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VERTEBRATE PEST RESEARCH

Working with Regional Councils

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Transferring vertebrate pest knowledge to regional councils using Envirolink

Flock of feral pigeons in flight over a Canterbury cropping farm.

Landcare Research and other research providers have a wealth of knowledge on managing vertebrate pests, but often that knowledge is either locked up in scientists' heads or hidden in hard-to-access published scientific papers, which may be difficult to understand. Staff of councils and the Ministry of Business, Innovation and Employment recognised that to improve access to such information there needed to be a funded mechanism to enable councils (especially the less financially well-off ones) to seek advice from research providers about improving environmental management.

In response, the Envirolink scheme was established in 2005, and it now provides $1.6 million (excluding GST) per year to enable eligible councils to contract Crown Research Institutes, universities and some not-for-profit research associations to adapt management tools to local needs and translate environmental science knowledge into practical advice. The scheme's objectives are to:

- improve science input into the environmental management activities of regional councils
- increase the engagement of regional councils with the environmental research, science and technology (RS&T) sector
- contribute to greater collective engagement between councils and the science system generally.

The scheme has four levels of funding: (1) small (up to $5000), (2) medium (up to $20 000), (3) large ($40 000) and (4) multi-year projects (up to $500 000).

Over the past 10 years Landcare Research scientists have contributed by providing advice on a range of vertebrate pest-related topics, and there have been 52 reports completed by researchers from Landcare Research and other agencies related to vertebrate pest management. However, from questions regularly asked it is clear that Envirolink and these reports are not as well known as they should be. Bruce Warburton and Phil Cowan have therefore compiled all the vertebrate pest reports (see Table), which can be easily accessed from the Envirolink web site (www.envirolink.govt.nz/Envirolink-reports/).

In compiling these documents Bruce and Phil grouped the reports into seven categories. This highlighted the fact that some councils have a particular interest in ungulates and bird pests – two groups that do not get much research attention at the national level. These animals can be significant regional pests, however, and might currently or in the future be included in a particular council's Regional Pest Management Plan (RPMP).

Having access to research knowledge through the Envirolink fund enables councils to get the most up-to-date information to help them make decisions about how best to manage a particular pest, including whether to use a particular management option, how best to monitor the outputs and outcomes of control operations, and, perhaps most importantly, whether to intervene or not.

The focus of the reports also gives an indication of changing pest problems; for example, ungulate management seems to be increasing in importance. Northland Regional Council has a particular interest in deer: their region has historically been deer free, but with continuing farm escapes, and perhaps illegal releases, they have an ongoing challenge to keep the region deer free. Some other regions also have a growing interest in ungulates, especially deer, whose numbers appear to be increasing nationally as a result of declining commercial venison recovery. Pigs also pose a challenge in terms of determining what impacts they have, what densities they might need to be reduced to in order to mitigate any damage,

Vertebrate pest related Envirolink funded reports, with identification number.

Improving ungulate management
128: Costs of deer in Northland
217: Economic and environmental risks from feral pigs in Northland
219: Pest control advice – feral pigs
291: Epro deer repellent for baits used in possum control
719: Preliminary results from Pukenui goat control analysis using Bayesian methods
1033: Wild ungulate impacts and management in lowland sites in Southland
1517: Options for updating large mammal distributions and relative abundance in New Zealand
1603: Strategic principles and tactical options for managing wild deer in Northland region
1636: A review of feral goats as a contributor to erosion and the benefits of goat control
Monitoring and measuring the outcomes of pest management
449: Tūī in town
15: Measuring impact of pest animals on indigenous biodiversity in Southland
723: Outcome monitoring of pest management
737: Measuring the benefits of possum control for pasture production
896: Linking regional pest management activities to outcomes – a template
494: Best practice operational and outcome monitoring for pest management – a review of existing council approaches and activity
Improving control of bird pests
253: Environmental issues associated with black swans – Aupouri, Northland
320: Faecal indicators in scats from black swans
218: Review of information relevant to the impacts of black swan in Northland
464: Review impacts to pasture production by black swans and Canada geese in Northland
738: Options for controlling feral pigeons in New Zealand
899: Future options for the management of rooks
971: Options for controlling peafowl in New Zealand
994: Priorities for rook research
1044: Looking for rooks: better surveillance and detection tools
1086: Could changes in rook population characteristics cause collapse of rookeries?
Improving rabbit control
503: Does conventional control of rabbits "re-set" the efficacy of RHD at sites where this biocontrol is failing?
89: Management of rabbits at sites where RHD has failed
1050: Potential to use generalized random stratified tessellation (GRST) survey design to monitor rabbits in Southland
1250: Non-target risks of 1080 and pindone for rabbit control
1435: Does control of introduced predators lead to greater abundance of rabbits?
Improving management of small mammal pests
140: Stoat traps for Landcare groups
468: An assessment of the potential threats to indigenous biodiversity posed by cats in urban environments
517: Southland Regional Council possum monitoring programme
519: Predator control to limit island reinvasion and restore the mainland, eastern Bay of Islands
632: A study design to assess the effectiveness of a modified trap-set for reducing by-catch of hedgehogs in stoat traps
720: Possum numbers in New Zealand
770: Wide-scale predator control in Hawke's Bay
912: Wide-scale predator control
New toxins and safer use of existing toxins
691: Trends in vertebrate pesticide use and development: alternatives to 1080 – what and when?
884: Environmental fate of brodifacoum in wildlife
1029: Environmental impacts of brodifacoum use: monitoring residues in wildlife
1035: PAPP for stoat and feral cat control
1294: Review of the toxicology and ecotoxicology of PAPP in relation to its use as a new predator control tool in New Zealand
1294: Predator control and PAPP – a brochure
1294: Toxicology and ecotoxicology of PAPP – a publication
1602: Trends in vertebrate pesticide use and the importance of a research pipeline for mammalian pest control in New Zealand
Improving strategic approaches to vertebrate pest management
402: NRC regional management strategy for vertebrate pests
467: Can the commercial possum fur industry help councils achieve their possum management goals?
512: Contribution of immigrant possums to population recovery and potential limiting role of fur harvesting
1416: The effect of possum fur harvest on reducing post-control possum recovery on adjacent land
1474: Strategic roadmap for biosecurity and biodiversity research
66: Optimising community pest control

and how best to monitor their number and impacts.

Measuring the benefits of pest control is always challenging, especially for regional councils, who either carry out control themselves or require others to do so to protect a variety of values, including conservation, production and ecosystem services. Research advice provided through Envirolink can help ensure councils' survey designs are statistically robust and nationally consistent, and as much as possible enable the results to be reported both regionally and nationally.

The bird species that have been the subject of reports (rooks, peafowl, feral pigeons, black swans, and Canada geese) span the range of management options, from eradication (e.g. rooks) to deciding whether there is a need to act (e.g. peafowl), and indicate the regional impacts that some species have in contrast to the nationally acknowledged pests such as possums, ship rats and stoats. Some bird species such as rooks and Canada geese can cause significant damage to crops and pasture, and because these species have little relevance to the Department of Conservation their management becomes the responsibility of councils if they are declared pests of regional importance under their RPMPs.

Rabbit management has always been a focus of regional councils, especially those that have rabbit-prone areas, and there is an ongoing appetite for information on how to address the waning effectiveness of rabbit haemorrhagic disease, options for regional monitoring, concern about poison residues, and the effects of predator control on rabbit populations.

Many regional councils implement their own small mammal control programmes targeting possums, stoats, feral cats and sometimes ship rats, or support such activities by community groups. To help with this, councils have sought a wide range of advice, including control methods, monitoring methods, and how control might be scaled up to a regional level. Because all councils use vertebrate toxic agents (VTAs) for pest control, questions continue to be raised about residues, humaneness and possible alternatives, with particular interest in poisons specific to predators (i.e. stoats, ferrets and feral cats).

At the higher level of strategy development, the councils have sought advice on research priorities (e.g. the Strategic Roadmap for Biosecurity and Biodiversity Research), how to optimise community pest control programmes, and the challenge of whether and how the possum fur industry might contribute to the improved regional management of possums, especially along habitat margins where commercial possum harvesting might reduce immigration.

From a researcher's perspective, the Envirolink fund has delivered on its three objectives by:

- improving the science input to the environmental management activities of regional councils
- increasing the engagement of regional councils with the environmental RS&T sector
- contributing to greater collective engagement between councils and the science system generally.

This engagement of councils with the R&D sector has been particularly effective with the development of the councils' research Roadmap and the ongoing important input they have into the Biological Heritage National Science Challenge.

The increasing scale and breadth of pests being included in regional council RPMPs is raising new challenges, particularly for measuring the benefits and assessing the risk of large-scale pest removal, and addressing the wide range of social and cultural views about such programmes. The Envirolink programme is well suited to help councils with advice on these and future issues in their attempts to minimise the impacts of vertebrate pests.

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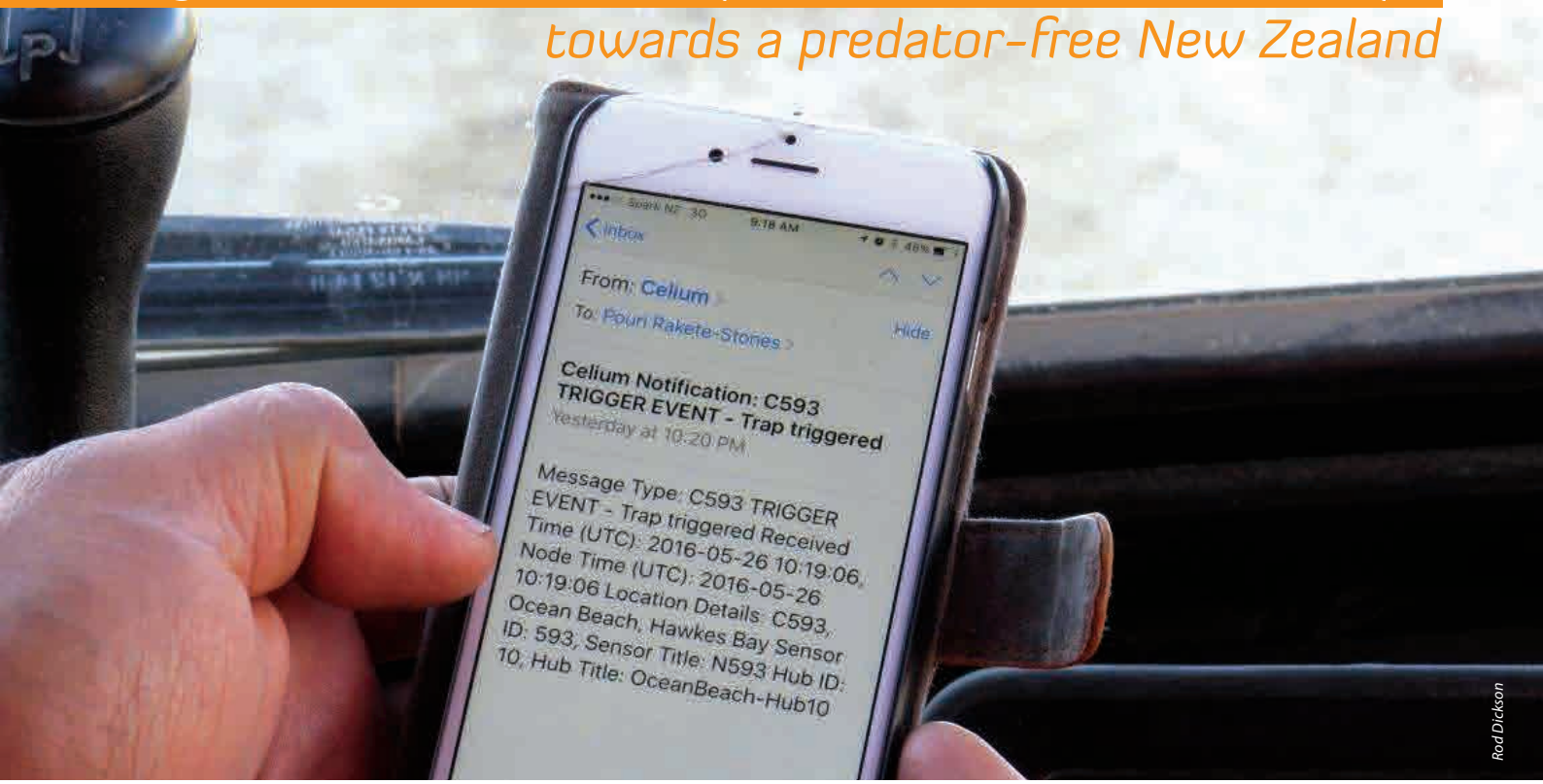
Regional-scale biodiversity restoration in Hawke's Bay:

towards a predator-free New Zealand



Rod Dickson

Cell phone display showing the data gathered from a triggered trap.

The Cape to City programme (http://capetocity.co.nz/) in Hawke's Bay is the largest wildlife restoration project across a primary production landscape in New Zealand, and the hope is that it will become a template for the large-scale restoration of New Zealand's unique biodiversity. This is especially important given New Zealand's recently announced goal of eradicating rats, possums and stoats by 2050.

Predator control and ecosystem restoration are usually confined to individual reserves and sanctuaries. Cape to City encompasses 26 000 ha of private and public land between Hastings and Cape Kidnappers, and extends south to include Waimarama and forest remnants at Kahuranaki. Most of it is productive farmland, and it involves 120 landholders. The aim is to allow native species to 'thrive where people live, work and play', and to see biodiversity, economic and social gains.

The work is a $6 million collaboration and joint funding venture between the Aotearoa Foundation ($2.3 million), Department of Conservation (DOC, $1.6 million), Hawke's Bay Regional Council (HBRC, $1.5 million) and Landcare Research ($0.7 million). Iwi and landowners are also key partners in the programme. Cape Sanctuary on the Cape Kidnappers peninsula is also spending $0.6 million annually on biodiversity protection.

An extensive research platform underpins most activities, providing an evidence-based approach to management. The results of the work are published in peer-reviewed literature, and the programme involves the training and development of students. The work builds on a pre-existing predator control programme nearby called Poutiri Ao ō Tāne on 8000 ha of productive land around the Boundary Stream Mainland Island (a public reserve), which showed that wildlife in scattered bush remnants can be protected if predator control is widespread. But in order to scale up to 26 000 ha, the costs of predator control must be ultra-low.

Smart strategy

Kill traps are being deployed across the Cape to City area to control feral cats, stoats, ferrets and hedgehogs. Rats are controlled only in selected areas or in particular habitats. Predator control costs are reduced through a wireless network of predator traps. Electronics attached to each trap send a signal to the cellular network and then on to the landholder's cell phone to indicate when and where traps are set off and need re-setting. Former Federated Farmers president Bruce Wills, who is on the Cape to City board, said time-efficient methods such as cell phone alerts when a trap is triggered mean farmers will support the programme.

Landcare Research scientists have modelled the optimum density of traps required to maximise captures. They have also modelled the effects of some landholders not participating in predator control. While almost all landholders are participating, a few are not. The modelling shows that placing additional traps on neighbouring properties can help offset the effects of the small number of non-participating farmers.

It is essential to know that trapping is successfully supressing predator numbers. However, monitoring the numbers of predators on such a large scale is challenging. Landcare Research is deploying motion-triggered cameras across the landscape in areas with and without predator control. This should provide sufficient data

to estimate residual predator densities and therefore trapping success.

Measuring up

Monitoring changes in native biodiversity is an essential component of the Cape to City programme. HBRC biosecurity advisor Rod Dickson said monitoring had shown that native lizard numbers at Poutiri Ao ō Tāne have 'gone through the roof' since pest control began compared to a similar area nearby without predator control.

The abundance of birds, lizards and invertebrates in the Cape to City pest control zone, and in a large, adjacent non-treatment area, is being measured using modified 5-minute bird counts, artificial refuges for lizards, tracking tunnels, wētā houses, tree wraps, and funnels that collect invertebrate faeces (frass) dropping from tree canopies. Additional research involves exploring the use of genetic techniques, called 'environmental DNA', for improving the ability to record the diversity of invertebrate species.

Wildlife monitoring is also taking place along the Maraetotara River where habitat restoration is combined with predator control. The Maraetotara Tree Trust, with support from HBRC and the DOC community fund, plant native species along this river system every year to restore habitat for wildlife.

The hope is that predator control will not only help the recovery of wildlife in the Cape to City area, but also native birds, such as robins, tomtits, pāteke (brown teal) and kākāriki that fly out of the Cape Sanctuary every year. Previously these emigrants stood little chance of survival outside the sanctuary in an environment full of predators. DOC is also translocating robins and tomtits to Cape to City, and pāteke and petrels to Poutiri Ao ō Tāne. The survival of these species is an important litmus test of the success of the predator control programme.

As a consequence of this control, Rod Dickson reports that tomtits and robins have started to turn up at Te Mata Peak, while Dave Carlton, DOC's Hawke's Bay operations manager, reports an increase in the number of lizards, kākā and invertebrates around Boundary Stream Mainland Island and suggests 'it's a bit of a window into what might happen with Cape to City.'

Economic and social benefits

Toxoplasmosis is a disease transmitted by feral cats that causes abortions in sheep, and lamb losses are estimated to cost the region $18 million per annum. The effect of cat control on toxoplasmosis levels in sheep is an important part of the research programme, and is being followed keenly by farmers.

The already successful possum control programme in the region will continue to reduce the risk of bovine TB to cattle and damage to pastures and crops. Landcare Research has completed trials to determine the optimal deployment of 'chewcards' across the landscape (see page 17 in this issue) to better identify where to target control efforts to mop up residual possums.

One of the main objectives of the programme is to involve and support the community in biodiversity protection. Landcare Research social scientists have conducted surveys of the general community and landholders to find out why people become interested in native biodiversity and what motivates them to get involved in protecting it. Changes in people's attitudes to biodiversity and levels of participation are being monitored throughout the programme and compared with areas outside Cape to City. Campbell Leckie, project chairperson, believes the heart of these projects is about people, with each of us having a role to play and making a difference for both our economy and our environment.

The Cape to City project team is also undertaking a biodiversity education programme for schools and educators designed to help students, their parents and teachers understand the value of what is present in the region.

In order for other agencies to emulate the successful components of this programme, Landcare Research is documenting the work as a case study by recording the opinions of the key individuals involved in the various projects within the overall programme.

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Building a community of practice:
sustainability monitoring and reporting

The New Zealand Sustainability Dashboard

The New Zealand Sustainability Dashboard[1] (NZSD) project aims to build a practical tool for sustainability assessment, auditing, reporting and learning. Catriona MacLeod teamed up with Kevin Collins (Collins Consulting Ltd) to identify opportunities for greater collaboration between the NZSD's researchers, its industry partners, and regional and central government. The purpose of this enhanced collaboration is to create a 'community of practice' to improve and harmonise the monitoring and reporting frameworks and systems being developed by all parties.

What is a community of practice?
"A group of people who share a concern for something they all actively do and who want to learn how to do it better through regular interactions."

Regional councils' interests and needs

Regional councils are heavily involved in regulating, monitoring and reporting on a large number of activities related to the NZSD. Kevin and Catriona surveyed councils to clarify what they need in terms of sustainability reporting and how the NZSD could be most helpful.

Regional councils were surveyed through the convenors of 20 special interest groups (SIGs), which are made up of council staff with a particular professional background, discipline or interest. Because the NZSD covers such a broad base, it is relevant to a number of the SIGs operating across the regional sector. The survey received 27 responses from 17 separate SIGs, as well as from some individual councils.

Although the NZSD was not well known among the councils, they still indicated a very high level of interest in what it is trying to do.

- Three-quarters of councils said data on the environmental, economic, social and cultural sustainability of primary industries would be extremely or very useful.
- Many councils wanted a harmonised sustainability assessment framework that could contribute to a national picture of sustainability.
- More than 80% of councils were interested in collaborating with the NZSD project.
- Almost all councils said they would share data with primary producers to help them improve the sustainability of their own operations.

The NZSD's four pillars (see Figure) are well aligned with the councils' primary interests. Agro-environmental integrity was ranked first or second by 96% of councils, economic resilience was ranked second or third by 72% of councils, social well-being was ranked third or fourth by 83% of councils, and good governance was ranked last by 52% of councils.

Two NZSD services stood out as highly useful to regional councils: 'standardised sustainability monitoring and reporting tools', at 59%, and a 'harmonised sustainability assessment framework to provide a national picture of sustainability', at 55%. This echoes a conclusion of a Living Standards Framework workshop, recently run by the Treasury, that end-users can be confused by the large number of sustainability frameworks available. There is an opportunity for the NZSD to reduce the confusion among end-users.

Lastly, the survey asked whether credible reporting on sustainability performance might reduce councils' need to adopt regulations. Responses were mixed, but most felt that it would have only a small impact on the need for regulations.

Overall, there was strong interest from regional councils in collaborating with the NZSD, not only to contribute to its development but also to use its products and services.

Building a community of practice

Regional and central government have invested considerable resources into

[1] See www.nzdashboard.org.nz/

Goals for New Zealand's production landscapes

SUSTAINABILITY - is a product of good governance that supports and maintains profitable enterprises while encouraging and protecting the environmental integrity of ecosystems and the social well-being of communities.

SUSTAINABILITY (Māori) - To maintain and enhance the mauri (life supporting capacity, vibrancy, and abundance) of ngā taonga katoa (all things valued and treasured). This definition of sustainability runs across all four pillars of sustainability, given that maintaining the mauri of something valued is likely to include the elements described in each of the four adjacent pillars.

GOOD GOVERNANCE	ECONOMIC RESILIENCE	AGRO-ENVIRONMENTAL INTEGRITY	SOCIAL WELL-BEING
Ensures sound decision-making and implementation	Sustains an economy through change and shocks.	Sustains natural capital, enhances natural heritage values and meets global environmental obligations	Ensures livelihood opportunities and respects social and cultural principles of all society

THE NEW ZEALAND SUSTAINABILITY DASHBOARD project wants a resilient and sustainable New Zealand that promotes good governance, social well-being and economic resilience both in the present and the future, while maintaining, if not enhancing, the environmental integrity of eco-systems. We will support this by co-creating - with primary industry partners - online, sustainability assessment, monitoring, reporting and learning tools that will empower New Zealand producers, processors and distributors of food, beverage, wood and fibre to meet their market, regulatory, business management requirements and societal expectations and contribute to New Zealand's resilience and sustainability.

The overarching goal and the four pillars of the NZSD framework.

improving monitoring and reporting practices. The NZSD believes that consciously fostering that kind of community of practice will help to maximise the value of that investment. The team's research found that:

- many projects sponsored by central or local government are communities of practice to some degree (e.g. the Land, Air, Water Aotearoa initiative[2] and the Environmental Monitoring and Reporting project) but were not specifically designed with community of practice outcomes in mind
- there is no single entity that captures the range of sustainability monitoring and reporting as well as the NZSD's four pillars
- refining the term 'sustainability framework' would make it clearer and more useful to end-users, because it currently encompasses a wide range of concepts, including frameworks, methodologies, indices, reporting frameworks, standards and certifications, guidance, principles and agreements[3]
- the NZSD is well placed strategically to engage more actively in the existing sustainability forums rather than initiating the creation of a new 'sustainability reporting' community of practice.

Next steps for the NZSD

There are a number of key actions to tackle based on this research.

- At the regional council level the NZSD is best known for its association with biodiversity monitoring. The relevance of the NZSD to high-profile issues such as soil status and water quality/yield needs to be promoted more widely.
- For the NZSD to collaborate more closely with regulators it is essential to reassure primary producers that such collaboration will also benefit the industries that provide the data.
- To expand the NZSD's impact beyond primary producers, the project should develop an engagement plan to connect with several governmental initiatives, including:
  - Land, Air, Water Aotearoa (regional councils and the Ministry for the Environment (MfE)
  - Environmental Monitoring and Reporting group (regional councils and MfE)
  - the Livings Standards Framework (Treasury)
  - regional council special interest groups
  - the Environmental Reporting Act (MfE and Statistics NZ).
- A workshop needs to be run that includes representatives from councils, government agencies and producers to refine the feedback received from the survey and to explore the reaction of primary industries.

This work is funded by New Zealand's Ministry of Business, Innovation and Employment as part of the New Zealand Sustainability Dashboard project (contract number AGRB1201).

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[2] See www.lawa.org.nz/
[3] See http://media.wix.com/ugd/ee198d_d5113dd03ea447a1bf57398e0e3aea2c.pdf

Impacts of mice in Waikato forests

Maungatautari Reserve in the central Waikato is the largest pest-free area in mainland New Zealand, with a 47 km pest-fence excluding pests from 3 300 ha of native forest. In 2008 all 13 species of local pest mammals except mice were eradicated from this wildlife sanctuary. Mice became extremely scarce for a while, but in February 2012 the Maungatautari Ecological Island Trust (MEIT) made the difficult decision to stop targeting them because of the high expense of mouse monitoring and removal in such a large area.

From 2011 to 2016 a diverse team of Landcare Research staff led by John Innes and Deb Wilson studied the density, behaviour and impacts of mice in and about Maungatautari Reserve, so that MEIT, Waikato Regional Council, Waipa District Council, the Department of Conservation and local iwi can assess the risks and benefits of their mouse policy.

Waipa District Council administers the reserve, and Waikato Regional Council has supported the mouse research with funding, over and above its general support for MEIT.

Mouse density in two study blocks

The research team studied the density of mice and their impacts on biodiversity in two adjacent forest blocks: one separately fenced, privately owned site (Q block), where mice reached 20–30 per hectare until they were eradicated in August 2013; and an adjacent part of the main reserve (M block), where mice were initially absent but have increased freely since 2012, a virtual 'treatment switch' between sites (Figure 1).

Mouse impacts on biodiversity

The researchers discovered that the main impact of mice was on ground-living invertebrates. There were about twice as many litter invertebrates (all kinds combined) in the block with no or few mice (Figure 2), including twice as many beetles, wētā and spiders, when counted and considered as separate individual groups.

Furthermore, on average, beetles and wētā were about half as large in the block with mice, showing that mice removed many larger individuals. One unexpected result was that there were also significantly fewer earthworms in the leaf litter and surface soil layers when mice were abundant. Mice are known from other studies to eat earthworms that feed on the surface of the soil at night, when mice are also active.

The researchers did not detect any effects of mice on seedlings, land snails or fungi. They showed that mice would eat small bird eggs artificially placed in used nests on

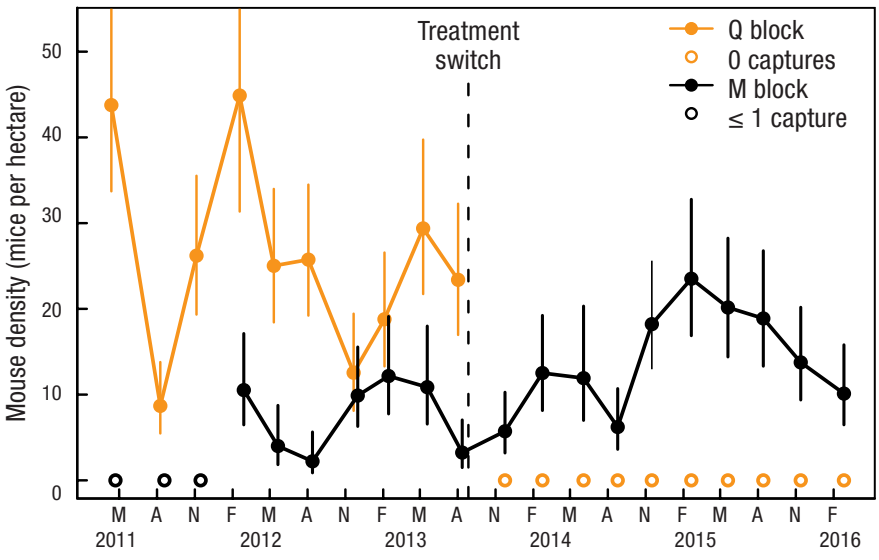

Figure 1. *Mouse density in the study blocks at Maungatautari, 2011–2016.*

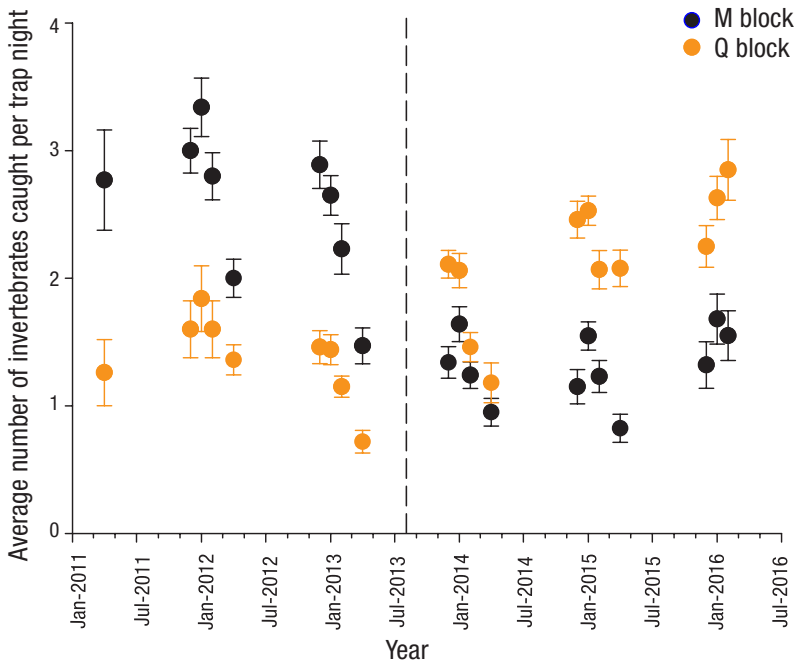

Figure 2. *Average number of litter invertebrates caught in Q and M blocks.*

the ground, but an attempted study of 'live' nests did not find enough of them to resolve whether mice will prey on eggs in these nests. Mice do climb trees, however. Across 20 sites in Maungatautari Reserve, mice were detected in 93% of chew-track devices at ground level, 35% of devices at shrub height (1.6 m above ground) and 17% of devices at subcanopy height (5 m). In a paired trial at nearby Te Tapui Reserve, where all pest mammals in the Waikato region are present, only one mouse was detected at one ground device, while ship rats and possums were found at all levels, including in the canopy (about 8 m).

So what?

The approximate halving of litter invertebrate numbers by mice shows clearly that mice are unhelpful for conservation. This predation reduces the food available for native ground-feeding insectivores such as kiwi. On the other hand, this impact is vastly less than that of the full suite of pest mammals, especially ship rats, stoats, possums and cats. Hedgehogs, in particular, will consume much larger numbers of invertebrates than mice, and even deer and goats are known to reduce litter invertebrates through their trampling.

Mice become very abundant when they are the only mammal in a wildlife sanctuary because they have no mammal predators or competitors. This also has some negative, non-biodiversity outcomes. First, mice may interfere with important monitoring devices set to detect other invading species (should they occur), like ship rats. Second, mice may burrow out of the sanctuary, creating tunnels under the fence that let worse predators like stoats and weasels back in. Third, visitors and volunteers are often unhappy to see mice in a sanctuary they have been told is 'pest-free'.

The researchers could conceive of only one reason why it may be *good* to have mice in a sanctuary: mice may in the short term distract larger predators, if any do manage to invade, from feeding on threatened species such as saddlebacks and tuatara. However, it is obviously important that such threatening invaders are rapidly removed.

This research adds to the complex body of knowledge that regional and district councils, wildlife sanctuary trusts and the Department of Conservation use to manage sanctuaries like Maungatautari. The research suggests that while mice are unhelpful for conservation, mice alone are definitely better than having any of the other pest mammals back at Maungatautari. The team hope that control tools will steadily improve, so that in the future mice can be eradicated from large, rugged forest reserves such as Maungatautari.

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Researchers developed this chew tag and tracking device that can be pulled up into the canopy to study mouse climbing.

Helping regional councils with strategic investment in research: *a roadmap for biodiversity and biosecurity*

Morgan Coleman

The science system in New Zealand is complex, with science capability housed in universities, Crown Research Institutes, government agencies, and numerous smaller consultancies and private contractors. The number of different cross-organisational collaborations can be confusing too: Centres of Research Excellence, National Science Challenges, Hubs … the list goes on. To add still further to the confusion, there is a plethora of potential funding mechanisms. Little wonder that, to the outside observer, New Zealand's science system can appear almost impenetrable.

Even for those looking to purchase or invest in research, things can be pretty confusing. As a consequence, in late 2013 the regional councils asked Andrea Byrom, from Landcare Research, and Matt Kavermann, an independent contractor, to help them take a broader view of the science system in order to help plan for longer-term needs in biodiversity and biosecurity research. The work was championed by Environment Southland, but was conducted on behalf of all New Zealand regional councils and unitary authorities.

The objectives of Andrea and Matt's work were to:

- complete a strategic scan of the science system to determine a set of high-level goals
- complete a critical review of key reports and legislation to help councils clarify research priorities
- workshop ideas with a subset of regional council bio-managers to help test, review and revise the information
- identify opportunities to leverage and speed the delivery of outcomes
- develop a strategic Roadmap for regional councils, with a priority list of councils' biosecurity and biodiversity research needs over a 10–20-year time frame.

Andrea and Matt interviewed regional councils' stakeholders and staff, reviewed relevant legislation, and investigated how other organisations were going about their own strategic planning in the biodiversity and biosecurity sectors in New Zealand.

Desired outcomes

Five high-level outcomes emerged:

1. Halt and reverse the decline of native biodiversity.
2. Reduce land-use and invasive-species impacts in terrestrial, freshwater and marine ecosystems.
3. Ensure the integrity of ecosystem services and natural capital.
4. Improve environmental outcomes through increased community awareness.
5. Anticipate and plan for future risks.

Research priorities to achieve the goals, and specific recommendations on pathways to increase uptake of research findings across the biosecurity and biodiversity sectors, were also identified.

Research priorities

The following are the recommended priority research areas:

1: Scaling up: landscapes and seascapes

The management of threats and responses across regional boundaries is required to achieve a national focus and determine how a network of interconnected ecosystems fits within a larger national picture. This priority brings a sharper focus to integrating site-based and landscape-scale management interventions.

2: Ecological monitoring and reporting

Monitoring is a fundamental part of activities for both biodiversity and biosecurity in order to evaluate management interventions, quantify ecosystem 'health' and ecosystem services, and determine the state and trend of exotic and native biota and habitats.

3: Surveillance and detection

Research needs under this priority are the development of best practice, and creating national protocols with up-to-date techniques that can be applied at regional and local scales. Tools and approaches need to be appropriate, affordable and practicable, and also coordinated and reported nationally.

4: Novel and improved tools, tactics and strategies for pest and weed control

This priority addresses the need for better tools and strategies to satisfy the demands of communities for a greater reduction of pest impacts on the environment and the economy.

5: Pathway analysis

Several drivers of global change have been linked to the emergence of new pests and diseases. Identifying, predicting and

mitigating potential routes of invasion are essential. Understanding invasion pathways would enable councils to take a proactive and nationally coordinated approach to biosecurity.

6: Data management
It was recognised that councils are not appropriate organisations to lead research initiatives on improved data management, but they have a keen interest in ensuring they are linked to such initiatives nationally to facilitate informed decisions.

7: Social science and citizen science
Better engagement of the public in biodiversity and biosecurity activities is regarded as a critical component of the current operating environment, with a growing awareness that the use of new tools and strategies for mitigating threats comes with a need for new social research methods, alongside building capacity for citizens to become more engaged in science.

8: Risk analysis and prioritisation
Prioritisation of risks and threats is needed, which requires earmarking resources in advance of problems emerging and developing plans for timely intervention. Research requirements include the need for cost–benefit analyses of management interventions.

9: Ecosystem services and valuation of natural assets
Healthy, resilient ecosystems are needed to meet societal needs and aspirations across biodiversity conservation and intensive primary production. Innovative management interventions are aimed at enhancing ecosystem functions and services while minimising biodiversity loss, thereby maintaining resilience.

10: Modelling to predict future scenarios and risks
This research need was seen as critical, underpinning research priorities 1–9 and a critical element in addressing future risks and threats, such as climate change. Predictive modelling helps provide explicit information to explore the outcomes of management decisions and actions.

How are regional councils and unitary authorities making use of the Roadmap?

Delivery of the Roadmap coincided with a major period of change in the New Zealand science system. The councils recognised that the Roadmap was a major step towards better engagement and coordination of science needs and priorities with other organisations, and with the scientific community.

Coincidentally, the National Science Challenges were designed to 'take a more strategic approach to the government's science investment by targeting a series of goals, which, if achieved, would have major and enduring benefits for New Zealand' (from the Ministry of Business, Innovation and Employment website).

The Regional Councils Bio-Managers' Group have now made use of the Roadmap to:

- provide the New Zealand's Biological Heritage (NZBH) National Science Challenge with a clear set of priority research needs for biodiversity and biosecurity
- coordinate science needs with other organisations via the NZBH Challenge process
- insert biodiversity and biosecurity research priorities into the updated regional councils' RS&T Strategy (2016)
- update their processes for annual scanning of research needs, in recognition that the Roadmap has provided them with a better awareness of the New Zealand science system
- link community engagement activities, including embedding mātauranga Māori research approaches
- coordinate and collaborate with industry and philanthropic partners seeking improved environmental outcomes as part of their wider mandate.

The Roadmap can be found online at: www.envirolink.govt.nz/PageFiles/1285/1474-ESRC265%20Strategic%20roadmap%20for%20biosecurity%20and%20biodiversity%20research.pdf

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Camera-trap set up to monitor predators.

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Assessing the suitability of citizen science data *for biodiversity reporting*

Biodiversity reporting is concerned with assessing or monitoring the status and trends of species over time. Monitoring can be thought of as either *structured* or *unstructured*. In *structured* monitoring surveys are performed at randomly selected sites using a consistent and repeatable methodology, typically by research technicians. A limitation of structured monitoring is that it is expensive and time consuming, and as a result only a limited number of locations can be monitored.

Over the past few years there has been a vast increase in the amount of species observation data gathered by members of the public (as opposed to professional technicians). *Citizen science*, as it is often called, is public participation in scientific research, whereby non-scientists take part in some aspect of science, most commonly the collection of data. There are many reasons why citizen scientists collect and enter observational data, including having a place to reliably store their own records or contributing to some larger database.

Monitoring by citizen scientists is often *unstructured*: individuals visit locations of interest to them and use their own survey methods. It is undeniable that these data repositories contain a lot of rich information; what is less clear is whether these data can be used to provide robust inferences about species distribution and changes.

Andrew Gormley and Catriona MacLeod have worked with the Greater Wellington Regional Council to assess the suitability of citizen science data for reporting on birds in the Greater Wellington region. They looked at the data contained in New Zealand (NZ) eBird, an online checklist program jointly administered by Birds New Zealand and the Cornell Laboratory for Ornithology, which enables a wide range of users to submit bird observations into a secure database. The volume of NZ eBird data from within the Greater Wellington region is vast, with 13,560 separate observation events from 2008 to 2014 (Figure 1). Andrew and Catriona identified a number of issues that can arise when attempting to aggregate unstructured data into a reporting metric and presented a number of solutions to partially mitigate these issues, as well as some recommendations for future data collection.

Aggregating unstructured data: issues and solutions

Unstructured data can suffer from a number of issues relating to the observation process (e.g. where we looked, how hard we looked and what we looked for) , including pseudo-replication, species reporting bias and spatial bias.

Pseudo-replication occurs when the same thing is measured multiple times. If multiple people carry out bird observations in the same location, then the records are not independent and cannot be treated as such. This issue arises in the NZ eBird database because observers tend to make observations close to where they live, resulting in the majority of records being around major cities and towns (Figure 1). One method to partially solve this is to aggregate the observations into spatial units (or grid cells) and report on the proportion of grid cells a species has been detected in (Figure 2).

Species reporting biases can occur when species are recorded in a manner that has little to do with their distribution or abundance and more to do with other characteristics. People will generally tend to record observations of species that are rarer and less widespread. There may also be a bias towards native/endemic species compared to introduced species. One potential solution with the current NZ eBird data is to use only records where observers indicated that they recorded every species present and that were able to be identified.

Spatial bias occurs due to observers favouring locations that are close to where they live. The majority of NZ eBird observations between 2008 and 2014 are located in the western half of the Greater Wellington Region and are highly clustered, with many records close to major populations (Wellington, Lower Hutt, Upper Hutt), and comparably few in the east of the region (Figure 1). Any species that is common in the east will be recorded less often and will therefore be assumed to be less common than a species that is common in the west and therefore observed and recorded more often. Furthermore, if the sampling distribution changes over time (e.g. increased sampling in the east), this may result in a change in the proportion of observations that contain species with an uneven spatial distribution, even if

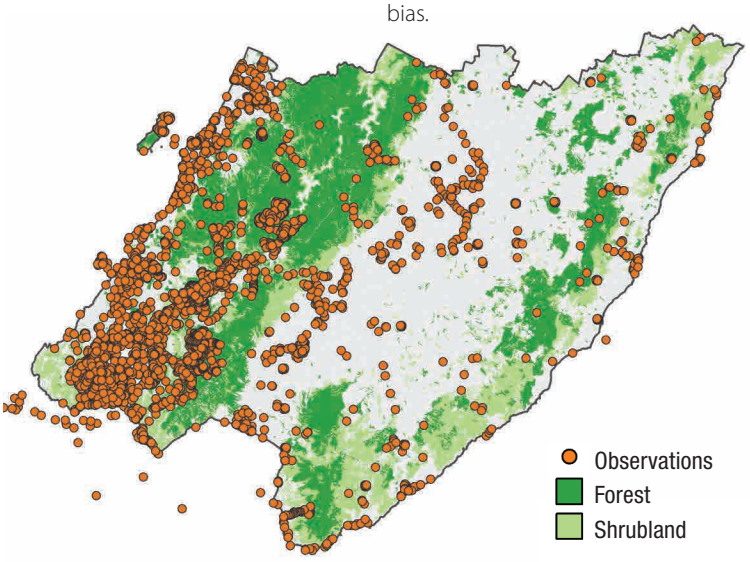

Figure 1. *Bird observations contained in NZ eBird from the Greater Wellington Region from 2008 to 2014.*

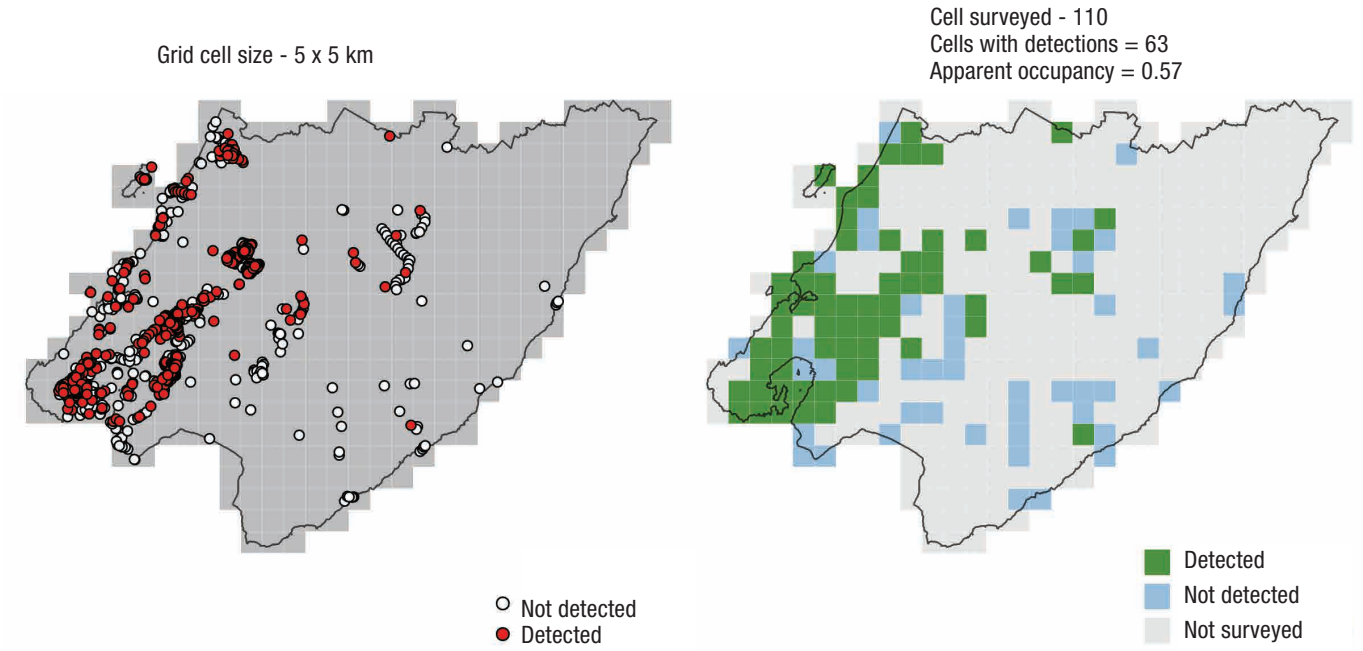

Figure 2. *Raw data of detections and non-detections of tūī in 2012 from NZ eBird, and aggregated 5 km × 5 km grid cells, with each cell classified as detected, not detected or not surveyed.*

the distribution of those species remains constant.

A related issue is *representativeness*. The paucity of records in the east means that any inference about birds from the data may not apply to the entire Greater Wellington region. Structured surveys do not survey every possible location, but sampling locations are chosen so as to remove the influence of the technicians and to ensure the set of locations are representative of the entire region. For the current data set Andrew and Catriona recommended narrowing the focus to only making inferences about sub-regions where there was suitable spatial coverage, such as around Wellington City.

Unstructured data, such as the observation records in NZ eBird, are arguably as reliable as any that would result from monitoring by research technicians, especially considering the skills and vast experience of many of the citizen science observers. It can therefore be assumed that if a record in a citizen science database includes an observation of a specific species, then that species was indeed detected. Issues with unstructured data arise only when attempts to aggregate them into a metric are made for reporting purposes.

A more structured approach to the survey effort, with observers using standardised monitoring methods, would greatly increase the coverage and value of the data gathered. This could result in large numbers of records from many skilled observers, with the data gathered in such a way that when combined they are unbiased and representative of the entire region. The challenge for the future is how to achieve this level of coordination to fully realise the potential value of the data.

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Councils reduce pest monitoring costs with chewcards

Peter Sweetapple

A chewcard mounted on a tree with the bait placement illustrated.

Chewcards are 18 cm × 9 cm pieces of plastic coreboard with palatable bait, such as peanut butter, pressed into the channels in the boards (see photos), which are used for monitoring the distribution and abundance of a range of pests, most commonly possums. They were developed in 2005 by Peter Sweetapple and Graham Nugent at Landcare Research as a simple and cheap alternative to existing tools (traps and tracking tunnels) for monitoring a range of pest species, and can show what species of small mammal pests are present by the tooth impressions made by pests that chew the cards.

For possum monitoring a major advantage of chewcards over traditional monitoring using leg-hold traps is their lightness (about 20 g each when baited, compared to about 400 g for a trap), so field workers are not limited by the number of chewcards they can carry. A second major advantage is that, unlike leg-hold traps, chewcards do not need to be checked every day, so they can be set for a week (or more) and only require two site visits (to set out and recover them) instead of the usual four visits for traps.

The Hawke's Bay Regional Council was an early adopter of chewcards for possum monitoring. It has about 650 000 ha, mainly farmland, under possum control, with possum abundance assessed across about 10% of this area each year. Council staff asked Peter in 2010 how they could use chewcards to reduce their monitoring costs. As a result, chewcards have replaced trapping for about 80% of this council's possum monitoring and have enabled a significantly expanded monitoring programme while reducing costs to ratepayers by about 50%.

To gauge the extent of chewcard use in other regions, Peter recently sent a short questionnaire to 12 councils and received eight replies. Four indicated that they used chewcards to some extent to complement other monitoring methods, with one other council having trialled them once. The main reasons cited by these four councils for using chewcards were low cost (four responses) and ease of use (three responses). Other reasons included the high acceptance of chewcards by possums, their acceptance by multiple pest species and, for one council, the availability of good interpretation resources.

Only Hawke's Bay Regional Council used chewcards solely for monitoring possums, while all other councils were interested in monitoring multiple pest species. Interestingly, it was this ability to monitor multiple species that prompted some councils *not* to use chewcards, because they perceived that high rodent detection rates were likely to have a negative effect on either possum detection or ease of interpretation of results. Two councils supplied chewcards to the public for citizen science or community group initiatives.

As a result of the increasing use of chewcards, the National Pest Control Agencies (NPCA) have recently developed a standard protocol for how to use chewcards for possum monitoring and have included this in their publication *A1 Possum Population Monitoring (2015)*. This official recognition of the chewcard method and the commercial production of chewcards (by Connovation and Pest Control Research) will probably lead to greater uptake by territorial authorities in the future.*

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* *Note: This document is no longer available from the NPCA website, but will shortly be loaded onto the Bionet (*http://bionet.nz/*) site.*

Possum biting a chewcard.

Interactive tools for regional council managers:

simulating kill-trap networks in the Cape to City predator control programme

Wendy Ruscoe

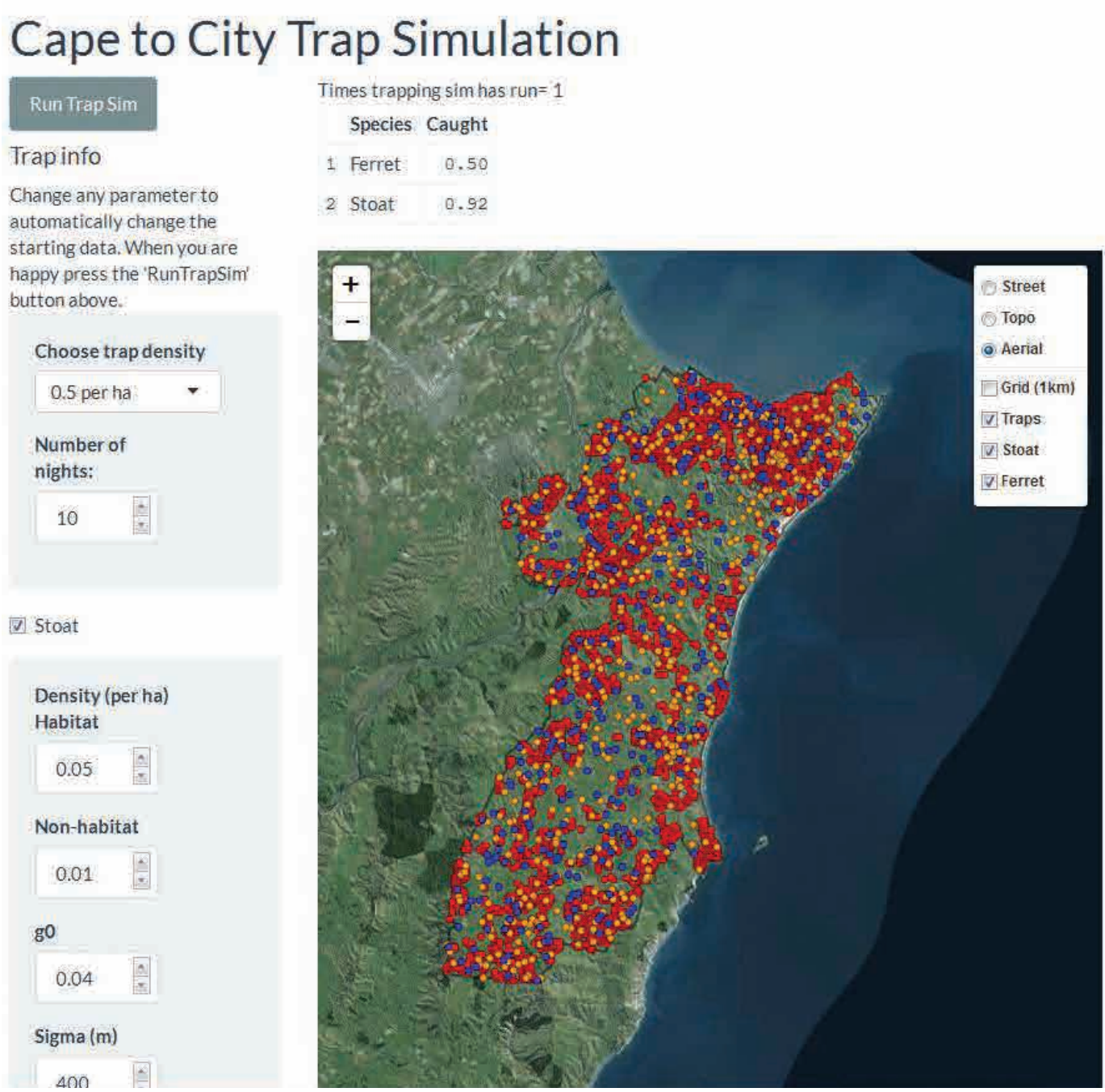
Permanent networks of kill traps have the potential to provide long-term, cost-effective control of vertebrate pests over large areas. Such networks are often initially established with large numbers of traps in order to quickly and substantially reduce the pest population to low levels. It is likely, however, that after the population has been reduced, the number of traps in the landscape is higher than that required for the long-term maintenance of a low-density pest population. Removal of a proportion of the traps at that time will reduce the cost of checking and maintaining the network without reducing its effectiveness.

The optimal number of traps in the landscape depends on a number of factors in addition to the population size of the targeted species. For example, the size of the home range of the species has a significant bearing on the density and/or spacing of the traps required. Rats, for example, have home ranges of about 3 ha, whereas mustelids have home ranges over 300 ha. Thus, if a trap network is set at a spacing of 400 m × 400 m, populations of rats could easily live between trap lines and never be exposed to capture, whereas ferrets and stoats would be likely to encounter multiple traps.

Another factor that can affect the number of traps required for an effective network is the time interval between checking the traps and resetting them. Checking traps too often when populations are low is a waste of resources, as there are likely to be very few traps to clear of carcases and reset. In contrast, checking traps too infrequently can result in many traps having been long triggered by pests and no longer able to catch surviving animals until they are reset. So how can managers decide on a trapping network that will meet their aims?

Cape to City is a predator control and ecological restoration programme covering 26 000 ha in the Hawke's Bay region, encompassing the Cape Sanctuary wildlife restoration project on the Cape Kidnappers peninsula. Andrew Gormley and Bruce Warburton have been working with staff from the Hawke's Bay Regional Council to develop an interactive tool (a developmental version is available at https://landcare.shinyapps.io/trapsC2C/) that allows managers to examine the effectiveness of various trap spacings on the capture of ferrets, stoats and cats within the Cape to City area (see Figure).

The current version of the tool allows managers to alter the density of traps, the trapping interval and the density of the target species, as well as the density of potential non-target species such as rats, possums and hedgehogs. The tool randomly locates populations of target and non-target species at densities specified by the user across the real landscape (using the LCDB 4.1 habitat map), and then simulates trapping in order to obtain estimates of the percent kill for each species. In its current state the tool can be used to



Screen shot of the trapping simulation tool for Cape to City, showing simulated locations of traps (red), stoats (orange) and ferrets (blue).

model the initial knock-down of each species and/or for modelling maintenance control over relatively short time periods (i.e. up to a month).

The next stage in the development of this tool is to expand its capability to simulate long-term maintenance control (i.e. several months). This requires incorporating data on population dynamics (births and deaths) into the simulation, along with the migration of each species into the Cape to City area.

The trapping simulation tool will enable managers to make more informed decisions about the effectiveness of various trapping networks, and, when integrated with remote wireless monitoring of traps (another Cape to City project), should significantly reduce the cost of controlling predators over large areas. The interactive tool has been developed in close collaboration with council staff to ensure it generates outputs relevant to their management needs and is accessible through an easy-to-use web-based interface.

This work was funded by the Hawke's Bay Regional Council and Landcare Research.

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What is happening with wallabies in mainland New Zealand?

Environment Canterbury

Bennett's Wallaby.

Five species of wallaby have been present in New Zealand for over 140 years, with populations centred in South Canterbury (Bennett's wallaby), Rotorua (dama wallaby) and Kawau Island (dama, parma, brush-tailed rock, and swamp wallabies). Since their initial releases wallabies on the mainland have increased in numbers and distribution, and they compete with livestock for pasture, browse seedlings in plantation forests and damage indigenous vegetation.

As part of their Regional Pest Management Plans, regional councils troubled by wallabies seek to keep them at low abundance, prevent their spread outside delineated containment areas, and, where they have spread, eliminate isolated populations. In recent years, however, numerous sightings of wallabies have been reported from outside such containment areas; for example, Bennett's wallaby has dispersed south of the Waitaki River, a natural barrier which prevented their spread for many years. Concern at the ongoing spread of wallabies has prompted affected regional councils and the Ministry for Primary Industries to request a review of the extent of the current spread of wallabies and to predict what their future distribution will be if they are not adequately contained. The review was carried out by Dave and Cecilia Latham and Bruce Warburton.

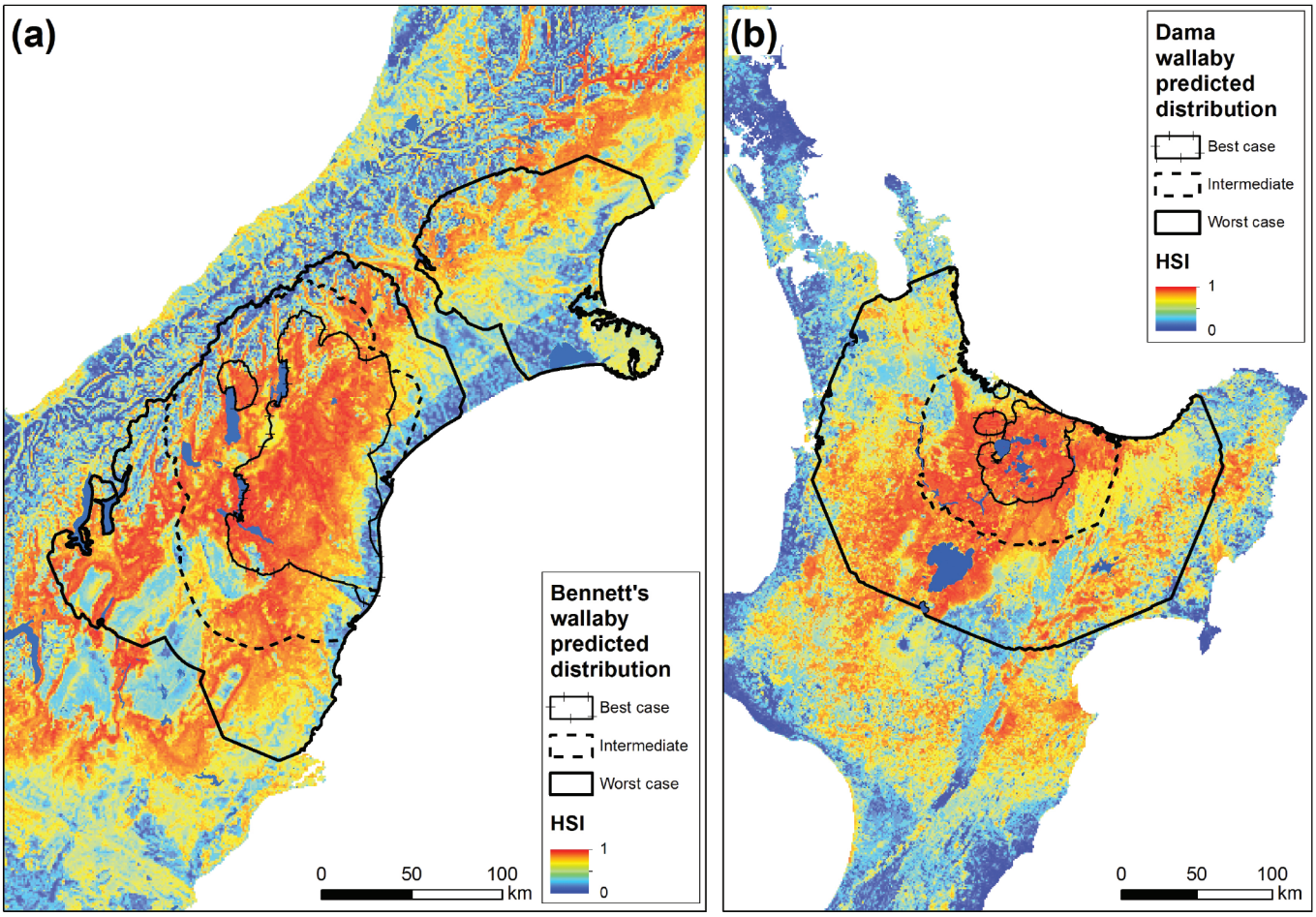
To ensure councils' needs were met, a steering committee was formed, with representatives from Environment Canterbury (ECan), Bay of Plenty Regional Council (BOP), Waikato Regional Council (WRC) and the Department of Conservation (DOC). This committee, along with Landcare Research staff, identified four desktop-based objectives:

- to update the current distributions of Bennett's and dama wallabies
- to estimate current rates of spread of both species and predict their distributions in 50 years
- to describe the extent of suitable habitat for each species on mainland New Zealand
- to conduct a simple cost–benefit analysis comparing the cost of the impacts of Bennett's and dama wallabies with the cost of different management strategies over the next 10 years.

The committee assisted with gathering the necessary data to support the analyses required, including incidental observations of wallabies, locations of animals shot outside containment areas, faecal pellet counts, and historical wallaby distributions.

At present, ECan estimates that Bennett's wallabies occupy about 5322 km^2 in the South Island. However, the large number of confirmed sightings and animals shot outside this area suggest they may currently occupy as much as 14 135 km^2. BOP and WRC estimate that dama wallabies presently occupy about 2050 km^2 in the North Island, but confirmed sightings outside this area indicate this figure could be as high as 4126 km^2.

Using natural rates of spread estimated from historical distributions, the distribution of Bennett's wallaby in 50 years is predicted to be between 9621 km^2 and 20 631 km^2, but possibly as much as 44 226 km^2 if the spread from recent illegally liberated populations is included (see Figure). In the North Island the distribution of dama wallaby in 50 years is predicted to be between 3265 km^2 and 11 070 km^2, but possibly as much as 40 579 km^2 if the spread from recent confirmed sightings from outside the currently delineated distribution is included (see Figure). Under the worst-case scenarios, wallabies could occupy one-third of each island. Further, within these future predicted distributions, habitat suitability models suggest there is ample good habitat for wallabies yet to occupy (see Figure). The areas they are likely to be absent from are high elevations, urban areas, and high-production exotic grassland (e.g. dairy farms), which have little cover for wallabies.



Best-, intermediate- and worst-case predicted distributions in 50 years for (a) Bennett's wallaby in the South Island, and (b) dama wallaby in the North Island. Habitat suitability index (HSI) for each wallaby species is shown as a continuous surface, ranging from poor (0) to good (1) habitat quality.

The team's simple cost-benefit analysis suggests there is a large net economic benefit from the widespread control of Bennett's and dama wallabies as opposed to doing nothing (i.e. the *status quo* of patchy control by landowners). However, the net benefit of containing them would be even greater. In quantitative terms, the team estimated that intensive widespread control and surveillance of Bennett's wallaby within a containment area over 10 years would cost about $6.2 million, which represents one-third of the expenditure and revenue lost if they were allowed to expand their range for 10 years before control was applied ($18 million), or one-seventh the revenue lost if allowed to expand their range in the absence of management ($43.4 million). For dama wallabies, intensive widespread control and surveillance within a containment area over 10 years would cost about $3.4 million, which is half the estimated expenditure and revenue lost if they were allowed to expand their range for 10 years and then controlled ($8.6 million), or one-third the estimated revenue lost if they were allowed to expand their range in the absence of management ($12.3 million).

There is an obvious net benefit from controlling wallabies, particularly if they are contained to prevent impacts to habitats in areas that could be invaded. Regional councils' attempts to contain them within delineated areas have not been successful, because new populations of both Bennett's and dama wallabies have been detected well outside these areas. Furthermore, illegal liberations outside containment areas have resulted in a number of established populations, adding to the complexity of wallaby range expansion. New surveillance and detection tools and further information on the species biology, applied within an appropriate control or eradication framework, may help to halt current wallaby range expansion.

This work was funded by the Ministry for Primary Industries.

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Assessing kill-trap welfare performance for regional council and community group pest control programmes

Grant Morriss

Modified Victor Easy Set rat trap.

Many designs of kill traps are used to control mammal pest species in New Zealand. Trap users include government agencies, community groups and private individuals. Increasingly the public expects that traps used to kill animals will do so as quickly and painlessly as possible. The welfare (killing) performance of many kill traps has been tested on captive wild-caught animals by Grant Morriss and colleagues at Landcare Research (see Table).

To assess the welfare performance of a kill-trap system (including the trap, any boxes or covers used, and the way the trap is set), a penned or caged animal is monitored while approaching and interacting with a trap, and the time to loss of consciousness and cessation of heartbeat are measured after capture. The International Organisation for Standardisation (ISO) published a standard for testing traps in 1999, and this standard was then adapted in New Zealand as a National Animal Welfare Advisory Committee [1] (NAWAC) guideline for testing traps. For kill traps to meet this guideline, either 10 of 10 or 13 of 15 target animals must be rendered irreversibly unconscious within 3 minutes of capture.

These sample sizes have been selected to minimise the number of animals required per trap tested and to provide a 90% probability that, at a minimum, traps meet the 3-minute limit 70% of the time. Unconsciousness is determined by using the palpebral (blinking) reflex, which stops when the animal loses consciousness. An observer is present at all times during trap testing so that the level of consciousness of a trapped animal can be assessed as soon as possible after it has been trapped and accurate times to unconsciousness and heart-stop can be recorded. Trap tests are also videoed using high-resolution cameras with either white light or infrared illumination. Frame-by-frame playback of video can be used to examine in detail the position of an animal in the trap at the time it is triggered. If a trap fails to kill a captured animal in the required time, the video and first-hand observations can be used to suggest to the manufacturer how to improve the performance of the trap.

All trap testing at the Landcare Research animal facility is approved by the Landcare Research Animal Ethics Committee. One of the underlying principles of this approval, which takes account of the costs and benefits of any planned 'manipulation' of animals, is that the test has the potential to significantly improve the welfare of captured

animals in the field. This will become increasingly relevant as more animals are trapped as part of the recently announced Predator-Free 2050 initiative.

Traps that pass the NAWAC guideline can be marketed as such, and a summary of the traps tested by Landcare Research is given below. Trap tests are funded either by the manufacturer of the trap or by agencies that wish to use the trap for their own pest control programmes. While it is not compulsory for kill traps to be tested using the NAWAC guideline, such testing allows an informed choice of kill traps by regional councils, community groups and the public. Using traps that pass the NAWAC guideline results in improved animal welfare without compromising trapping efficacy. Although a number of leg-hold traps are now officially prohibited, to date no kill traps on sale in New Zealand have been legislated against.

Community acceptance of trapping of pest animals, which includes considering animal welfare, is becoming increasingly important in pest management. Part of that involves demonstrating a willingness to use methods that reduce any impacts on animal welfare, and this is an area where regional councils have an opportunity to show leadership in the advice they provide to the public and community groups about best practice trapping.

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Testing modified Victor Easy Set rat trap on stoats.

Number of traps tested by Landcare Research for use against vertebrate pests in New Zealand and their approval/failure[2].

Pest species	Passed	Failed
Feral cat	4	3
Stoat	5	3
Ferret	1	10
Norway rat	5	0
Ship rat	2	0
Possum	3	3
Hedgehog	3	0

[1] https://www.mpi.govt.nz/protection-and-response/animal-welfare/overview/national-animal-welfare-advisory-committee/

[2] For a full listing of all traps listed, see www.landcareresearch.co.nz/science/plants-animals-fungi/animals/vertebrate-pests/traps. Trap models tested but not commercially available have been excluded from the list.

Some recent *relevant publications*

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