operations to control possums, rats and stoats in the bush, so it is not really just *"one of the tools"*.

In this chapter three groups of alternatives to 1080 are assessed – trapping, poisons and biological control. As far as is possible, they are assessed against the effectiveness, safety and humaneness criteria laid out in Chapter 4.

## 7.1 Trapping

For many people, trapping is associated with the cruel and now banned gin trap. Over two decades, traps have been developed to kill pests more efficiently and humanely, and to reduce the risk of accidental by-kill. However, this means that when different pests are to be controlled, a different type of trap will be needed for each one.

Possums, rats and stoats can all be killed with traps. However, an intensive ground operation will typically involve trapping possums and stoats, but poisoning rats because there are so many more of them.

In a mast event, populations of rodents rapidly increase as much as ten-fold, and traps simply cannot be deployed rapidly enough or in sufficient numbers to knock them down.

Ground operations of which trapping is an important component have been shown to help populations of native birds.

Some terrain is too rugged or dangerous for trapping, and trapping is not practical on a large scale. In one day a single trapper can check traps on tens of hectares, whereas an aerial 1080 drop can cover tens of thousands of hectares.

Once a trap has 'snapped' it will not catch another animal unless it is reset. Traps need to be checked and reset regularly, which makes them labour-intensive.

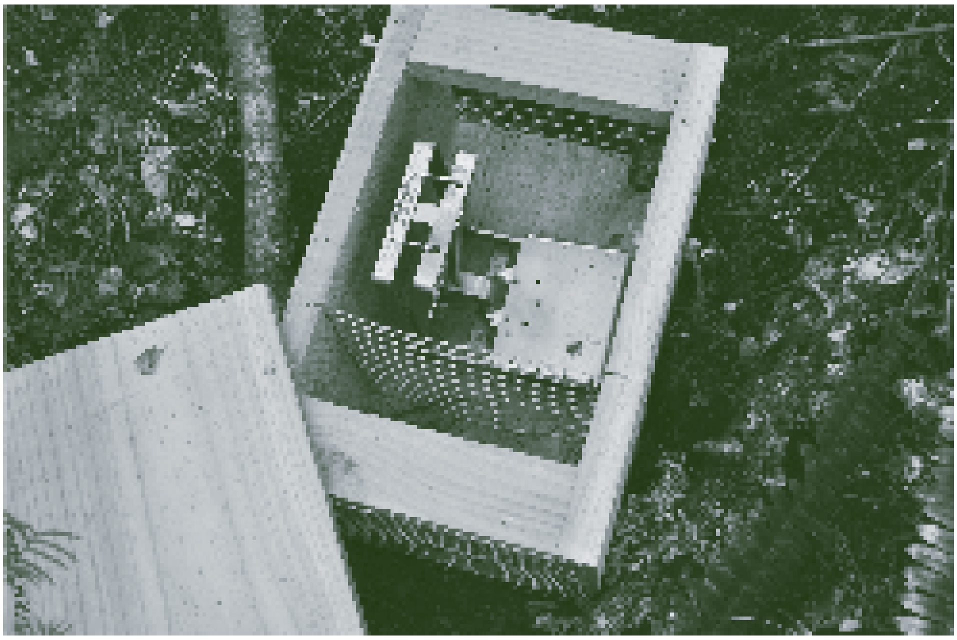
Self-resetting traps are being developed and trialled and could in the future significantly reduce labour costs and increase the cost-effectiveness of ground control operations.[166]

Traps do not leave residues in water or soil, but may be abandoned to rust away.

23 species of native birds have been reported as having been killed by leg-hold traps[167], and many kiwi have suffered leg or beak damage.[168] These traps are now required to be set up off the ground on conservation land where kiwi or weka live, and this has reduced by-kill from these traps to very low levels.[169]

Leg-hold traps capture an animal alive and hold it until it is killed by a trapper, so are considered to be less humane than kill traps. Kill traps are now widely used and should comply with welfare standards.[170] However, a recent assessment of 23 commonly used kill traps found that only 13 met the standard.[171] By-kill from kill traps is low because they have to be set under covers.

Trapping can be a safe and effective method to control possums and stoats in forest edges, along rivers, and in intensively managed patches of forest, but it can only ever play a supplementary role on the great majority of the conservation estate.



Source: Parliamentary Commissioner for the Environment archives

**Figure 7.1: Kill traps are designed to quickly kill specific pest species. They are set under covers to stop non-target animals getting killed in the trap.**

## 7.2 Poisons

In this section, poisons other than 1080 that are commonly used are discussed, followed by three poisons that are likely to be in use soon. The ones in current use are pindone (and other first generation anticoagulants), brodifacoum, cyanide, and cholecalciferol. The three that are likely to be in use soon are PAPP, zinc phosphide, and sodium nitrite.



Although there are a number of research projects underway investigating other poisons for pest control, these alternatives are a long way from any potential use and any discussion would be premature.

None of the poisons discussed in this section are used in exactly the same way as 1080. Therefore, it is not possible to judge them against the criteria as fully as 1080 has been assessed in Chapters 5 and 6. It is possible however, to assess many of their fundamental properties and highlight where they do, or can be expected to, perform better or worse than 1080 in controlling possums, rats and stoats.

### Pindone (and other first generation anticoagulants)

Pindone is a poison that works by stopping the blood from clotting. These poisons, known as anticoagulants, have been used for a long time to control rats and mice. Pindone is a first generation anticoagulant. First generation anticoagulants require pests to feed on the poisoned bait repeatedly over days in order to accumulate a lethal dose. (In contrast, second generation anticoagulants are powerful enough to kill pests after taking one bait.)

Diphacinone and coumatetralyl, along with pindone, are the other first generation anticoagulants most commonly used for pest control. These poisons are used in bait stations to control rats. Pindone is the only one allowed for aerial use and is sometimes used for large-scale rabbit control by councils and private landowners.

First generation anticoagulants will kill possums[172] and rats (and mice) and because they are slow to break down in carcasses of dead animals, will also kill stoats through secondary poisoning. An advantage of anticoagulants is that rats do not develop bait shyness; because it takes a long time for the poison to work, they do not learn to associate poisoning with the bait.[173]

**First generation anticoagulants can't be used tactically to knock down rats and mice during a mast event**

Because first generation anticoagulants are generally used in bait stations, they contribute to the increase of native species in forests in intensive ground control operations.

First generation anticoagulants cannot be used tactically to knock down rapidly irrupting rats and mice during a mast event for two reasons - they kill too slowly and multiple feeds would be required.

Pindone is licensed for aerial use and therefore could be used to kill possums, rats and stoats on a large scale in remote rugged backcountry, but it is not used this way because the risks associated with its use are greater than the risks associated with using 1080.

Anticoagulant baits are generally more expensive than 1080 pellets, but the cost of operations using first generation anticoagulants is largely driven by the cost of labour involved in setting and refilling bait stations. For instance, controlling rats in forests during normal bird breeding seasons (not mast years) using first generation anticoagulants in bait stations requires the bait stations to be visited six or seven times to restock the stations with baits.

Anticoagulants break down very slowly in water and soil. They also accumulate in the liver tissue of live animals that have been exposed to the poison (either by eating bait or feeding on an animal that has eaten bait) and in carcasses.

Anticoagulants are considered to be very inhumane because they are slow and painful killers.[174] A rat takes 5 to 8 days to die after a deadly dose of diphacinone, and during that time suffers severe internal bleeding that is likely to cause extreme pain.[175]

By-kill of native species is a significant risk from the use of first generation anticoagulants. Birds that have been found dead after pindone operations in open habitats for rabbits, including plovers, rails, wrybills, Southern black-backed gulls, Australasian harriers, silvereyes and grey warblers. In most cases the actual cause of death is unknown as testing for residues has rarely been done. However, pindone residues have been found in Australasian harriers, Southern black-backed gulls and Moko skinks after pindone operations.[176]

First generation anticoagulants can affect people – indeed warfarin as been used medically for many years as a blood thinner. However, they are generally less toxic to people than 1080.[177] Accidental poisoning with anticoagulants can be treated with Vitamin K1.[178]

## Brodifacoum

Brodifacoum is a second generation anticoagulant, so is powerful enough to kill pests after taking one bait. Its effectiveness, however, comes with a cost – long term persistence in the environment and very high risk of by-kill.

Brodifacoum is licensed for killing possums and rats. Like 1080, it will kill stoats that feed on poisoned animals. It has been successfully used in aerial operations to completely eradicate possums and rats and stoats on several offshore islands and fenced 'mainland islands' that are now sanctuaries for endangered animals.[179]

**By-kill of native species is a significant risk from the use of anticoagulants**

On the islands where it has been used aerially, brodifacoum has clearly increased populations of native species because it has eradicated the pests that prey on them. An example is Ulva Island off Rakiura/Stewart Island. DOC cleared Ulva Island of rats in 1997, and since that time populations of rare birds like tīeke (South Island saddlebacks), toutouwai (Stewart Island robin) and mōhua have been successfully established on the island.[180] Rats reinvaded the island in 2010, and DOC is currently planning an aerial brodifacoum operation to eradicate them again.

Brodifacoum could potentially be used to knock down populations of rapidly irrupting rats and mice (and therefore stoats) during mast events, although it is unlikely to be as effective as 1080.

This is because brodifacoum would not be used aerially to control a mast on the mainland, and because of the behaviour of rats and mice. When using brodifacoum on the mainland, DOC ties it into bait stations to reduce the risks of by-kill from spilled bait. When seeds are abundant during the mast, rats appear to prefer this 'takeaway' food that they can pick up and carry away to a safe place to eat it, rather than eating brodifacoum baits at a bait station.



Like 1080, brodifacoum could be used aerially to control possums, rats and stoats over large remote rugged areas, but the Department of Conservation does not use it in this way on the mainland because of the risks associated with its use.

Brodifacoum is more cost-effective than first generation anticoagulants when used in ground operations because bait stations do not need to be replenished nearly as often. The cost of an aerial brodifacoum operation – in situations where it can be used this way – is broadly similar to an aerial 1080 operation. However, on the mainland brodifacoum is effectively only used in bait stations, meaning an aerial 1080 operation will often be a far cheaper option.

**Brodifacoum is considered an extremely inhumane poison**

Brodifacoum takes a very long time to break down in soil and water and accumulates in the tissue of exposed animals for years.

Consequently, there is a very high risk of by-kill – at least 21 species of native birds including kiwi, kākā, kākāriki and tūī are known to have been killed by brodifacoum.[181] An area where brodifacoum has been used must be closed for hunting for three years after the operation. In comparison, an area must be closed for four months following an aerial or ground 1080 operation.[182]

Brodifacoum is considered an extremely inhumane poison.[183] It takes up to 21 days for a possum to die after a deadly dose of the poison and it is thought to cause severe pain.[184] Rats can take a week to die after eating a deadly dose of brodifacoum.[185]

As with the first generation anticoagulants, accidental poisoning with brodifacoum can be treated with Vitamin K1.

## Cyanide

Cyanide has been used in New Zealand since the 1940s and is licensed for killing possums and wallabies. It is a highly lethal, broad-spectrum poison that depletes cells of energy, quickly resulting in respiratory arrest and death.[186]

Cyanide kills possums and will kill rats (and mice) that eat bait laid for possums. But because it kills so rapidly and breaks down very quickly in carcasses, it is very unlikely to kill stoats through secondary poisoning. Some forms of cyanide bait lose their toxicity quickly; this lowers effectiveness and leads to bait shyness as more animals receive a sub-lethal dose and learn to avoid the bait. Some animals can detect cyanide by its smell.

Encapsulated pellets of compressed cyanide increase its effectiveness because the pellets prevent the animal smelling the cyanide and remain toxic for longer. The results of possum control operations using cyanide are highly variable with kill rates ranging from 28 to 100 percent.[187]

Cyanide is one of the poisons used in bait stations so contributes to the increase in native species that follows ground control operations.

Like other poisons only used in ground operations, cyanide cannot be used tactically to knock down rats and mice during a mast event.

Because it is so lethal, it seems impossible that cyanide would ever be approved for aerial operations, so it could never be used for pest control on a large scale in remote rugged areas.

While cyanide itself is very cheap compared to 1080, the encapsulated bait pellets that give the best delivery results are more expensive.

Cyanide is very volatile and does not leave residues in water and soil or in the carcasses of animals it has killed. Because it is so volatile it can lose its toxicity too rapidly making it ineffective, as discussed above.

High by-kill of native species (including kiwi, kea, weka, and bats) following cyanide operations has been reported in the past, particularly when cyanide paste has been laid by hand. Cyanide will not kill dogs for the same reason it cannot kill stoats – it breaks down so quickly in poisoned animals that secondary poisoning is very unlikely to occur.

**Because it's so lethal, it's unlikely that cyanide would ever be approved for aerial operations**

Cyanide is more humane than other poisons used for controlling possums because it kills very quickly – within minutes.[188] The short time to death makes it the poison of choice for fur harvesters as animals die close to the bait stations and are easily found.

Cyanide is lethal to humans and while there are antidotes to cyanide poisoning, their effectiveness is controversial and the rapid action of the poison limits the time in which they can be used.[189]

## Cholecalciferol

Cholecalciferol naturally occurs as Vitamin D3 in many foods including fish. It was developed as a poison to control rats and mice in the 1980s. It works by leaching calcium from the bones of the poisoned animal into its blood stream leading to organ failure.[190]

Cholecalciferol is licensed for controlling possums and rats and is only used in bait stations. While residues can be found in sub-lethally exposed animals for 3 months, the levels are too low to lead to secondary poisoning of stoats.[191]

Like other poisons used in bait stations, cholecalciferol contributes to the increase in native species following intensive ground operations.

Because it is only used in ground operations and will not kill stoats, and because poisoned rodents take a long time to die, cholecalciferol cannot be used to deal with mast events.

For the same reasons, it cannot be used to control pests on a large scale in remote areas.



Cholecalciferol is more expensive to produce than 1080. Some promising results have been obtained by combining cholecalciferol with other substances such as aspirin to make it more cost-effective and faster acting.[192] Combining the active ingredients in coumatetralyl with cholecalciferol is also being investigated as a potential new poison.

Although cholecalciferol itself is broken down rapidly by sunlight and exposure to moist air, the baits containing it can take a long time to break down and release the poison – up to two years in trials.[193]

The risk of by-kill is considered low, especially as trials have shown that birds are less sensitive to this poison, and that invertebrates do not appear to be affected by it.[194] However, dogs are sensitive to the poison.

Cholecalciferol is considered to be extremely inhumane. It takes a long time for animals to die – possums take up to ten days  - and is thought to cause severe suffering.[195]

No specific antidote exists for cholecalciferol; however, intensive treatment including the use of charcoal and saline solution can reverse the effects of poisoning.[196]

## Para-aminopropiophenone (PAPP)

Para-aminopropiophenone, known as PAPP for the obvious reason, is a new poison developed to control stoats, weasels, and feral cats.[197] It kills by preventing red blood cells from carrying oxygen, and was approved and registered this year.

PAPP kills stoats directly, but not possums and rats. It is approved for use in paste form or in fresh minced meat, so will only provide effective stoat control as part of intensive ground control.

While PAPP is clearly a useful new weapon in the battle against pests, it cannot substitute for 1080.

**While PAPP is a useful new weapon in the battle against pests, it can't substitute for 1080**

PAPP does not leave residues in soil or water or bio-accumulate in animals so the risk of by-kill through secondary poisoning is low. It is thought to be relatively humane because poisoned stoats lose consciousness after about 17 minutes and do not appear to suffer painful symptoms.

A research project is underway aimed at developing self-setting delivery systems that could improve the efficiency of this control method, and indeed others, in the future. One possibility is a tunnel through which a stoat would run triggering a device that would spray the poison on to its fur, which the stoat would then lick off.[198]

## Zinc phosphide

Zinc phosphide has been widely used overseas for decades, predominantly to control rats and mice on agricultural land. It causes death by heart or respiratory failure.[199]

Zinc phosphide may soon be approved by ERMA for ground control of possums and rats. It could potentially be registered for aerial control of possums and rats. It does not bioaccumulate in the tissue of poisoned animals,[200] so is unlikely to kill stoats through secondary poisoning.

Zinc phosphide is highly toxic and will kill birds and other animals, including fish, but acidity in moist soil or water oxidises and breaks it down over days to weeks.[201]

Zinc phosphide will kill possums and rodents within 24 hours.[202]

Zinc phosphide is considered moderately humane, similar to 1080[203] and there is no antidote.[204]

## Sodium nitrite

Sodium nitrite is a naturally occurring substance commonly used as a meat preservative but toxic at higher doses. It kills in a similar way as PAPP, by reducing the ability of red blood cells to carry oxygen.

Research has shown that sodium nitrite could be an effective and affordable poison for the control of possums and feral pigs, and registration is currently sought for ground control of these pests. Sodium nitrite is unlikely to be effective for controlling rats. This is because animals need to eat large amounts of this poison in one feed due to its relatively low toxicity - much more than a rat will eat. It will also not kill stoats through secondary poisoning because it does not bioaccumulate.

Because sodium nitrite is biodegradable and does not bioaccumulate in poisoned animals, the risk of by-kill is low. It is regarded as humane, and an antidote is available should accidental poisoning occur.

Sodium nitrite may become widely used in ground and possibly aerial operations for killing possums, and thus could become particularly useful for the AHB.

## 7.3 Biological control

Biological control (biocontrol) methods involve controlling pests with biological agents, such as natural predators and parasites, or the use of organisms that cause disease-like viruses, bacteria and fungi. In theory, a successful biocontrol method could decimate or even eliminate pests over large inaccessible areas.

The introduction of stoats and ferrets into New Zealand as a biocontrol method for rabbits clearly did not work and has had a devastating effect on native animals. Bringing in new predators to prey on possums, rats and stoats is not an option.



However, in recent years a number of research projects have been directed at different biocontrol methods for reducing the fertility of possums. No work has been carried out in New Zealand to develop biocontrol methods for rats or stoats.

Two main approaches for the biocontrol of possums have been taken – contraceptive vaccines and hormone toxins.

### Contraceptive vaccines

The proposed contraceptive vaccines use genetically modified organisms to trigger a possum's immune system to attack its own reproductive system, thus making the possum infertile.[205] Several ways of delivering such a vaccine have been investigated.

- Genetically engineered empty bacterial cells (called 'bacterial ghosts') or components of viruses (virus-like particles) trick the possum's immune system into attacking its own reproductive function. This makes the possum less fertile or infertile. These biological agents would not be able to reproduce and spread themselves through the possum population. Instead, they would need to be delivered in baits in the same way that poisons are.[206]
- Plants can be genetically engineered to produce molecules that would make possums less fertile.[207] Research has focused on crops such as carrots that would be fed as baits to possums.[208]
- A parasite worm that is specific only to possums has been identified. These worms could be genetically engineered to cause possums' immune systems to attack their own reproductive cells. Such a parasite would remain alive, and therefore transmit through possum populations and persist indefinitely in the environment.[209] It is possible, but unlikely, that a genetically engineered version of the worm could make its way back to Australia where it could also impact their native possum populations.

### Hormone toxins

This approach involves using a modified hormone to carry a toxin to cells that produce the possum's fertility hormones.[210] The toxin would kill only those cells and cause the possum to become sterile.[211] The main hormone that was being investigated is not specific to possums, which would make the method suitable for controlling other pests, but may put other animals at risk too. Such a hormone could be put in bait, which would not involve genetic engineering. Alternatively it could be transmitted through the possum population by the parasitic worm mentioned above. In this case, the worm would be genetically engineered to produce the hormone toxin.

Significant research effort and resources were put into these biocontrol options,[212] but all funding ceased in September 2010 after progress was deemed too slow and a research milestone was not met. Other factors were doubtless at play, such as the risks associated with the uncontrollable and irreversible release of biological control agents and the controversy over genetic engineering.[213]

Biological control options cannot be considered as a realistic alternative to 1080 in the foreseeable future.

## 7.4 Conclusions

The alternative methods currently used for pest control all have their place. Different methods are selected for particular characteristics that suit particular situations.

*Trapping* can be cost-effective in forested margins and patches, but not over large inaccessible areas. Current advances with self-resetting traps will reduce costs because trapping is so labour intensive. While possums and stoats may be successfully controlled with traps in these relatively small areas, high influxes of rats are impossible to keep at bay with traps.



*Alternative poisons* are currently only able to be used in ground operations, apart from the occasional use of brodifacoum under very specific conditions for exterminating rodents, and the use of pindone to control rabbits. This means that, like trapping, these poisons can only be used in relatively small accessible areas. Moreover, if they can be used in ground control over larger areas, they will inevitably be less cost-effective than 1080 because of the labour costs. Having a suite of poisons that can be used in ground operations is important for avoiding bait shyness and the build-up of resistance.

- Anticoagulants are generally very effective at controlling rats to keep their numbers low but cannot effectively deal with sudden population surges. Anticoagulants are also the most inhumane of the poisons currently used. Different types of anticoagulants need to be rotated to avoid populations becoming bait-shy or building up resistance.
- Brodifacoum will kill stoats as well as possums and rats because it bioaccumulates in the tissue of poisoned animals. It is very slow to break down in the environment, so while it is very effective, the risk of by-kill is very high.
- Cyanide is used to kill possums and does so quickly and humanely. But its effectiveness varies because of bait shyness. Cyanide breaks down quickly and does not leave residues in the environment, but this means it does not kill stoats through secondary poisoning. Ground-laid cyanide has killed native species and other animals in the past and it takes only a tiny amount of cyanide to kill a human.
- Cholecalciferol will reduce populations of possums and rats, but not stoats since it does not bioaccumulate in animals. It breaks down readily in the environment and the risk of by-kill is considered to be low. Cholecalciferol is very inhumane.
- PAPP is a new poison designed to kill stoats humanely. Its mode of operation means that it will not kill possums and rodents. The risk of by-kill is likely to be low since it does not leave residues in the environment.
- Zinc phosphide may be approved for ground control of possums and rats in New Zealand, but will not kill stoats because it breaks down quickly in the environment and in poisoned animals. By-kill would be expected to be low.
- Sodium nitrite is expected to be used for killing possums, but not rats. It will not control stoats because it will not knock down rat populations or bioaccumulate in poisoned animals. It does not leave residues in the environment and the risk of by-kill is expected to be low. It is much more humane than 1080.

*Biological control methods* for killing possums, rats and stoats do not currently exist. Research projects aimed at developing such methods made very slow progress and have now ceased. Most of these methods involved some form of genetic engineering, and if developed further would attract a great deal of public opposition.



Although there are other methods that are effective in particular situations, the only practical and cost-effective option that is available for controlling possums, rats and stoats in large and inaccessible areas is an aerially delivered poison. And there is no alternative poison available now or in the near future that could be used aerially and would be preferable to 1080.

# 8

# Conclusions and recommendations

## 8.1 No moratorium on 1080

The native plants and animals in New Zealand are unique because they have evolved in almost total isolation from the rest of the world. This makes them particularly vulnerable to predators because they have not developed defences against them. In particular, because there were virtually no native land mammals, the invasion of small mammals that followed the arrival of Europeans requires constant vigilance and effort. Possums, rats and stoats are increasingly damaging our national parks and other conservation land, and possums, rabbits and hares lower the productivity of our agriculture and forestry.

Traps and bait stations play a crucial role. But it is a limited role. In our great forests on the conservation estate, possums, rats and stoats breed virtually unhindered, and ground control methods, no matter how sophisticated, simply cannot cover large areas of rugged terrain or prevent the devastation of mast years. The only option for controlling possums, rats and stoats on almost all of the conservation estate is to drop poison from aircraft. And 1080 is the only poison currently available for aerial pest control on the mainland that can do this job.

Dropping a poison from the sky will always be contentious and understandably so, even if a poison were to be developed that was perfectly effective, safe and humane. In this report, 1080 has been systematically assessed for its effectiveness, safety and humaneness. While it is not perfect, it scores surprisingly well, due in large part to the increase in scientific understanding, the establishment of a strong body of evidence, and the addition of many controls over the years.

Research to develop better poisons (and possibly biocontrol options) should absolutely continue. Alternatives, whether currently available or on the horizon, can complement the use of 1080, but cannot replace it. The huge effort, expenditure and achievements to date in bringing back many species and ecosystems from the brink would be wasted if the ability to carry out aerial applications of 1080 was lost.

*I recommend that:*

**1. Parliament does not support a moratorium on 1080.**

## 8.2 Simplify regulations

The labyrinth of laws, rules and regulations that govern 1080 and the other poisons used to control introduced pests creates unnecessary complexity and confusion.

Under the RMA, the use of poisons for controlling pest mammals is treated differently by different councils. Some councils treat the use of poisons as a permitted activity with only a few conditions, while other councils treat exactly the same use as a discretionary activity requiring a resource consent. In one case the number of aerial 1080 operations that can take place under the consent is specified, making it very difficult to respond to mast events. Many of the rules also replicate controls already in place under other legislation.

There is considerable scope to simplify and standardise the management of these poisons. There is a strong case for the use of 1080 and other poisons to be permitted activities under the RMA, with local control reserved to those activities that are not covered by already existing controls under other legislation. One way to achieve this standardisation and simplification could be with a National Environmental Standard.

There may also be other opportunities for simplifying various practices associated with the use of 1080, some required under regulations and some not. For instance, over 2,500 water samples have been taken for more than 20 years from drinking water supplies, streams and lakes after aerial 1080 operations. In all this time 1080 residues have never been detected in drinking water supplies, and only found in vanishingly small and harmless levels in 3 percent of the remaining samples. We do not need more water samples to tell us that the way 1080 is used poses no real risk to water.

*I recommend that:*

2. **The Minister for the Environment investigate ways to simplify and standardise the way 1080 and other poisons for pest mammal control are managed under the Resource Management Act and other relevant legislation.**

## 8.3 The Game Animal Council

The Government has committed to establishing a Game Animal Council to advise on and manage hunting interests on the conservation estate. The Council will report to the Minister of Conservation and work with her department.

While greater collaboration between different interest groups on the conservation estate should be encouraged, the proposal has the potential to conflict with the Department of Conservation's ability to carry out pest control.

The discussion paper on the Game Animal Council suggested that DOC and the Council work together to identify priority areas '*where animals need to be actively controlled for conservation purposes*'. Outside these areas the paper suggests the Council should have responsibility managing game animals.

While the Council would not be tasked with responsibility for managing possums, rats and stoats, it could under the suggested management structure effectively halt 1080 operations for these pests if it thought game animals may be at risk. This would place an unacceptable constraint on DOC's ability to carry out pest control effectively and efficiently.

*I recommend that:*

3. **The Minister of Conservation establishes the Game Animal Council as an advisory body that works collaboratively with the Department of Conservation, but ensures that responsibility for all pest control remains with the department.**

## 8.4 The Animal Health Board & the Official Information Act



The goal of the Animal Health Board (AHB) is to eliminate bovine TB from New Zealand. Most of its effort goes into killing possums and other carriers of the disease. The AHB is a major user of 1080, mostly in ground control operations along with trapping and other poisons such as cyanide.

The Department of Conservation and regional councils are subject to the Official Information Act and the Ombudsmen Act, but the AHB is not. Moreover, New Zealand's principal manufacturer of 1080 baits, Animal Control Products Ltd, is subject to both Acts.

The AHB receives about $30 million of central government funding and about $6 million of regional council funding every year. As a recipient of government funding, it would be consistent with sound public policy to increase the transparency and accountability of the AHB by making it subject to the Official Information Act and the Ombudsmen Act.

Currently the Biosecurity Law Reform Bill 256-1 (2010) before Parliament would see this occur at least in part. The relevant proposed amendment (clause 79) is not specific to the AHB, but rather is directed to any agency "*if they are corporate bodies, in their role under pest management plans or pathway management plans*".

However the question arises as to whether the coverage proposed in the amendment is as comprehensive as is desirable. If the intent is to ensure the AHB is fully transparent in a manner consistent with other public agencies, then AHB should be specifically named in the Ombudsmen Act.

Including the AHB in the Ombudsmen Act would also automatically subject the AHB to the Official Information Act. The Official Information Act provides for requests to be made for information and sets time limits for responses. If the AHB were made subject to the Official Information Act, then an individual or group would have much greater access to information. For instance, someone concerned about whether buffer zones were actually adhered to in an aerial 1080 drop might request a copy of a map of the actual flight tracks recorded on the GPS system in the helicopter.

*I recommend that:*

4. **The Minister of Justice introduces an amendment to the Ombudsmen Act 1975 to add the Animal Health Board to Part 2 of Schedule 1 of the Act, and thereby make the Animal Health Board also subject to the Official Information Act 1982.**

## 8.5 Economic value from pests without undermining conservation



During this investigation the economic potential of the possum fur industry has been raised. Some have argued that large scale possum fur harvesting would be an effective pest control method. Others have suggested that reducing possum numbers could actually make things worse, by leading to higher populations of rodents because there would be more food for them, and then stoats would multiply because there would be more rodents for them to eat.

While "a good possum is a dead possum", commercial fur harvesting is unlikely to benefit the conservation estate. Unless possum fur becomes much more valuable than it is now, commercial harvesters would probably stop catching possums long before their numbers have been reduced to levels that are low enough to benefit native animals and plants. Nevertheless there is every reason to encourage possum fur harvesting on the conservation estate, provided it does no damage.

Currently agreements between pest control agencies and fur harvesters appear to be *ad hoc*. Where possums are being controlled entirely by ground methods commercial trappers are sometimes allowed in to have "first crack". But there could be considerable potential in large areas of back country where there is no pest control at all taking place.

It is not cost-effective to control pests using ground operations in large areas of back country. However, well-organised large scale fur harvesting, like the wild venison hunting of the seventies, may be economically viable.

A working group involving the Department of Conservation, the Animal Health Board, regional councils, and industry representatives has been established to consider developing policies and procedures for testing the economic potential of fur harvesting, but it is not at all clear that it is a priority.

*I recommend that:*

5. **The Minister of Conservation asks the Department of Conservation to prioritise the development of national policy and operational procedures on possum fur harvesting.**

## 8.6 Department of Conservation: improve transparency

In the course of this investigation it has become clear that the quality of communication about 1080 operations and the relationships between pest control agencies and communities varies across agencies and regions.

A key communication tool is the Department of Conservation website. Currently it contains four-monthly updates on pest control operations and conservancy plans for pest control, including maps. The provision of such information makes an extremely valuable contribution and should be encouraged. However, the information given in conservancy plans is not consistent; for example, only some conservancies state the size of the area that is to be treated. And no conservancies provide information on why a particular operation is being carried out, such as the need to knock down rodents to protect kōkako nestlings.

Providing relevant information on 1080 operations on the website in a consistent, readily accessible format is essential.

Reports on completed operations should also contain the results to demonstrate what worked, what did not work and why. Open communication of success and failures is critical for building good relationships between pest control agencies and the public.

*I recommend that:*

6. **The Minister of Conservation improve information about pest control on the conservation estate by providing consistent and accessible information on the Department of Conservation website, including the purposes and results of different pest control operations.**

# Endnotes

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14 Two species of seal (the New Zealand fur seal and the New Zealand sea lion) breed at sites on the coasts of the North and South islands, while a further five species breed in our territorial waters in the Antarctic or sub-Antarctic (King, C.M. (ed.). 2005. *The handbook of New Zealand mammals*. Oxford University Press, Auckland).

15 Developing and maintaining predator defences is energetically costly. The ability to fly, for example, requires very large amounts of food for energy. If flight is not required because there are no mammalian predators, then much less food is required, or that food can be put into other things such as breeding.

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18 http://www.teara.govt.nz/en/kiore-pacific-rats/3

19 Dama wallabies (*Macropus eugenii egenii*) are established in the Rotorua region where they can have major impacts on native forests (Waburton, B. 2005. Dama wallaby. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland). Bennett's wallabies (*M. rufogriseus rufogriseus*) are established around Waimate in South Canterbury, where they can cause economic damage to pasture and pine forest (Waburton, B. 2005. Bennett's wallaby. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland.

20 Kākāpō, hihi, tīeke are all threatened by introduced predators. For example, being flightless makes kākāpō easy prey for stoats, while hihi and tīeke are very vulnerable to possums, rats, and stoats when they are on their nests. They have been assessed as being unable to coexist with these species, and are now only found on predator-free islands or in fenced sanctuaries (Innes, J., Kelly, D., Overton, J.M. and Gillies, C. 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology* 34: 86-114).

21 Newman, D.G. 1994. Effects of a mouse, *Mus musculus*, eradication programme and habitat change on lizard populations of Mana Island, New Zealand, with special reference to McGregor's skink, *Cyclodina macgregori*. *New Zealand Journal of Zoology* 21: 443-456. See also the chapters on mice and rats in King, C.M. (ed.). 2005. *The handbook of New Zealand mammals*. Oxford University Press, Auckland.

22 Ladley, J.J. and Kelly, D. 1995. Explosive New Zealand mistletoe. *Nature 378*: 766.

23 Clout, M.N. and Hay, J.R. 1989. The importance of birds as browsers, pollinators and seed dispersers in New Zealand forests. *New Zealand Journal of Ecology* 12 (Supplement): 27-33; Wotton, D.M., Clout, M.N. and Kelly, D. 2008. Seed retention times in the New Zealand pigeon, *Hemiphaga novaeseelandiae. New Zealand Journal of Ecology 32: 1-6.*

24 Innes, J., Kelly, D., Overton, J.M. and Gillies, C. 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology* 34: 86-114.

25 Warburton, B., Toucher, G. and Allan, N. 2000. Possums as a resource. *In:* T.L. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln: 251-261.

26 Recorded possum densities range from 3.6–25.4 $ha^{-1}$ in podocarp-broadleaf forest; 0.5–1.7 $ha^{-1}$ in beech forest; 0.9–3.0 $ha^{-1}$ in pine forest; and 0.2–16.7 $ha^{-1}$ in pasture and scrub (Efford, M. Possum density, population structure and dynamics. *In:* T.L. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln: 47-61).

27 The study by Landcare Research also estimated that without the current possum control efforts of DOC, the AHB and other pest controllers, there would be around 48 million possums in the country (Warburton, B., Cowan, P. and Shepherd, J. 2009. *How many possums are now in New Zealand following control and how many would there be without it?* Report prepared for Northland Regional Council, Landcare Research, Palmerston North).

28 Nugent, G., Whitford, J., Sweetapple, P., Duncan, R. and Holland, P. 2010. Effect of one-hit control on the density of possums (*Trichosurus vulpecula*) and their impacts on native forest. Department of Conservation, Wellington.

29 Powlesland, R.G., Dilks, P.J., Flux, I.A., Grant, A.D., Tisdall, C.J. 1997. Impact of food abundance, diet, and food quality on the breeding of the fruit kereru, Parea *Hemiphaga novaeseelandiae chathamensis*, on Chatham Island, New Zealand. *Ibis* 139: 353-365.

30 Innes, J., Hay, R., Flux, I., Bradfield, H., Jansen, P. 1999. Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations, by adaptive management. *Biological Conservation* 87: 201-221.

31 Sadlier, R. 2000. Evidence of possums as predators of native animals. *In:* T.L. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln.

32 Small isolated populations of kiore appear to still exist in parts of Fiordland, Southland and South Westland. They are also found on a number of islands off Northland, the Coromandel, Hauraki Gulf, Nelson and Rakiura/Stewart Island (Atkinson, I.A.E. and Towns, D.R. 2005. Kiore. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland.

33 Rutland, J. 1890. On the habits of the New Zealand bush rat. *Transactions of the New Zealand Institute* 22: 300-307.

34 They are most abundant in lower elevation mixed podocarp-broadleaf forests (e.g. forests containing species like tawa, lemonwood, rimu, rātā and miro), where food and nesting sites are abundant. They are generally less common in pure beech forests, except after heavy beech tree seeding.

35 Bell, B.D. 1978. The big South Cape Island rat irruption. *In:* P.R. Dingwall, I.E.A. Atkinson and C. Hay (eds). *The ecology and control of rodents in New Zealand nature reserves*. New Zealand Department of Lands and Survey Information Series No. 4, Wellington.

36 Innes, J., Kelly, D., Overton, J.M. and Gillies, C. 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology* 34: 86-114.

37 Galbreath, R. 1989. *Walter Buller: the reluctant conservationist*. GP Books, Wellington.

38 This is thought to largely be due to the lack of suitable food for weasels in New Zealand. In their natural range in Europe, small mammals like voles – which are absent from New Zealand – make up most of their diet. Without this steady food supply, weasels struggle to find enough food to survive.

39 Clapperton, B.K. and Byrom, A. 2005. Feral ferret. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland.

40 King, C.M. and Murphy, E.C. 2005. Stoat. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland.

41 http://blog.doc.govt.nz/2011/03/16/stoat-on-a-plate [Accessed 2 May 2011].

42 McLennan, J.A., Potter, M.A., Robertson, H.A., Wake, G.C., Colbourne, R., Dew, L., Joyce, L., McCann, A.J., Miles, J., Miller, P.J. and Reid, J. 1996. Role of predation in the decline of kiwi, *Apteryx* spp, in New Zealand. *New Zealand Journal of Ecology* 20: 27-35.

43 Powlesland, R., Merton, D.V. and Cockrem, J.F. 2006. A parrot apart: the natural history of the kakapo (*Strigops habroptilus*), and the context of its conservation management. *Notornis* 53: 3-26; Taylor, S., Castro, I. and Griffiths, R. 2005. *Hihi/stitchbird (Notiomystis cincta) recovery plan 2004–2009*. Threatened Species Recovery Plan 54. Department of Conservation, Wellington.

44 The term 'mast' comes from the Old English word 'maest', meaning the nuts and seeds on forest floors that provided food for pigs.

45 Harper, G.A., Elliott, G.P., Eason, D.K. and Moorhouse, R.J. 2006. What triggers nesting of kakapo (*Strigops habroptilus*). *Notornis* 53: 160-163.

46 Elliott, G. and Suggate, R. 2007. *Operation Ark: Three year progress report*. Department of Conservation, Christchurch.

47 In pure beech forests, it is mice rather than rats that undergo population irruptions and drive the increases in stoats. Figure based on data in King, C.M. and Murphy, E.C. 2005. Stoat. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland; Blackwell, G.L., Potter, M.A. and Minot, E.O. 2001. Rodent and predator population dynamics in an eruptive system. *Ecological Modelling* 25: 227-245; and Blackwell, G.L., Potter, M.A., McLennan, J.A. and Minot, E.O. 2003. The role of predators in ship rat and house mouse population eruptions: drivers or passengers? *Oikos* 100: 601-613.

48 A rate of decline of 5.8% per year has been published for brown kiwi, although recent data indicate that the rate of decline may be lower in some regions. In Northland, for example, the rate of population decline is thought to be close to 2% per year. In the national kiwi recovery plan, DOC uses a mid-point figure 3% annual decline for unmanaged populations of brown kiwi, and a 2% decline for unmanaged populations of other species (see Holzapfel, S., Robertson, H.A., McLennan, J.A., Sporle, W., Hackwell, K. and Impey, M. 2008. *Kiwi (Apteryx spp.) recovery plan: 2008–2018*. Threatened Species Recovery Plan 60. Department of Conservation, Wellington.

49 Supporters of the project include the Animal Health Board, the Department of Conservation, Dairy NZ, Solid Energy, the Isaac Wildlife Foundation, Meat & Wool New Zealand, PGG Wrightson, Deer Industry New Zealand, and Bush and Beyond. Press release, 8 April 2010, www.1080facts.co.nz/1080_newsroom [Accessed 18 May 2011].

50 S 36(1), Animal Welfare Act 1999.

51 As of 1 January 2011, under the Animal Welfare (Leg-hold traps) Order (see http://www.biosecurity.govt.nz/regs/animal-welfare/stds/traps#leg-hold [Accessed 9 February 2011]).

52 http://goodnature.co.nz.s52206.gridserver.com/news/?cat=10 [Accessed 29 April 2011].

53 All poisons must be registered as vertebrate toxic agents under the Agricultural Compounds and Veterinary Medicines Act 1997, and must be approved for use under the Hazardous Substances and New Organisms Act 1996.

54 Morgan, D. and Hickling, G. 2000. Techniques used for poisoning possums. *In:* T.L. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln. Paste bait for cats or goats is usually applied to earth 'spits' or up-turned turf that is turned back over after the poisoning operation.

55 Some regional councils use brodifacoum in bait stations to control possums in urban parks and reserves. For example, Greater Wellington Regional Council uses brodifacoum in bait stations to control possums and rats in its regional parks around Wellington city (http://www.gw.govt.nz/Possums-targeted-on-Tinakori-Hill; http://www.gw.govt.nz/Possum-control-operation-to-start-in-Whiteman-s-Valley [Accessed 11 May 2011]).

56 Auckland Council used aerial brodifacoum to eradicate possums, rats and stoats from a predator-fenced area of Tawharanui Regional Park in 2003 (http://www.arc.govt.nz/albany/index.cfm?A6FA346B-14C2-3D2D-B961-557E260B50CB [Accessed 20 May 2011]) and has an aerial drop of brodifacoum planned for fenced area in Shakespear Regional Park in 2011 (Press Release, Auckland Council, 2 March 2011).

57 DOC has used phosphorus in the past for rabbit and possum control. Magnesium phosphide is sometimes used as a rabbit burrow fumigant in habitats where rabbits can reach high numbers, like tussock grasslands.

58 It is also used to control wallabies in some places.

59 Eason, C.T. and Hickling, G.J. 1992. Evaluation of a biodynamic technique for possum pest control. *New Zealand Journal of Ecology* 16: 141-144. Supporters of biodynamic methods of pest control claim the research trials carried out by Landcare Research were not conducted under the correct conditions (Blake, G. and Bacchus, P. 2000. Possum peppering trial on the Thames Coast. *Harvests* 53: 22-25).

60 DOC. 2007. *Department of Conservation annual report ended 30 June 2007*. Department of Conservation, Wellington.

61 ERMA. 2010. *Annual report on the aerial use of 1080 for the year ended 31 December 2009*. Environmental Risk Management Authority, Wellington.

62 This is 15% of DOC's budget for the management of natural heritage. A further $7 million was spent on controlling deer and goats, and $39 million were spent on other actions to protect threatened species, such as captive breeding programmes or management of populations on predator-free islands. DOC. 2010. *Annual report for the year ended 30 June 2010*. Department of Conservation, Wellington: 110.

63 See http://www.doc.govt.nz/conservation/threats-and-impacts/animal-pests/pesticide-summaries/ [Accessed 17 May 2011].

64 Stoats can carry TB. However, they prefer forest habitats and are rare in farmland, and so are unlikely to come into contact with cattle. In comparison ferrets, which also carry TB, are more common in farmland and forest edges, and are therefore much more likely to come into contact with cattle. In a small number of areas with no ferrets and large areas of forest, the AHB does do some monitoring of TB infection rates in wild stoat populations (Animal Health Board, 2010. Annual report for the year ending 30 June 2010. Animal Health Board, Wellington).

65 The AHB uses ground techniques on about 90% of the land it controls pests on and aerial 1080 for the rest (ERMA. 2010. *Annual report on the aerial use of 1080 for the year ended 31 December 2009*. Environmental Risk Management Authority, Wellington).

66 ERMA. 2010. *Annual report on the aerial use of 1080 for the year ended 31 December 2009*. Environmental Risk Management Authority, Wellington.

67 AHB. 2010. *Annual report for the year ending 30 June 2010*. Animal Health Board, Wellington.

68 The proposed changes relate to the AHB and other management agencies as defined under the Biosecurity Act.

69 Marlborough District Council, Environment Canterbury, the Otago Regional Council, and Environment Southland list rabbits as pest animals in their pest management strategies.

70 ERMA (2010), Annual report on the Aerial Use of 1080 for the year ended 31 December 2009. Environmental Risk Management Authority, Wellington.

71 New Zealand Government. 6 April 2011. *Game Animal Council to be established.* Press release. http://www.beehive.govt.nz/release/game-animal-council-be-established [Accessed 18 May 2011].

72 Data obtained from DOC and AHB.

73 ERMA. 2007. *Environmental Risk Management Authority Decision. Application for the reassessment of a hazardous substance under section 63 of the Hazardous Substances and New Organisms Act 1996: sodium fluoroacetate (1080) and formulated substances containing 1080.* Environmental Risk Management Authority, Wellington.

74 Most councils include vertebrate pest control agents in rules relating to 'agrichemicals'. Three councils have separate rules relating to 'pesticides', and one council has rules specific to 'vertebrate toxic agents'.

75 These councils are Auckland, Waikato, Bay of Plenty, Gisborne, Hawke's Bay, Horizons, Marlborough (private land in the Wairau/Awatere region), and Chatham Islands.

76 Northland, Greater Wellington, Tasman, West Coast, Southland, and Canterbury (if not discharging in or near water supplies).

77 Taranaki, Nelson, Marlborough (on public land), Canterbury (in or near water supplies), and Otago.

78 Aerial discharge of toxins other than 1080 is currently discretionary (rather than permitted) in the Manawatu-Wanganui region, and restricted discretionary (rather than controlled) in Southland.

79 S 95A, RMA 1991.

80 S 69ZZO, Health Act 1956.

81 Using cereal baits with a 1080 concentration of 0.15% and a drop of non-toxic baits before the poison operation. This 'pre-feeding' overcomes any wariness that pest animals may have to the bait itself, to help prevent bait-shyness (Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton). The effectiveness of 1080 operations can be improved by up to 15% by the practice of pre-feeding. (Morgan, D.R. 2004. *Maximising the effectiveness of aerial 1080 control of possums (Trichosurus vulpecula).* Thesis (PhD). Lincoln University, Lincoln.)



82 Using cereal baits with a 1080 concentration of 0.15% and a non-toxic pre-feed. Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

83 For ship rats, see Innes, J.G. 2005. Ship rat. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland. For mice, see Ruscoe, W.A. and Murphy, E.C. 2000. House Mouse. *In:* C.M. King (ed.). *The handbook of New Zealand mammals*. Oxford University Press, Auckland.

84 Gillies, C.A.; Pierce, R.J. 1999. Secondary poisoning of introduced mammalian carnivores during possum and rodent control operations at Trounson Kauri Park, Northland, New Zealand. *New Zealand Journal of Ecology* 23: 183-192; Murphy, E.C., Robbins, L., Young, J.B. and Dowding, J.E. 1999. Secondary poisoning of stoats after an aerial 1080 poison operation in Pureora Forest, New Zealand. *New Zealand Journal of Ecology* 23: 175-182; Alterio, N. 2000. Controlling small mammal predators using sodium monofluoroacetate (1080) in bait stations along forestry roads in a New Zealand beech forest. *New Zealand Journal of Ecology* 24: 3-9.

85 Data spans 1 January 2008 – 1 October 2010. Monitoring of pest populations before and after an aerial operation is not legally required.

86 Data from the Pestlink reporting database (ERMA, unpublished data).

87 Nugent, G., Whitford, J., Sweetapple, P., Duncan, R. and Holland, P. 2010. Effect of one-hit control on the density of possums (*Trichosurus vulpecula*) and their impacts on native forest. Department of Conservation, Wellington.

88 For examples, see ***Whio*****:** Beath, A. 2010. *Securing Whio (blue duck) in Tongariro Forest*. Technical Report No. 6, Ruapehu Area Office, Department of Conservation. ***Kereru*****:** Innes, J., Nugent, G., Prime, K. and Spurr, E.B. 2004. Responses of kukupa (*Hemiphaga novaeseelandiae*) and other birds to mammal pest control at Motatau, Northland. *New Zealand Journal of Ecology* 28: 73–81. ***Kiwi*****:** The survival of brown kiwi chicks following an aerial 1080 drop in Tongariro Forest in the central North Island was twice as high as before the operation. This effect lasted for two years before stoat numbers increased again and chick survival dropped back to pre-control levels (DOC, unpublished data). ***Tomtits*****:** Powlesland, R.G., Knegtmans, J.W. and Styche, A. 2000. Mortality of North Island tomtits (*Petroica macrocephala toitoi*) caused by aerial 1080 possum control operations, 1997–98, Pureora Forest Park. *New Zealand Journal of Ecology* 24: 161-168. ***Robins*****:** Powlesland, R.G., Knegtmans, J.W. and Marshall, I.S.J. 1999. Cost and benefits of aerial 1080 possum control operations using carrot baits to North Island robins (*Petroica australis longipes*), Pureora Forest Park. *New Zealand Journal of Ecology* 23: 149-159. ***Kākāriki and mōhua*****:** Elliott, G. and Suggate, R. 2007. *Operation Ark: Three year progress report*. Department of Conservation, Christchurch.

89 Nugent, G., Whitford, J., Sweetapple, P., Duncan, R. and Holland, P. 2010. *Effect of one-hit control on the density of possums (Trichosurus vulpecula) and their impacts on native forest.* Department of Conservation, Wellington.

90 Urlich, S. and Brady, P.L. 2005. Benefits of aerial 1080 possum control to tree fuchsia in the Tararua Range, Wellington. *New Zealand Journal of Ecology 29*: 299-309; Pekelharing, C.J., Parkes, J.P. and Barker, R.J. 1998. Possum (*Trichosurus vulpecula*) densities and impacts on Fuchsia (*Fuchsia excorticata*) in South Westland, New Zealand. *New Zealand Journal of Ecology 22*: 197-203.

91 Innes, J., Hay, R., Flux, I., Bradfield, H. and Jansen, P. 1999. Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations, by adaptive management. *Biological Conservation* 87: 201–221.

92 Adult kiwi do remain vulnerable to attacks from ferrets and dogs however.

93 Source data: DOC Powerpoint presentation *'Survival of brown kiwi (Apteryx mantelli) in Tongariro Forest New Zealand'*. DOC Tongariro/Taupo Conservancy.

94 Elliott, G. and Suggate, R. 2007. *Operation Ark: Three year progress report*. Department of Conservation, Christchurch.

95 Due to its properties, 1080 can knock down populations of possums and rats very quickly – in one to two days, independent of whether it is used in a bait station or aerially. However, a 1080 operation will take longer in total due to the need to pre-feed first with non-toxic baits. The pre-feeding is required to get the target pest used to the bait, not the poison.

96 The pest control was carried out as part of a Department of Conservation project known as Operation Ark. This project, commenced in June 2004, aims to preserve populations of whio (blue duck), orange-fronted parakeet (kākāriki karaka), mōhua (yellowhead) and pekapeka (short and long-tailed bats) on the mainland South Island. The objective of the project is to protect these species from possums, stoats and rats and to mitigate the effects of predator plagues in the South Island beech forest sites where the species occur.

97 Elliott, G. and Suggate, R. 2007. *Operation Ark: Three year progress report*. Department of Conservation, Christchurch.

98 ERMA. 2009. *Annual report on the aerial use of 1080*. Environmental Risk Management Authority, Wellington.

99 DOC, pers. comm.

100 DOC, unpublished data.

101 Rosevear, M. and Urlich, D. 2010. *Bovine TB strategy: review of costs.* Report produced for MAF Biosecurity by Outcome Management Services, Wellington.

102 Rosevear, M. 2003. *Scientific research and aerial possum control: a cost/benefit study*. Evaluation report prepared for the Foundation for Research, Science and Technology by Outcome Management Services, Wellington.

103 The cost of monitoring the effectiveness of the ground operation was higher than for aerial control because the ground operation would need to be done in smaller blocks that could be feasibly controlled by a field team. Each block would then require monitoring to check if possums had been satisfactorily controlled. DOC, unpublished data.

104 Bioaccumulation occurs when a substance is added to an environment more quickly than it can be broken down or removed. Some substances can be concentrated up the food chain; mercury is an example.

105 One of the breakdown products is fluoride. The addition of fluoride to urban water supplies in order to reduce tooth decay remains somewhat controversial, and some are concerned that 1080 is 'fluoridating' water. A study that looked at the levels of fluoride in water after 1080 operations in Taranaki found the concentrations of fluoride in waterways in treated areas were completely within the range of natural levels of fluoride in New Zealand waterways. The levels of fluoride recorded in both treated and untreated areas in the study were 10 times lower than the Ministry of Health's standard for fluoride in drinking water of 1.5 grams per cubic metre (Fowles, C.R. and Williams, J.R. 1997. Water quality monitoring in relation to a possum control operation on Mount Taranaki/Egmont. *New Zealand Natural Sciences* 23: 93-99).

106 Parfitt, R.L., Eason, C.T., Morgan, A.J., Wright, G.R. and Burke, C.M. 1994. The fate of sodium monofluoroacetate (1080) in soil and water. *In:* A.A. Seawright and C.T. Eason (eds). *Proceedings of the Science Workshop in 1080*. Miscellaneous Series 28. The Royal Society of New Zealand, Wellington. More than 70% of 1080 in water is broken down within one day.

107 Eason, C.T., Gooneratne, R., Wright, G.R., Pierce, R. and Frampton, C.M. 1993. The fate of sodium monofluoroacetate (1080) in water, mammals and invertebrates. *Proceedings of the New Zealand Plant Protection Conference* 46: 297-301.

108 Eason, C., Miller, A., Ogilvie, S. and Fairweather, A. 2011. An updated review of the toxicology and ecotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand. *New Zealand Journal of Ecology* 35: 1-20.

109 Suren, A.M. 2006. Quantifying contamination of streams by 1080 baits, and their fate in water. *New Zealand Journal of Marine and Freshwater Research* 40: 159-167.

110 In some instances water samples were taken within 48 hours (Landcare Research, pers. comm.). The current protocol recommends taking water samples within 8 hours of the 1080 drop (see Booth, L.H. and Wright, G.R.G. 2008. *Guideline for sampling and testing of water associated with monitoring of aerial 1080 baiting operations.* 2nd ed. Landcare Research New Zealand Ltd).

111 The first water samples were taken in 1990 following aerial 1080 operations at Waipoua Forest in Northland (September) and Rangitoto Island in the Hauraki Gulf (November) (Eason, C.T., Wright, G.R. and Fitzgerald, H. 1992. Sodium monofluoroacetate (1080) water-residue analysis after large-scale possum control. *New Zealand Journal of Ecology* 16: 47-49).

112 Landcare Research, unpublished data.

113 King, D.R., Kirkpatrick, W.E., Wong, D.H. and Kinnear, J.E. 1994. Degradation of 1080 in Australian Soils. *In:* A.A. Seawright and C.T. Eason (eds). *Proceedings of the Science Workshop in 1080*. Miscellaneous Series 28. The Royal Society of New Zealand, Wellington.

114 Fisher, P. and Northcott, G. 2011. *Aerobic transformation of 1080 in soil.* Animal Health Board Project No. R-10695, Wellington.

115 0.01 mg/kg is one part in 100 million by weight.

116 Wright, G.R.G., Booth, L.H., Morriss, G.A., Potts, M.D., Brown, L. and Eason, C.T. 2002. Assessing potential environmental contamination from compound 1080 (sodium monofluoroacetate) in bait dust during possum control operations. *New Zealand Journal of Agricultural Research* 45: 57-65.

117 1080 concentrations of 90mg/kg have been recorded as reducing cocoon production. The maximum recorded concentration in New Zealand of 1080 in soil is 0.19 mg/kg – about 500 times lower than this level (O'Halloran, K., Jones, D., Booth, L. and Fisher, P. 2005. Ecotoxicity of sodium monofluoroacetate (compound 1080) to soil organisms. *Environmental Toxicology and Chemistry* 24: 1211-1218.

118 Ogilvie, S.C., Booth, L.H. and Eason, C.T. 1998. Uptake and persistence of sodium monofluoroacetate (1080) in plants. *Bulletin of Environmental Contamination and Toxicology* 60: 745-749.

119 Kāramuramu (*Coprosma robusta*) was used by Māori as part of many traditional medicine and cultural customs. For example, Tūhoe priests would use kāramuramu branches in cleansing rituals (Gouldie, W.H. 1904. Article 1: Maori medical lore: notes on the causes of disease and treatment of the sick among the Maori People of New Zealand, as believed and practiced in former times, together with some account of various ancient rites connected with the same. *Transactions of the New Zealand Institute* 37: 1-120), or would wear girdles made from kāramuramu (Best, E. 1907. Art. XV.—Maori forest lore: being some account of native forest lore and woodcraft, as also of many myths, rites, customs, and superstitions connected with the flora and fauna of the Tuhoe or Ure-wera District.—Part I. *Transactions of the New Zealand Institute* 40: 185-254).

120 Ogilvie, S., Ataria, J., Waiwai, J., Doherty, J., Lambert, M., Lambert, N. and King, D. 2006. Uptake and persistence of the vertebrate pesticide, sodium monofluoroacetate (compound 1080), in plants of cultural importance. *Ecotoxicology* 15: 1-7.

121 Miller, A., Ogilvie, S.C., Ataria, J.M., Waiwai, J. and Doherty, J.E. 2009. *Sodium fluoroacetate (compound 1080) uptake by puha, a culturally-important food plant.* Lincoln University Wildlife Management Report No. 48. Lincoln University, Lincoln.

122 Eason, C. and Gooneratne, R. 1993. An evaluation of the risk to man of secondary poisoning with sodium monofluoroacetate (1080). *New Zealand Medical Journal* 106(949): 41.

123 Tree wētā dosed with 15 µg 1080/g eliminated > 90% of the 1080 within 4–6 days (Eason, C.T., Gooneratne, R., Wright, G.R., Pierce, R. and Frampton, C.M. 1993. The fate of sodium monofluoroacetate (1080) in water, mammals, and invertebrates. *Proceedings of the forty-sixth New Zealand Plant Protection Conference*: 297-301). Ants dosed with 0.3 g 1080/kg still had detectable levels of 1080 (0.27 mg/kg) seven days after dosing (Booth, L.H. and Wickstrom, M.L. 1999. The toxicity of sodium monofluoroacetate (1080) to *Huberia striata*, a New Zealand native ant. *New Zealand Journal of Ecology* 23: 161-165). 1080 residues in sub-lethally poisoned kōura decrease by a factor of five after eight days, which the study authors attributed to the animals metabolising or excreting the compound (Suren, A.M. and Bonnett, M.L. 2006. Consumption of baits containing sodium fluoroacetate (1080) by the New Zealand freshwater crayfish (*Paranephrops planifrons*). *New Zealand Journal of Marine and Freshwater Research* 40: 169-178).

124 There is one recorded instance of a morepork dying following an aerial 1080 operation using carrots (Powlesland, R.G., Knegtmans, J.W. and Styche, A. 1999. Impacts of aerial 1080 possum control operations on North Island robins and moreporks at Pureora in 1997 and 1998. *Science for Conservation* 133. Department of Conservation, Wellington). There have been no mortalities of harriers or falcons recorded following 1080 operations (Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton).

125 After these operations, 748 birds were found dead, of which 508 were introduced species such as blackbirds and chaffinches. There were 240 individual native birds killed, including tomtits, robins, whiteheads, grey warblers, riflemen, fantails and silvereyes (Spurr, E. 2000. Impacts of possum control on non-target species. *In:* T.L. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln).

126 Veltman, C.J. and Westbrooke, I.A. 2011. Forest bird mortality and baiting practices in New Zealand aerial 1080 operations from 1986 to 2009. *New Zealand Journal of Ecology* 35: 21-29.

127 DOC, unpublished data.

128 The concentration of 1080 required to have a 50% chance of killing trout has been estimated as 54 mg 1080 per litre (Fagerstone, K.A., Savarie, P.J., Elias, D.J. and Schafer Jr, E.W. 2000. Recent regulatory requirements for pesticide registration and the status of compound 1080 studies conducted to meet EPA requirements. *In:* A.A. Seawright and C.T.Eason (eds). *Proceedings of the Science Workshop in 1080*. Miscellaneous Series 28. The Royal Society of New Zealand, Wellington).

129 Suren, A.M. and Lambert, P. 2006. Do toxic baits containing sodium fluoroacetate (1080) affect fish and invertebrate communities when they fall into streams? *New Zealand Journal of Marine and Freshwater Research* 40: 531-546.

130 Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

131 Sherley, G., Wakelin, M. and McCartney, J. 1999. Forest invertebrates found on baits used in pest mammal control and the impact of sodium monofluoroacetate ('1080') on their numbers at Ohakune, North Island, New Zealand. *New Zealand Journal of Zoology* 26: 279-302.

132 Booth, L.H. and Wickstrom, M.L. 1999. The toxicity of sodium monofluoroacetate (1080) to *Huberia striata*, a New Zealand native ant. *New Zealand Journal of Ecology* 23: 161-165; Powlesland, R.G., Stringer, I.A.N. and Hedderley, D.I. 2005. Effects of an aerial 1080 possum poison operation using carrot baits on invertebrates in artificial refuges at Whirinaki Forest Park, 1999–2002. *New Zealand Journal of Ecology* 29: 193-205.

133 http://poisons.co.nz/fact.php?f=24 [Accessed 16 May 2011].

134 According to a recent survey of veterinary practices the two most commonly reported poisonings in dogs were rat poison and slug baits; most would have been domestic incidents (Massey University, unpublished data). Between 2007 and 2009 the National Poison Centre received over 4000 calls from the public about exposure of dogs to poisons, of which the majority related to anticoagulant rat poison, and slug and ant baits (National Poisons Centre, unpublished data).

135 For a summary see ERMA. 2010. *Annual report on the aerial use of 1080, for the year ended 31 December, 2009*. Environmental Risk Management Authority, Wellington.

136 A 1080 operation in the Blue Mountains in Otago in 2001 is estimated to have killed between 67% and 75% of a fallow deer population. (Nugent, G. and Yockney, I. 2004. Fallow deer deaths during aerial 1080 poisoning of possums in the Blue Mountains, Otago, New Zealand. *New Zealand Journal of Zoology* 31: 185-192.) In three aerial operations carried out between 1988 and 1999, between 5% and 54% of red deer were killed. Aerial 1080 operations in Pureora Forest in the 1990s using carrots killed between 30% and 93% of deer (Nugent, G., Fraser, K.W., Asher, G.W. and Tustin, K.G. 2001. Advances in New Zealand mammalogy 1990–2000: Deer. *Journal of the Royal Society of New Zealand* 31: 263-298).

137 Minister of Conservation. 12 April 2005. Press release. The eight recreational hunting areas are Pureora, Kaimanawa, Aorangi, Lake Sumner, Oxford, Whakatipu, Blue Mountain and Kaweka.

138 The fish-based deer repellent costs around $2 per kilogram of bait (data from ERPO Ltd). For an aerial 1080 operation sowing 1 kg of prefeed and 2 kg of toxic baits, the use of deer repellent adds around $6/ha to the cost of the operation.

139 DOC has not used carrot baits to control possums or rats in forests since 2008, while the AHB has used carrots in forests in 15 different operations (ERMA, unpublished data).

140 ERMA, unpublished data.

141 DOC, unpublished data.

142 Sources: ***1973–1997:*** Operations targeting possums using cereal bait only. Adapted from: T.L. Montague (ed.) 2000. The brushtail possum. Manaaki Whenua Press, Lincoln: 146.

***1998–2003:*** Sowing rates are from operations on conservation land only. Adapted from: Veltman and Westbrooke 2011 New Zealand Journal of Ecology 35: 21-29.

***2008–2010***: Average sowing rates of all operations targeting possums and/or rodents. ERMA data (operations from 1 January 2008 – 31 October 2010).

Note: Carrot and cereal baits have been combined for the figures years 1998–2010.

143 Based on 14 gram cereal baits with a 1080 concentration of 0.15% (21 mg of 1080), and assuming an adult weight of 70 kg and a child weight of 25 kg. Estimates of lethal doses are based on the LD50 method, that is, a lethal dose is one that has a 50% chance of killing. A range of LD50 values have been published for humans (see Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.; Eason, C., Miller, A., Ogilvie, S. and Fairweather, A. 2011. An updated review of the toxicology and ecotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand. *New Zealand Journal of Ecology*, 35: 1-20). The value used in all calculations in this report is 2.5 mg/kg body weight.

144 ERMA 2007. *Evaluation and review report: Appendix M. Application for the reassessment of a hazardous substance under section 63 of the Hazardous Substances and New Organisms Act 1996: sodium fluoroacetate (1080) and formulated substances containing 1080*. Environmental Risk Management Authority, Wellington.

145 The 1994 report into possum management by the first Parliamentary Commissioner for the Environment noted that jam-based paste baits posed a major risk to bees. The report recommended that paste baits should be modified or changed to make them less attractive to bees – essentially recommending the banning of jam-based pastes (Parliamentary Commissioner for the Environment. 1994. *Possum management in New Zealand*. Wellington). The 2007 ERMA reassessment noted that pastes that are now approved for use have been modified in light of the Commissioner's 1994 recommendations (ERMA, pers. comm.).

146 The coroner concluded at the time that the man died as a result of 1080 poisoning. No official conclusion was reached as to how or why the man consumed the 1080 (reported in *The Press*, 26 November 2009. See http://www.stuff.co.nz/the-press/news/3097688/Hunters-family-in-1080-battle [Accessed 12 May 2011].

147 ERMA 2007. *Evaluation and review report: Appendix M. Application for the reassessment of a hazardous substance under section 63 of the Hazardous Substances and New Organisms Act 1996: sodium fluoroacetate (1080) and formulated substances containing 1080*. Environmental Risk Management Authority, Wellington.

148 The concentrations of 1080 measured in eels tissue ranged from 0.0174 to 0.0306 mg/kg of eel tissue (Lyver, P. O'B., Ataria, J., Throught, K. and Fisher, P. 2005. Sodium fluoroacetate (1080) residues in longfin eels, *Anguilla dieffenbachii*, following exposure to contaminated water and food. *New Zealand Journal of Marine and Freshwater Research* 39: 1243-1252). Using an LD50 for humans of 2.5 mg 1080/kg body weight (Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

149 Calculations for deer are based on the highest recorded concentration of 1080 found in live deer muscle (1.5mg/kg muscle) (McIntosh, I.G. and Staples, E.L.J. 1959. The toxicity of muscles, liver, and heart of deer poisoned with sodium monofluoroacetate. *New Zealand Journal of Science 2*: 371-378; cited in Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton). Calculations for kōura are based on the highest concentrations of 1080 recorded in kōura tail muscle of 5 mg/kg of muscle (Suren, A.M. and Bonnett, M.L. 2006. Consumption of baits containing sodium fluoroacetate (1080) by the New Zealand freshwater crayfish (*Paranephrops planifrons*). *New Zealand Journal of Marine and Freshwater Research* 40: 169-178).

150 See Eason, C., Miller, A., Ogilvie, S. and Fairweather, A. 2011. An updated review of the toxicology and ecotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand. *New Zealand Journal of Ecology* 35: 1-20.

151 This calculation is based on the Acceptable Operator Exposure Limit (AOEL) set by ERMA of 0.2 micrograms of 1080 per kg of body weight per day. At the highest concentration of 1080 recorded in the Lyver et al. 2005 study (0.0306 mg 1080/kg eel muscle), a 70 kg person would need to eat 458 grams of eel every day for a period of months to be at risk of sub-lethal effects.

152 Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

153 Tremblay, L.A., Fisher, P. and Leusch, F.D.L. 2004. Potential of sodium monofluoroacetate (1080) and fluorocitrate to bind to the estrogen receptor. *Australasian Journal of Ecotoxicology* 10: 77-83; Tremblay, L.A., Fisher, P., Leusch, F.D.L., van den Heuvel, M.R., Nicolas, J-C., Pillon, A. and Balaguer, P. 2005. Potential of sodium fluoroacetate (1080) and fluorocitrate to bind to androgen and oestrogen receptors. *Australasian Journal of Ecotoxicology* 11: 155-162.

154 Eason, C., Miller, A., Ogilvie, S. and Fairweather, A. 2011. An updated review of the toxicology and ecotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand. *New Zealand Journal of Ecology* 35: 1-20; Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

155 Local public health officers are delegated by ERMA under the HSNO Act to set conditions on pest control operations that use 1080 or other poisons in drinking water-supply catchments (see http://www.moh.govt.nz/moh.nsf/indexmh/issuing-permissions-vertebrate-toxic-agents-guideline?Open [Accessed 7 April 2011]). Under the HSNO Act, any 1080 residues detected must be below 2 ppb before the water supply can be reconnected. Testing of a drinking water supply is not required following an aerial 1080 operation if specific conditions are met. These include things such as data that shows 1080 was not detected in previous operations in the same location that used the same methods, or evidence that the water intake is more than 3 km from the boundary of the 1080 operation (DOC. 2011. *Obtaining consents for animal pest control operations standard operating procedure. Appendix 5: Public health model permission conditions*. Department of Conservation, Wellington.

156 ERMA reassessment of 1080 regulation 28. See http://www.ermanz.govt.nz/search-databases/Pages/controls-details.aspx?SubstanceID=39609&AppID=1807 [Accessed 29 April 2011]. DOC also sets requirements and standards for the monitoring of bait and carcass breakdown for its own operations (see DOC 2011. *Obtaining consents for animal pest control operations standard operating procedure, Version 3.22*. Department of Conservation, Wellington).

157 Set by the New Zealand Food Safety Authority as part of the registration conditions (Condition 49) for 1080 baits (see https://eatsafe.nzfsa.govt.nz/web/public/acvm-register?p_p_id=searchAcvm_WAR_aaol&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_count=1&_searchAcvm_WAR_aaol_action=view&_searchAcvm_WAR_aaol_id=29746 [Accessed 13 May 2011]).

158 A Biological Exposure Index (BEI) of 15 micrograms of 1080 per litre of urine has been set by the Department of Labour. Concentrations of 1080 in urine below the BEI are not considered to pose any short- or long-term health risks to the worker or anyone else – such as unborn young (Department of Labour, 2002. *Workplace exposure standards effective from 2002*, Occupational Safety and Health Service, Department of Labour, Wellington). ERMA used the Department of Labour's guidelines to set exposure levels for workers involved in the manufacture of 1080 and 1080 baits as part of the 1080 reassessment (ERMA. 2007. *Environmental Risk Management Authority decision. Application for the reassessment of a hazardous substance under section 63 of the Hazardous Substances and New Organisms Act 1996: sodium fluoroacetate (1080) and formulated substances containing 1080.* Environmental Risk Management Authority, Wellington).

159 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor, D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species.* Unpublished report prepared for Biosecurity New Zealand, Project No. 11326. 86 p.

160 Morgan, D. and Hickling, G. 2000. Techniques used for poisoning possums. In: Montague, T.L. (Ed). *The brushtail possum: Biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln.

161 Wilson, P., and Stafford, K.J. 2002. Welfare of farmed deer in New Zealand. 2. Velvet antler removal. New *Zealand Veterinary Journal,* 50: 221–227.

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163 Eason, C., Miller, A. Ogilvie, S. and Fairweather, A. 2011. An updated review of the toxicology and ecotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand. *New Zealand Journal of Ecology*, 35: 1-20; Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor, D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species.* Unpublished report prepared for Biosecurity New Zealand, Project No. 11326. 86 p.

164 Marks, C.A., Gigliotti, F. and Busana F. 2009. Assuring that 1080 toxicosis in the red fox (*Vulpes vulpes*) is humane. II. Analgesic drugs produce better welfare outcomes. *Wildlife Research* 36: 98-105.

165 Broome, K.G., Fairweather, A.A.C. and Fisher, P. 2009. *Sodium fluoroacetate*. Version 1.13. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

166 http://goodnature.co.nz.s52206.gridserver.com/news/?cat=10 [Accessed 29 April 2011].

167 Spurr, E. 2000. Impacts of possum control on non-target species. *In:* T. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln.

168 Parliamentary Commissioner for the Environment. 1994. *Possum management in New Zealand*. Wellington.

169 Spurr, E. 2000. Impacts of possum control on non-target species. *In:* T. Montague (ed.). *The brushtail possum: biology, impact and management of an introduced marsupial*. Manaaki Whenua Press, Lincoln.

170 Satisfactory performance as defined by the National Animal Welfare Advisory Committee (NAWAC) – target animals must be rendered unconscious within 3 minutes of capture.

171 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species*. Unpublished report prepared for Biosecurity New Zealand, Project No. 11326. 86 p.

172 Pindone is registered under the Agriculture Compounds and Veterinary Medicines Act for use against possums, although diphacinone and coumatetralyl are not.

173 Green, W. 2004. The use of 1080 for pest control, a discussion document. Prepared for the AHB and DOC.

174 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species*. Unpublished report prepared for Biosecurity New Zealand, Project No. 11326. 86 p.

175 Fisher, P. and Fairweather, A. 2010. *Diphacinone. A review of current knowledge.* Pesticide information reviews series, Part 3 (Version 2.2 updated April 2010).

176 Fairweather, A. and Fisher, P. 2010. Pindone. . *A review of current knowledge.* Pesticide information reviews series, Part 10 (Version 2010/1 updated August 2010).

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178 Fisher, P. and Fairweather, A. 2010. *Brodifacoum. A review of current knowledge.* Pesticide information reviews series, Part 6 (Version 2.6 updated June 2010); http://www.vspn.org/Library/misc/VSPN_M01287.htm [Accessed 3 May 2011].

179 Fisher, P. and Fairweather, A. 2010. *Brodifacoum. A review of current knowledge.* Version 2.6. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton; http://www.arc.govt.nz/albany/index.cfm?A6FA346B-14C2-3D2D-B961-557E260B50CB [Accessed 20 May 2011].

180 http://www.doc.govt.nz/parks-and-recreation/places-to-visit/southland/stewart-island-rakiura/ulva-island-open-sanctuary/ [accessed 24 may 2011].

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182 DOC. 2010. *Obtaining consents for animal pest control operations standard operating procedure*. Department of Conservation, Wellington.

183 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species*. Unpublished report prepared for Biosecurity New Zealand, Project No. 11326. 86 p.

184 Littin, K.E., O'Connor, C.E., Gregory, N.G., Mellor, D.J. and Eason, C.T. 2002. Behaviour, coagulopathy and pathology of brushtail possums (*Trichosurus vulpecula*) poisoned with brodifacoum. *Wildlife Research* 29: 259-267.

185 Fisher, P. and Fairweather, A. 2010. *Brodifacoum. A review of current knowledge.* Version 2.6. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

186 Eason, C.T. and Wickstrom, M. 2001. *Vertebrate pesticide toxicology manual (poisons)*. Department of Conservation Technical Series 23.

187 Fisher, P. and Fairweather, A. 2009. *Cyanide. A review of current knowledge*. Version 1.5, Department of Conservation, DOCDM-25420.

188 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species*. Unpublished report prepared for Biosecurity New Zealand, Project No. 11326. 86 p.

189 Fisher, P. and Fairweather, A. 2009. *Cyanide. A review of current knowledge.* Pesticide information reviews series. Part 1 (Version 1.5 updated June 2011).

190 Eason, C.T. and Wickstrom, M. 2001. *Vertebrate pesticide toxicology manual (poisons).* Department of Conservation Technical Series 23.

191 Fisher, P. and Fairweather, A. 2009. *Cholecalciferol. A review of current knowledge.* Version 1.4. Department of Conservation Pesticide Information Reviews series. Department of Conservation, Hamilton.

192 Eason, C., Murphy, E., Ogilvie, S., Blackie, H., Ross, J., Kaveramann, M., Sam, S., Statham, M., Statham, H., Lapidge, S., Humphrys, S., Henderson, R., MacMorran, D., Gibson, T., Gregory, N., Harrison, J., Giles, G., Sammut, I., Jansen, P., Conole, D., Rennison, D. and Brimble, M. 2010. Trends in vertebrate pesticide use and new developments: New Zealand initiatives and international implications. *Proc. 24$^{th}$ Vertebrate Pest Conference* (R.M. Timm and K.A. Fagerstone, eds.).

193 Morgan, D.R. 2004. Enhancing maintenance control of possum populations using long-life baits. *New Zealand Journal of Zoology* 31: 271-282.

194 Eason, C., Wickstrom, M., Henderson, R., Milne, L. and Arthur, D. 2000. Non-target and secondary poisoning risks associated with cholecalciferol. *New Zealand Plant Protection* 53: 299-304.

195 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species*. Unpublished report prepared for Biosecurity New Zealand, Project No. 11326.

196 http://www.vspn.org/Library/misc/VSPN_M01287.htm [Accessed 3 May 2011].

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200 Marsh, R.E. 1987. Relevant characteristics of zinc phosphide as a rodenticide. Great Plains wildlife damage control workshop proceedings, University of Nebraska, Lincoln.

201 Gervais, J.A., Luukinen, B., Buhl, K. and Stone, D. 2010. *Zinc phosphide/phosphine technical fact sheet*; National Pesticide Information Center, Oregon State University Extension Services, Portland. http://npic.orst.edu/factsheets/znptech.pdf [Accessed 14 April 2011].

202 Beausoleil, N.J., Fisher, P., Warburton, B. and Mellor D.J. 2010. *How humane are our pest control tools? Part 1. Vertebrate toxic agents and kill traps in mammal species*. Unpublished report prepared for Biosecurity New Zealand, Project No. 11326.

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204 http://pmep.cce.cornell.edu/profiles/rodent/rodent_M_Z/zinc-phosphide/zincphos_prf_0185.html [Accessed 3 May 2011].

205 Target reproductive areas that the research programme on biological control of possums focused on were: a coating around the eggs called the 'zona pellucida'; a reproductive hormone called gonadotrophin-releasing hormone; and a coat protein (CP4) associated with the uterus and developing embryo (Cross, M.L., Zheng, T., Duckworth, J.A. and Cowan, P.E. 2011. Could recombinant technology facilitate the realisation of a fertility-control vaccine for possums? *New Zealand Journal of Zoology* 38: 91-111).

206 Landcare Research, 2004. *Biological control of possums. Information sheet.*

207 A possum gene from a target reproductive process, such as the zona pellucida, plus a bacterial gene would need to be inserted into the plant. The bacterial gene helps to stimulate the immune response against the possum's reproductive cells.

208 Parliamentary Commissioner for the Environment, 2000. *Caught in the headlights: New Zealanders' reflections on possums, control options and genetic engineering. Appendix D.* Office of the Parliamentary Commissioner for the Environment, Wellington.

209 Cross, M.L., Zheng, T., Duckworth, J.A. and Cowan, P.E. 2011. Could recombinant technology facilitate the realisation of a fertility-control vaccine for possums? *New Zealand Journal of Zoology* 38: 91-111.

210 The hormone that was being targeted is called gonadotrophin-releasing hormone. This hormone is produced in the hypothalamus in the brain and is important in the regulation of the reproductive cycle, particularly the timing of ovulation. The toxin that was being used only had toxic effects when it could get into cells by being linked to gonadotrophin-releasing hormone.

211 http://www.biotechlearn.org.nz/focus_stories/biological_control_of_possums/hormone_toxins_to_r educe_possum_fertility [Accessed March 2011].

212 Over $30 million was invested in biocontrol research between 1993 and 2010 (D. Eckery, pers. comm., May 2011).

213 Wilkinson, R. and Fitzgerald, G. 2006. *Public attitudes toward possum fertility control and genetic engineering in New Zealand.* Landcare Research Science Series No. 29.