# Kararehe Kino

Vertebrate Pest Research

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## COMMUNITY CONSERVATION

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*Front cover: Tūī (Prosthemadera novaeseelandiae) feeding on Taiwan cherry nectar. This bird was captured, banded and radio-tracked for a study on nesting success and seasonal movements of Waikato tūī. Photo by Neil Fitzgerald (www.neilfitzgeraldphoto.co.nz)*

*Pg 3: Gecko photo by Sarah Herbert. Al Glen checking an artificial cover object, photo by Wendy Ruscoe. John Innes and rat photo by Neil Fitzgerald.*

*Pg 14: Photo courtesy of Nga Manu Images (www.ngamanuimages.org.nz)*

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# In this issue...

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*John Innes holding a ship rat cage-trapped just outside the pest-fenced sanctuary at Maungatautari. This male rat was radio-collared and released inside the fence, to experimentally determine how invader ship rats would behave. Quite unexpectedly, most climbed back out again!*

# Working with communities and sanctuaries – an introduction

*This 9.6 km pest-proof fence at Cape Kidnappers around 2600 ha of private land keeps predators at very low densities. The fence is 'leaky', so small numbers of predators must constantly be removed. Fenced cells have been set up inside the main block to protect seabirds and tūatara. Brown teal, brown kiwi, fluttering shearwater and grey-faced petrels have been relocated into these cells.*

Community-based conservation is a growing phenomenon globally, and New Zealand is no exception. Sustaining and restoring native biodiversity in New Zealand is increasingly being undertaken by private citizens. There is an extraordinary diversity of conservation and restoration projects underway on the 70% of New Zealand that is privately owned, and there are also many community-led projects on public land. This issue of Kararehe Kino features aspects of vertebrate pest research in these settings.

Restoration practitioners include iwi, wealthy benefactors, community trusts and private landowners. There are now 3,500 Queen Elizabeth II National Trust covenants covering 96,000 ha of land, mainly in farmed environments, and 199 Ngā Whenua Rahui kawenata (covenants) on Māori land covering 170,000 ha. The New Zealand Landcare Trust works with more than 150 groups to improve the sustainability of landscapes. There are 62 site-focussed 'biodiversity sanctuaries' that seek to control multiple pests to restore ecosystems. Their combined area – 56,000 ha – is larger than that of all pest-free islands but still only 0.2% of New Zealand's land area. Partnerships are the norm, e.g. between practitioners and the Department of Conservation (DOC), Regional and City Councils, corporates and iwi.

No sanctuaries employ their own researchers. Yet there are a myriad of questions and uncertainties about how sanctuaries and restorations of various kinds should be managed. What should their goals be? What science principles should underpin their management? What outcomes should be measured to assess the project's success? What habitats and land area do different threatened species need when translocated into these places? How are ecological interactions between newly introduced species managed? Are predator-proof fences worth the upfront cost? Should we worry about mice, which frequently are the only mammals remaining in, or reinvading, fenced sanctuaries?

There is also increasing realisation that sanctuaries must be sustainable socially as well as ecologically. A lot has been learned about why people choose to be involved in restoration projects, and what the key factors are that make projects successful. The late Diane Campbell-Hunt who wrote cogently on New Zealand sanctuaries argued that such participants have a "shared perception of ecological loss, together with the motivation to act in the landscape that has meaning for that community". Communities are very diverse, and so are the needs and aspirations of different people. Sanctuaries have to be conceived, established and then maintained in the long-term, perhaps under different management.

Finally, the future of New Zealand restoration is undoubtedly large-scale. There are many reasons for this. First, both native biota (e.g. kererū and the seeds they disperse) and some of their predators (e.g. stoats) move tens of kilometres, heedless of legal boundaries, in their daily or seasonal foraging. Movements are even greater at some times of year, such as when young animals disperse from their birthplace to where they will breed. Second, vertebrate populations must remain large to be genetically healthy and numerically safe, which in turn demands large-scale pest control – often spanning tens of thousands of hectares. The apparently haphazard 'placement' of different restoration projects across large landscapes demands a better understanding of how they fit together, both ecologically and in terms of national prioritisation. Furthermore, there is increasing pressure from government for DOC to incorporate community-based conservation efforts into their conservation planning efforts, but this is not a trivial exercise.

Landcare Research works with restoration practitioners to investigate many of these questions. This issue of *Kararehe Kino* highlights recent vertebrate pest research undertaken with communities of many kinds, from urban to rural, drylands to islands, and from very small scale to very large. The common theme among the articles is that communities and agencies operating together can make a real difference to biodiversity condition in the places where they choose to work.

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**Andrea Byrom**

# Can possum fur harvesters both make a living and help protect forest biodiversity?


Grant Morriss

Possums cause significant damage to biodiversity values in much of the approximately 6.5 million hectares of indigenous forest in New Zealand. Possum control programmes by the Animal Health Board and Department of Conservation (DOC) cover less than 40% of this area. In the remaining area of forest, there is little or no systematic possum control although in some localities possums are killed for their skins and/or fur. The commercial market for both of these products has survived peaks and troughs from the start of legal harvesting in 1921 through to the present day. Currently possum fur woven with merino wool forms the basis of a luxury garment industry worth around NZ$100 million per year. More than one million possums are now harvested annually to service this growing industry, but its future growth is constrained by the availability of sufficient fur.

Possum harvesting has previously been considered an unsustainable strategy to protect biodiversity values because it requires possum numbers be maintained at levels sufficient for a sustainable long-term income. In contrast, biodiversity protection (and/or bovine TB mitigation) requires much lower possum densities. Preliminary economic models, based on contemporary contractor rates and fur prices, confirm that possum fur harvest is only economically viable if possums are maintained at reasonably high densities.

In a multi-faceted project being undertaken in collaboration with the Tūhoe Tuawhenua Trust, a team of researchers led by Chris Jones has been looking at whether the apparently conflicting outcomes of an economically viable harvest and biodiversity protection can both be accommodated in native North Island podocarp forests. The researchers used interviews with local Tūhoe harvesters, trapping data, and a combination of economic and spatial population models. The interviews provided information on fur prices, local harvest strategies and trappers' economic expectations and 'pull-out thresholds'. The trapping data was used to estimate the effective trapping area around a harvest line and the decline in daily capture rates on the line over time. This information was then used in the models to look at the effects of two overall strategies (defined by pull-out trap-catch indices (POTCIs) of 25% and 5% (see *Kararehe Kino*, February 2011 for a more detailed explanation of strategies), while varying trap-line spacing and the time between successive harvests on specific lines.

Harvesters hoped for trap-catch indices (TCIs) of 50–70% when initiating a trap-line. They stopped trapping when the POTCI was about 26% (range 20–30%), and left trapped areas for at least a year before returning. The effective trapping distance at which possums were vulnerable to capture around a trap line was 200 m. Possum captures on a line monitored over 24 harvest-days declined exponentially from an initial TCI of 63% on day 2 to under 8% from day 21 onwards (*Fig.*).

Simulations by the team predicted that the optimum long-term economic harvest strategy for contractors required access to sufficient habitat for 20–30 trap lines, with trapping ceasing at 25% POTCI and leaving possum populations about each trap-line to recover for three years. However, this strategy does not maintain possums at low enough densities to protect forest biodiversity. The simulations also predicted that trapping down to 5% POTCI annually with closely-spaced lines led to possum populations being held below 20% TCI over the year, which is likely to provide biodiversity gains. Furthermore, possum populations harvested during winter (which is normally the case) will be at their lowest densities during the subsequent spring and summer, when native birds and flowers of possum-preferred species are most vulnerable to predation and browse. Unfortunately, this strategy cannot provide a sustained income for a harvester, who would suffer a shortfall of $13.60 per ha of forest protected per year at the fur price of about $140 per kilogram current when the research took place.

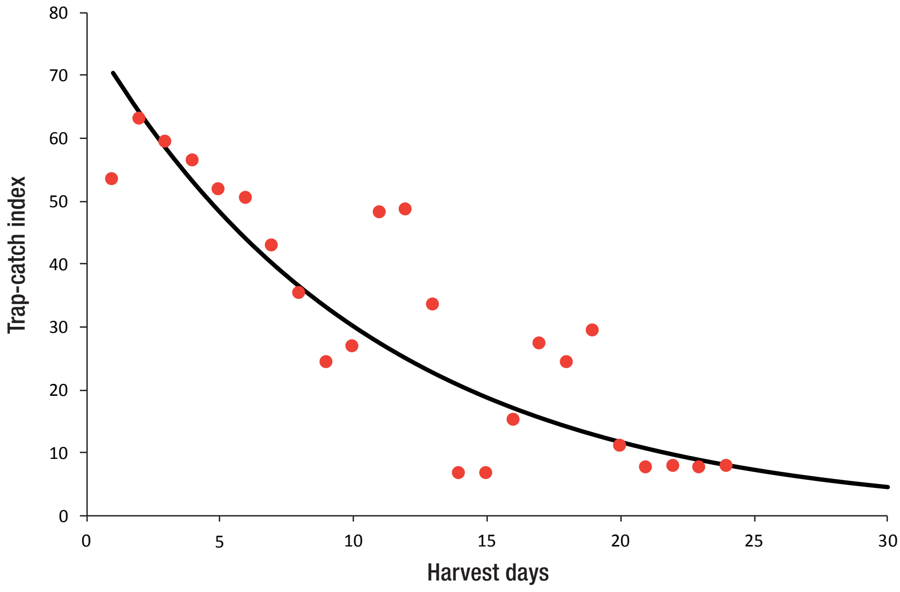

**Fig.** *Decay curve for possum captures on a single trap-line in tawa–podocarp forest in the central North Island. Dots represent field data to which the line was fitted.*

The researchers suggest that if this shortfall was subsidised by management agencies, harvest trapping could deliver the same level of possum control at lower cost than standard ground control ($45–80 per ha). The cheaper option of aerial control is still the best option for targeting possums in very rough terrain where trapping is difficult. However, to maintain pests at low densities over prolonged periods it is necessary to keep repeating the operation, and this is not economic. Aerial control does not deliver any socio-economic benefits to local communities, whereas a harvest industry could provide secure long-term employment where it is most needed and support local communities' kaitiakitanga (traditional guardianship/duty of care) of their forest environment.

The potential therefore exists for trialling an integrated management approach, with input from the fur industry, conservation and TB disease managers, to support harvesters to trap to lower-than-normal trap-catch rates and thereby test the predicted possum recovery rates and associated effects of harvest on biodiversity values. The research team stresses that its findings only apply to the modeled system and cautions that these findings need to be extended to other forest types or harvest systems elsewhere in New Zealand.

This work was funded by the Ministry for Science and Innovation through Landcare Research Capability funding.

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# National *sanctuary* workshops

Neil Fitzgerald

*Sanctuariesnz.org workshop attendees, Cape Kidnappers August 2009.*

There are many kinds of restoration projects underway in New Zealand and many possible definitions of a 'sanctuary'. In this article, sanctuaries are considered to be places in which the *control or eradication of a broad range of mammal pests* is pursued to *restore ecosystems* to indigenous species dominance and full species occupancy. These terms mean simply that key ecological processes (e.g. herbivory, seed dispersal and decomposition) are achieved mainly by native rather than exotic taxa, and that all the native species that could possibly be present at a site (i.e. that are not extinct), are actually present. Routinely, increasing indigenous dominance and species occupancy are achieved by pest control and translocations respectively. Using this definition, there are 63 sanctuaries on or near the New Zealand mainland, totalling about 56,000 ha, with most established in the last decade (*Fig.*). In the absence of a national sanctuaries agency of some kind, Landcare Research

**Fig.** *North and South Island biodiversity sanctuaries.*

has, since 2004, hosted both a website – *sanctuariesnz.org* – and an annual workshop for sanctuary practitioners. A research agency is a logical choice for this role because there is substantial uncertainty about many aspects of how sanctuaries should be managed, and research can help to improve this situation.

Any interested person is welcome at the workshops. On average, each is attended by about 100 people, of whom half are sanctuary practitioners, a quarter are researchers or students, and the rest are from the Department of Conservation (DOC), territorial authorities, funding agencies and consultancies of various kinds (*see photo*). The first day of each workshop features talks on subjects relevant to sanctuaries, while the second day includes both workshops and a field trip or two to nearby sanctuaries. In the last two years, topics covered on the first day have included fungi, ship rat–mouse relationships, translocation procedures, sanctuary governance, environmental education, land snails, robin translocations, detecting mice, DOC mainland islands, and reviews of the outcomes and challenges faced by managers of particular sanctuary sites.

John Innes reports that the key outcome of past workshops is the recognition that most sanctuaries share the same problems and challenges. This finding has helped clarify key national research priorities, including the ongoing improvement of pest detection and control (especially when pest densities are very low); mammal pest behaviour at the ends of peninsula fences and at breaches in ring fences; and how best to measure ecosystem responses to the two major regimes of pest control – near-eradication of all pests, and the sustained removal of key pests. The workshops have also helped build relationships between sanctuary practitioners to the point where coordinated experiments between some sanctuaries could be possible. Finally, practitioners are concerned about the financial sustainability of all sanctuaries, and believe that this deserves fuller evaluation.

The 2012 workshop will be in South Taranaki in August. It will focus on the pest-fenced 230-ha Rotokare sanctuary near Eltham and all interested practitioners are welcome. This work is funded by the Ministry of Science and Innovation (Programme CO9X0503).

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*Tūī feeding on kōwhai flowers, a preferred food, at Lake Waikari.*

# Restoring tūī in Hamilton

Tūī are found in most New Zealand forests and in many towns but are scarce where nearly all forest is gone, especially in the South Island east of the Southern Alps. They are also scarce in Hamilton in the central Waikato. Public reports and surveys by John Innes and his team prior to 2004 showed that tūī appear in rural and urban places in the Waikato from about May until October, and that they feed mainly on nectar of exotic *Banksia integrifolia*, camellias, flowering cherries and eucalypts, plus native kōwhai.

Neil Fitzgerald attached small radio transmitters to the tails of tūī captured in Hamilton to record their movements and habitat use (the transmitters fell off when the birds' tail feathers moulted in the autumn). The average length of 'vegetation patches' that tūī foraged in was 62 m and these had a mean canopy height of 11 m. The vegetation was 91% planted, and was dominated (64%) by exotic species. Within each patch there were, on average, four individual trees that tūī fed on. Distances between the patch and the nearest house varied considerably, from 0–300 m. Tūī are obviously quite happy near houses and roads.

In spring, tūī flew 12–20 km back to native forest areas to nest (*map*). Nesting success of forest birds in New Zealand is typically poor – only around a quarter of all attempts succeed – due to predation by pest mammals, especially ship rats, possums and stoats. This is also true for tūī in the Waikato, since only 3 of the 11 tūī nests found in this study successfully fledged young.

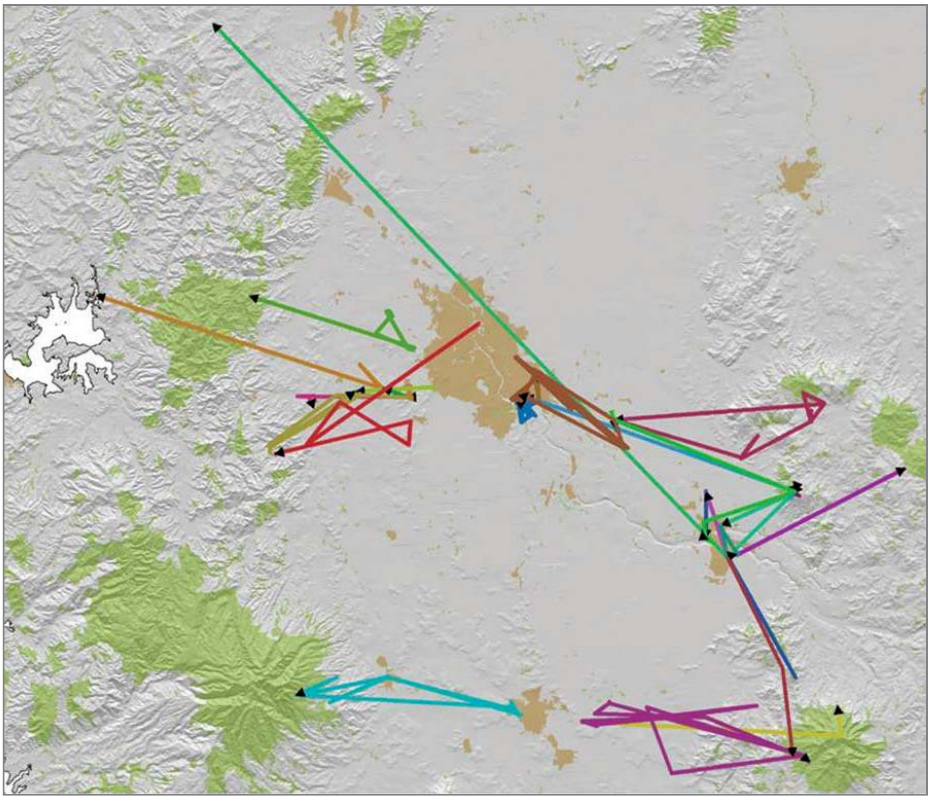
To improve tūī nesting success, the Waikato Regional Council (WRC) offered to target two key pests – ship rats and possums – in the forests where radio-tracked tūī went to breed. In 2007 WRC launched Project Halo in which these pests were managed to very low levels with various regimes of best-practice toxin application, including 1080, anticoagulants and others. Pests were successfully targeted in a pulsed regime of 3 years of toxic baiting followed by 2 years of no baiting.

Biennial counts in August of bird species and numbers in urban Hamilton by John's team (in partnership with the Hamilton City Council) since 2004 showed that the proportion of count stations with tūī in parks and other green areas of the city increased from around 6% to 23% between 2004 and 2010. This was undoubtedly due to WRC's pest control.

In December 2007, for the first time in living memory, tūī nested in Hamilton at the Hamilton Gardens. One nest in a macrocarpa was unsuccessful but a nest in bamboo successfully fledged chicks. Observations in 2011–2012 of tūī chicks and fledglings in Hamilton, combined with the sustained summer presence of tūī in parts of the city that had none in previous years, suggest that the number of tūī nesting (rather than just visiting) has recently increased greatly. Better data on this will be obtained when counts resume in November 2012.

The future focus of this management and research will be on protecting tūī and other birds nesting in the City with predator control similar to that undertaken in surrounding forests. John and his team

*John Innes releasing a tūī equipped with coloured leg-bands and a transmitter glued to its tail at Cambridge.*



*Spring movements of Waikato tūī as revealed by radio transmitters, 2004-07. Birds spent winters in urban areas like Hamilton (centre, brown), then returned to native forests to nest.*

will also explore whether the locally rarer bellbirds (korimako) and kererū are also increasing.

This research is funded by the Waikato Regional Council, Hamilton City Council and the Ministry of Science and Innovation (Programme CO9X0503).

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# Mokomoko **dryland sanctuary**


Grant Norbury

*An alert adult Otago skink.*

In 2005, the Central Otago Ecological Trust was established to restore lizard communities and the indigenous dryland habitats in which they once thrived. The Trust works near Alexandra, and is restoring a critically-endangered, strikingly-marked, flagship species, the Otago skink. Otago skinks have been locally extinct in the Alexandra basin for 40 years. They are now relegated to the western and eastern extremities of their former range and are extinct over 90% of it.

The Trust, which is chaired by Grant Norbury, recently completed a proof-of-concept experiment that demonstrated captive-bred Otago skinks will persist when released into an area free of introduced predators. In November 2009, 12 skinks were released into a 0.3 ha fenced sanctuary, and another 16 skinks were released there last December. Three of the latter group were progeny of wild skinks. This marks the beginning of the Trusts' out-breeding programme to improve the genetic composition of the population. Three baby skinks were seen in February 2011, and another 4 baby skinks were seen last February, demonstrating recruitment into the population. Annual survival is about 80%, which is enough to hold the population steady. This is an acceptable survival rate given the small size of the sanctuary, the small founder population, and the fact that most of the skinks are bred in captivity. The Trust believes the survival rate will improve when, later this year, the fence is expanded to protect 14 ha of lizard habitat and a larger number of progeny of wild-born lizards are released. In the next few years other species like grand skinks and jewelled geckos will be included in the programme.

The Department of Conservation's (DOC) lizard conservation work at Macraes Flat in Otago suggests that, for grand and Otago skinks, it may not be necessary to exclude mice from such sanctuaries because skink numbers recover in the presence of mice. Every predator-proof fence in New Zealand struggles to exclude mice. Indeed, the Trust recently discovered mice inside its fence for the first time in 2 years. The Trust has therefore been working with Tim Whittaker (DOC, Alexandra) to design a cheaper fence that will not exclude mice. Given that a mouse was seen recently attacking an adult Otago skink inside the fence, the Trust is deliberating on whether or not to exclude mice from the new 14-ha site. In 2 years, the Trust will consider introducing grand skinks.

This project is as much about people as it is about lizards. A number of volunteers and agencies are involved. Regular field days are held to restore habitat for lizards by removing invasive weeds and planting indigenous species that favour lizards. People enjoy searching for and photographing the Otago skinks, which can be individually identified by their unique golden markings. A variety of groups help out, such as school students, ecotour groups, scientists, Forest & Bird, University of the Third Age, district councils, and DOC.

DOC is a major collaborator in this project and provides tremendous support for the Trust. The Alexandra Museum has a


Grant Norbury

*Looking across to the experimental predator-proof fence where captive-bred Otago skinks have been thriving.*


TV1

*DOC staff and local community members after releasing 16 Otago skinks inside the predator-proof fence.*


*Both adults and children alike are fascinated by New Zealand's endemic lizards, shown here during one of the Trust's field days.*

live display of Otago skinks and weekly feeding times at the Museum attract good crowds. This promotes lizard conservation, which now appears regularly in local newspapers and school curricula, and on radio and television. In addition to materials donated by businesses and cash donations by generous benefactors, the Trust has received grants from the Central Lakes Trust, the Otago Community Trust, DOC, Worldwide Fund for Nature, Transpower, and the Lotteries Commission.

The Trust has also received three awards in recognition of its work: regional winner of TrustPower's Heritage and Environment Community Award; supreme award at the TrustPower Central Otago District Community Awards; and DOC's Otago Conservation Award.

This work is summarised by **Grant Norbury**.
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# New Zealand *Garden Bird Survey*

New Zealand has a number of native bird species that are either resident in domestic gardens year round or visit them in winter. Most (e.g. tūī, bellbird (korimako), and kererū) are not currently of conservation concern, but it is not known whether their populations are stable, increasing or decreasing. If they are decreasing, they could be of concern in the future. Monitoring the population trends of bird species nationally is an enormous task, but one that is possible with the public's help.

The New Zealand Garden Bird Survey, organised by Eric Spurr, is now in its sixth year. Volunteers spend one hour in midwinter observing birds in their home gardens, recording the largest number of individuals of each species seen or heard at any one time.

The two most numerous species counted to date have been the house sparrow and silvereye (*Table, Fig.*). However, counts vary between regions (*Table*). For example, house sparrow counts have been higher in Northland and Auckland than in Canterbury, Otago and Southland, while silvereye counts have been higher in these southern South Island regions than in the two northern North Island regions.

Counts of house sparrows increased over the first 4 years of the survey (2007 to 2010) then declined slightly in 2011 (*Fig.*). The survey could not determine the causes of these changes, but the increase from 2007 to 2010 may have been recovery from an outbreak of salmonellosis in 2000, which caused major mortality in house sparrow populations in many parts of the country.

Silvereye counts declined from 2007 to 2009, increased markedly in 2010, and then declined markedly in 2011 (*Fig.*). Again, the survey could not determine the causes of these changes, but circumstantial evidence suggests the 2008–2009 decline was at least partly caused by an outbreak of avian pox, and the 2011 decline by a mild winter prior to the count. This latter may seem counter-intuitive but the lack of snow and frosts may have meant that silvereyes in forests had no need to move into domestic gardens in search of food.

Apart from geographic region, several other factors influenced the number of birds counted in gardens, including whether the garden was urban or rural, and whether supplementary food was provided for birds. More species, and more individuals of most species, were counted in rural than in urban gardens. This was probably because rural gardens are larger and more diverse than urban gardens. However, more house sparrows, silvereyes and greenfinches were counted in urban than in rural gardens, probably as a consequence of supplementary feeding which occurred more often in urban than in rural gardens.

Gardens in which supplementary food (e.g. bread, fat, fruit, seeds, sugar-water) was provided had higher counts of some species (e.g. house sparrow, silvereye, starling, chaffinch, bellbird and greenfinch) than gardens without supplementary food. This is not surprising, because these species are attracted to the food provided. However, gardens with supplementary food had lower counts of other species, such as goldfinch, fantail and grey warbler. Goldfinch may have been supplanted at bird feeders by the bigger, more aggressive greenfinch, and the insectivorous fantail and grey warbler may have avoided gardens with supplementary food because the local invertebrate populations had been depleted by the large numbers of other species present (e.g. silvereyes).

Eric notes that the gardens surveyed are not randomly selected so the results apply only to the gardens of survey participants. Nevertheless, the survey has the potential to alert authorities to changes in garden bird populations, and to provide circumstantial evidence for the success (or otherwise) of management actions, particularly mammalian pest control. Many contributors to the survey commented on how the number of birds in their gardens had increased since local authorities had undertaken pest control in nearby forest reserves.

This year's survey is planned for 30 June – 8 July. Anybody able to identify birds in their garden can take part. Details will be placed on the Garden Bird Survey website close to the time of the survey: www.landcareresearch.co.nz/research/biocons/gardenbird

This work was supported by Forest and Bird, New Zealand Ornithological Society, and Topflite bird foods.

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**Table.** *Average maximum number of birds counted at any one time per garden for 22 species in the four major regions in 2011. The national average was calculated from all regional averages weighted by the proportion of all households in each region.*

| Species | Auckland | Wellington | Canterbury | Otago | National average |
|---|---|---|---|---|---|
| House sparrow | 13.2 | 14.1 | 10.4 | 9.3 | 13.0 |
| Silvereye | 3.5 | 4.1 | 9.0 | 9.2 | 5.5 |
| Starling | 1.3 | 3.1 | 3.5 | 2.6 | 2.5 |
| Blackbird | 2.1 | 2.7 | 2.4 | 2.1 | 2.4 |
| Myna | 3.0 | 0.01 | 0 | 0 | 1.7 |
| Tūī | 1.4 | 1.5 | 0.04 | 1.3 | 1.3 |
| Fantail | 0.8 | 1.0 | 0.9 | 0.8 | 1.1 |
| Chaffinch | 0.5 | 1.5 | 0.9 | 0.9 | 0.9 |
| Song thrush | 0.7 | 0.6 | 0.6 | 0.5 | 0.7 |
| Goldfinch | 0.5 | 0.6 | 0.6 | 0.6 | 0.7 |
| Greenfinch | 0.4 | 0.6 | 1.4 | 1.4 | 0.7 |
| Rock pigeon | 1.0 | 0.2 | 0.6 | 0.3 | 0.5 |
| Black-backed gull | 0.5 | 0.7 | 0.7 | 0.9 | 0.5 |
| Welcome swallow | 0.4 | 0.2 | 0.3 | 0.6 | 0.4 |
| Magpie | 0.2 | 0.2 | 0.7 | 0.3 | 0.4 |
| Yellowhammer | 0.2 | 0.9 | 0.4 | 0.2 | 0.4 |
| Bellbird | 0.02 | 0.1 | 0.6 | 1.6 | 0.4 |
| Red-billed gull | 0.5 | 0.2 | 0.3 | 0.7 | 0.4 |
| Eastern rosella | 0.6 | 0.2 | 0 | 0.1 | 0.3 |
| Grey warbler | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 |
| Dunnock | 0.03 | 0.2 | 0.7 | 1.2 | 0.3 |
| Kererū | 0.3 | 0.2 | 0.2 | 0.4 | 0.3 |

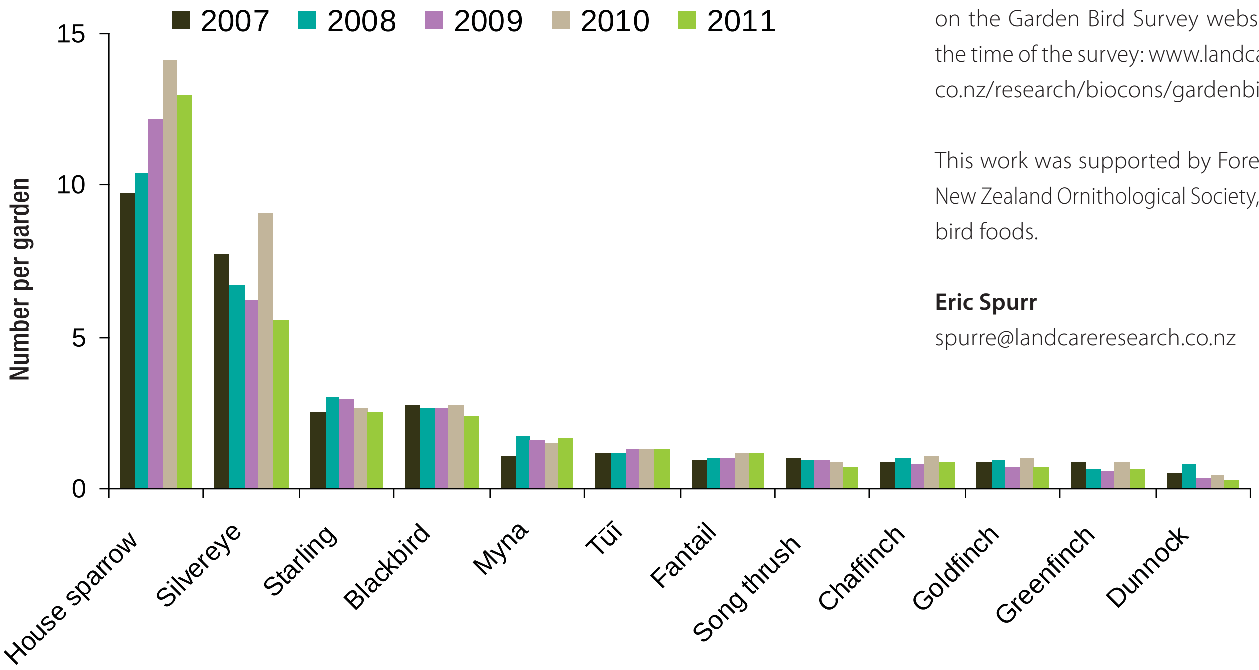

**Fig.** *Average counts of the 12 species that have occurred in the top 10 in one or more years, 2007–2011 (calculated from regional average counts weighted by regional proportions of all households).*

# *Data collection and use* by community-based pest managers

*Controlling rats increases the survival of native bird populations. Here, two ship rats are predating eggs from a fantail's nest.*

Why do volunteer pest controllers keep records? Apart from the satisfaction of documenting their sustained effort, the most likely reason is to demonstrate to themselves and others that they have made a difference in suppressing pests and reducing the damage they cause.

Roger Pech and his colleagues report that most pest controllers record either the number of pest animals killed or the amount of resources used to kill them. Some pests are killed by trapping or shooting, which provide direct counts of animals removed. Other techniques, such as poisoning, do not, so that any suppression of pest populations has to be inferred, e.g. from the amount of bait removed from bait stations. With either the direct or indirect method, it is essential to record 'zeros' (no kills or no bait taken) to track periods of low pest abundance. It is also necessary to record the total effort put into pest control because this will influence the kill rate. Then the 'catch per unit effort' (CPUE), which is the ratio of the catch (number of kills or amount of bait removed) to the control effort (number of traps or number of bait stations, multiplied by the number of days the devices are set), can be used as an index of the size of the pest population. When pests are more abundant, more animals are likely to be removed for a particular level of effort, i.e. CPUE is higher.

Invariably some individual pests are difficult to trap or avoid bait stations. Then the problem with CPUE as a measure of pest abundance is that it provides no information about the part of the pest population that is not trappable or is bait-shy. Ideally, pest populations should be monitored using a technique different to the control method. For example, rodents can be measured using tracking tunnels (tubes lined with inked paper to record animal tracks), and larger pests can be monitored using spotlight counts or movement-activated cameras. Measures such as CPUE or percentage of tracking tunnels showing animal activity provide an index of pest abundance but not an estimate of population size. Often it is not necessary to know exactly how many pests are present in an area: an index of abundance will show whether the pest population is increasing, static, or decreasing (preferably to extinction).

Usually it is easier to measure changes in pest abundance than it is to measure the benefits from controlling them. However, an ability to demonstrate that pest damage has been reduced is essential because gaining benefit (e.g. in increased survival of native birds) is the primary motivation of pest control and, ethically, is one criterion to justify killing pest animals. Measures of conservation benefit typically include counts of bird species recorded per unit time, number of lizards under artificial covers, or number of wētā per artificial gallery ('motel'). As with CPUE, it is essential to record the total effort for each recording session (e.g. number of 5-minute bird counts or number of wētā motels).

What information can be gleaned by pest managers from records such as CPUE and bird counts? Usually the data are plotted as a time-series. For example, figure 1 shows that CPUE for stoats and weasels at Whangarei Heads dropped substantially immediately after trapping commenced (www.backyardkiwi.org.nz) and has been held at consistently low levels since then. Similar graphs for other species may not show similar patterns. Roger expects species such as rats and mice would show much larger fluctuations between years because they can be affected more rapidly by favourable and unfavourable years. Records of the benefits of pest control also can be plotted as time-series. Figure 2 shows a steady increase in the number of kiwi calls per hour in the pest control area at Whangarei Heads.

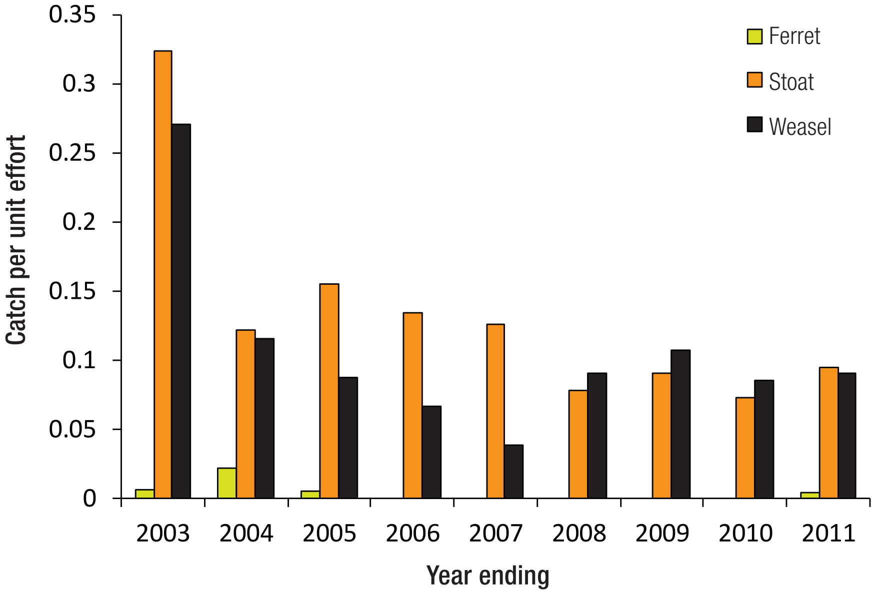

**Fig. 1** *Annual capture rates of invasive mustelids at Whangarei Heads from 2003 to 2011. (Redrawn from Glen et al. Conservation Evidence 9: 22–27).*

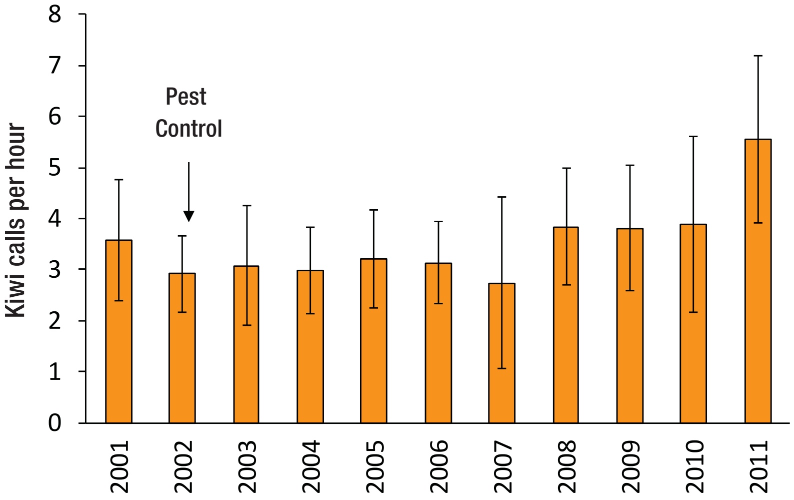

**Fig.2** *Mean kiwi abundance (with 95% confidence intervals) as indexed by hourly call rates at 12 listening stations on Whangarei Heads. (Redrawn from Glen et al. [see Fig 1].)*

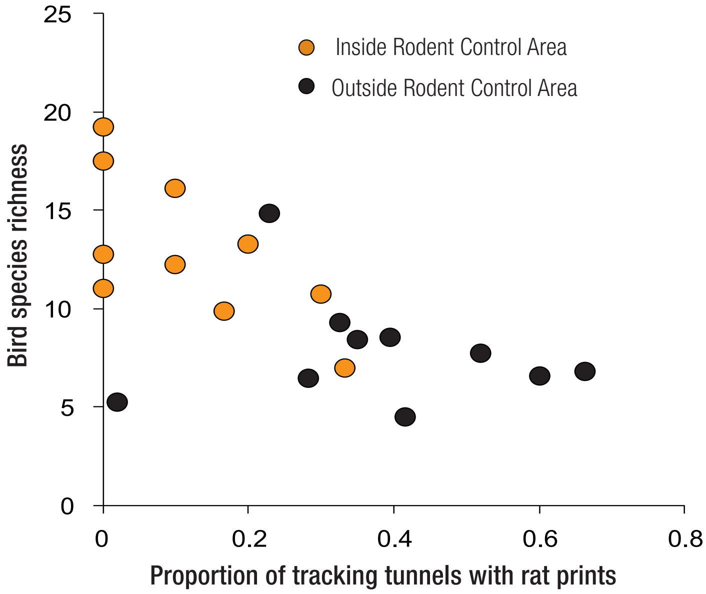

**Fig. 3** *Number of bird species and an index of rat abundance recorded at each monitoring session over 4 years by the Bluff Hill/Motupōhue Environment Trust in controlled and uncontrolled areas at Bluff Hill, Southland.*

Graphs such as figures 1 and 2 provide some encouragement that a pest control programme is reducing pest numbers and producing real benefits for conservation. Simple re-plotting of the data can provide an insight into how much control effort is needed to be beneficial. Figure 3 shows data on rat abundance and bird species richness collected on Bluff Hill by the Bluff Hill/Motupōhue Environment Trust. The percentage of tracking tunnels with prints of rats is used to index rat abundance, and the number of bird species ('species richness') recorded for each monitoring session is the measure of conservation benefit. Figure 3 shows that few bird species are recorded when the index of rat abundance is above approximately 0.3. As rats are reduced below this level, there is a progressive increase in the number of bird species present, although even at low rat abundance there is still some variability in the bird species count. Figure 3 is an example of a 'damage-density' relationship: it provides an indication of how much the density of pests needs to be reduced in order to achieve measurable benefits. Graphs like this are useful for setting a target for pest control. In a similar way, data on the costs of control and monitoring, when plotted against indices of pest abundance or conservation benefit, can show how much needs to be spent to achieve effective control of pests and a desirable conservation outcome.

This work was funded by the Ministry for Science and Innovation (Programme CO9X0909) and MSI core funding to Landcare Research ('Managing Invasive Weeds, Pests and Diseases').

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# Monitoring invertebrates in community-led sanctuaries

With the rapid increase in community-led conservation projects trying to reduce mammal pests to zero or near-zero densities, there are many more opportunities to investigate how the native invertebrate fauna responds to pest control.

Over the past decade, Corinne Watts and colleagues have monitored invertebrates in two fenced sanctuaries – Maungatautari and Karori (Zealandia). The response of wētā populations to the eradication of mammal pests within the southern exclosure on Maungatautari Ecological Island was monitored using pitfall traps in combination with footprint tracking tunnels. Within two years of mammals being eradicated, wētā captures (*Fig. 1*), wētā tracking rates (*Fig. 2*), and the incidence of wētā footprints per tracking card dramatically increased. The mean number of adult Auckland tree wētā per trap increased 12-fold after mammal eradication and 52-fold for other wētā. This may simply reflect increases in wētā abundance following mammal eradication or it may reflect behavioural changes, or be caused by a combination of both.

Since sampling began in 1998, the ground-dwelling beetle community within Karori Sanctuary has shown no change in abundance, species richness, size distribution and trophic distribution: the beetle fauna was the same as that in the experimental control site at nearby Otari-Wilton's Bush. However, beetle community ordination analyses (a process of grouping like species) indicate that its composition changed after most mammal species were eradicated from Karori Sanctuary. Periodic incursions of mice into the Sanctuary and the high number of ground feeding insectivorous birds (including translocated weka, tīeke, North Island robin and kiwi), may account for the lack of change in beetle densities. There appear to be species which are beetle 'winners and losers'. These probably arise from the different feeding strategies and changes in predation pressures from introduced mammals, compared to the strategies and pressures when only mice and native birds are present.

There are now 62 community-led conservation projects on or near the New Zealand mainland, and the managers of most of them wish to introduce native birds and reptiles as soon as possible, in part to attract visitors and funding. There is also a growing demand to have iconic insect species in some of these sanctuaries. For example, Cook Strait giant wētā were translocated to Karori Sanctuary in 2007 – the first time this species has occurred on the mainland for over 100 years. These wētā were intensively monitored using radio transmitters (*see photo*) and were found to travel significantly further than expected (males moved up to 294 m and females up to128 m between daytime refuges over the 4-week study). The project received considerable media attention, and many people visited Karori to see the wētā. Corrine believes that within community-led sanctuaries, projects that focus on threatened invertebrates should be encouraged, as they provide easy viewing of such species for the general public and increase awareness of invertebrate conservation in New Zealand.

*A female Cook Strait giant wētā with BD-2 transmitter attached (Holohil Systems Ltd., Canada).*

As more mammal-free conservation sanctuaries with pest-proof fences are established in New Zealand, understanding of how invertebrates respond to the removal of pest mammals will become clearer. Pest mammal predators may simply be replaced by native predators, especially birds (e.g. a significant decrease in invertebrate catch frequency and diversity was observed on Kapiti Island after rats were eradicated). Unfortunately, increases in the abundance and diversity of invertebrates do not always follow the eradication of mammals. Interpreting changes in the invertebrate community is difficult, complicated by both abiotic and biotic factors, and such interactions within ecosystems are poorly understood.

This work was funded by the Ministry of Science and Innovation through Landcare Research's Sustaining and Restoring Biodiversity core funded research programme.

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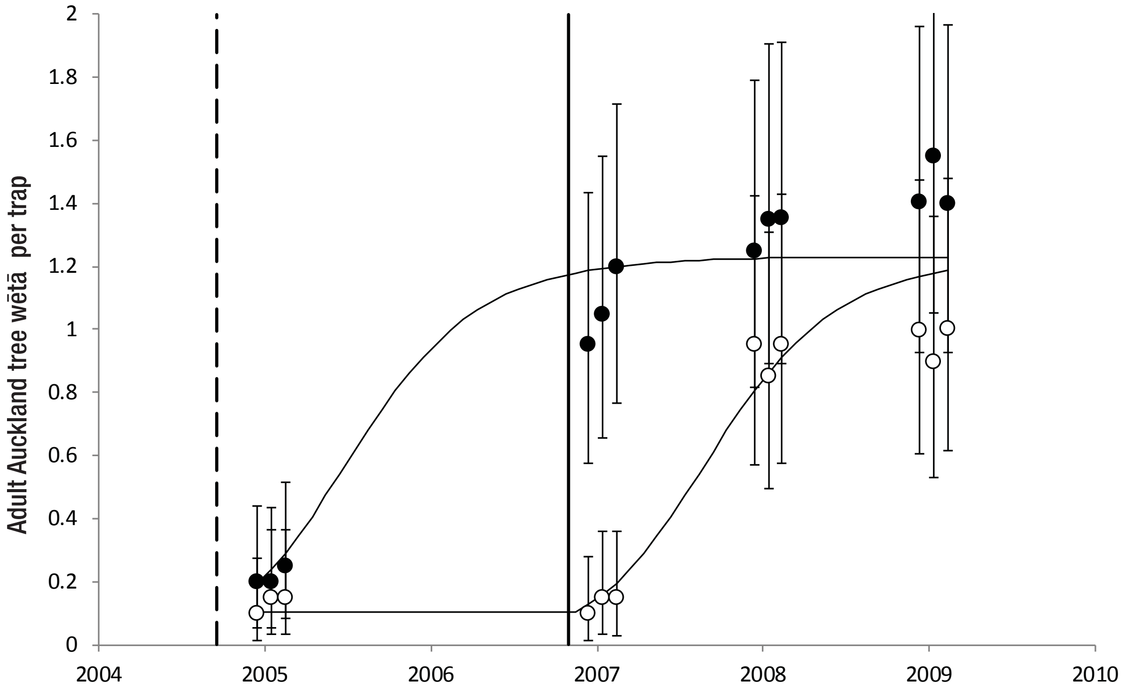

**Fig. 1** *Changes in pitfall capture rates of Auckland tree wētā after mammal eradication in the southern exclosure (black circles) and in the adjacent forest on Maungatautari (open circles). Time of mammal eradication is shown with the dashed vertical line for the southern exclosure and the solid vertical line for the adjacent forest.*

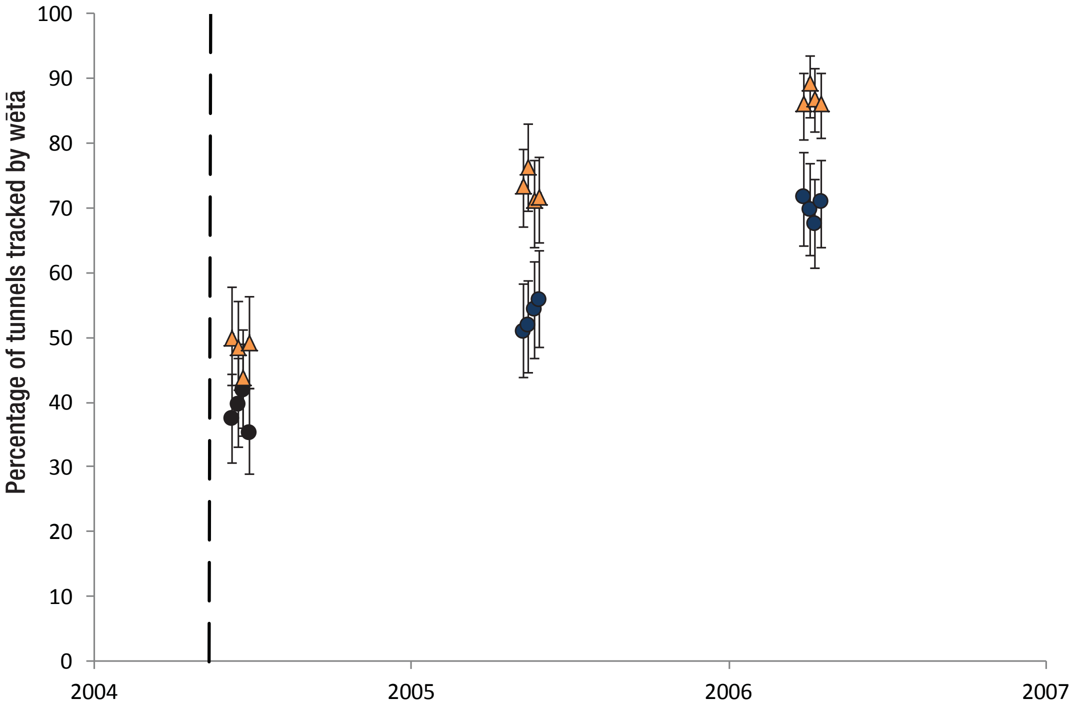

**Fig. 2** *Changes in tracking rates of wētā after mammal eradication in the southern exclosure on Maungatautari. Time of mammal eradication is shown with the dashed vertical line. Black circles indicate adult Auckland tree wētā and orange triangles indicate other wētā.*

# The re-establishment of a customary harvest of kuia (grey-faced petrels) by Ngāti Awa, Bay of Plenty


Caroline Thomson

*Adult kuia (grey-faced petrel) sitting outside its burrow on Moutohorā Island.*

Ngāti Awa from the Bay of Plenty have applied a rāhui (temporary ban) on the customary harvest of fledgling *kuia* (grey-faced petrel; called oi by neighbouring iwi) chicks on Moutohorā (Whale Island) since the late 1950s because of concerns over declining numbers.

Although the exact cause of the decline in kuia isn't known, rats and rabbits on the island are believed to have had such significant impacts that few chicks fledged between 1972 and 1977. Both pests were eradicated from Moutohorā by 1987, and subsequently the birds' breeding success increased. However, the rāhui has remained because of uncertainties about what constitutes a 'safe' level of harvest. The island is managed by *Te Tapatoru a Toi*, a committee consisting of representatives from Te Rūnanga o Ngāti Awa, Department of Conservation (DOC) and the general public.

Scientists from Maanaki Whenua, in collaboration with Te Rūnanga o Ngāti Awa are studying kuia to determine the population size, adult survival and breeding rates on Moutohorā, and what an annual customary harvest would mean for the population.

Phil Lyver says that the first goal was to estimate the current size of the kuia breeding population. The researchers carried out breeding burrow occupancy surveys during peak incubation and late chick-rearing periods over three breeding seasons and also investigated how burrow entrance densities varied with predictors such as soil, topography and vegetation. These data were analysed to estimate breeding success and the total number of breeding pairs on the island.

Researcher Amy Whitehead estimated burrow densities based on habitat characteristics. Of these burrows, 55% were occupied by breeding kuia and 46% of these pairs successfully hatched chicks. Burrow densities across the island were predicted most strongly by soil type, altitude, topography, vegetation canopy and ground cover. When these finer-scale habitat-linked variations in burrow density were scaled up using a GIS-based habitat model for the whole island, the data indicated that there are likely to be approximately 84,000 breeding pairs on the island (*Fig. 1*).

The second goal of the study was to determine what would be a safe customary harvest, and to compare the relative effects of a range of harvest rates and strategies. A mathematical population modelling approach was used to assess the impacts of removing from 5% to 60% of pre-fledging chicks each year.

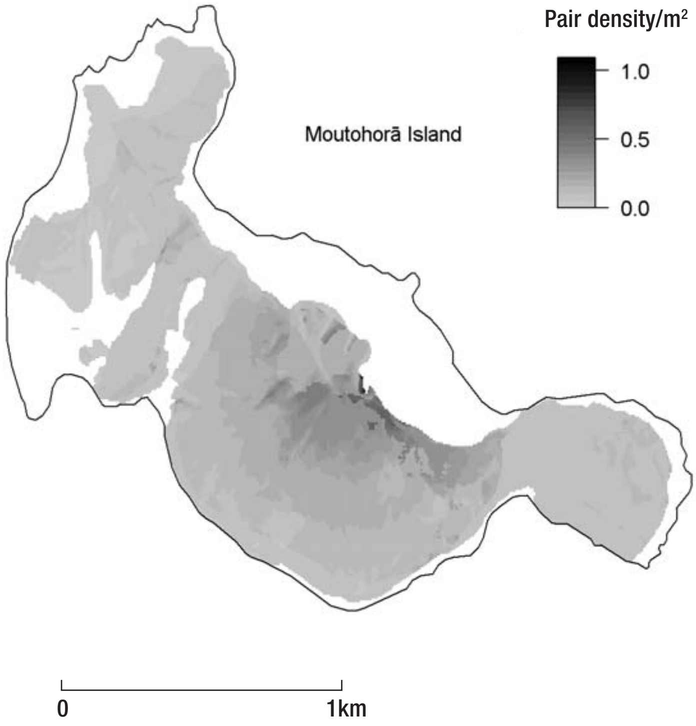

**Fig. 1** *The predicted density distribution of breeding pairs of kuia on Moutohorā. Darker colours indicate areas of higher pair density (per m²). Density predictions were not made for the white areas, which are unsuitable habitat and where few, if any, breeding pairs were thought to exist (i.e. steep cliffs, or rocky or sandy substrate).*

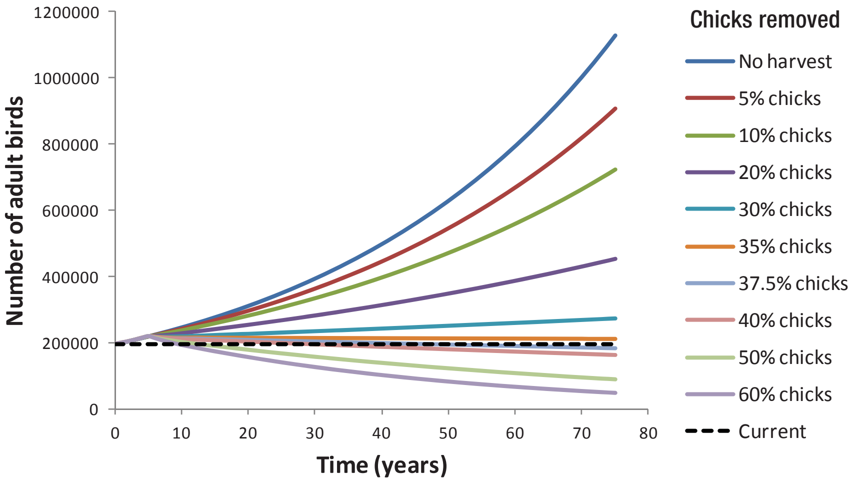

**Fig. 2** *The (modelled) relative impacts of potential customary harvest levels on the number of breeding kuia over 75 years on Moutohorā. The black dashed line indicates the current estimated number of adult birds in the population.*

Researcher Chris Jones says that without any harvesting, the kuia population probably grows at just over 2% per year, which is within the range of published estimates for long lived, slow-reproducing petrel species. With harvest intensities of up to 30% of chicks, the population is likely to continue growing, albeit at a reduced rate (*Fig. 2*).

The study found that, in general, harvesting a fixed proportion of chicks is 'safer' for sustaining the population than a fixed quota strategy, which is based on taking a set number of chicks each year. This is because with a proportional harvest strategy, if the population declines for some reason, the number of chicks harvested is reduced accordingly. However, in practical terms, a fixed quota system is easier to manage because it is easier to count the number of chicks harvested than to estimate the total population size every year (as would be required to guide a fixed proportion harvest).

Chris and Phil therefore proposed two options for managing the harvest of kuia chicks on Moutohorā:

- Set a very conservative fixed quota to limit the harvest to what would be sustainable under most circumstances outside of some unpredictable catastrophic impact on the breeding population.
- Develop an index of population size (such as a 'harvest rate' or burrow entrance counts) and use this to detect changes in the breeding population over time. This would then allow a proportional harvest strategy to be used.

This research was funded by Ministry of Science and Innovation through the C09X0509 (Mauriora ki nga Oi) and C09X0908 (Te Hiringa Tangata) grants.

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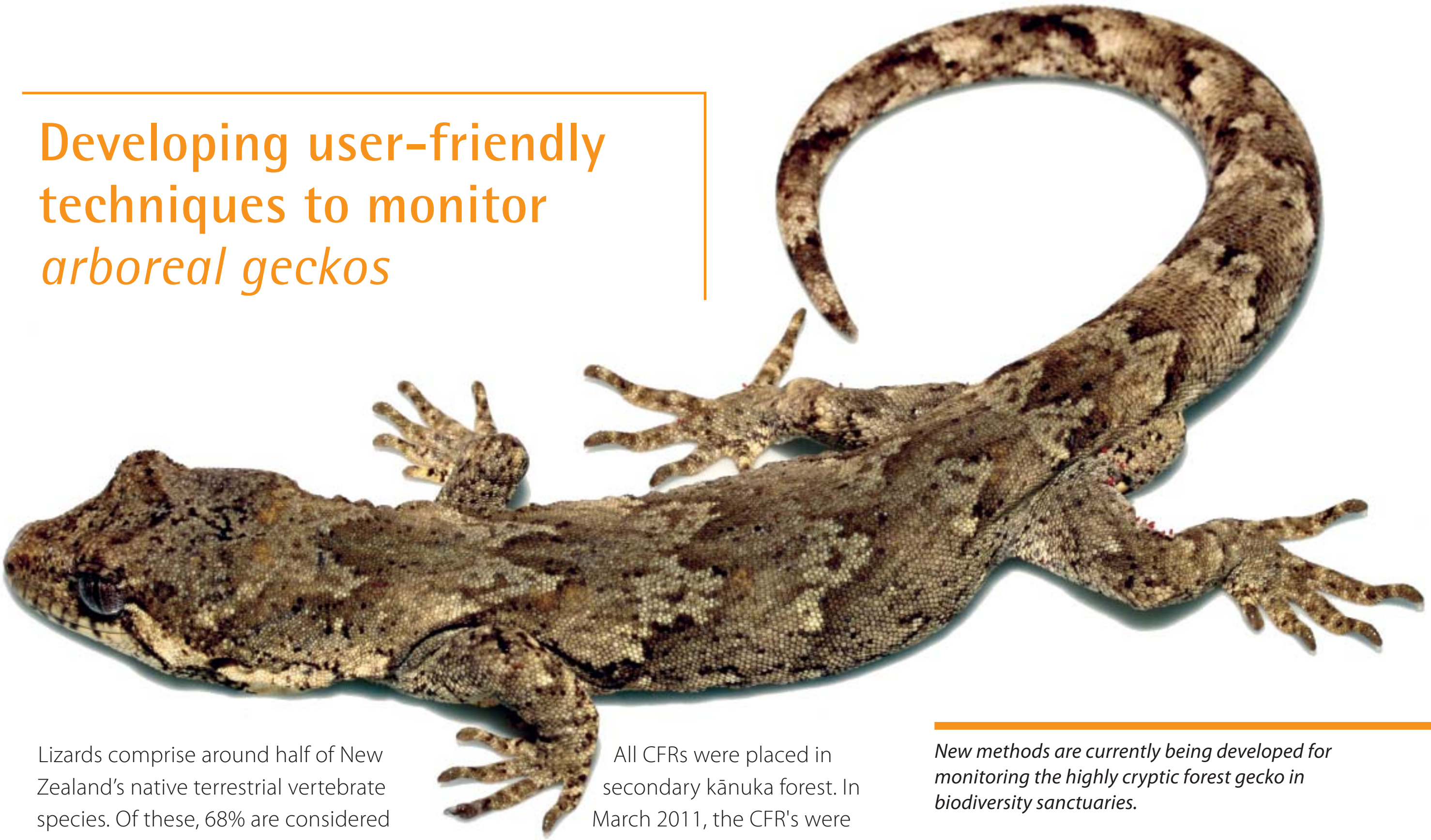
# Developing user-friendly techniques to monitor *arboreal geckos*


Trent Bell

*New methods are currently being developed for monitoring the highly cryptic forest gecko in biodiversity sanctuaries.*

Lizards comprise around half of New Zealand's native terrestrial vertebrate species. Of these, 68% are considered threatened or at risk, predominantly due to predation by introduced mammals and habitat loss. All invasive predatory mammals prey on lizards. Two lizard species have become extinct, and more have suffered extensive range contractions and fragmentations. Others remain widespread but persist at lowered densities on the mainland.

Biodiversity sanctuaries may be able to help reverse this decline. However, how arboreal and nocturnal geckos respond to pest control is poorly understood, largely because no user-friendly monitoring method currently exists for these geckos. Arboreal geckos are small, secretive, well-camouflaged inhabitants of complex habitats and are difficult to monitor.

To address these issues, a research programme has been set up:

- develop robust monitoring methods which can be used by sanctuary staff and volunteers for nocturnal arboreal geckos, and
- study the responses of these geckos to pest management in sanctuaries.

In winter 2010, 200 closed-cell foam retreats (CFRs) were placed on tree trunks inside a non-fenced sanctuary in which rodents and stoats are baited and trapped. Possums and weasels are absent and geckos persist in reasonable abundances. A further 200 CFRs were placed in reference areas (no pest control) surrounding the sanctuary.

All CFRs were placed in secondary kānuka forest. In March 2011, the CFR's were checked every second day over 12 days and the following data recorded: the number of geckos per CFR, their sex and snout-vent length (SVL), and weather covariates (temperature, relative humidity, cloud cover, and wind strength).

To analyse the data collected occupancy modeling of gecko presence/absence in CFR's was trialled as an indicator of abundance. Occupancy modeling is a relatively new technique that is well suited for monitoring rare or cryptic species. Because it infers detection probability from the detection history of each CFR, individual geckos need not be identified, and the sampling effort required is usually predictable and manageable.

Single-season models were run in the computer program PRESENCE 4.0 to estimate occupancy of sanctuary and reference CFRs. While estimated occupancy of reference CFRs was about half that of sanctuary CFRs, the difference was not statistically significant (*Fig. 1*). However, simulations based on the estimated occupancies and averaged detection probabilities indicated that the difference would have been significant had eight checks of reference and six checks of sanctuary CFRs been performed. Detection probability of geckos differed each day, between 4.2% and 45.9% for sanctuary CFRs and 4.5% to 40.6% for reference CFRs, highlighting the difficulty of detecting forest geckos.

For every female gecko found under CFRs, 2.2 males were found but this male:female ratio did not differ significantly between sanctuary and reference sites. Nor was there a significant difference in the sizes of geckos in sanctuary and reference CFRs, although noticeably more geckos with SVLs between 81 and 95 mm were found under sanctuary CFRs (*Fig. 2*). The sanctuary may have more large geckos due to improved survival rates following pest management.

Data collection for indices of animal occupancy or abundance is less resource-intensive than for estimation methods, but indices can be unreliable because they do not incorporate detection probability. Five occupancy and abundance indices were calculated from the gecko data for comparison against occupancy estimates (*Fig. 3*). Encouragingly, all indices performed similarly to the occupancy estimates (*Fig. 3*), suggesting that indices can provide a reasonable indication of gecko abundance.

The weather conditions affected CFR use by geckos. They were used by fewer geckos when it was warmer and more humid, but by more geckos when it was windier and cloudier. Therefore, it is best to check CFRs when it is cool, dry, overcast and breezy.

Occupancy estimation of CFR use proved to be an appropriate method for monitoring forest geckos. Using these models, it was estimated that twice as many geckos occupied sanctuary compared to non-managed CFRs. Detection probability was very similar between reference and sanctuary CFRs suggesting that geckos benefit from intensive pest control. When resources are limited, index estimates could also be used but validation against occupancy or mark-recapture estimates is advisable. The challenge now is to further develop the model using habitat covariates and apply this method to other study locations and species.

This research was funded by the Ministry for Science and Innovation (Programme COX0903J) and Auckland Council.

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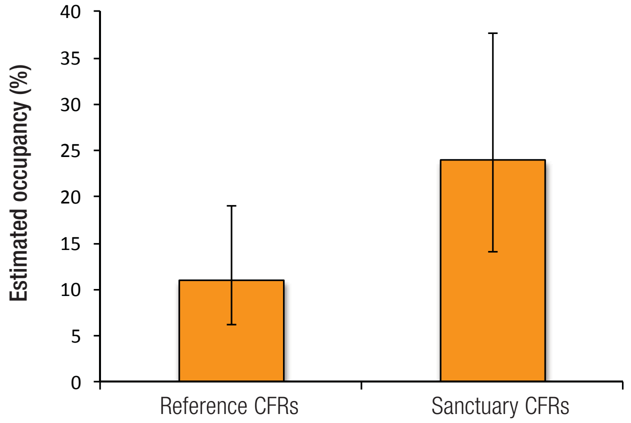

**Fig. 1** *Estimated occupancy ( ± 95% CI) of forest geckos under CFRs.*

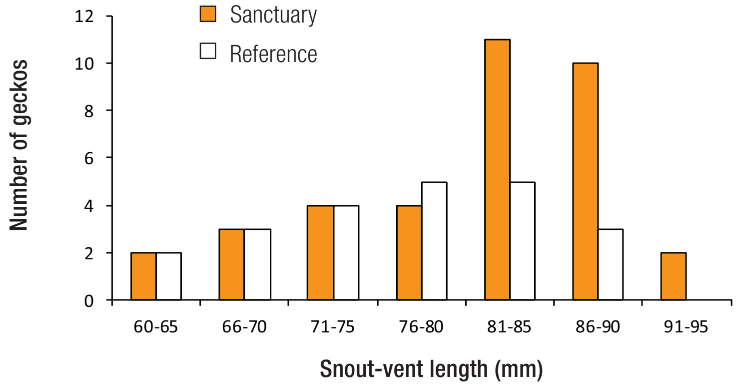

**Fig. 2** *Snout-vent lengths of forest geckos found underneath CFRs.*

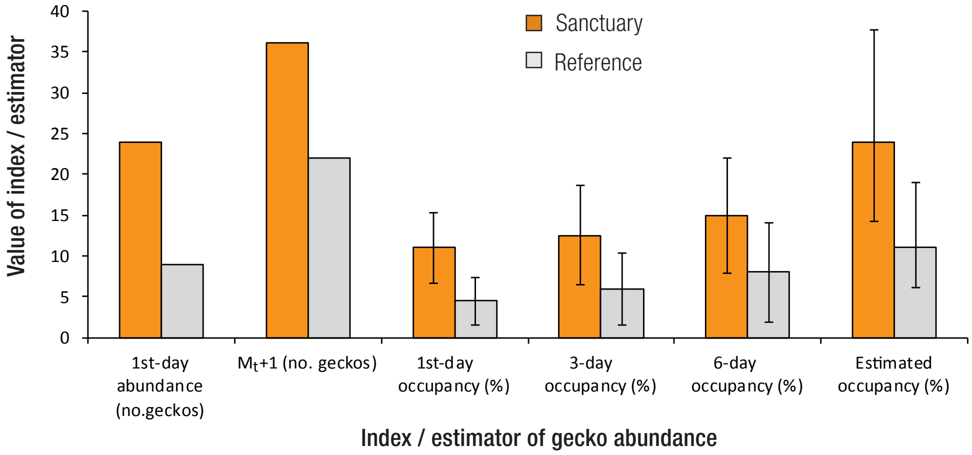

**Fig. 3** *Comparison of index methods for forest geckos underneath CFRs with estimated occupancy. 1st day abundance = number of geckos caught during the first check; $M_t$+1 = number of individual geckos caught over 6 checks; occupancy index (1 day, 3 day and 6 day) = cumulative percentage of CFRs occupied without estimating detection probabilities.*

# A new approach to biodiversity protection: local to landscape scale

Management of invasive pest species is rarely conducted at a landscape scale. More typically, pests are managed intensively in small areas that are deemed to be of high importance, with little or no management undertaken in the surrounding landscape. This helps some native species persist in places where invasive animals are controlled, and individuals may occasionally disperse between protected areas. Such disjunct small sub-populations are known as metapopulations.

Wendy Ruscoe and colleagues have been investigating how concepts from metapopulation theory can be used to improve management for native biodiversity. Conservation groups in New Zealand often focus on preserving, restoring and even re-introducing native species in relatively small areas. An obvious practical means of adopting metapopulation concepts is to use these small protected areas as 'source' areas for re-establishing species nearby, or as 'stepping stones' that help native species disperse across whole landscapes.

One example of such an approach is the 'Wide-scale Predator Control Programme' being undertaken in Maungaharuru-Tutira in Hawke's Bay. There, pests have been controlled at Boundary Stream Mainland Island (BSMI) for about 15 years. The Bellbird Bush and Opouahi Reserves and many smaller privately owned blocks also provide protected native habitat but are separated from the BSMI by unprotected agricultural land. Populations of native species including kiwi, kōkako, robins, and Hawke's Bay tree wētā persist in the BSMI but are under threat from invading animal pests. The threat of predation is especially intense when native animals move between these protected areas.

To better protect biodiversity in Maungaharuru-Tutira, the Robertson Foundation Aotearoa, Hawke's Bay Regional Council, Department of Conservation (DOC) and Landcare Research are applying metapopulation concepts to local pest control. Wendy and her colleagues will evaluate whether the level of predator control recently implemented is sufficient to allow a suite of native species (birds, reptiles and insects) to make more effective use of the network of native forest remnants within the pastoral landscape. The researchers will use both linear distance from the reserve and models of connectivity between patches to see whether forest fragments close to the mainland island show a quicker or more marked response to predator control (in terms of native species occupancy and abundance) than more isolated fragments.

So far, only one pre-control and one post-control monitoring session have been completed (*Table 1*). Pest monitoring is being undertaken using standard tracking tunnels. Native skinks, wētā and other invertebrates are also recorded using tracking tunnels and other specific devices. These devices include wētā houses and Artificial Cover Objects (ACO's) for invertebrates and skinks, and were checked for the first time in February 2012 (*Table 2*).

Bird song is being recorded using experimental devices produced by DOC. These were placed on the bush-pasture margin on a subset on lines in each of the two experimental areas. Bird song recordings were done in 8-hour blocks

*Al Glen checking an artificial cover object used for monitoring invertebrates and skinks.*

(05:30–13:30 and 17:30–01:30) over three days, and the recordings saved onto memory cards. (SD-Secure Digital Flash Memory Card.)

Although vertebrate pests are being controlled over a relatively large area, reinvasion is likely to occur. Samples of genetic material are being collected from the carcasses of cats and ferrets trapped within the predator control area to determine where the pests are coming from and hence allow for more targeted control in the future. This technique has been used by Landcare Research and the University of Auckland for mapping possum dispersal in Hawke's Bay.

The metapopulation approach means that both large and small sites, from small community-led initiatives to large-scale agency-funded pest control operations, have the potential to contribute to the survival of species throughout the landscape, with immigrants from neighbouring areas providing a 'rescue effect' whenever necessary. The resilience of this network of sites, or metapopulation, is much greater than that of a species confined to a single, isolated site.

This work is funded by the Ministry of Science and Innovation (Programme CO9X0909 'Invasive Mammal Impacts' Program within the 'Managing Invasive Weeds, Pests and Diseases Portfolio).

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**Table.1** *Species recorded by tracking tunnel lines in February 2012 (post-control).*

| Species (15 Lines) | Predator removal area (15 Lines) | Non-treatment area (14 Lines) |
|---|---|---|
| Stoat/weasel | 4 | 1 |
| Ferret | 0 | 0 |
| Cat | 1 | 3 |
| Rat | 4 | 3 |
| Possum | 6 | 0 |
| Hedgehog | 6 | 10 |
| Mouse | 7 | 5 |
| Wētā | 6 | 7 |
| Skink | 3 | 0 |

**Table 2.** *The number of lines on which each native species was found*

| Species | Predator removal area 15 Lines | | Non-treatment area 14 Lines | |
|---|---|---|---|---|
| | Wētā house | Lizard ACO | Wētā house | Lizard ACO |
| Skink | n/a | 1 | n/a | 0 |
| Tree wētā | 7 | 0 | 2 | 1 |
| Cave wētā | 9 | 0 | 8 | 0 |
| Spider | 9 | 6 | 10 | 6 |
| Cockroach | 7 | 7 | 2 | 5 |
| Other | 1 | 7 | 1 | 9 |


*Mike Perry*

*Hawke's Bay wētā in a wētā house*

## Some recent vertebrate-pest-related *publications*

**Fisher P, Nugent G, Morgan D, Warburton B, Cowan P, Duckworth J 2011.** Possum management using aerial 1080 – not new, definitely improved. *New Zealand Journal of Forestry 56:* 5–8.

**Glen AS, Hamilton T, McKenzie D, Ruscoe WA, Byrom AE 2012.** Kiwi *Apteryx mantelli* population recovery through community-led trapping of invasive non-native mammals in Northland, New Zealand. *Conservation Evidence 9:* 22–27.

**Jones CJ, Clifford H, Fletcher D, Cuming P, Lyver POB 2011.** Survival and age-at-first-return estimates for grey-faced petrels (*Pterodroma macroptera gouldi*) breeding on Mauao and Motuotau Island in the Bay of Plenty, New Zealand. *Notornis 58:* 71–80.

**MacLeod CJ, Tompkins DM, Drew KW, Pyke N 2011.** Does farm-scale habitat composition predict pest-bird numbers and distribution? *Wildlife Research 38*: 464–474.

**Monks A, Tompkins DM 2012.** Optimising bait-station delivery of fertility control agents to brushtail possum populations: field test of spatial model predictions. *Wildlife Research 39:* 62–69.

**Morriss GA, Warburton B, Cross ML, Nugent G 2011.** Hoarding behaviour by ship rats (*Rattus rattus*) in captivity and its relevance to the effectiveness of pest control operations. *European Journal of Wildlife Research 58*: 483–488.

**Nugent G 2011.** Maintenance, spillover and spillback transmission of bovine tuberculosis in multi-host wildlife complexes: A New Zealand case study. *Veterinary Microbiology 151:* 34–42.

**O'Brien DJ, Schmitt SM, Rudolph BA, Nugent G 2011.** Recent advances in the management of bovine tuberculosis in free-ranging wildlife. *Veterinary Microbiology 151:* 23–33.

**Orr-Walker T, Adams NJ, Roberts LG, Kemp JR, Spurr EB 2012.** Effectiveness of the bird repellents anthraquinone and D-pulegone on an endemic New Zealand parrot, the kea (*Nestor notabilis*). *Applied Animal Behaviour Science 137:* 80–85.

**Ritchie EG, Elmhagen B, Glen AS, Letnic M, Ludwig G, McDonald RA 2012**. Ecosystem restoration with teeth: what role for predators? *Trends in Ecology & Evolution 27:* 265–271.

**Spurr EB 2012.** 1080 impacts on invertebrate populations: a review and response to Benfield 2011. *New Zealand Journal of Forestry 56*: 46–47.

## ISLAND INVASIVES: ERADICATION AND MANAGEMENT


IUCN

Island Invasives:
Eradication and Management

Proceedings of the
International Conference on Island Invasives

Edited by C. R. Veitch, M. N. Clout, and D. R. Towns

SSC

Proceedings of the International Conference on Island Invasives

This 542 page volume includes 95 peer-reviewed papers from a conference held in Auckland in 2010 which was attended by 240 delegates from at least 20 countries. The conference covered aspects of invasive species relating to natural insular ecosystems. The diverse array of subject matter is divided into four sections in the book: the first deals with overviews and planned or attempted eradications; the second introduces new technologies and approaches to eradications, such as dealing with multiple invasive species; the third concentrates on the results and outcomes of eradications, especially responses by native species; and the final section covers the roles and approaches that involve people, policy and invasion prevention (biosecurity).

The major purposes of the conference and of publishing this proceedings were to encourage and assist the management of invasive species, particularly on islands. Managers and potential managers of invasive species will find that information in this book will assist their endeavours to conserve natural ecosystems.

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