



# Kararehe Kino

## Vertebrate Pest Research

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### CONTENTS

Where Do Waikato Tūi Nest, and How Successful Are They?	1
Foliar Chemistry Provides an Explanation for Observed Patterns of Possum Browsing on Southern Rātā	3
Feral Horses in Aupouri Forest: Numbers and Impacts	5
Rats!	7
Rat Research Titbit	8
When the Rats Are Away the Mice Really Do Play!	9
Developing Vaccine Delivery Systems to Reduce Possum Fertility	10
Tb Transmission Rates in Possums are Critical to Disease Eradication	12
Integrating GPS and Habitat Maps for Assessing Possum Ground-Control Coverage	13
Contacts and Addresses	15
Some Recent Vertebrate Pest-Related Publications	16



Manaaki Whenua  
Landcare Research

## Where Do Waikato Tūi Nest, and How Successful Are They?

**T**ūi are iconic songsters, and welcome visitors to rural and urban gardens in many parts of New Zealand. They are also important pollinators of native tree flowers and dispersers of native fruits, and so play a key functional role in native forest ecology. But research on them has been limited. In the central Waikato, tūi are uncommon, and factors limiting their populations are poorly understood.

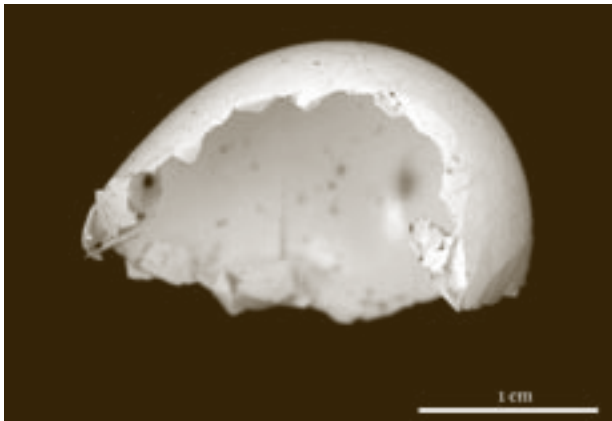
To determine where tūi nest and how successful they are, John Innes, Neil Fitzgerald, Corinne Watts and colleagues colour banded and attached radio transmitters to Waikato tūi caught in urban and rural areas during October 2004, and attempted to follow the birds back to their nest sites in the breeding season (November to February). Results confirmed

reports from landowners that suggested tūi were winter visitors to such towns as Hamilton, Cambridge and Te Awamutu. Transmitted tūi flew 7–16 km from urban areas back to nesting places, mostly in or near to the closest native forest remnants.

Finding nests was a trickier matter! Only female tūi build nests and incubate the eggs but just one of the 17 transmitted birds was female. The visits to nests by males last only a few seconds, so following transmitted males rarely helped. Instead, most nests were found by following unmarked females. In all, 11 nests were monitored, of which only three fledged young successfully. John says that this success rate (27%) is typical of all mainland forest birds in areas of New Zealand where mammal pests are not controlled.

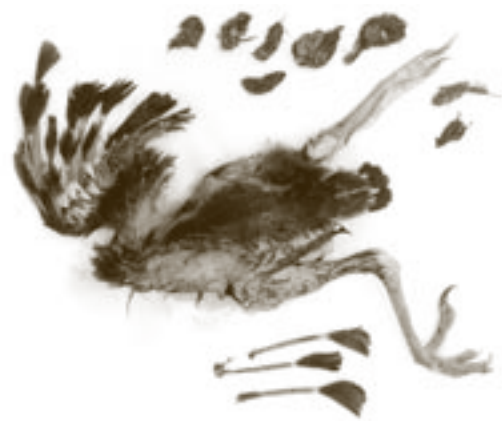


John Innes releasing a tūi equipped with coloured leg-bands and a transmitter (glued to tail; aerial just visible) at Cambridge.



Neil Fitzgerald

A tui eggshell after predation by ship rat. Note the large shell fragment with jagged rather than crushed margins.



Neil Fitzgerald

Remains of tui chick. The roughly eaten chick, regurgitated feather pellets and chewed pin feathers unmistakably implicate a possum as the culprit.

Time-lapse video cameras, and the sign left at nests, showed possums and ship rats were major predators of tui, taking eggs, chicks, or the sitting female at four nests in this study. Australasian harriers took eggs or chicks from two nests; one chick fell from a nest, and one nest failed for unknown reasons.

Predation sign left at the tui nests was sometimes highly diagnostic. When eating eggs, ship rats left one large shell piece with jagged margins and several smaller shell pieces. Often they also left scats (droppings). By comparison, possums left smaller shell pieces with crushed margins; they ate chicks and adults messily, starting with the upper surface (head and back), and they chewed the bases of emerging pin feathers (see photos).



A possum eating a tui egg near Cambridge.

The predators (ship rats, possums, and harriers) identified in this small tui study were exactly those revealed by previous studies of kōkako and kererū in North Island podocarp-broadleaved forest. Ship rats are very light (100–200 g), superb climbers, and able to access all bird nests — thus they are key predators of small forest birds such as robins, tomtits and fantails.

An exciting discovery recorded by the team was of one tui nesting in a park environment on the western edge of Hamilton, and another in a planted lemonwood hedgerow on a farm near Whatawhata. This shows that tui will nest in exotic trees and landscapes, and that at least one pair is already nesting near Hamilton. Both these nests failed because ship rats ate the eggs before the female had finished laying!

Tui abundance has frequently increased greatly when pest mammals have been controlled in 'mainland islands'. This suggests that the number of tui visiting Waikato urban areas can also be greatly increased by controlling ship rats and possums in tui nesting areas during November to February, particularly in areas of native forest areas 10–15 km away from urban sites. That is, the answer to

increasing tui numbers in Hamilton and surrounding towns lies not in the urban areas themselves but in the surrounding forests where tui nest. This will bring more tui to the many urban gardens where food plants have been maintained or enhanced in the last 20 years.

Finally, locating and protecting the nesting attempts of the few birds that are already nesting near Hamilton and other urban centres should also enhance species nesting within the urban areas, since young tui are known to nest near to where they themselves were fledged.

This research was funded by the Foundation for Research, Science and Technology, with assistance from the Department of Conservation and the Hamilton City Council.



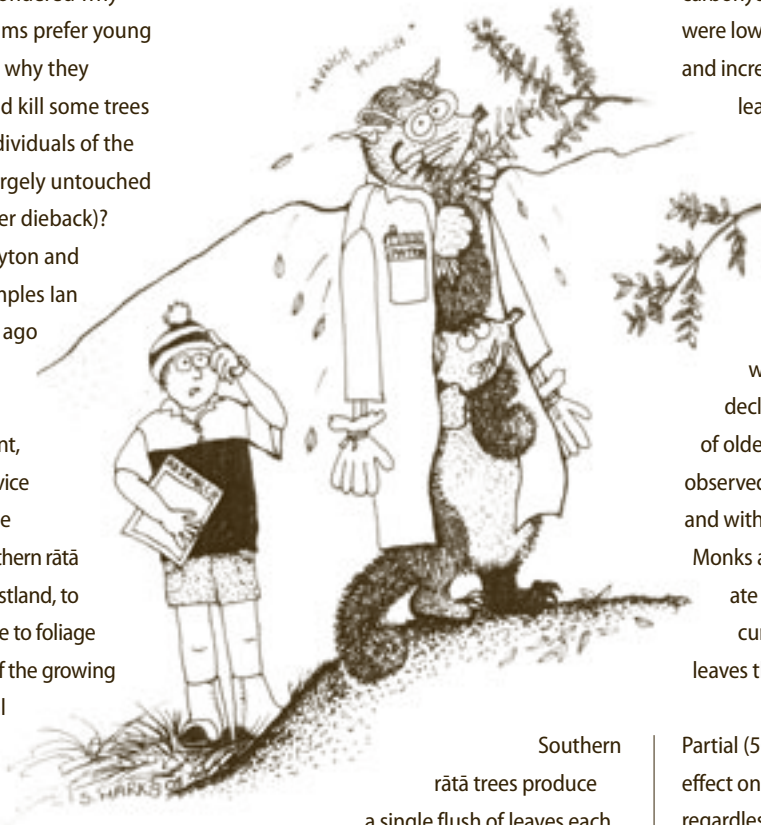
**John Innes**  
innesj@landcareresearch.co.nz

**Neil Fitzgerald, Corinne Watts (not shown)**

## Foliar Chemistry Provides an Explanation for Observed Patterns of Possum Browsing on Southern Rātā

**H**ave you ever wondered why brushtail possums prefer young leaves to older ones, or why they repeatedly defoliate and kill some trees while neighbouring individuals of the same species remain largely untouched (termed salt-and-pepper dieback)? Jeanne Kuhajek, Ian Payton and Adrian Monks used samples collected over 20 years ago to try and find out.

In the original experiment, New Zealand Forest Service staff under Ian's guidance artificially defoliated southern rātā trees at Camp Creek, Westland, to determine their response to foliage loss at different stages of the growing season. All experimental trees were banded with sheet tin and the surrounding foliage was cleared away to prevent access by possums (see photo). Three defoliation treatments (0%, 50%, 100%) were imposed on entire small trees (8–14 cm diameter) and major branches of large trees (37–62 cm diameter). Trees (or branches) were partially or completely defoliated either before budbreak (September–December), after budbreak (January–February), or at the end of the growing season (April–May). In addition to measuring changes in leaf, twig and stem growth, foliage samples were taken to determine the nutrient (nitrogen, phosphorus, potassium), carbohydrate (soluble sugars, starch) and polyphenolic (condensed tannins, total phenolics) composition of the leaves. From the animal's perspective, these are the foliar constituents that are generally regarded as 'nice' (nutrients, carbohydrates) or 'nasty' (polyphenolics).



Southern rātā trees produce a single flush of leaves each year and typically retain these for 3–5 years. Nutrient concentrations were highest in leaves immediately after budbreak, and then gradually declined. This pattern was reversed for

carbohydrates, where concentrations were lowest in newly emerged leaves and increased with the completion of leaf expansion and the onset of winter (Fig. 1). In mature (fully expanded) leaves nutrient concentrations declined slowly but significantly with age, while carbohydrate and polyphenolic concentrations were independent of leaf age. This decline in the nutrient concentrations of older leaves is consistent with observed patterns of possum browsing, and with a recent field study by Adrian Monks and Murray Efford where animals ate more than eight times as much current-season foliage as they did leaves that were more than 2 years old.

Partial (50%) defoliation had little effect on the chemistry of the leaves, regardless of when it was carried out. However, where shoots were totally defoliated before budbreak the new leaves produced had significantly higher concentrations of nitrogen, phosphorus, and potassium and lower concentrations of



Experimental trees banded with sheet tin to prevent access by possums.

condensed tannins, than those of non- or partially defoliated shoots (Fig. 2). The increase in potassium was short-lived (6–9 months), but nitrogen and phosphorus concentrations remained above and condensed tannin concentrations remained below those of non- or partially

defoliated shoots for at least 21 months after defoliation. The new foliage also proved palatable to several native insects, including a geometrid (*Pseudocoremia* sp.) and a tortricid (*Ctenopseustis obliquana*) moth, that restriped the trees (branches) 3–4 months after the initial defoliation.

In trees totally defoliated after budbreak the leafless shoots remained healthy through to the end of the growing season, but died overwinter. By contrast, where trees were totally defoliated at the end of the growing season most undamaged buds survived the winter, but failed to expand the following spring. In both cases, the end result was the death of all canopy shoots within 12 months of the tree being totally defoliated. In the short-term the survival of these trees was ensured by the presence of epicormic (or coppice) shoots on the main branches and at the base of the trunk. Twenty years later all of the non- or partially defoliated trees remain healthy, and all of the totally defoliated trees have died.

The data show that defoliation of southern rātā during winter and early spring (i.e., after the cessation of growth in autumn and before budbreak the following summer) results in young leaves that are more nutritious than those on trees that have not been defoliated. This is consistent with northern hemisphere studies which demonstrate that browsing or pruning that results in shoot death increases foliar nutrient concentrations in the surviving shoots by reducing the competition for nutrients within the plant. It also provides a mechanism to explain why brushtail possums often systematically defoliate one or a few trees, while leaving neighbouring individuals of the same species largely untouched. In addition, the data suggest that possum browsing patterns on southern rātā (and possibly other native plant species) are driven by nutritional rather than energetic (carbohydrate) or deterrent (polyphenolic) considerations.

The authors thank staff of the former New Zealand Forest Service who helped defoliate the trees and collect the foliage

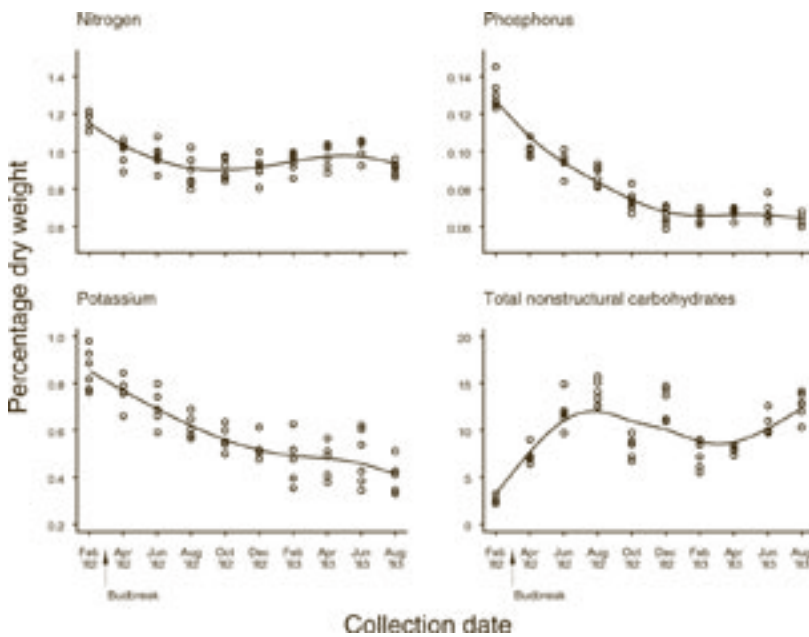


Fig. 1. Nutrient and carbohydrate concentrations in young (< 2 years old) southern rātā foliage.

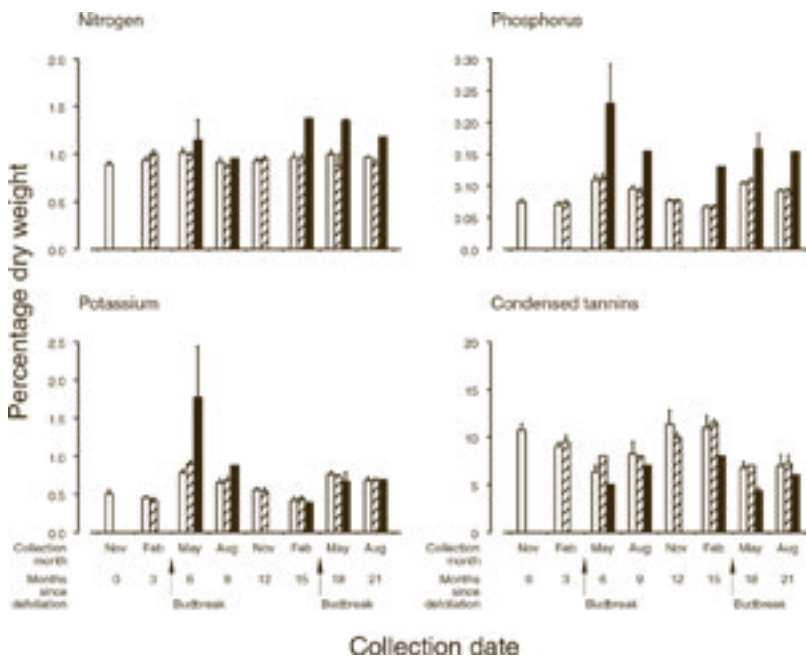


Fig. 2. Effect of defoliation on nutrient and condensed tannin concentrations in young (< 2 years old) southern rātā foliage. Clear bars 0% defoliation, hashed bars 50% defoliation, solid bars 100% defoliation.

samples. The foliage samples were analysed by Carl Kelland (nutrients), Graeme Rogers (carbohydrates), and Linda Hill (polyphenolics).

This research was supported by a Landcare Research postdoctoral fellowship to Jeanne Kuhajek, and the Foundation for Research, Science and Technology.



**Ian Payton**  
paytoni@landcareresearch.co.nz



**Jeanne Kuhajek**  
jeanne@tasmanextracts.co.nz

**Adrian Monks** (not shown)

## Feral Horses in Aupouri Forest: Numbers and Impacts

**A**upouri Forest in Northland is the largest sand dune forest in the country, and occupies about 25% of the Aupouri Peninsula. It was established in the 1960s to stabilise an area of extensive sand dunes, to protect newly established farmland, and to provide employment for the local community.

Horses were first introduced to the area in 1820 and left to roam over the then unoccupied Crown land. Land development for farming has since restricted their movement. Although the herd has never been 'officially' managed, local people have regularly mustered horses for their own use and for sale. Occasionally, horses have been intentionally released to improve the herd.

Like most feral horses, the Aupouri herd lives in bands. Each usually has a leading stallion, his harem of mares, and their offspring (see photo). There are also bands of bachelor colts, and a few solitary horses (usually older animals).

Concerns about damage to forest plantings by the horses were first noted in the early 1980s, although no control

measures were ever actioned. The recent increase in horse numbers is believed to be linked to the increased area of favourable habitat. This results from recent large-scale harvesting operations that have been followed by oversowing with nitrogen-fixing legumes and replanting with *Pinus radiata*. The increase in horses has prompted concerns about their impacts in recently planted forests and on the vulnerable natural habitats within the adjacent Te Arai Reserve. In the last few years, seedling mortality

has increased apparently due to horse damage, and there has been at least one vehicle accident involving a feral horse.

Wayne Fraser and John Parkes recently assessed the current size of the herd and the level of damage in the exotic forest. This has provided some baseline data for foresters and landowners to better manage the horses.

Wayne and John estimated horse numbers using two techniques. Where



Wayne Fraser

A typical band of Aupouri wild horses among recently planted *Pinus radiata*.

horses were clearly visible in the open, newly planted compartments and on DOC's Te Arai Reserve, they conducted total counts. Where visibility was limited in the mid-rotation and mature forest compartments, they used line transects (drive and walk). Total horse numbers were estimated at 400–660, with an overall density of about 6.4 horses/km<sup>2</sup>. Densities were highest in newly planted compartments and the Te Arai Reserve (11.0 horses/km<sup>2</sup>) and in mid-rotation and mature forest within 5 km of open areas (13.4 horses/km<sup>2</sup>). The horses occurred in bands of 2–26, but most (16 of 28) bands had ≤10 animals. The ratio of adults to yearlings to foals indicated that approximately 70% of adult mares produced a foal in each of the last 2 years — an approximate rate of increase of 21% per annum. Allowing for some mortality, this suggests the Aupouri horse population has the potential to double in 4–5 years.

The well-used horse trails observed in many of the mid-rotation and mature forest compartments indicate that individual horse bands move extensively throughout Aupouri Forest. Horse trails are also common along the adjacent Ninety Mile Beach indicating that horses also use the beach as a travel route.

Assessments of seedling condition were conducted in eight recently planted (2001–2003) forest compartments. In those where seedlings were about 18 months old, legumes and weeds were well established, and the level of horse use was high. The consequent damage from trampling was significant but no browsing on seedlings was recorded. Total seedling mortality increased from 9.2% 6 months after planting, to 16.5% 30 months after planting (see Fig.). Other seedlings were

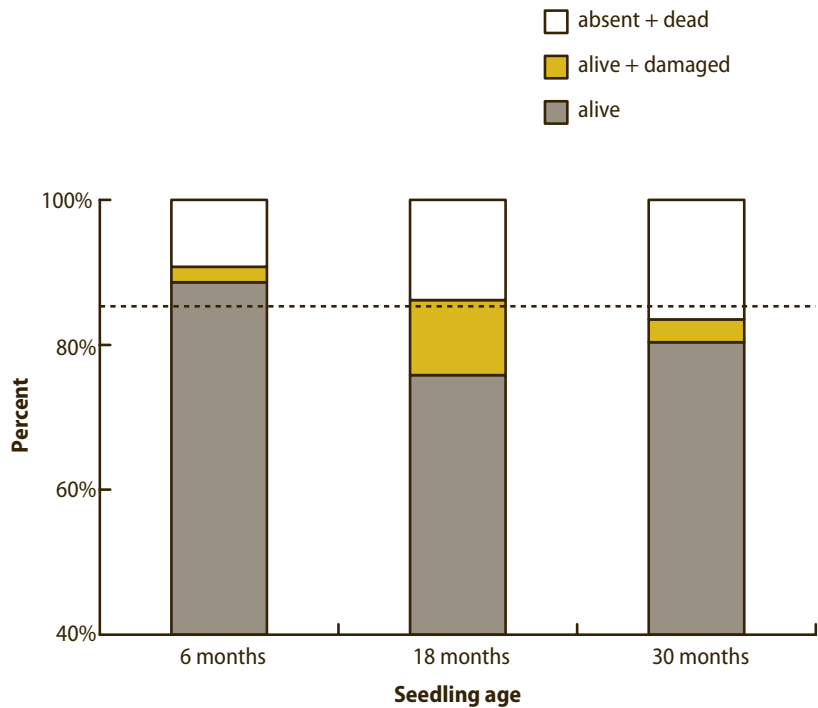


Fig. Frequencies of live undamaged seedlings, live damaged seedlings, and missing or dead seedlings, by seedling age. The dashed line indicates the minimum acceptable survival rate for foresters (i.e. 85% or 850 seedlings/ha).

damaged and may either eventually die or be of limited production value.

Such unacceptably high levels of damage to production plantings and the risk of serious vehicle accidents involving horses on forest roads will continue unless the horse herd is better managed. However, the largely unrestricted movement of horses throughout Aupouri Forest means that any reduction in horse numbers needs to be applied throughout the study area, and not just on the open areas favoured by the horses. All the stakeholders including the Māori lessors and the Crown recognise that local managers have a dilemma. Any reduction in the size of the Aupouri herd is likely to arouse significant concern from the public who hold horses in high esteem. Managing the Aupouri feral horse herd has

the potential to become another difficult environmental issue.

This work was funded by the Crown Forestry Group, Ministry of Agriculture and Forestry.



**Wayne Fraser**  
fraserw@landcareresearch.co.nz

John Parkes (not shown)

## Rats!

Ship rats established in New Zealand during the mid-19th century. They arrived as stowaways on ships and readily took up residence in New Zealand ports. At that time, Norway rats (which arrived earlier on ships) and kiore (Polynesian rats) were already present in forests and they are thought to have hindered the spread of ship rats outside coastal towns. Over the next 50 years, however, ship rats slowly displaced the other rat species, and are now the most common rat on the New Zealand mainland.

Ship rats are most abundant in mature, diverse podocarp-broadleaved forests where they reach density-indices of up to 50 captures per 100 trap nights. By comparison, they are scarce or often absent in pure beech (*Nothofagus*) forests (normally <2 captures per 100 trap nights). For example, at Mt Misery, Nelson Lakes National Park, ship rats occur in very low numbers in red beech forest and are extremely rare in stands of pure mountain beech or silver beech.

Since 1998, Peter Dilks and other DOC staff have been trapping stoats in the Eglinton Valley, Fiordland National Park, to protect threatened mōhua (yellowhead) and kākā.

At the same time, Wendy Ruscoe, Richard Heyward and Ivor Yockney have been trapping rodents in the northern part of the Eglinton Valley, since 1999, as part of a large pest-removal experiment.

The forest in the Eglinton Valley is dominated by red beech but both silver beech and mountain beech also occur, especially near the tree line. In 1999 and 2000, this area experienced an extremely uncommon event with two beech 'mast' seedfall events in successive years. Peter



Richard Heyward

An ear-tagged ship rat *Rattus rattus* in the Eglinton Valley.

reported falls of 14.5 g and 30.7 g of seed per square metre in these years. Concurrently, ship rat numbers increased to levels not previously recorded in beech forest in New Zealand. Wendy and her team, using live-capture traps on small grids (3.24 ha), trapped 50 rats in one trapping session (see Fig., about 10 captures per 100 trap nights) in November 1999. They estimated that the density of rats on one of their trapping grids reached 4.6 rats/ha.

Normally, most breeding activity in ship rats occurs over summer, with peak population densities in autumn, although, breeding may extend into winter in podocarp forest in years of heavy falls of fruit.

In the Eglinton Valley, rats bred in the summer of 1998/99 prior to initial trapping, and continued to do so throughout the following autumn and winter, leading (unusually) to a population peak in spring 1999. By contrast, in 2000, breeding and juvenile recruitment into the areas covered by the trapping grids following the second seedfall was lower but still sufficient to maintain rat populations at elevated levels. Surprisingly, rat kill-trapping by DOC over the same period indicated that rat numbers were higher following the second seedfall year than after the first. This contradiction may reflect differences in the methods used and their effects on

population stability (i.e. removal trapping versus live mark-and-release trapping), and requires further investigation.

Some rats also bred in the Eglinton Valley in 2001, a low seedfall year, but breeding was insufficient to maintain population levels. Ship rats died at a faster rate than juveniles were recruited into the population. As a result, the rat population dropped to undetectable levels in winter 2001, and has remained that way ever since.

It is tempting to blame the rat population eruptions in the Eglinton Valley on the extensive predator control undertaken by

DOC. However, Wendy cautions against jumping to this conclusion. The double seeding of red beech, which was recorded in the Eglinton Valley in 1999 and 2000, also occurred widely in other red-beech-dominated forests throughout the South Island. It was followed by equally widespread increases in ship rat numbers, apparently as a result of high food (seed) availability and favourable climatic conditions in the intervening winter that may have allowed extended winter breeding and high survival. For example, rat numbers at that time in beech forests in the Nelson Lakes National Park increased greatly to 8 captures per 100

trap nights in areas both with and without predator control. These results indicate that predators in the beech forests in New Zealand are unlikely to stop rodent population eruptions.

This work is funded by the Foundation for Research, Science and Technology.

**Other reading:**

Dilks et al. 2003: *New Zealand Journal of Ecology* 27: 1–9.

Moorhouse et al. 2003: *Biological Conservation* 110: 33–44.

Yom-Tov et al. 1999: *Journal of Biogeography* 26: 947–958.

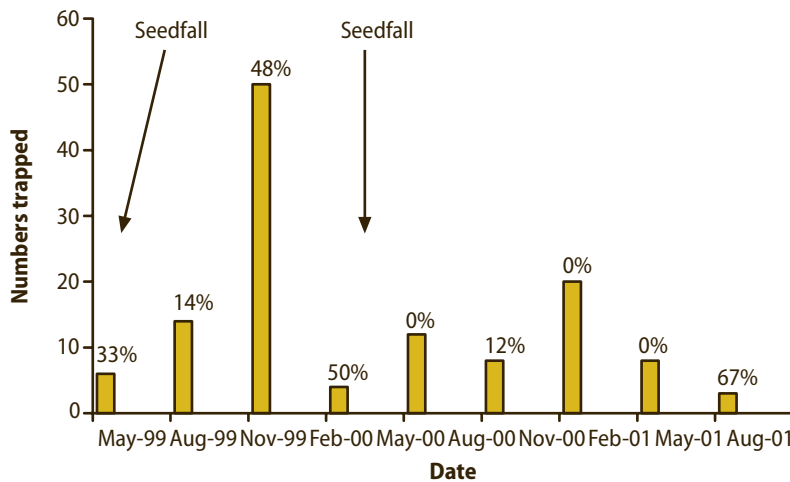


Fig. Ship rats trapped in the Eglinton Valley each season (bars), from 486 traps set for 5 nights. The numbers shown above each bar are the percentages of the population judged to be juvenile (< 70 g). No ship rats were trapped from August 2001 to August 2004.



**Wendy Ruscoe**  
ruscoew@landcareresearch.co.nz

**Richard Heyward, Ivor Yockney, Peter Dilks (DOC) (not shown).**

## Rat Research Titbit

**F**rom among the ship rats trapped in the Eglinton Valley (see above), Wendy Ruscoe reports that the smallest rat was only 20 g, with a head-body length of 85 mm. Possibly, it was trapped while making its first foray from the nest.

The largest non-pregnant rat was 190 g, with a head-body length of 205 mm. A pregnant animal weighed in at an impressive 204 g, and was as heavy as most other ship rats documented in the New Zealand literature. Such large rats are rare in the Eglinton Valley, where generally they are smaller than in New Zealand forests further north. Small local body size may reflect the co-occurrence in the Eglinton Valley of all three of the rat species present in New Zealand, and the competition for food that such coexistence brings. Clearly Wendy's rats do not follow Bergmann's Rule, a classical biological tenet on body size, which states that body size usually increases with increasing distance from the equator.



## When the Rats Are Away the Mice Really Do Play!

**A**erial 1080 possum control operations also affect other mammals such as rats and mice, which are almost universally present in our native forests. Typically, aerially-sown 1080 baits kill most rats but proportionately far fewer mice. Many studies have observed a rapid increase in the trapping rates of mice following possum control, particularly during the first six months or so, when rat numbers typically are low. Does this represent a real increase in mouse numbers, perhaps due to a reduction in competition from or predation by rats? Or as some researchers have suggested, does some change in mouse behaviour increase their trappability?

Peter Sweetapple and Graham Nugent used rat snap-back traps to trap mice and rats before and after an aerial control operation for possums at Waihaha, Pureora Forest, in late August 2000. Before the control operation, rat trapping rates were high (30–40%). The 1080 killed nearly all the rats, as none were trapped during three separate surveys over the 7 months following the control operation (Fig.1). In contrast, mouse trapping rates were low before and immediately after the possum control operation, then increased 12-fold within 3 months. Peter says that this apparent rate of increase was beyond the reproductive capabilities of mice, and was unlikely to be the result of immigration

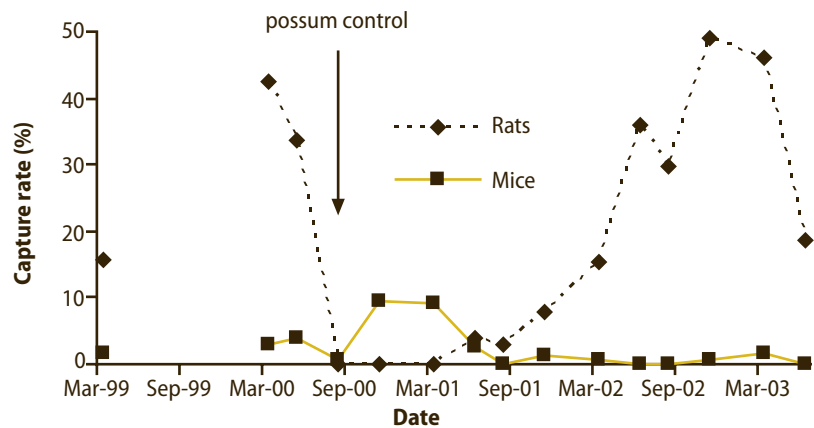


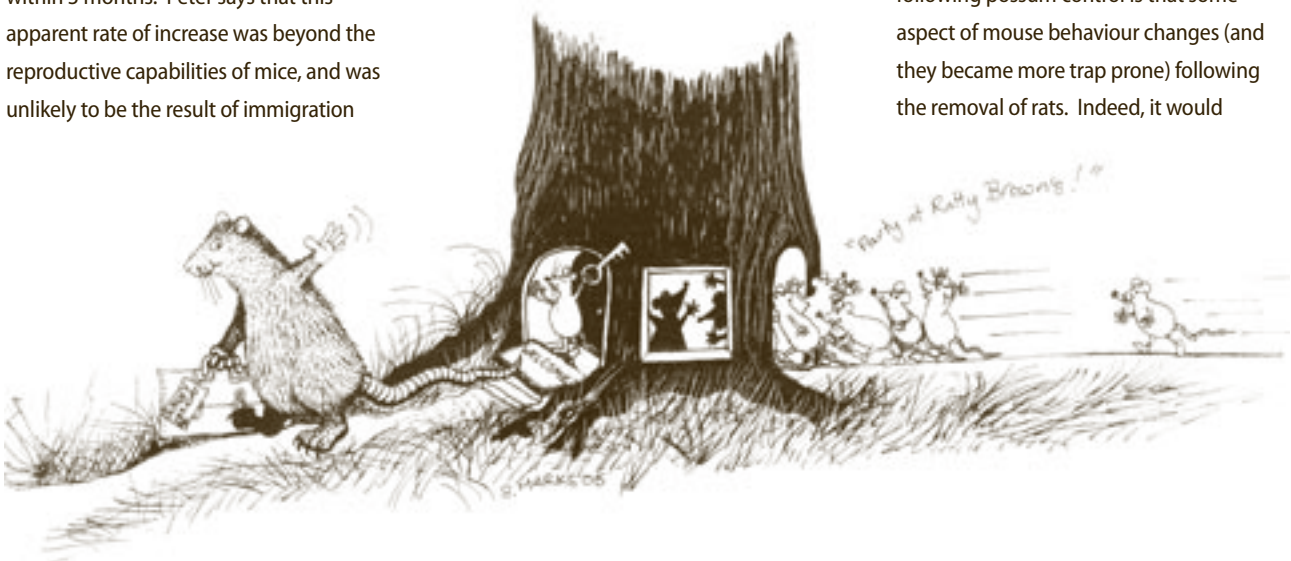
Fig. 1. Rat and mouse capture rates, before and after possum control at Waihaha.

from uncontrolled areas that were at least 3 km away. Also, all but one of the 20 mice trapped 3 months after the control operation were at least 6 months old (Fig.2). Clearly the vast majority of mice taken after possum control had been present beforehand, but had avoided the traps set to monitor their population.

An equally dramatic change in mouse trapping rates occurred 10 months after the control operation when rats started to be caught again. While only a handful of rats were trapped during the May and

August 2001 surveys, mouse trapping rates plummeted back to pre-control levels and remained at very low levels for the rest of the study (Fig.1). Peter thinks it is unlikely that the changes in rodent catches were due to competition for resources, because rat numbers were still very low. Rat predation on mice is also unlikely, as Peter did not find any mouse remains in the 235 rat stomachs examined from this area between June 2001 and June 2003.

A much more likely explanation for the apparent increase in mouse numbers following possum control is that some aspect of mouse behaviour changes (and they became more trap prone) following the removal of rats. Indeed, it would



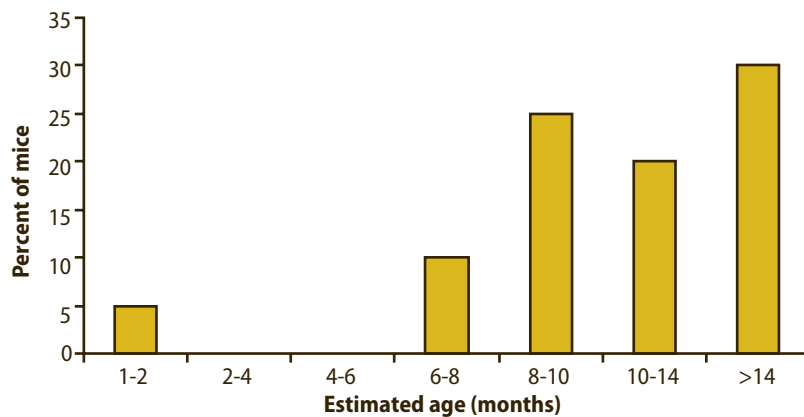


Fig. 2. Age structure of mice, estimated from tooth wear, captured three months after possum control.

appear that the mice really do come out to play when the rats are away. Mouse behaviour that leads to low trappability when rats are present may contribute to high mouse survival during 1080 poisoning

operations. Equally intriguingly, such changing trappability patterns bring into question the meaning of indices such as trapping and tracking rates of mice in terms of mouse abundance.

This work was funded by the Foundation for Research, Science and Technology.



**Peter Sweetapple**

[sweetapplep@landcareresearch.co.nz](mailto:sweetapplep@landcareresearch.co.nz)

**Graham Nugent** (not shown)

## Developing Vaccine Delivery Systems to Reduce Possum Fertility

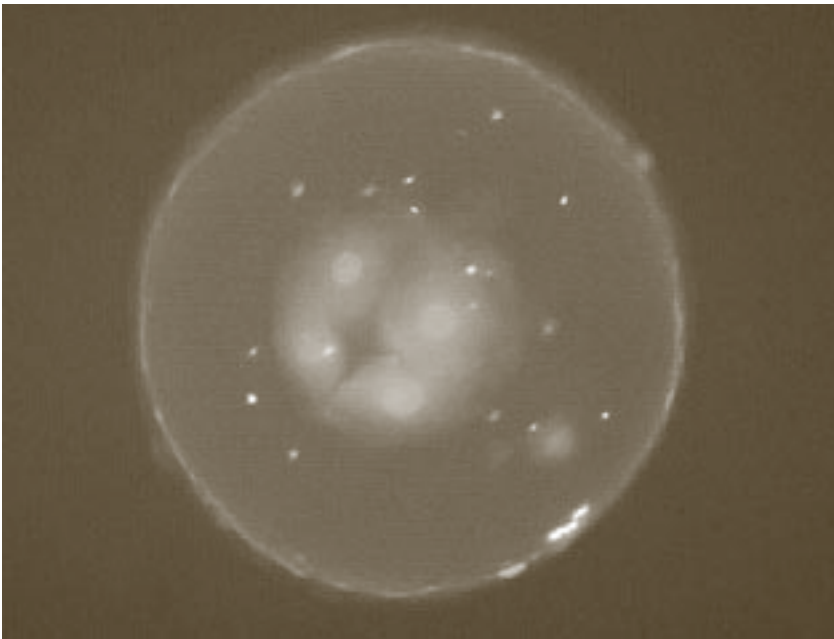
Combining non-lethal fertility control with lethal trapping and poisoning techniques for possum control could reduce potential risks to non-target species and to the environment.

Research by the Possum Biocontrol Group at Landcare Research, led by Janine Duckworth, has shown that the fertility of captive female possums can be greatly reduced by using injectable vaccines that target the key proteins of the coating (zona pellucida) around the possum egg. Immunisation interferes

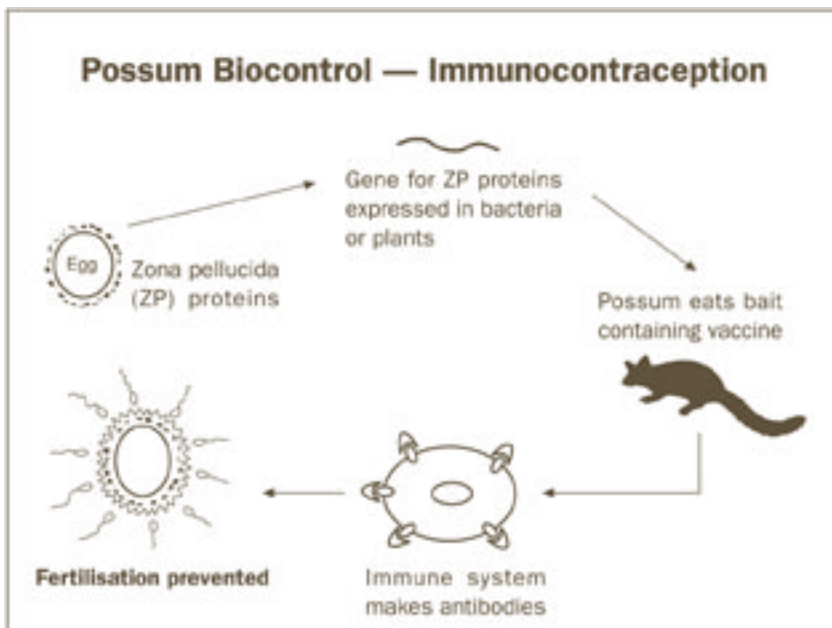
with the development of eggs in the ovaries and prevents fertilisation, and immunised females produce fewer eggs and embryos. These trials have identified which proteins, or parts of the proteins, produce the infertility effect and are likely to be specific to possums.

The next important step in developing possum fertility control is to develop an effective technique to vaccinate possums in the field. Manually injecting individual possums in the wild is not practical. Hence the group is testing 'bacterial ghosts', which were developed

overseas for medical vaccines to fight disease in humans. A protein, ZP2, found in the egg coat of female possums, is inserted into a harmless strain of the common *E.coli* bacterium. These bacteria are then killed, so that the cell contents are expelled, leaving the empty, inert shells of the bacteria as 'bacterial ghosts'. The possum's immune system recognises the bacterial ghosts as foreign, and produces antibodies against them. At the same time, the immune system is tricked into developing antibodies against the ZP2 egg protein, producing a contraceptive effect.



A fertilised egg of a possum, stained to show the four nuclei of the embryo. The small flecks are the nuclei of sperm cells trapped in the coating of the egg.



In trials held in containment, 20 possums were dosed with the plain bacterial ghosts, and 20 with the bacterial ghosts containing the possum ZP2 egg protein. The vaccine was applied in a way that mimicked a nasal spray, entering the possum's body through the mucosal surfaces of the eyes and nose. The possums were then artificially inseminated

to assess effects of the vaccine on fertility. For possums given only the plain bacterial ghosts, 90% of the eggs were fertilised. This figure dropped significantly to 59% for possums given the vaccine containing the ZP2 egg coat protein.

This is the 'proof of concept' that the group has been looking for, and the first

demonstration worldwide that such a vaccine is capable of reducing fertility in wildlife. The next tasks are to improve the vaccine so that it reduces possum fertility even further, prolong the contraceptive effect, and develop an oral version of the vaccine that can be delivered in bait. The aim is to have a bait that reduces the fertility of possum populations by 60% for more than 2 years. If this can be achieved, then in the future, fertility control vaccines will be a useful and perhaps more publicly acceptable addition to the possum control toolbox.

Janine and her group will continue working with collaborators, Professor Werner Lubitz and Petra Walcher at the University of Vienna, Austria, to refine the vaccine design and test different delivery formulations in containment. The researchers plan to apply to ERMA for approval in 2008 to run limited field trials on the same formulations.

This research was done under contract to the Foundation for Research, Science and Technology, and the Animal Health Board.



**Janine Duckworth**

[duckworthj@landcareresearch.co.nz](mailto:duckworthj@landcareresearch.co.nz)

**Xianlan Cui, Prof Werner Lubitz and Petra Walcher (not shown)**



## Tb Transmission Rates in Possums are Critical to Disease Eradication

**K**nowing rates of disease transmission is fundamental to managing disease in wildlife and in determining what level of control is necessary for disease eradication—as fundamental as knowing what the interest rate is on one’s mortgage, and hence how many and how large the payments must be to guarantee its eventual ‘extermination’ or ‘eradication’. Given this, it may come as a surprise to find there are no published empirical estimates (i.e. those based on real data) of the rate of Tb transmission among possums!

Inferring rates of disease transmission from how the prevalence (rate) of disease in a population increases as individuals grow older is a standard technique in the study of many human diseases, such as measles, mumps and rubella. The greater the increase in prevalence with age, the higher the estimated transmission rate. Where there is a reasonable amount of

mixing (socialising) within a population, the typical pattern is for the proportion of individuals who have been exposed to disease to increase with age—ultimately leading to 100% of the population being exposed. Assuming the evidence of exposure (e.g. the presence of antibodies) is permanent, 100% of the population should show serology of past exposure to such diseases—should they live long enough.

For bovine tuberculosis infection in brushtail possums, lethal cross-sectional surveys of populations have been the most common approach to surveying disease prevalence, beginning with pioneering surveys about the Hohonu Range in Westland by Jim Coleman and the late Bert Cooke during the early 1970s. However, early examination of the way the prevalence of Tb infection varied with age revealed that after an initial rapid rise in prevalence, the disease subsequently decreased, or even disappeared from older

animals. This was unusual, as evidence for the resolution (healing) of disease in Tb-infected possums, while documented, remains rare.

Peter Caley’s analyses of additional data, collected during a further survey of the still infected possum population about the Hohonu Range in 1997, confirmed that the Tb age-prevalence curve from a cross-sectional survey initially rose then fell. The effect is produced by a combination of pronounced spatial clustering of disease (i.e. the classical foci of Tb infection in possum populations) and disease-induced mortality.

How does this occur? Basically, within the clusters of disease, one after another individual inevitably catches Tb and subsequently dies of it, resulting in few aged animals. Outside the disease clusters, where little or no disease acts on the population, possums have a greater chance of living to a ripe old age. The net result of this is that a cross-sectional survey that samples possums both inside and outside Tb clusters will reveal an increase in prevalence of disease with age, followed by a decline, as the only surviving old possums are those from outside clusters and thus from where there is no disease.

It’s one thing to find a model that explains the curious age-prevalence curves for Tb in possums, but another to put it to good use. Critically, some of the parameters that determine Tb prevalence, such as the rate of disease-induced mortality and the proportion of the habitat that harbours Tb-infected possums, have been estimated independently by other researchers in separate studies. Peter incorporated this data into his model to produce the fitted age-prevalence curve for possums shown

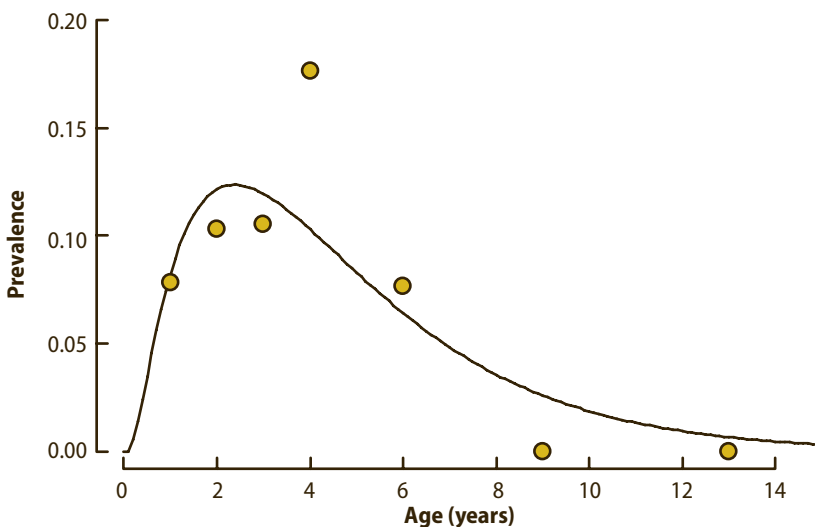


Fig. Observed (points) and fitted (curve) prevalence of bovine Tb in brushtail possums captured during 1997 from the flanks of the Hohonu Range, Westland.

in the figure. The model is process-based, allowing for mixing between healthy and diseased possums to occur only within a proportion of the available habitat, following the early models of the late Nigel Barlow. The model was parameterised using Bayesian Monte Carlo Markov Chain methods.

An important result for control is that within clusters of infection, the force of infection (instantaneous prevalence) is in fact quite high (about 0.4 per year, 95% uncertainty interval 0.15–0.95). This translates to nearly every second possum within clusters of disease being infected

each year. In addition, the large uncertainty interval suggests that the force of infection could in fact be much higher.

Peter's results demonstrate how seemingly rare wildlife diseases have higher rates of transmission than are initially apparent based on their overall low prevalence. The clear implication is that the control targets for the eradication of Tb within clusters of possums need to be considerably lower than those estimated using the broadscale prevalence. This is a result that Tb vector managers have been reporting for some time, and is a feature of the last possum/Tb model of the late Nigel Barlow.

These data were collected under funding from the Foundation for Research, Science and Technology.



**Peter Caley**  
Peter.Caley@anu.edu.au

## Integrating GPS and Habitat Maps for Assessing Possum Ground-Control Coverage

The Animal Health Board (AHB) is attempting to reduce the density of possum populations that are infected with Tb to levels where the disease dies out. However, Tb persists in some possum populations that have been controlled and in nearby livestock. One explanation for this is that ground-based possum control teams often miss some areas, giving rise to localised high possum numbers where Tb may persist. Identifying such gaps (and ensuring their subsequent control) would help speed up the eradication of Tb from controlled possum populations.

Contractors who aerially sow bait for possum control routinely use global positioning systems (GPS) to eliminate gaps in bait coverage. In contrast, coverage achieved by ground-based possum control operators is rarely checked but such checks are urgently needed, as the cost of such control is rising rapidly. Bait coverage also has wider implications in terms of the

AHB's national Tb eradication goals. Greater coverage of key areas of possum habitat will lead to higher kills of Tb-infected possum populations, reduced reactor rates in livestock, extension of the intervals between possum control operations, and long-term savings in control costs.

Ben Reddiex, Morgan Coleman and Steve Ferriss used field data provided by Environment Southland to develop and field test a quality-check system for ground control, that integrates GPS and habitat maps. The data related to 10 maintenance (i.e. annual or biannual) operations over a wide range of habitats (e.g. rolling hills, exotic and native forest, and rocky habitat), where contractors had been required to use GPS units to record the location of all traps and bait stations used.

The national possum monitoring protocol defines possum habitat as 'areas where possums may potentially nest'. Using this definition, all potential possum habitat

was mapped for each of the 10 operations, using two datasets—airial photographs from Land Information New Zealand, and the physical characteristics of the land cover as detailed by the Land Cover Database from the Ministry for the Environment.

Trap and bait station locations and habitat maps were then integrated to identify areas of potential possum habitat at least 150 m from any control, i.e. the gaps in control coverage.

Gaps of widely varying size were found in all 10 operations—28–90% of potential habitat was not controlled (see Table). However, the size of these gaps may have been exaggerated as contractors may not have recorded trap or bait station locations in all forest situations where GPS is sometimes unreliable. Other operations achieved low coverage despite the absence of native and/or exotic forest. Clearly, there is considerable room for

**Table.** Areas of possum maintenance control sites mapped and of potential possum habitat within each site. The percentage of potential possum habitat not controlled, with or without native and exotic forest is also shown.

Site	Area of possum control site (ha)	Area of potential possum habitat (ha)	Possum habitat not controlled	
			(1) All habitat types (%)	(2) Native and exotic forest excluded (%)
1	12 629	1 495	41.1	44.7
2	4 188	1 344	87.2	87.2
3	4 870	905	49.1	45.8
4	2 753	87	82.7	84.7
5	6 127	704	39.8	34.7
6	2 454	296	65.9	65.9
7	2 282	1 501	90.1	81.7
8	550	115	28.8	26.5
9	2 994	961	83.4	54.7
10	1 212	115	62.5	62.2

improvement and the newly developed system has considerable potential to help contractors improve their effectiveness in control operations by measuring the coverage they achieve.

Most importantly, the system identifies possum habitat that may unintentionally have not been controlled (e.g. where control lines are too far apart). It will also enable contractors to decide whether

or not to reassess the significance of intentional gaps based on accurate spatial information on gap size (see Fig.) and whether they need to treat them. Treatment of gaps will also help contractors to meet vector control performance targets (and be paid for their work).

The new system is both affordable and easy to implement, as only one-off purchases of GPS units, the Land Cover

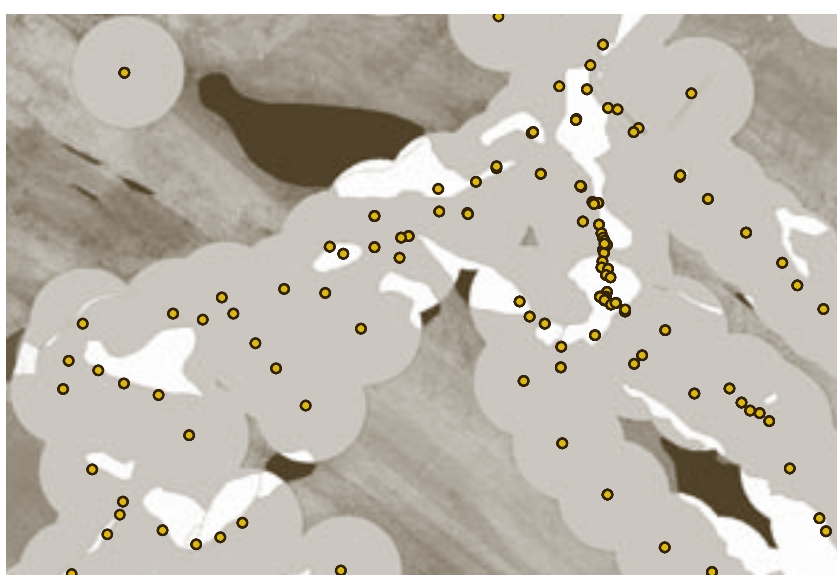
Database, and GIS computer software are required. Further, a step-by-step manual developed by the team now enables the methodology to be easily applied to possum control operations. However, like all new systems, there are some potential limiting factors, including the need for users to have a working knowledge of GPS units and GIS software, the availability of recent aerial photographs, and GPS reliability in continuous forest cover. The latter problem does not, of course, affect the large proportion of the AHB's control operations carried out in pasture/scrub habitats where GPS works well.

This work was done under contract to the Animal Health Board.



**Ben Reddix**  
breddix@doc.govt.nz

**Morgan Coleman, Steve Ferriss**  
(not shown)



**Fig.** Possum control locations (yellow dots) with a 150-m 'area of control' overlaid on digitised possum habitat: Controlled possum habitat (white = scrub), controlled non-possum habitat (light brown shading), and uncontrolled potential possum habitat (dark brown shading = scrub).

## Contacts and Addresses

Researchers whose articles appear in this issue of *Kararehe Kino – Vertebrate Pest Research* can be contacted at the following addresses:  
Also, for further information on research in Landcare Research see our website: <http://www.landcareresearch.co.nz>

*Morgan Coleman*

*Xianlan Cui*

*Janine Duckworth*

*Steve Ferriss*

*Wayne Fraser*

*Graham Nugent*

*John Parkes*

*Wendy Ruscoe*

*Peter Sweetapple*

*Ivor Yockney*

Landcare Research

PO Box 69

Lincoln

ph: +64 3 325 6700

fax: +64 3 325 2418

*Neil Fitzgerald*

*John Innes*

*Corinne Watts*

Landcare Research

Private Bag 3127

Hamilton

ph: +64 7 858 3700

fax: +64 7 858 4964

*Richard Heyward*

Landcare Research

PO Box 282

Alexandra

ph: +64 3 448 9930

fax: +64 3 448 9929

*Adrian Monks*

Landcare Research

Private Bag 1930

Dunedin

ph: +64 3 477 4050

fax: +64 3 477 5232

*Jeanne Kuhajek*

Tasman Extracts

Factory Rd

Brightwater

Nelson

ph: +64 3 542 3895

fax: +64 3 542 4012

*Prof. Werner Lubitz*

*Petra Walcher*

Department of Medical/Pharmaceutical

Chemistry

Section Microbiology and Biotechnology

UZA II, 2B522

Athanstrasse 14

1090 Vienna

Austria

ph: + 431 4277 55115

fax: +431 4277 55120

*Peter Caley*

CSIRO Entomology

GPO Box 1700

Canberra, ACT 2601

Australia

ph: +61 2 6246 4076

fax: +61 2 6246 4000

*Peter Dilks*

Southern Regional Science Centre

Department of Conservation

PO Box 13049

Christchurch

ph: +64 3 371 3732

fax: +64 3 353 7418

*Ben Reddiex*

Department of Conservation

PO Box 5086

Wellington

ph: +64 4 472 5821

fax: +64 4 499 0077



## Some Recent Vertebrate Pest-Related Publications

**Ball, S. J.; Lindenmayer, D. B.; Possingham, H. P. 2003:** The predictive accuracy of population viability analysis: a test using data from two small mammal species in a fragmented landscape. *Biodiversity and Conservation* 12: 2393-2413

**Fisher, P.; Wright, G.; Eason, C. 2003:** Water monitoring for contamination after 1080 pest control operations : an update. *Water and Wastes in NZ* 131: 20-21.

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**Ruscoe, W.A.; Wilson, D.; McElrea, L.; McElrea, G. 2004:** A house mouse (*Mus musculus*) population eruption in response to rimu (*Dacrydium cupressinum*) seedfall in southern New Zealand. *New Zealand Journal of Ecology* 28(2): 259-265.

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**Sweetapple, P. J. 2003:** Possum (*Trichosurus vulpecula*) diet in a mast and non-mast seed year in a New Zealand *Nothofagus* forest. *New Zealand Journal of Ecology* 27: 157-167.

**Sweetapple, P.J.; Fraser, K.W.; Knightbridge, P.I. 2004:** Diet and impacts of brushtail possum populations across an invasion front in South Westland, New Zealand. *New Zealand Journal of Ecology* 28(1): 19-33.

**Warburton, B. 2004:** Do chain springs on leghold traps reduce injuries to captured possums? *Surveillance* 31(1): 19-20.

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Editors: Jim Coleman  
colemanj@landcareresearch.co.nz  
Caroline Thomson  
thomsonc@landcareresearch.co.nz

Cartoons: Susan Marks  
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Christine Bezar

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PO Box 69  
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