Kararehe Kino
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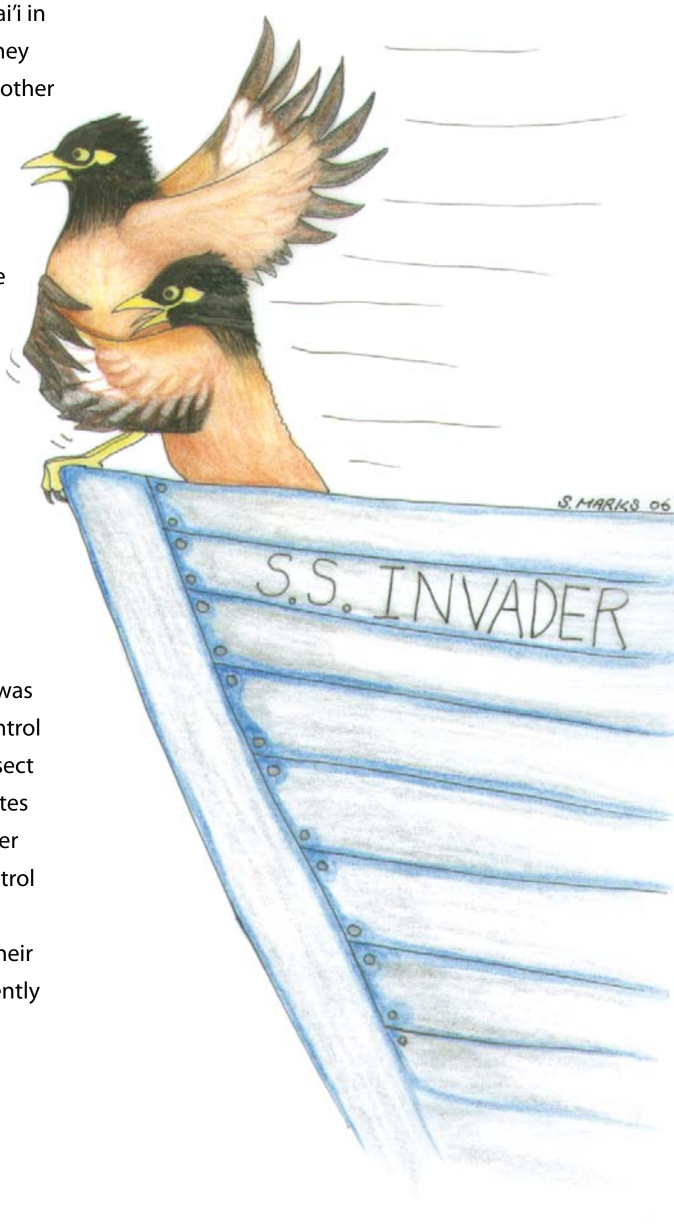
Landcare Research
Manaaki Whenua

Eradication of Common Mynas

The common myna (*Acridotheres tristis*) is native to the Indian subcontinent and Sri Lanka, but has invaded (with human help) many islands in the Pacific, Indian, and Atlantic oceans – as well as New Zealand, Australia and South Africa. In many Pacific islands, mynas are often the most common birds seen around towns and villages. Mynas were first introduced to New Zealand, Australia, Fiji and Hawai'i in the late 1800s and from there they have been spread to at least 40 other Pacific islands. The last known liberations were on Mangaia Island in the Cook Islands about 1960, and on Tutuila Island in American Samoa in the mid-1980s. In New Zealand, mynas are now common throughout the North Island north of a line between Wanganui and Waipukurau, and no attempt has been made or is being planned to control their populations.

One reason for deliberate introductions to Pacific islands was that mynas were thought to control insect pests such as the stick insect (*Graeffea crouanii*) that defoliates coconuts. It is not clear whether mynas were an effective biocontrol agent during times when the copra industry flourished, but their presence in Fiji does not apparently stop periodic outbreaks of stick insects. People seem to have stopped deliberately introducing mynas; but the common and jungle myna (*A. fuscus*) are still occasionally hitching rides on ships and reaching new islands – such as Fakaofo Atoll in Tokelau via a ship from Samoa.

Whatever the benefits might have been, mynas are now usually seen as pests throughout the Pacific. They




Bill Nagle

Common mynas feeding on boiled rice and pawpaw, Mangaia Island.

damage fruit crops, are a nuisance in peoples' houses, eat food put out for chickens and pigs, disrupt power and radio systems, and appear to outcompete or kill native birds.

The evidence for the latter is anecdotal, or circumstantial and qualified. Mynas harass other hole-nesting birds, and few native birds are seen in mynas' preferred habitats in and around villages and towns. On Tutuila Island, where there were most mynas there were fewest native kingfishers (*Halcyon chloris*) (Fig.), while on Tahiti, the native flycatcher (*Pomarea nigra*) was least successful at raising its chicks in places with most mynas (and another introduced pest, the red-vented bulbul (*Pycnonotus cafer*) (Blanvillain et al. 2003). On Kauai Island in Hawai'i, mynas destroyed 23% of wedge-tailed shearwater (*Puffinus pacificus cuneatus*) eggs and chicks (Byrd 1979).

Mynas are smart birds and not easy to control, let alone eradicate, as people found out on Indian Ocean islands. Nevertheless, Pacific island communities (from Vanuatu to Samoa and the Cook islands) have been requesting help to deal with them. The Pacific Invasives Initiative (PII), with funding by Conservation International under the Critical Ecosystem Partnership Fund, has, with the Fakaofa Council of Elders (Taupulega Fakaofa), recently investigated the feasibility of eradicating the few birds from Fakaofo Atoll and the many thousands of mynas from the 5180-ha Mangaia Island. In 2006, Ian Karika and Gerald McCormack of the Taporoporoanga Ipukarea Society (a Cook Island conservation group), Bill Nagle of PII, and John Parkes of Landcare Research conducted a study of the mynas on Mangaia that concluded that eradication was possible, that most islanders wanted it, but that the benefits to biodiversity (largely an endemic kingfisher, the tanga'eo (*Halcyon ruficollaris*)) were uncertain – although probable (see www.issg.org/CII/PII for full reports).

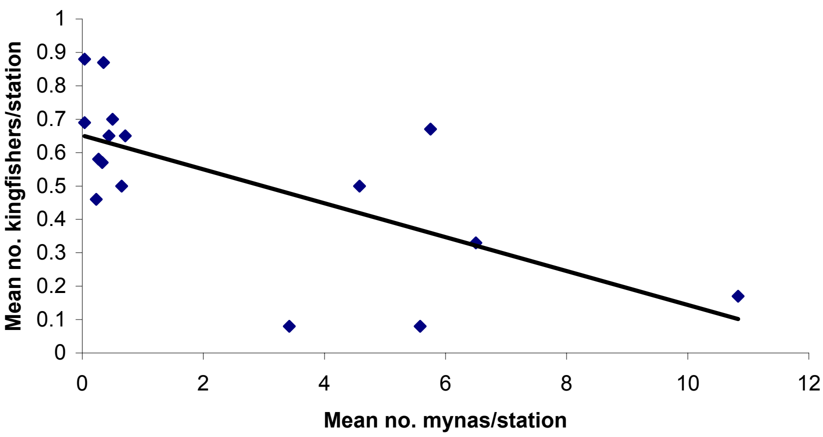


Fig. Relationship (linear regression) between myna and native kingfisher abundance at sites with mynas on Tutuila Island (data from Freifeld 1999).

The consideration of which tactics to use to achieve this eradication (either to protect biodiversity, reduce damage, or as a demonstration that eradication from oceanic islands is possible) and when to apply them during the myna's annual life cycle may prove useful for other eradication or control operations.

Pre-baiting with non-toxic foods such as boiled rice followed by toxic baiting with the avicide DRC1339 (Starlicide®) in the late afternoon near roost sites (many mynas spend the night in communal roosts out of their breeding season), or near places such as pig stys where mynas gather, was recommended as the best way to achieve a large initial kill.

DRC1339 is registered as an avicide in New Zealand and in the USA, but is not yet legally available in most Pacific islands. It appears the best toxin for use in warm climates, and it has the advantage of producing delayed symptoms (important in a clever social bird like the myna), being readily metabolised while the bird is still alive and so presents less risk of secondary poisoning, does not accumulate in the environment, appears humane, and has low toxicity to mammals.

However, the PII team thought that it would be very lucky if such an operation killed them all, and so a secondary phase to find and kill survivors would be required. Lessons from attempts on Indian Ocean islands suggest trapping in nest boxes and shooting are the best methods of eliminating birds surviving initial baiting.

References

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Is Pre-Feeding of Aerial Baiting for Possums Worthwhile?

Although unconfirmed by quantitative studies, most pest managers believe that pre-feeding with non-toxic bait improves the effectiveness of aerial 1080 baiting operations against possums. They also believe that the higher kill rate achieved provides a longer period of protection before possum numbers recover to levels where control needs to be repeated.

To test this belief, Jim Coleman and Wayne Fraser compared the kills obtained in four paired forest control blocks – two pairs of which were sown with cereal baits and two with carrot baits, and one of each pair was pre-fed. Each treatment block was about 1000 ha, and the two treatments selected from each of four larger control blocks were closely similar in habitat.

For each treatment in each replicate, the nationally accepted Trap Catch Index (TCI) was used to establish pre- and post-control density indices of possums and to estimate population change. All TCI surveys were at approximately twice the intensity of that used for routine operations to enable more robust comparisons between treatments.

Using a theta-logistic growth equation, Jim and Wayne 'modelled' population recovery within each treatment block, estimating when populations would exceed the control targets set for each operation and reach pre-control densities.

Overall, the four operations provided strong evidence to support the belief that pre-feeding produces greater possum kills (i.e. overall results of 90.8% kill with pre-feeding vs 50.7% for no pre-feeding, $P < 0.01$) irrespective of whether cereal or carrot bait was used. TCIs were, on average, about two-thirds lower where pre-feeding was used (Fig.). Taken separately, surveys of two of the replicates produced significantly higher possum kills when pre-fed, and two did not have significantly higher kills.

The growth equation produced unequivocal results on possum population recovery. In the two operations classed as successes (Matakuhia and Waitohi-Okuku Gorge in Fig.), the time for the possum population to exceed the 2%* TCI operational target, now widely accepted as the standard for successful Tb-possum control, was approximately 10 years for the prefeed treatments and roughly half that for no-prefeed treatments. By comparison, both replicates considered to be failures (Copland-Karangarua and Whareorino-Moeatoa in Fig.) were never reduced to below this target regardless of whether they were pre-fed or not.

Such modelling also indicated that in 'successful'operations (i.e. <2% TCI), the time taken for the surviving possum populations to recover to pre-control levels was 13–16 (no prefeed) and

** The widely accepted standard for measuring success of Tb-possum control operations and for the protection of some low-density conservation values (e.g. mistletoe and tree fuchsia).*

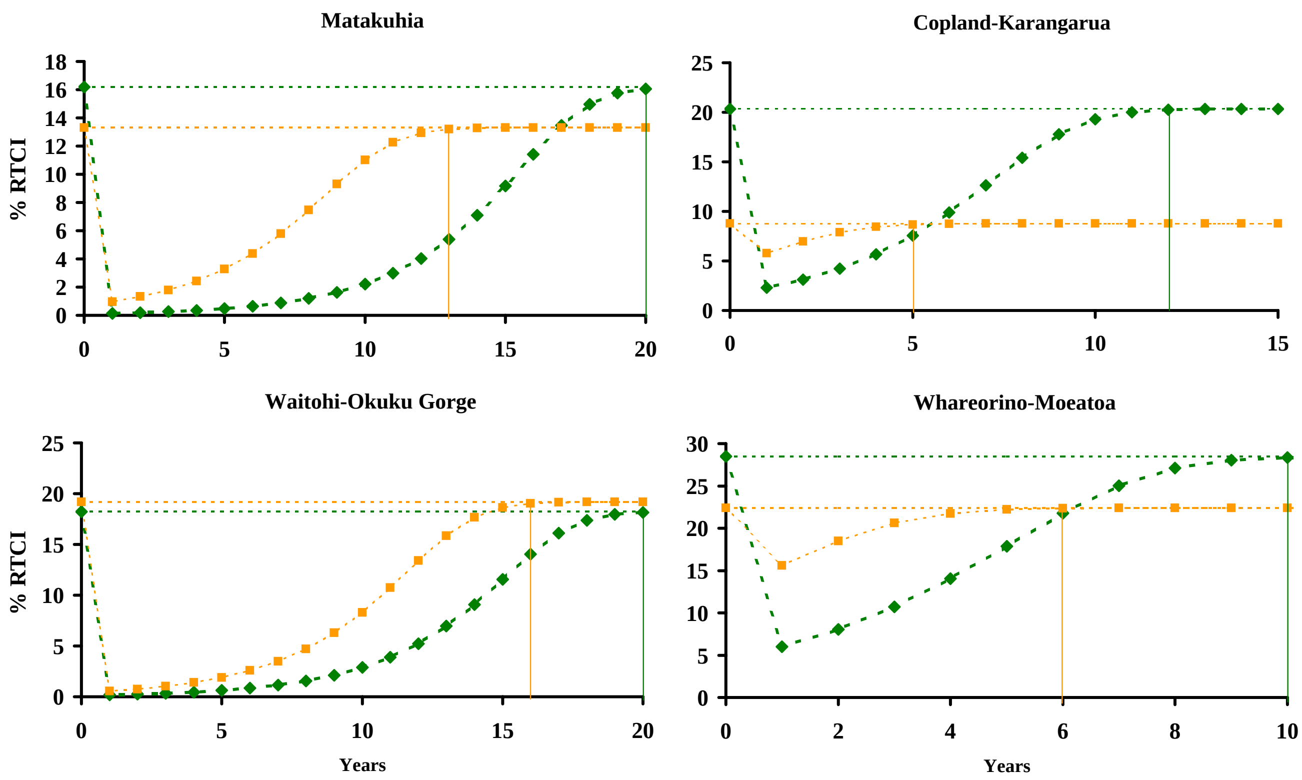

Fig. Predicted rates and times of recovery from post-control levels to pre-control densities (horizontal broken lines) for prefeed (green) and no-prefeed (orange) treatments in the four replicates. Time to recovery to pre-control levels for each treatment is indicated by the vertical lines.

20 years (prefeed) and the benefit associated with pre-feeding based on this parameter is modest.

Conversely, in the failure operations, recovery to pre-control levels was only 5 and 6 (no prefeed) and approximately 10 and 12 years (prefeed), indicating the benefits arising from pre-feeding such operations is proportionately more clear-cut. Thus, as with the achievement of operational TCI targets, the overall operational benefits of pre-feeding possum populations prior to control are probably greatest (i.e. population recovery is slowest) where there is reason to believe control operations undertaken without pre-feeding are likely to fail.

Jim and Wayne have little doubt that pre-feeding generally results in better possum kills, but its effectiveness is mitigated by three factors:

- The overall level of operational success. Two of the replicates were classed as successes and two as failures. In the case of the two successes, there appears to be little immediate benefit, based solely on achieving TCI targets, for pest managers in pre-feeding operations, since the operational targets were also met without pre-feeding.
- The intermediate-term benefit. The population recovery time (and hence the need for retreatment) is directly dependent on the level of control achieved overall. In the case of the two failure operations, there is clearly some benefit in pre-feeding as the no-prefeed treatments produced significantly poorer kills than the prefeed treatments.
- The numerous operational baiting variables. Even within traditionally run operations, kills of possums vary unpredictably. Pre-feeding appears to partly overcome such variation and substantially improve the percentage kill achieved, as well as reducing the risk of operational failure.

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

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Wayne Fraser *(not shown)*

Can 1080 in Harvested Native Plants Pose a Threat to Tangata Whenua?

Tangata whenua throughout New Zealand are one of the sectors in the community that have strong concerns about the fate of 1080 in the environment. Ngāti Ruapani and Ngāi Tūhoe near Lake Waikaremoana still harvest food and medicinal plants in the area, and are particularly concerned that culturally significant plant species could be taking up 1080 from cereal and carrot baits. Their concern was highlighted in 2003 when an area immediately south of Lake Waikaremoana was scheduled for an aerial 1080 control operation against possums.

The proposed operation provided a research opportunity. A multi-agency research team identified plants harvested by local people over the months coinciding with the 1080 aerial baiting. 1080 levels in the foliage were monitored. The team comprised James Ataria (Landcare Research), Shaun Ogilvie (Lincoln University), James Waiwai and Neuton Lambert (Lake Waikaremoana Hapū Restoration Trust), Jim Doherty (Tūhoe Tuawhenua Trust), Dave King (Department of Conservation), and Michelle Lambert (Te Whare Wānanga o Awanuiarangi). From the extensive list of plant species harvested, two species emerged as appropriate for studies on 1080 uptake: the fern pikopiko (*Asplenium bulbiferum*), which is normally collected for food, and karamuramu (*Coprosma robusta*), taken for medicinal purposes.

Within the aerial application zone, Neuton Lambert identified sites where both of these species were growing. Unfortunately for the research team, the proposed aerial control operation was cancelled. However, a 'worst case scenario' trial was established in the area, by placing one cereal bait loaded with 1080 at 0.15% wt:wt (and identical to the toxic bait programmed for use in the control operation), at the base of each of 10 pikopiko and 10 sapling (2–3 m high) karamuramu plants. Emerging pikopiko fronds and karamuramu leaves and shoots were collected from each plant at 0, 3, 7, 14, 28 and 56 days after bait placement, and 1080 levels in them measured at Landcare Research's toxicology laboratory. Rainfall and soil moisture were recorded throughout the collection period, and some of the baits were collected at the conclusion of the experiment and analysed for remaining levels of 1080.

No 1080 was found in any of the pikopiko frond samples collected throughout the exposure period. This was despite a loss of more than 99% of 1080 from the bait after 56 days (the final sampling) – presumably leached from all baits into the surrounding environment by the 120 mm of rain that fell in five significant rainfall events during the intervening period. However, 1080 levels of up to five parts per billion were detected in three of the karamuramu foliage samples (Fig.).

Members of the research team and other interested parties. Left to right: John Hauwaho, Michelle Lambert, Shaun Ogilvie, James Ataria, Dave King, Jim Doherty, Neuton Lambert.

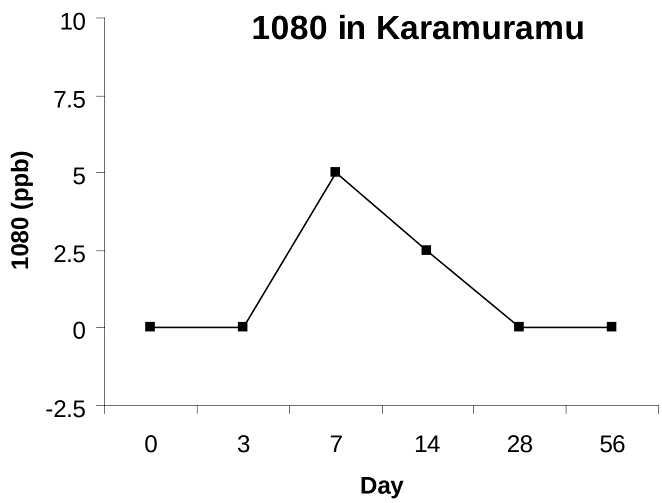

Fig. Uptake and persistence of 1080 in karamuramu. 1080 was detected in only three of the 10 plants monitored, and only the highest value recorded at each sampling time is shown.

Highest levels were detected 7 days after bait placement, and levels then decreased to zero 28 days after bait placement.

So does this amount of 1080 present a risk to those who utilise karamuramu foliage for medicinal purposes? Based on an assumed LD_{50} value for humans (i.e. the estimated amount of 1080 required that would kill 50% of human consumers, and approximated from that calculated for a range of mammal species), James and his colleagues have concluded that even at the maximum concentration of 1080 measured, there is a negligible risk to users of karamuramu of their being poisoned. This finding is in keeping with an earlier study of 1080 in plant products by Landcare Research staff and research colleagues who detected similar levels of 1080 routinely occurring in a range of tea leaves commercially packaged and retailed in New Zealand.

This work was done under contract to the Animal Health Board, with logistical support from the Department of Conservation.

Other reading:

Twigg, L.E. et al. 1996: *Natural Toxins 4:* 122–127.

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Weta and Mice – Prey and Predators in an Alpine Habitat

House mice are omnivorous, opportunistic feeders that eat a wide range of invertebrates and seeds, and possibly also lizards and the eggs of small birds. They are present throughout the New Zealand mainland, and occur above treeline in alpine regions. There, snow tussocks are the dominant plants, and produce large amounts of seed every few years in masting events. How mice populations respond to snow tussock masts is, however, not known. But if mice do increase in a fashion similar to what occurs in beech forest following mast years, these little rodents could be significant pests of alpine regions.

Since 2003, Deb Wilson and her team have been studying mouse populations in the Borland Valley in Fiordland National Park. As part of this study, snap traps are set two or three times a year at 25 sites over 3 nights in each of three alpine basins. Analysis of mouse stomach contents shows mice have mostly been eating invertebrates, especially ground weta, spiders, grasshoppers, and caterpillars (Fig. 1). Plant material was not often detected, perhaps because it was difficult to separate from the peanut butter and oats used to bait traps and also present in most stomachs.

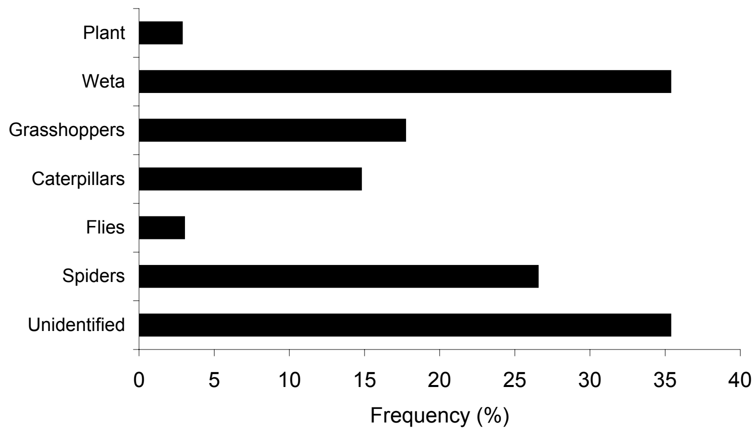

Fig. 1. Percentage of 34 mouse stomachs containing plant material and different groups of invertebrates. The 'unidentified' category refers to invertebrates.

Unexpectedly, ground weta (*Hemiandrus maculifrons*) were sometimes also caught in traps set for the mice. This bycatch yielded new insights into the possible impacts of mice on weta populations. Capture rates of mice and ground weta were inversely related, i.e. when no or few mice were caught, weta captures were highest, and vice versa (Fig. 2). Predation by mice may reduce the numbers of these flightless insects. While this type of inverse correlation can be an artefact of trap competition, the team is confident that this is not the situation here. The capture indices were low (ensuring there were many unsprung traps, thus little competition for them) and the team corrected the indices to account for traps sprung by each species.

Hemiandrus maculifrons is widespread, long-lived, and slow-growing but the stability of its populations is unknown. However, mice prefer large prey (these weta are up to 2 cm long), and because weta spend much of their time in burrows in moss and soil, where they also lay their eggs, they are likely to be a preferred quarry of mice. Weta nymphs hatch after many months, and develop into adults after 2 – 3 years. Hence, it takes a long time to replace individuals eaten by predators.

Deb and her team also caught live mice as part of a trap, mark and release

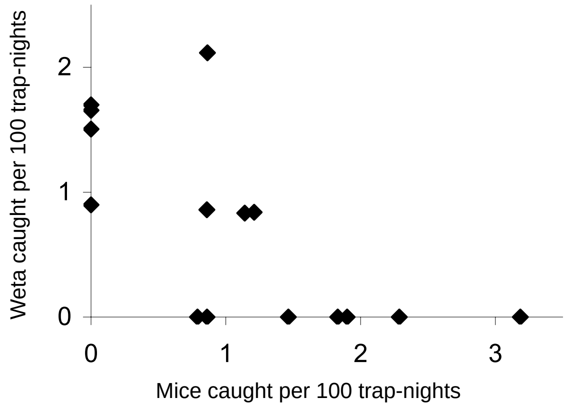

Fig. 2. Relationship between captures of ground weta and mice caught in snap traps at three alpine sites on five trapping occasions (shown as the square root of each capture index).

study that enabled them to estimate mouse population sizes based on the ratio of marked to unmarked animals caught. Since the study began, populations have been low, similar to those in beech forest in non-mast years. However, snow tussocks in the Borland Valley flowered profusely last summer (2005/06). By last autumn, many of the mice were in breeding condition. Trapping in November 2006 revealed that the population continued to increase over winter, as often happens in beech forest after

a mast. If the mouse population continues to grow, it may support a stoat population increase similar to the beech forest situation. Stoats are certainly present in alpine tussock regions, where they prey on mice, birds and ground weta. The unfortunate ground weta may receive a double whammy if both mice and stoats become plentiful in the coming year.

The project's results to date indicate that even small numbers of mice may have a measurable effect on ground weta populations. The consequences of heavy seeding by snow tussocks still remain to be seen, and further research in alpine environments is needed to clarify the risks to ground weta. Further study could include experimentally manipulating mouse density within exclosures or intensive mouse removal, combined with basic indices of ground weta abundance from standard ink tracking tunnels, and intensive sampling to gather data on the numbers and sizes of ground weta present. With this information, Deb and her team could predict how predation is likely to affect ground weta population dynamics. For example, if mice target large adults, the population's reproductive capacity may be reduced.

D. Wilson

Two of the alpine basin study sites can be seen in the distance above the true left of the South Branch of the Borland Burn.

This work was funded by the Department of Conservation.

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Where Do Rats Hang Out in the Bush?

Anyone who's spent time trapping animals will have noticed a universal phenomenon – some traps capture lots of animals and others capture none. And some areas always seem to have animals 'hanging out' in them, while others do not.

Species such as ship rats and possums are mobile and relatively cryptic. Local rat or possum control is therefore usually done over large areas when pests are abundant and causing damage, without quantitative landscape-level knowledge of their distributions, and with limited understanding of how (a) pest control and (b) habitat patchiness affect those distributions.

However, managers are becoming increasingly aware of local landscape effects on the distributions and dynamics of pest species such as rats, and the value of focusing pre-emptive control in key parts of the landscape is implicit in many pest control strategies. There is an emerging paradigm of site-based management (such as kiwi sanctuaries, private conservation initiatives, and Project Ark sites) in an attempt to mitigate such effects. However, better management of pest species (from mice to deer) at a range of spatial scales requires quantitative landscape-level knowledge of the distributions and dynamics of each species. For example, some rats and possums do survive control operations, and some of these survivors may recolonise controlled areas and rapidly negate the benefits.

The Orongorongo Valley study site

Andrea Byrom and co-workers are addressing these issues in a project using 'landscape' approaches to manage intractable mammalian pests in New Zealand ecosystems. The project has three themes dealing with (1) patterns in the distribution of possums and ship rats, (2) processes that lead to these patterns, and (3) predictive models to support pest management:

(1) Assessing the *distributions of possums and ship rats in podocarp-broadleaved forests*. Uncontrolled possum populations are relatively stable, so their abundance will be mapped for major habitat types (at the scale of 100s of hectares). The abundance and distribution of uncontrolled rat populations are highly variable, and will be characterised at a relatively fine scale (<100 ha).

(2) Predicting where 'hotspots' of rats and possums are likely to occur. This requires knowledge of the *processes (competition with possums and predation by stoats) that determine the distribution of rats in podocarp-broadleaved forests*.

(3) Synthesising data and constructing *mapping algorithms and predictive models to support pest management* in a GIS framework. Models will be developed to describe the spatial dynamics of rat and possum populations and to assess the cost-effectiveness of controlling pest animals in 'hotspots' compared with broad-area control.

A. Byrom

The team heading out to lay traps for rats in the Orongorongo Valley study site.

This work will enable the team to examine the potential for increased cost efficiencies of controlling ship rats (and possums) in localised 'hotspots' in the landscape. These efficiencies will depend on several factors: the population dynamics of each species including habitat-specific rates of increase, dispersal patterns and rates of recolonisation, and the ability of pest managers to define, locate and treat 'hotspots' during periods when rats or possums are scarce. There will be an economic trade-off between managing rats and possums when they are concentrated in hotspots, and potentially causing little or no damage, compared with when they are widespread and significantly affecting native flora and fauna. The research should help managers decide where and when to best spend their money targeting pest animals to ensure more effective control at the landscape scale. Using detailed mapping of the distributions of pest animals in the landscape, and modelling their predicted abundances both in response to natural fluctuations in food availability as well as to control, Andrea and her team aim to provide managers with a quantitative set of 'rules' for managing animal species at a range of spatial scales. Targeted, effective pest control will benefit a wide range of indigenous species, including critically endangered species (e.g. yellowhead, orange-fronted parakeet, blue duck, kiwi, and *Powelliphanta* snails) and more widespread species with depleted or declining populations (e.g. kākā, robin, and kererū).

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

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Roger Pech, Deb Wilson, Dave Ramsey, James Shepherd, Jake Overton *(not shown)*

When is the Best Time to Control Eruptive Pest Populations?

In the June 2004 edition of *Kararehe Kino*, Tony Sinclair explained how to take advantage of 'density-dependence' to conserve native fauna threatened by predation. In essence, high-density populations that are reduced suddenly are more likely to compensate through increased reproduction or survival than populations already at low density. Roger Pech suggests that similar ideas can apply to pest control, although here the aim is to increase control efficiency rather than protect a species.

Occasionally, populations of some small mammals can erupt, reaching very high densities and damaging agriculture or the environment. Eruptions can be triggered by a variety of species-specific factors. For example, forest 'mast' years in New Zealand, i.e. years with exceptionally heavy seed production in podocarp–hardwood or beech forests often lead to sharp increases in house mice. Similarly, in grain-growing areas of south-eastern Australia, eruptions of house mice tend to follow above-average winter and spring rainfalls that generate high crop yields. Brandt's voles in the grasslands of Inner Mongolia and plateau pikas

R.Pech

Sexing and measuring a 40g Brandt's vole live-trapped during ecological research near Xilinhot in Inner Mongolia.

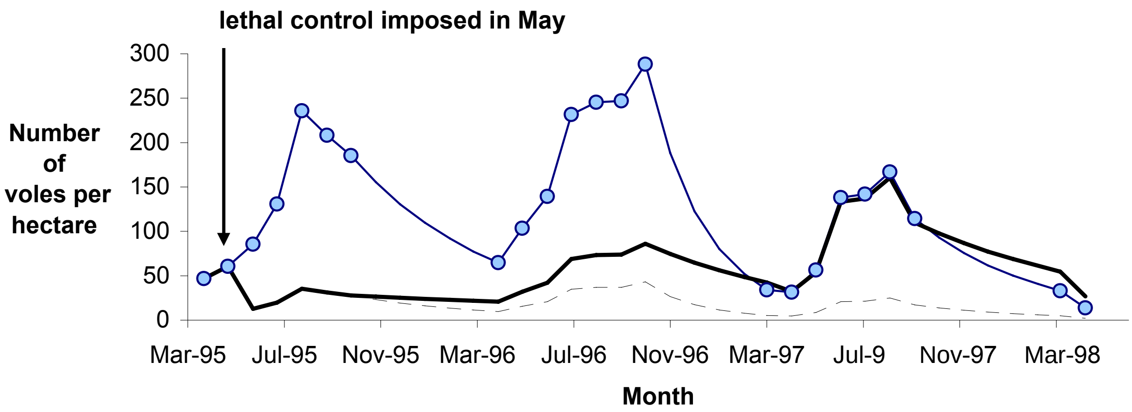

Fig. Measured abundance of Brandt's voles (blue line) compared with predicted changes (black line) that would have followed a poisoning programme if imposed in May 1995. The dashed line represents the population's trajectory if there was no density-dependent survival over winter; the solid line includes density-dependence.

in alpine meadows in Tibet may erupt following an increase in grazing by livestock that produces more of their favoured, short-grass, habitat. All three species – house mice, Brandt's voles and plateau pikas – provide examples of when to avoid or exploit density-dependence to improve the efficiency of management programmes.

Roger and his colleagues have been investigating the effect of density-dependence on the post-control recovery of Brandt's vole (Fig.). Survival of these voles over winter is density-dependent: the higher the population at the start of winter (October), the greater its decline, probably due to competition for grass and forbs stored in vole burrows. Control campaigns using grain bait are highly effective when carried out in early *spring* (April/May), before new grass growth starts to provide alternative food. The remnant population builds up during the following summer, with a rate of increase determined by the balance between pasture productivity and its consumption by livestock.

If populations of Brandt's voles are controlled in *spring* they start the following winter at a lower density, and consequently have higher survival, than uncontrolled populations. The outcome is that control programmes in spring typically reduce the abundance of Brandt's voles for about 2 years before compensatory survival over the subsequent winters returns them to pre-control levels. Control carried out in *autumn* is even less effective, as increased survival over winter in a low-density population rapidly compensates for control.

The causes of density-dependence in the rates of increase of house mice, Brandt's voles and plateau pikas are not clearly understood, but the consequences for conducting control programmes are. Regardless of how efficient control techniques are in producing an immediate reduction in pest numbers, the benefits last longest if control is imposed when the rate of increase is *not* density-dependent.

Jiebu

A plateau pika at a burrow entrance in alpine meadow in central Tibet. Despite large increases in numbers of yaks and Tibetan sheep over recent decades, plateau pikas have been blamed for causing severe overgrazing and extensive soil erosion across the Tibetan plateau.

Table. *Seasons where/when the rate of increase of house mice, Brandt's vole, and plateau pikas is density-dependent.*

	SEASON			
	Autumn –Winter	Winter –Spring	Spring –Summer	Summer –Autumn
House mice in beech forest, New Zealand	Yes	Yes	Yes	Yes
House mice in podocarp–hardwood forest, New Zealand	Yes	Yes	No	Yes
	Autumn – Winter – Spring		Spring – Summer – Autumn	
House mice in dryland crops, southeast Australia	Yes		No	
Brandt's vole in grassland, Inner Mongolia	Yes		No	
Plateau pikas in alpine meadow, Tibet	Yes (but depends on livestock management)		Yes	

Conversely, the benefits are negated most rapidly by compensatory breeding or survival during periods when density-dependence is strongest (Table).

Research by Dave Choquenot and Wendy Ruscoe indicates that house mice populations in New Zealand podocarp–hardwood forests will respond to control in a similar way to house mice in Australian croplands and Brandt's vole in grasslands. Density-dependence has little or no effect during summer, so the benefits of control programmes last longest if imposed in spring. Unfortunately for lethal control programmes, the year-round density-dependence of house mice populations in New Zealand beech forests is most like populations of plateau pikas living above 4000 m in Tibet. In both these cases, populations recover rapidly regardless of when control is imposed. At a study site in central Tibet, populations of plateau pikas that had been reduced by more than 90% by control programmes in spring (April) 2004 or 2005 had completely recovered to pre-control densities after one summer.

The consequences of density-dependence are somewhat different if the control aims to reduce the fertility of animals rather than kill them. For example, autumn would be the best time to sterilise Brandt's voles because strong density-dependent survival would still deplete the population over winter, leaving a residual population with low levels of fertility at the start of the breeding season in spring.

Current research in New Zealand forests and grasslands is designed to increase our knowledge of how to manipulate the mechanisms – predation or competition – that lead to density-dependent rates of change in populations of house mice and ship rats.

The work in China was funded by the Australian Centre for International Agricultural Research, CSIRO, and AusAID.

R.Pech

A social group of plateau pikas in typical alpine meadow habitat in central Tibet.

Other reading

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Probability of Freedom from Pests and Disease

Can managers be totally sure they have eradicated a pest as soon as they have done so? The short answer is no. The exception is where whole areas can be surveyed with the certainty that every pest present is detectable. In large areas this is always prohibitively expensive. The alternative approaches are either to:

- Wait and see – if the pest is still present it will eventually show up somewhere,
- Selectively survey the area. The difficulty is that if no pests are detected, then either they have been eradicated, or the survey sensitivity is less than 100%. A solution to this problem is to quantify the probability of freedom. The theory for this is perhaps most advanced for disease surveillance, but the principles also apply to pest eradication and to detecting pest incursions.

The probability of freedom from disease is typically based on setting a 'design' prevalence below which the disease is considered to be functionally extinct, then determining the likelihood that the existing prevalence is below this level. The design prevalence is always very low, so large sample sizes are needed when the sample is assumed to come from a very large (nominally infinite) population. Where hosts such as possums have been reduced to low densities, large sample sizes cannot be obtained. Instead, sampling theory for finite populations is applied. This requires an estimate of the actual population size, but getting it is usually expensive, adding uncertainty to the estimated probability of freedom.

Graham Nugent and Dave Ramsey from Landcare Research, and Peter Caley from the Australian National University, have recently developed an alternative approach to estimating disease freedom. The team was commissioned by the Animal Health Board to develop a national framework for integrating the surveillance of bovine Tb in livestock and wildlife.

The framework proposed has three components: (1) determining, for any given survey, the probability that Tb will be detected if present; (2) using that probability to update a prior estimate of the likelihood of Tb absence, given the duration and intensity of the possum control applied; and (3) subsequently updating the revised 'posterior' estimate of Tb absence as new data become available.

To estimate the probability of detection from a single survey, Graham developed the concept of using each major Tb host (whether possum, cow, ferret, deer, or pig) as a detection 'device' or sentinel. Starting with wild deer, he estimated the likelihood of a deer becoming infected if it shared its home range continuously with a single infected possum – he did this by comparing Tb incidence rates in possums with those in deer from the same area. These data suggested that a deer living alongside a single infected possum has only a 0.4% chance per year of becoming infected (P_d), and about a 1% chance during its lifetime. Another way of looking at this is that where Tb occurs in 10% of deer, each deer on average is likely to have been continuously exposed to about 10 infected possums.
Pigs are much more sensitive, with an estimated P_d of 20–30% per year. Ferrets are intermediate between these extremes. The P_d for possums is likely to be even higher than for pigs – about half the uninfected possums that regularly come into contact with an infected possum are likely to become infected per year.

For Tb-tested livestock, the numbers of infected animals in short-lived, isolated outbreaks of Tb was presumed to reflect transmission from a single wild animal. The data suggested that

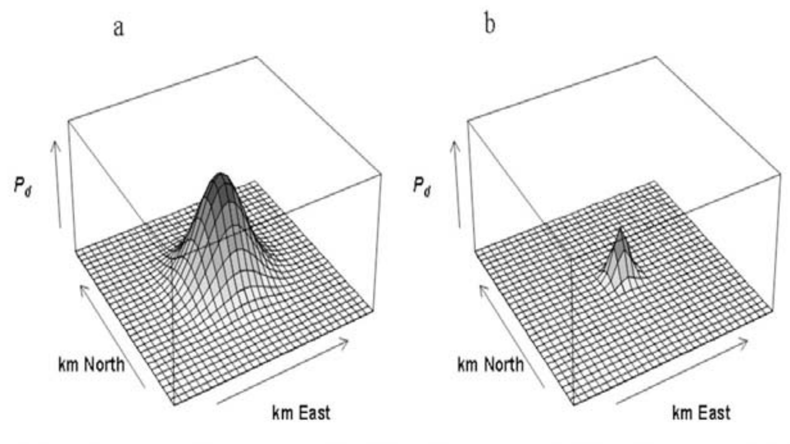

Fig. 1. Detection kernels for a 1-year-old pig (a) and a 4-year-old female deer (b), highlighting both the greater height of the pig kernel and the much greater area 'surveyed' by pigs.

livestock are probably detecting only about 20% of infected possums. Individual cattle have only a very small chance of becoming infected, similar to wild deer.

Given these per-sentinel detection probabilities, the sensitivity of an entire survey could be estimated by combining the individual P_d values – this is theoretically possible but too complex mathematically. Dave Ramsey has therefore developed an intuitively more robust and easily understood 'spatial' alternative. A detection 'kernel' spatially representing the P_d values given above (Fig. 1) is centred on each sentinel kill site, and represents the area the animal has effectively 'surveyed' while moving around its home range. Combining such kernels in a GIS generates a 'detection' surface. The average height of the surface represents the probability of detection across the whole area. The beauty of this approach is its visual simplicity. It also allows easy identification of gaps in survey coverage, and avoids having to accurately estimate density.

Peter and Dave then applied Bayesian logic to convert this probability of detection into an estimate of Tb freedom, and to integrate data from multiple surveillance sources. First, a so-called 'prior' probability that Tb has been eradicated is estimated. This might be simply a best guess, or it might be the probability of eradication predicted by a simulation model. The 'prior' probability is then updated using the survey outcome. The approach basically estimates the likelihood that no disease would be detected *if* the prior probability was correct, and then adjusts that value upward to take

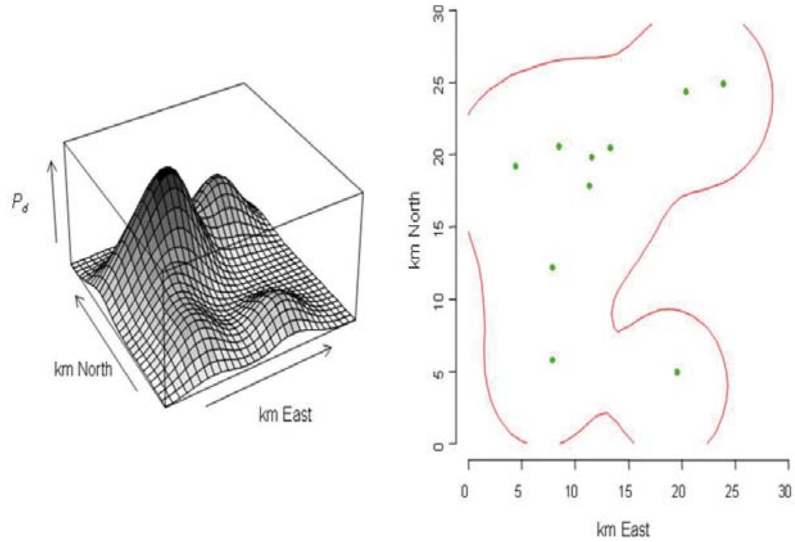

Fig. 2. Hypothetical 'probability of detection' surface (a) and coverage (b), provided by 10 one-year-old pigs sampled within a 30 × 30 km area. Here coverage is represented as the area over which the pigs provided some minimum level of 'surveillance effort' (arbitrarily $P_d > 0.1$).

into account the increased amount of evidence indicating Tb absence, producing an updated so-called 'posterior' probability of freedom from Tb. This updating process is repeated as more data come to hand from other sources or subsequent resurveys.

The 'posterior' probability allows managers to estimate the risk of Tb re-emerging if they stop vector control, and, conversely, the risk of wasting money by continuing vector control long after Tb has been eradicated. Optimising the balance between these risks will enable managers to shift their efforts to remaining problem areas at the earliest sensible time.

The team is now using this approach in pest control and eradication. The major change needed for each new situation is to develop a practical way of measuring the relevant detection probability. Dave is using this approach to confirm that a New Zealand company, Prohunt, has eradicated pigs from Santa Cruz Island, California.

He is using a variety of data from hunters and their dogs, sentinel pigs, and field surveys, to estimate the probability of being able to find surviving pigs using each method. Graham is using the 'detection kernel' idea to define empirical risk strata in low-density possum populations, by trying to define the area around surveyed sites where no possums were detected that can be safely left out of follow-up control. These two examples illustrate the range of potential applications for these tools.

Graham Nugent
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Dave Ramsey and Peter Caley *(not shown)*

Envirolink Projects Undertaken by Landcare Research

Envirolink is a fund administered by the Foundation for Research, Science and Technology for use by regional councils to seek advice on environmental topics and projects from Crown Research Institutes, universities, and some not-for-profit research associations. The website featuring the reports being generated by Envirolink projects (www.envirolink.govt.nz) will be up and running shortly. In the meantime you can contact Bill Dyck, the Envirolink Coordinator (billdyck@xtra.co.nz), for copies of any reports. The following table sets out topics relating to vertebrate pests that have been completed or are 'in progress' by Landcare Research.

Council requesting advice	Project description	Project leader
Northland	Multiple capture devices for vertebrate pests	B Warburton
Northland	Snap-traps for controlling stoats	B Warburton
Northland	Environmental costs of stoats	E Spurr*
Northland	Environmental costs of new deer populations	P Sweetapple*
Northland	Stakeholder involvement in developing RPMS's†	C Horn*
Northland	Economic and environmental risks of feral pigs	J Parkes
Northland	Distribution, abundance and impacts of black swan	J Coleman
Hawke's Bay	Pros and cons of input monitoring for pest control	B Warburton
Hawke's Bay	Optimising pest control using adaptive management	B Warburton*
Hawke's Bay	Options for feral pig control	I Yockney
West Coast	Risk of cyanide baits used for possum control to weka	J Coleman
Manawatu/Wanganui	Pest impacts on biodiversity and RPMS review	P Cowan*
Southland	Impacts of vertebrate pests on biodiversity	G Norbury
Southland	Impacts of vertebrate pests on biodiversity & benefits of pest control	G Norbury*
Marlborough	Managing rabbits where RHD has failed	J Parkes

* In progress

† Regional Pest Management Strategy

Contacts and Addresses

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Also, for further information on research in Landcare Research see our website: http://www.landcareresearch.co.nz

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Some Recent Vertebrate-Pest-Related Publications

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