Kararehe Kino

Vertebrate Pest Research

Issue 22 / July 2013

PEST CONTROL TECHNOLOGIES FOR A PREDATOR-FREE NZ

Landcare Research
Manaaki Whenua

ISSN 1175-9844 (Print) ISSN 1170-3016 (Online)

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Also available electronically:
http://www.landcareresearch.co.nz/publications/newsletters/kararehe-kino

In this issue...

Clarification Note Issue 21

The article by John Parkes in *Kararehe Kino* Issue 21 (pp. 4–5) credited Sir Paul Callaghan with the 'Pest-Free New Zealand' vision. It has been pointed out that others (e.g. the Predator-Free New Zealand lobby group set up by Les Kelly) have been promoting this idea for some years. It is of course the grander successor to the failed 'last rabbit' or 'last deer' campaigns of the 20th century. Sir Paul's vision was slightly different; he focused on the 'Zealandia' or 'halo' model. This model, with its focus on protecting biodiversity in core areas with export of benefits from the core and a gradually enlarging core, arose out of the mainland island strategies (fenced or not) developed by DOC and private trusts. In a management sense it is the mirror of earlier 'onion' models, first discussed by Parkes and Nugent in 1995, where the core and layers of management around it were focused on the pests with the flow of biodiversity benefits an outcome of the layers of pest management.

Parkes JP, Nugent G 1995. Integrating control of mammal pests to protect conservation values in New Zealand. *Landcare Research Contract Report LC9495/104*.

New developments in vertebrate pest control technologies

Grant Morriss

Bait buckets used to sow 1080 baits from helicopters in a pest control operation in the Cascade Region, South Westland.

'Silver bullets' and better mouse traps capture the imagination of pest managers, but while development of new technologies for effective pest control is one important aspect of Landcare Research's science programme, pest control is much more complex than 'new tools' or 'just killing animals'. This issue of *Kararehe Kino* provides a wider appreciation of the pest control technology initiatives being investigated by Landcare Research: initiatives that could ultimately contribute towards a 'Predator-Free New Zealand'. However, all successful control technologies must not only kill individual animals but also function at the pest population level, the wider ecosystem level, and within existing social and regulatory frameworks. Consequently, spatial, temporal, and social factors influence the effectiveness of control programmes. No matter how smart a technology might be, control programmes will fail if they are not based on robust biological and ecological principles, don't meet regulatory requirements, and are not acceptable to communities.

New Zealand's current suite of lethal vertebrate pest control tools includes traps, toxins, firearms, and a biocontrol agent. Traps, toxins, and firearms have been available for several centuries, with some current technologies (e.g. leghold traps) still similar to their 18th century predecessors. Importantly though, traps and toxins and their best-practice application have improved significantly over the past 20–30 years through incremental improvements in their effectiveness, target specificity, residues (in the case of toxins), animal welfare impacts, and cost. There is room for further improvements, but ultimately cost will be the major constraint in using these technologies, particularly if managers seek to realise initiatives like predator-free New Zealand.

Going forward, development of 'silver bullets' and 'step' changes in pest control need to sit alongside incremental improvements in such technologies. One such potential step change, investigated over two decades, was fertility control of possums. Ways were found to make possums infertile, but the research foundered over oral delivery of the infertility agent. This failure does not mean, however, that searches for new biotechnologies should stop, but there does need to be an objective funding allocation process based on costs, benefits, and risks that provides optimal effort in both incremental improvements (often short–medium term) and step changes (long-term). Proposed benefits must be realistically discounted based on time to delivery and probability of success, which in turn must reflect the technological, social, regulatory and long-term funding risks. High risk projects need to be tempered by measured optimism from both researchers and funders. For example multinational agro-chemical and pharmaceutical companies invest huge sums of money in new product research, even though success rates are less than one in a hundred.

Increasingly, incremental improvements are being made to the application of tools, rather than to baits, toxins or traps per se. A good example of this is the use of global positioning systems (GPS) for more accurate aerial application of baits (see Nugent, pp.14-15) and for monitoring coverage of ground-based trapping and poisoning operations. Research-driven reductions in the sowing rates of 1080 bait (Nugent et al., *Kararehe Kino* Issue 14) have enabled significant reductions in costs, residues, and non-target risks (see Fisher, p11), and current research on bird repellents (see Cowan, pp.12-13) will further reduce the risk to non-target species. Recent incremental product improvements include a simple modification of snap-back traps (see Morriss, p19), the adaptation of radio-frequency identification tags for assessing detection systems (see Brown, pp. 20-21), and the testing of sex pheromones as lures for pest animals (see Duckworth, pp. 7-8).

In terms of step changes, Landcare Research is using molecular biology techniques and genomics (identifying specific receptors in animal bodies that provide lethal physiological control targets) to develop novel control tools that will be species-specific and humane. These approaches will provide either lethal tools (see Hopkins, p5) or reduce the reproductive capacity of populations (Duckworth, *Kararehe Kino* Issue 14, and Tompkins, p10). Additionally, new, more virulent strains of rabbit haemorrhagic disease (Duckworth, *Kararehe Kino* Issue 21) are being sought – in partnership with the Invasive Animals Cooperative Research Centre in Australia – to address the waning effectiveness of current strains and the possible resistance conferred by non-lethal strains of the virus in New Zealand.

Success in developing control tools, through both incremental and step changes, will assist managers of vertebrate pests to meet ongoing threats to native biodiversity and agricultural production. Management of vertebrate pests in New Zealand, at least in the short-to-medium term, will continue to rely on the suite of existing control tools, but research on novel tools must continue. Scaling up pest control will be a key requirement if New Zealanders embrace current initiatives to work towards a Predator-Free New Zealand. Incremental improvements must continue in parallel with the scoping, development and field application of new tools to provide the means to achieve that goal. Future advances will also require more cross-disciplinary research where biologists, engineers, geneticists, physiologists, pharmacologists, and social scientists work together to find novel solutions.

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Phil Cowan

Developing species-selective novel control tools for pest control

Most vertebrate pest control has been achieved through the use of acute poisons and first- and second-generation anticoagulants. Collectively, these poisons have varying degrees of success but one common disadvantage – they are all broad-spectrum and pose primary and secondary non-target risks to humans, domestic pets, wildlife, and livestock. Moreover, these poisons variously pose risks through environmental contamination, accumulation in the food chain and a general lack of humaneness. These concerns are likely to become more prominent at the scale at which control would need to be undertaken to achieve Predator-Free New Zealand.

The increased worldwide concern and public disapproval of the use of broad-spectrum poisons for pest control means that regulatory authorities are imposing ever-increasing restrictions on their use. Clearly, there is an immediate, growing, national and worldwide need and opportunity for alternative 'cleaner' methods of pest control that provide greater safety at all levels, from governmentally and municipally controlled programmes for environmental protection, to the efforts of individual farmers and citizens to protect their food, crops and homes from pest damage.

Consequently, over the last decade Brian Hopkins and colleagues have progressed research programmes aimed at developing species-selective control tools. Their initial focus has been on developing new agents mainly targeting the rat as this pest is by far the most destructive globally, and its control depends heavily on the use of broad-spectrum anticoagulants.

Despite the millions of dollars spent annually in controlling rats, they still cause billions of dollars of damage worldwide to agricultural crops and stored foods. As vectors of disease, rats also pose serious health risks to humans and domestic animals, and are one of the invasive species most responsible, worldwide, for the loss of native biodiversity. This is especially so in ecologically fragile ecosystems of island environments such as New Zealand. Predation by rats is considered the fourth largest cause of decline of New Zealand's native animal species.

Brian's research to date has focused on two approaches. The first is based on peptide/protein differences between species, and the second is based on novel chemistry. These approaches represent a major scientific advance in the development of low-risk pest control tools.

The proteomic approach takes advantage of species-specific differences in the peptide sequence of cell surface proteins that are involved in key physiological processes of the body, e.g. respiration. Agents have been developed that when injected into animals specifically bind to the species-specific protein sequence, resulting in extensive cell death within key organs, e.g. lungs, and leading to an acute and humane death of the animal. To date, experimental agents that kill rats, mice, stoats and possums have been produced. Recent work has focused on optimising formulations of the agents to maximise the potential for oral delivery and minimise the cost of manufacture.

The chemistry approach is based on norbormide (NRB), a compound discovered in the 1960s that is selectively toxic to rats and relatively harmless to other rodents and mammals. In spite of its initial promise, this compound failed commercially due to palatability problems that resulted in sub-lethal dosing, bait aversion, and variable kill rates. All the usual methods to mask problems associated with potential taste affects (e.g. inclusion of a variety of palatable ingredients into bait), or unattractive physicochemical properties (e.g. microencapsulation) failed to increase consumption and efficacy in cage trials. Taking a leaf from the pharmaceutical industry, the team shifted its focus to the use of medicinal chemistry to overcome the inherent problems associated with NRB. Through manipulation of NRB's chemical structure using a structure–activity relationship, Brian, in collaboration with the Chemistry Department, University of Auckland, designed, synthesised and screened more than 100 novel variants in an attempt to increase the palatability and efficacy of the NRB molecule. As a consequence, Landcare Research has patented several series of novel compounds that show a significant enhancement in rat-selective efficacy, and discussions are ongoing with industry partners for further product development.

Building on these successes, new funding is being sought to extend the range of pest species targeted, through a generic technology 'platform' based on genomics. Essentially, techniques commonly used in the pharmaceutical industry for elucidating disease mechanisms will be utilised to confirm the identity of the receptor through which NRB mediates its lethal response. This knowledge will then be used to identify NRB receptor equivalents in other key pest species for the development of alternative species-selective poisons. The same approach can be used to identify other relevant species-specific receptors suitable for as yet unknown orally-deliverable species-selective poisons.

Once validated this platform technology can be extended to a broad range of pest species including pest invertebrates and possibly even weeds, and will hopefully act as a catalyst for a paradigm shift in how pest control tools are designed.

This work was funded by the Ministry of Business, Innovation and Employment and government Core funding to Landcare Research.

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Rat eating a fantail chick taken from its nest.

Sex pheromone attractants to improve the trapping and monitoring of mammal pests at low densities

A male possum used in the trial.

Increasingly, now and in the future, mammalian pests will be controlled at low densities, such as after successful broad-scale control or a pest reinvasion of an island. In such situations, where the food supply is plentiful, there is likely to be a role for non-food-based lures to increase the efficiency of trapping and monitoring operations. Many of New Zealand's major pests, such as stoats and possums, are solitary animals and seldom interact with their conspecifics. However, the one exception to this is during the mating period. Both possums and stoats are highly effective at finding mates using sex pheromone cues even at low densities, despite the period of oestrus (when the female is receptive) generally lasting only a few days and ending once mating has occurred.

A successful example of the use of non-food-based lures was the trapping of stoats after they recently reinvaded Kapiti Island. A stoat was seen on the Island in November 2010 and its presence confirmed by DNA analysis of scats located by trained predator dogs. The area was intensively trapped using traditional food-based lures for 3 months without success. Landcare Research supplied the Department of Conservation team on Kapiti Island with stoat bedding material in early February 2011 and within 10 days a male stoat was captured. By chance, the bedding material was collected from captive female stoats that were in oestrus and this may have been an important factor in the ability of the bedding material to be an effective lure. Scent lures containing odours or secretions from male or female possums, ferrets and stoats have been shown to be attractive to both sexes of their species, but no one has looked at the effect of reproductive state on attractiveness of such secretions.

Janine Duckworth has been investigating whether sex pheromone lures increase the encounter and interaction rates of possums and stoats with traps or monitoring devices. Janine's team collected urine from captive female possums at the height of oestrus (24 to 72 hours before mating), as well as from non-breeding females and males. These samples were presented to penned possums by applying 0.05 ml of the urine on a gauze pad inside a plastic perforated lure station to determine how often and how long male and female possums spent investigating the urine-based lures and a saline control preparation.

Male or female possums didn't usually interfere with ('paw" or touch) a lure station when no pheromone-based lure was present. For both male and female possums, the number of interferences and the time spent interacting with preparations from non-breeding and oestrous females was significantly greater than for the control lure (*Figs 1 & 2*). Neither sex displayed any interest in male urine but there was no indication of avoidance either. Both male and female possums responded to the different lures in the same way. Female-derived preparations showed the greatest promise.

Collecting urine from a captive female possum during oestrus.

To test the ability of the possum secretions to increase trapping efficiency under field conditions when compared to the standard National Pest Control Agencies flour blaze, the oestrous female lure is currently being assessed in field trials (under contract to the Animal Health Board) using possums collared with radio-frequency identification tags (see Brown, pp. 20-21). Early results look promising.

In the longer term, sourcing sufficient biologically-derived active ingredients (bedding materials, urine or anal gland secretions) would limit the practicality of such lures for widespread pest control. Gas chromatography is therefore currently being used to identify differences in the profiles of volatile components present in the lure preparations from breeding and non-breeding females and from males. This will allow synthetic versions of the sex pheromone compounds to be developed and then tested for their ability to attract possums. New potent and potentially species-specific lures may be key to improving encounter and interaction rates with traps and monitoring devices for better, more effective pest control in the future and to make the goal of a 'predator-free New Zealand' more attainable.

This work was funded by Landcare Research Capability funding and field trials done under contract to the Animal Health Board.

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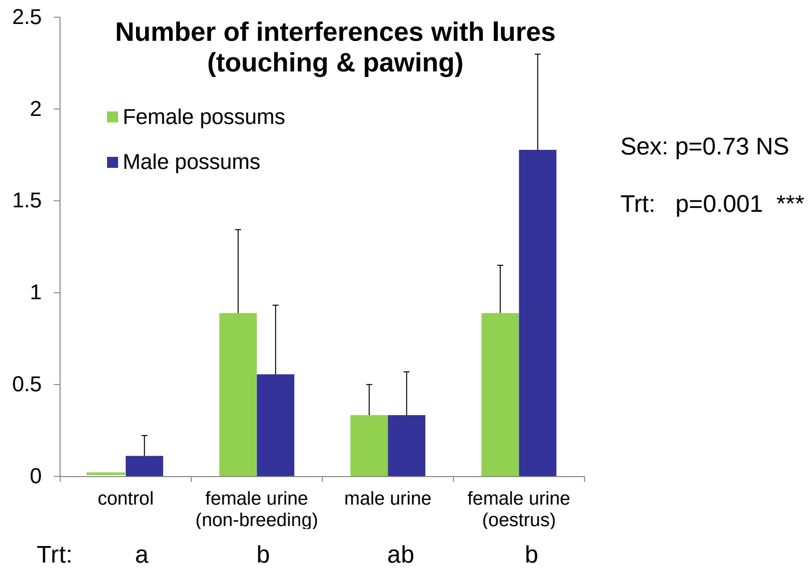

Fig. 1 *Effect of lure type on the mean number of interferences when possums pushed, pawed or moved the lure station. Treatment groups assigned different letters are significantly different (P < 0.01). There was no significant effect of sex.*

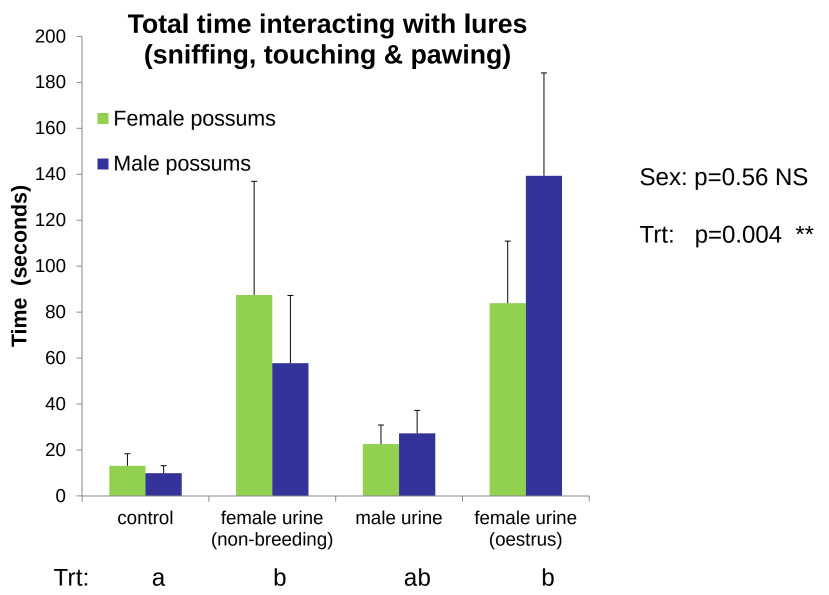

Fig. 2 *Effect of lure type on the time possums spent interacting with lures (in seconds), either sniffing, touching or pawing the lure station. Treatment groups assigned different letters are significantly different (P < 0.01). There was no significant effect of sex.*

Camera traps for monitoring cat, stoat and hedgehog populations

When stoats ran quickly, camera traps often captured only their hind quarters. Colour photographs taken with a white flash more easily identified pest animals than those taken with an infrared flash.

Feral cats, stoats and hedgehogs are controlled in New Zealand to reduce their impacts on native fauna. However, practical, affordable techniques are needed to determine whether control is effective in reducing their abundance. Such techniques will be a critical part of efforts to achieve Predator-Free New Zealand. Camera traps (trail cameras) are useful for monitoring wildlife, but until recently have only been used to monitor relatively large animals. Their use with small animals presents some challenges. First, small animals are less likely to trigger the infrared sensors used by most camera traps. Second, identifying small animals from pictures requires that they are photographed at close range. This means the camera must focus on a small area and fast-moving animals may cross the field of view before a photograph is taken. Finally, small species may be difficult to identify from photographs. Using captive animals, Al Glen and colleagues conducted a series of trials to determine the optimal specifications for a low-cost camera trap to monitor cats, stoats and hedgehogs. The factors tested were:

- Trigger speed (the time taken from when an animal is detected by the sensor until it is photographed – in these trials, 0.2 to 2.1 seconds)
- Type of sensor (infrared vs microwave)
- Type of flash (white vs infrared)
- Type of image recorded (still photograph vs video clip)

Camera traps were set in observation pens, where the behaviour of captive animals was constantly monitored by video cameras to determine how often animals encountered a camera trap, how they behaved, and whether the camera detected the animal and produced an identifiable photograph.

The continuous video footage revealed that stoats frequently ran around the perimeter of the pen at high speed; seemingly as a consequence of their captivity. None of the trigger speeds tested was fast enough to photograph stoats behaving in that way. However, even the slowest trigger speed used (2.1 seconds) successfully photographed 90% of stoats that were not running. Trigger speed had little influence on success rates of photographs for cats and hedgehogs, which moved more slowly than stoats.

Infrared sensors performed consistently better than the microwave sensor, which was often triggered by wind or rain, and occasionally by animals walking behind the camera. In contrast, infrared sensors reliably detected all three species and were rarely triggered by weather.

Each type of flash had advantages and disadvantages. Photographs taken with an infrared flash are black and white, and can appear blurred or grainy. This sometimes made it difficult to identify animals (e.g. if part of them was outside the camera's field of view; see *Photo*). Cameras with a white flash took clear, colour photographs, allowing animals to be more easily identified (see *Photo*). However, a white flash is conspicuous; it may frighten some animals, causing them to avoid camera traps, and potentially increases the risk of these cameras being stolen or vandalised.

Camera traps that recorded video footage had similar success rates to those that took still photographs, but required much more analysis time and computer memory. A 30-second video clip required 10.4 megabytes of memory, whereas still images required between 250 and 750 kilobytes. Video footage also took much longer to upload and view.

Cats and stoats frequently reacted to camera traps but hedgehogs did so rarely. Three of the six cats tested appeared to be frightened by cameras with a white flash, while one cat also reacted to a camera with an infrared flash. In contrast, stoats frequently showed curiosity towards camera traps, as did one of the six hedgehogs. These behaviours led Al to wonder whether the animals could see the infrared flash, or whether they reacted to some sound made by the cameras. The team therefore tested five commercially available camera-trap models marketed as having an invisible flash. In a fully darkened room, the flash of all cameras was faintly visible to human observers. Using ultrasonic recording equipment, they also found that cameras emitted sound at various frequencies, some of which are inaudible to humans but well within the hearing range of cats.

Camera traps show great promise as an inexpensive method for monitoring the outcomes of pest control. However, most commercially available models are not designed to photograph small animals at very close range. A camera trap for small animals should not emit visible light or audible sound. Field trials are being planned to confirm the effectiveness of camera traps for monitoring cats, stoats and hedgehogs.

This work was funded by the Department of Conservation.

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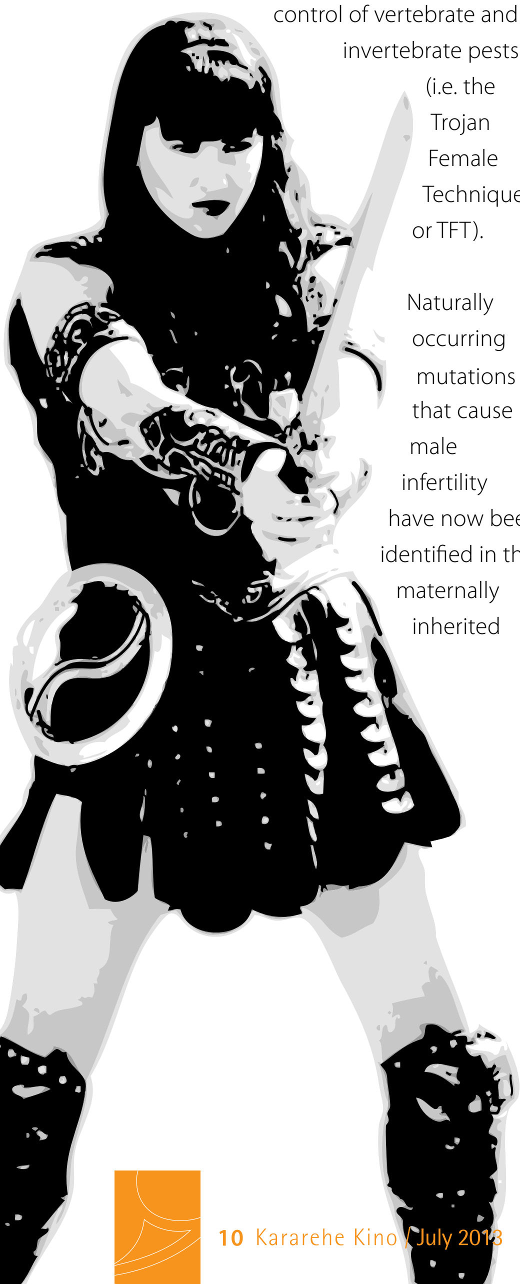
The Trojan Female Technique: a novel non-lethal approach for pest control

Although there are substantial gains in efficiency to be made from the more refined and coordinated application of existing pest control technology, the general consensus at the Pest Summit convened by the Department of Conservation in December 2012 was that the use of cutting-edge science to develop new tools and approaches is also needed to protect both agriculture and biodiversity in New Zealand. To this end, a research consortium comprised of Landcare Research, the University of Otago and Monash University have proposed a novel and cost-effective technology platform for the specific (i.e. no potential for non-target effects), persistent, non-lethal and non-GMO (genetically modified organism) control of vertebrate and invertebrate pests (i.e. the Trojan Female Technique or TFT).



Naturally occurring mutations that cause male infertility have now been identified in the maternally inherited mitochondrial DNA (mtDNA). These have little or no impact on females, and hence are minimally or not selected against (i.e. are self-perpetuating in nature). While these mutations have thus far only been identified in model systems such as fruit flies and mice, they are likely to be widespread in nature where they may pose a threat to the viability of small populations of endangered species. The consortium aims to harness these mutations to develop a widely applicable capability for pest control, through the release of Trojan females carrying the mutations.

Reproductive management is an effective approach to pest control. For example, the Sterile Male Technique (SMT), commonly applied to invertebrates, has eradicated the parasitic screwworm fly from multiple countries, with an estimated $1 billion p.a. saving to the USA alone. However, the SMT requires large quantities of sterile males to be produced and released each year in a costly process that can limit its use. The TFT, a novel twist on the SMT paradigm, could provide similar control at greatly reduced effort; large potential cost savings of the TFT arise from it being self-perpetuating in nature, making it economically viable to apply to a wider range of invertebrate species under a wider range of contexts than the SMT, and even to vertebrates (for which the SMT is not cost-effective).

The Trojan Female Technique is thus relevant across the animal pest spectrum (i.e. from possums, rabbits, stoats and rats, to mites, aphids, moths and weevils). It will be applicable to both reducing current pest impacts (and associated management costs) and combating new pest incursions. Once developed, TFT application to new species would be inexpensive. For example, naturally occurring mutations appropriate for use in TFT were identified by screening just 55 male brown hares. Successful application of the TFT would thus allow substantial reductions in both the current losses of $885 million p.a. in New Zealand's agricultural sector caused by invertebrate and vertebrate pests, and pest impacts to native biodiversity. The TFT would both support New Zealand's economy and enhance protection of the natural environment, while avoiding concerns over non-target effects, GMO, welfare issues, environmental contamination and toxin resistance.

The TFT would be highly complementary to and most effective when combined with conventional control (e.g. population reduction obtained with conventional control, and then maintained by the release of Trojan females into the residual population). Depending on the desired outcome, the TFT could be used to decrease pest populations from high levels, drive populations to extinction, or maintain populations at desired levels. In addition, low-density populations with high mutant frequencies could be used as 'wild nurseries': sources of individuals for introduction to other populations or natural dispersal into adjacent inaccessible areas. This strategy would generate significant cost savings. The TFT is thus a strong candidate for the effective, persistent and specific reproductive control of multiple pests, providing synergies with conventional control that allow extension to the landscape scale.

The proposed technology platform is the topic of a current 'Smart Ideas' grant application to the Ministry of Business, Innovation and Employment Biological Industries fund, for its application to agricultural pests. Funding applications to develop this technology for the protection of biodiversity (in alignment with the remit of Predator-Free New Zealand) are pending.

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James Smith

Improving baiting for rabbit control and minimising risks to non-target animals

Declining efficacy of the rabbit haemorrhagic disease virus has seen a renewed need for broad-scale conventional rabbit control, including aerial baiting. This has prompted research into improvements to the cost-efficacy of aerial baiting for rabbit control, and reassessment of the non-target risks associated with this control method. Apart from their economic impacts, rabbits also help support predator populations. Improved rabbit control could therefore help with initiatives to make New Zealand predator free.

Dave Latham is working to refine aerial application of 1080 carrot bait to keep rabbit populations low. Field trials completed in Otago (winter 2011 and 2012) showed reduced per-hectare amounts of bait sown in strips can achieve effective rabbit control, with cost savings of about 40% over current 'total cover' baiting practices. Further trials to investigate bait sown in strips are underway and will be completed in 2014.

The non-target animals present in habitats where baits with 1080 or pindone are used for rabbit control can differ substantially from those present where the same toxins are used to control possums and rodents. Also, toxin concentrations are lower in the chopped carrot or pellet baits applied for rabbits. With these differences in mind, Penny Fisher reviewed the non-target risks of baiting for rabbit control. This research revealed a significant lack of toxicological and field data about pindone relative to 1080, which created higher uncertainty around its estimated risks to non-target species. Both 1080 and pindone were estimated to present a high risk of primary poisoning to some non-target mammals and birds that might eat bait laid for rabbit control, and also medium–high risks to mammals and birds that might scavenge the carcasses of poisoned rabbits.

Both projects identified carrot bait quality, i.e. uniformity of bait size and toxin concentration, as a critical factor in the success of rabbit baiting operations. Current manufacturing and distribution practices still produce large numbers of small carrot fragments (chaff) with higher concentrations of toxin relative to larger baits. Such bait pieces may be sub-lethal to rabbits yet lethal to small non-target animals, so poorly prepared carrot bait will not only decrease the efficacy of rabbit control, but also increase the risk of unwanted non-target mortality.

Additional field-based information is needed to improve managers' understanding of non-target risk in rabbit baiting, and their ability to mitigate unacceptable risks. Key information needs are estimates of:

- annual usage of pindone and relative use of carrot, pellet and oat baits for rabbit control to identify areas where the primary risk to non-target animals is likely to be highest
- quality of 1080 and pindone carrot bait (size distribution, chaff content and toxic concentration) as an aid to improving best-practice bait preparation
- rates at which toxic baits are removed after application, what animals remove bait, and the degradation/detoxification rates of uneaten bait
- availability of rabbit carcasses to scavengers following 1080 or pindone baiting, and of the rates at which carcasses of poisoned rabbits degrade and detoxify under various environmental conditions

Dave's project was funded by the Ministry for Primary Industries' Sustainable Farming Fund (Grant no. 12/058) and was conducted in collaboration with Otago Regional Council.

Penny's review was undertaken for the Marlborough District Council under an Envirolink Advice Grant (MLDC82) (access to the full report can soon be found here: http://www.envirolink.govt.nz/)

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Dave Latham

Repellents to protect native birds from 1080 baits

New research on bird repellents may provide a means to further reduce the risk of deaths of native birds from aerially sown baits for possums and rats. Addressing the issue of non-target risk will be a major challenge if control of possums and rats becomes more widespread as part of the Predator-Free New Zealand initiative.

Research into optimising aerial 1080 poisoning for possum and rat control has enabled >50% reductions in the amount of poison bait used (see *Kararehe Kino* Issue 14). This has reduced the potential risk that native birds will be killed by primary or secondary poisoning. However, adverse incidents still occasionally occur, such as the deaths of seven kea after 1080 possum control operations in Westland in 2008 and 2011. In response to these deaths the Department of Conservation (DOC) and the Animal Health Board (AHB) have worked with the Kea Conservation Trust, Unitec and Landcare Research to evaluate chemicals that could be added to cereal baits sown for possums and rats to deter kea and other native birds from eating the baits.

A review of previous research identified d-pulegone and anthraquinone as the most promising candidates. D-pulegone is a primary repellent and is avoided due to its unpleasant taste, smell or irritancy. Anthraquinone is a secondary repellent, inducing an unpleasant feeling shortly after ingestion that results in subsequent avoidance of the bait.

Although both chemicals are effective repellents by themselves, previous research suggested the use of these repellents in combination might produce greater repellency than the use of either alone. If both were present in non-toxic prefeed bait, the primary repellent in toxic bait could remind birds that ate prefeed of their previous unpleasant experience and so increase repellency.

Before proceeding to more trials, DOC, AHB and Landcare Research agreed on further evaluation of the responses of possums and rats to bird-repellent baits, primarily because there was little information about their responses to different concentrations of anthraquinone and most previous trials had used only carrot baits rather than the more commonly used cereal baits.

Landcare Research therefore undertook trials with individually caged possums and ship rats to assess the palatability and efficacy of different combinations of RS5 cereal pellets containing anthraquinone and d-pulegone (*Table 1*). To simulate aerial operational practice, animals were offered a choice between their normal food pellets and test pellets for 3 days (when most prefeed in an aerial operation will be eaten), given normal pellets only for 5 days, and then given a choice between normal pellets and test pellets containing 0.15% 1080 for 2 days. Baits were manufactured by Animal Control Products and quality assurance testing done by the Landcare Research toxicology laboratory.

Test group	Prefeed pellets d-pulegone + anthraquinone		Toxic pellets (0.15% 1080) d-pulegone + anthraquinone	
1	0	0	0	0
2	0.17%	0	0.17%	0
3	0	0.25%	0	0.25%
4	0.17%	0.1%	0.17%	0.1%
5	0.17%	0.25%	0.17%	0.25%
6	0	0.25%	0.17%	0.25%

Table 1. *Levels of bird repellents in non-toxic prefeed and toxic pellets available to six test groups of possums (n = 15) and ship rats (n = 20).*

Test group mortality (%)						
	1	2	3	4	5	6
Possums	87	87	53	93	83	73
Rats	71	75	10	15	35	0

Table 2. *Mortality of possums and rats in each of the six test groups when offered toxic pellets.*

For possums, overall palatability of the test pellets and the weight of test pellets eaten during the 3 days of prefeeding were lower for groups 3 and 6 than the other groups. Groups 3 and 6, unlike the other groups, showed a progressive decline in palatability of test pellets over the 3 days. Both groups ate less of the toxic test pellets than the other groups and this was reflected in mortality, which was lower for group 6 and significantly lower for group 3 than for the other groups (*Table 2*). These results suggest possums developed an aversion to pellets after exposure to non-toxic pellets containing 0.25% anthraquinone. The inclusion of d-pulegone with anthraquinone in the prefeed pellets appeared to mitigate development of this aversion in terms of mortality, but consumption of toxic pellets was somewhat less in groups 4 and 5 than groups 1 and 2 (which had no exposure to anthraquinone).

For ship rats, aversion to pellets containing anthraquinone was more pronounced. Groups 3–6 all had palatability, weight of test and toxic baits eaten, and mortality significantly less than groups 1 and 2, which did not differ. Consumption of test pellets by groups 3–6 declined significantly over the 3 days of prefeeding (unlike groups 1 and 2), and only one or two rats in each of groups 3–6 ate any toxic pellets. The inclusion of d-pulegone with anthraquinone (groups 4 and 5) appeared to have a mitigating effect on the aversion, although it was not as pronounced for rats as for possums.

Based on these results, DOC and AHB have agreed to proceed to observational trials with free-living kea at carparks to test their response to non-toxic RS5 baits containing 0.17% d-pulegone and to a case study operation where kea survival will be monitored. If those trials indicate sufficient repellency, operational field trials will be undertaken later in 2013 to test for efficacy against rats and possums. Based partly on the apparent mitigating effect of d-pulegone on anthraquinone aversion, field testing may follow on rats of the repellent combination used in the original Kea Conservation Trust tests, namely prefeed with 0.17% d-pulegone and 0.1% anthraquinone followed by toxic bait with 0.17% d-pulegone. Results from an earlier DOC field trial of that combination did not show the strong aversion found in the present cage trials.

If the observational and operational trials are successful, then DOC and AHB will gather further information to underpin an application for registration of RS5 bait containing bird repellents for possum and rat control.

This work is funded by the Ministry of Business, Innovation and Employment, Science and Innovation Group (contract no. C09X1007), the Animal Health Board and the Department of Conservation.

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Robins may investigate toxic baits wherever they find them.

Precision aerial sowing of baits for possum and rat control

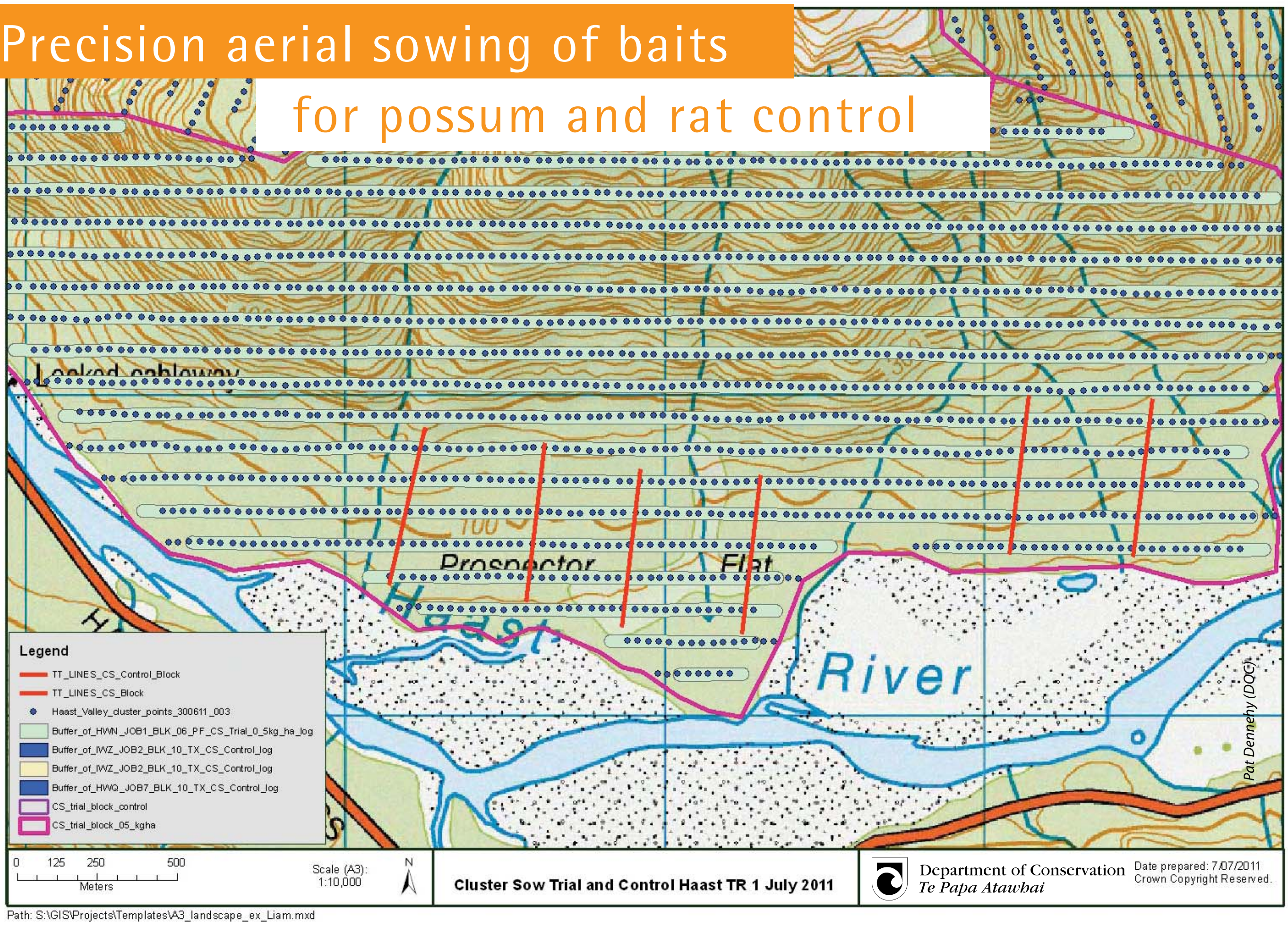

Fig. 1 *Map of cluster release points in a large-scale field trial, showing the designated flight paths (turquoise bands) and cluster release points (green dots).*

Aerial baiting is a crucial technology in possum and rat control, and for over 20 years has involved sowing from a helicopter along GPS-guided parallel flight paths 100–200 m apart. A spinner under the sowing bucket spreads the bait over a swath at least as wide as the flight-path spacing, thereby ensuring no part of the area is unbaited. However, the vagaries of wind, topography, and pilot skill in following designated flight paths can lead to some imprecision in where the margins of the baited swath occur. That imprecision requires buffers around the area to be baited and around exclusions zones within it to be set conservatively wide, creating scope for possums and rats to survive.

To overcome this problem, new techniques of sowing bait in clusters or strips have been developed. In the case of strip sowing, the spinner is slowed down, and bait falls from the aircraft continuously, while for cluster sowing, the bait falls in clusters intermittently through a controlled-release 'gate'. The main research aim was to find ways to reduce baiting costs by reducing the amount of toxic bait sown, and, for strip sowing only, to enable the use of lower-cost fixed-wing aircraft rather than helicopters to sow the bait (see *Kararehe Kino* Issue 14). However, cluster sowing in particular opens the door to more precise control over *where* bait is sown, because the size of each bait cluster (typically 8–10 m by 10–15 m is much smaller than the size of a continuous 100–180 m wide broadcast swath.

As part of the process of developing a bucket designed specifically for cluster sowing Graham Nugent and Grant Morriss worked with Graeme Gale (HeliOtago), Tony Michelle (Amuri Helicopters) and Colin Brown (TracMap NZ) to produce a lightweight medium-sized prototype with a GPS-controlled cluster release mechanism (*Photo*). GPS-control of the bait-release gate ensured bait was reliably released at specified intervals along the flight path. For the first time, sowing rate was independent of helicopter speed, and more consistent than traditional sowing.

Initial sowing trials were conducted in April 2010 using a helicopter flown at different heights and different speeds. The bucket was then used operationally in two large-scale field trials and delivered high-density bait clusters at 50-m intervals on 100-m-spaced flight paths (i.e. <2% of the landscape; *Fig. 1*).

However, the prototype GPS-controlled release system relied on the pilot to initiate and terminate sowing along the flight path leaving a small risk of 'overflies' in which sowing continued briefly over a designated boundary. To eliminate this risk, TracMap extended the GPS-control software to include an automatic shut-off over exclusion zones and boundaries. Preventing overflies but still delivering bait up to the boundaries of control areas is surprisingly complicated. This is because the forward speed of the helicopter is imparted to the bait when it is released, with the 'throw-forward' distance between the release point and landing point of the bait varying with helicopter speed and its height above the ground (*Fig. 2*).

The prototype automatic shut-off system worked as envisaged, with no cluster release points in the bait exclusion zone. However, forward momentum carried some bait well into it (*Fig. 2*, *Table*). This led to the development of a throw-forward buffer (TFB) in the software that turns the sowing on or off a set number of seconds in advance of a boundary. At 40 knots, a TFB of 1.5 seconds equates to approximately 30 m, so the software would turn sowing on (or off) 30 m before the boundary.

In a test of the system with a TFB, the zigzag effect arising from the alternate direction of successive flight paths was much reduced and all but one of the bait clusters fell at least 10 m outside the nominal exclusion zone. That cluster aside, the results indicated that at 40 knots, it is feasible to reduce buffer widths to as little as 60 m, well within the home-range diameter of possums and rats.

This research and development indicates that controlled cluster sowing has potential to improve the precision of bait placement in relation to area boundaries, and could be used to avoid sowing bait in narrow buffers (<100 m) around waterways and tracks without greatly increasing the risk of not exposing some possums and rats to toxic bait. Such safety features are likely to be critical if aerial poisoning is scaled up to help achieve Predator-Free New Zealand.

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

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Flying speed (knots)	Flying height (m)	Average cluster length (m)	Average cluster width (m)	Throw forward (m)
40	50	5.9	3.7	49.5
40	50	6.6	4.6	43.0
40	100	6.8	5.9	49.0
40	100	8.5	5.8	61.5
50	50	7.2	3.9	57.3
50	50	6.3	4.9	61.5
50	100	8.8	6.0	68.0
50	100	11.3	5.8	66.0
60	50	11.8	4.9	68.0
60	50	8.6	8.2	63.5
60	100	10.7	7.9	78.5
60	100	13.4	6.4	80.0
Average		**8.5**	**5.5**	**60.7**

Table. *Cluster size and throw-forward distance of bait clusters, relative to the location at which they were released.*

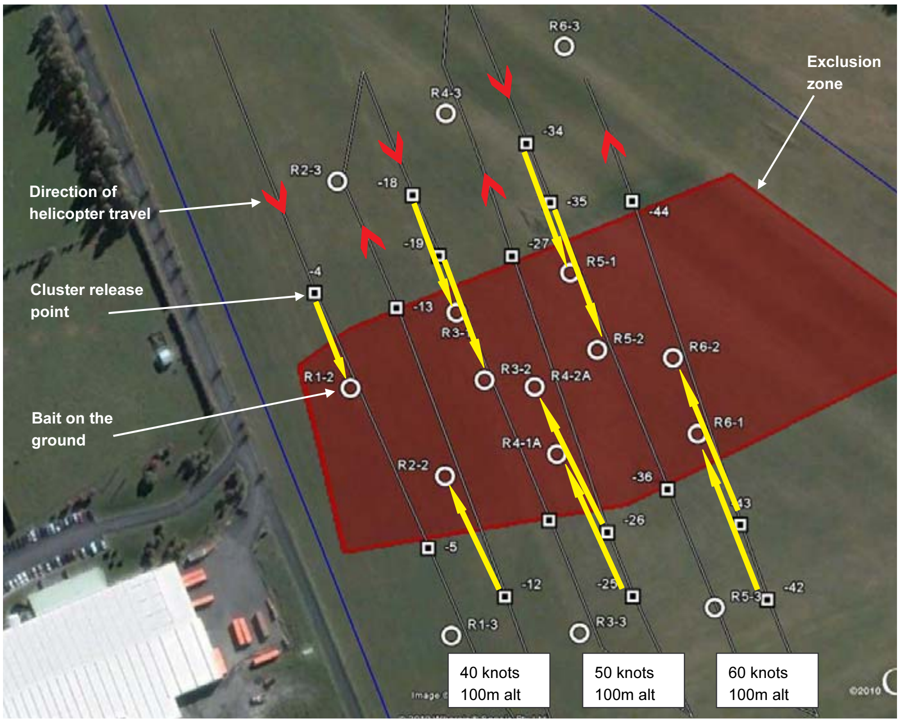

Fig. 2 *Distribution of non-toxic bait clusters resulting when the GPS-controlled cluster-release software was programmed to prevent cluster release when the helicopter was inside the red exclsusion zone (i.e. with no throw-forward buffer). The red arrow heads indicate the direction of helicopter trial, and the yellow arrows link cluster release points (squares – bait clusters are numbered) to where the bait landed on the ground (circles). (R is the baiting run number).*

Fig. 3 *The Tracmap GPS-controlled Landcare Research/HeliOtago cluster-sowing bucket.*

Evaluating and prioritising community-based biodiversity conservation projects

The Banks Peninsula Tūī Restoration group translocated a total of 72 tūī from Maud Island, Marlborough Sounds to Hinewai Reserve, Banks Peninsula in 2009 and 2010.

Vertebrate pests are an ever-present threat to native biodiversity, and managing pest impacts is time-consuming and costly. It is therefore important that pest control is wisely targeted to get the best possible outcome from limited conservation budgets.

Tools that formally evaluate the costs and benefits of environmental projects and allow them to be compared and ranked are used by management agencies such as the Department of Conservation, but rarely by community-based organisations (CBOs) to plan, evaluate or prioritise their work. Using two such existing tools, Les McNamara and Chris Jones worked with Marie Haley and her colleagues at the Banks Peninsula Conservation Trust to evaluate and prioritise a set of existing community-led species conservation projects from the perspective of potential tool users in CBOs.

INFFER (The Investment Framework for Environmental Resources) and PPP (Project Prioritization Protocol) evaluate projects using techniques based on 'Benefit Cost Analysis' (BCA). Many people are uncomfortable linking economics with conservation, but when organisations make big investments using public money, there is a strong case for documenting thoroughly how decisions are made, what is planned and why, and what might go wrong. For a funding body, it helps if the benefits and costs of different projects can be compared to make sure they get the best return on their investment.

Both INFFER and PPP require that users set clear management outcomes, or 'SMART' targets (Specific, Measurable, Achievable, Relevant and Time-bound), for their projects, and both tools require estimates of project costs, experts' or managers' assessments of the likelihood that a project will succeed, and estimates of the likely effects of a successful project on the species the project aims to protect. INFFER requires that users document and quantify a wide range of factors that may affect project success, e.g. the monetary value of the asset and the effects of a range of social, economic and environmental factors. To help prioritisation decisions, PPP uses a weighting factor in the evaluation based on the 'taxonomic distinctiveness' of the species likely to be protected by the project. INFFER also seeks other information that can help the user understand where there are knowledge gaps and what spin-off benefits and impacts there might be.

Les and his colleagues identified several challenges to applying these tools to small-scale community-led projects. One of the biggest was finding a consistent way of valuing the species, subspecies or populations being protected. INFFER uses a scoring approach that combines environmental, social and economic values associated with the 'asset' into a single value between 0 and 100, whereas the PPP distinctiveness measure is less subjective, but unlikely to be relevant outside of central or regional government agencies charged with maintaining native biodiversity.

Although the tools indicated that none of the projects examined were attractive in purely economic terms, they don't account for the many accessory benefits derived from community-led conservation projects where economics are important, but not

Banks Peninsula Conservation Trust Wildside Coordinator Marie Haley with local trapper John Stuart inspecting trap lines near the sooty shearwater enclosure at Stony Bay.

the sole driver of decisions. For example, many projects on Banks Peninsula are initiated by landholders and supported by the community because people feel a strong bond with the species being eliminated by pests in their local area, not because of national priorities, threat status or the ecosystem services the at-risk species provides (e.g. pollination and seed dispersal). Also, such projects often receive funding because of a desire to build stronger links between government agencies and the community, to foster a conservation ethic, and to educate people about biodiversity.

The main benefit for CBOs from these tools was that they provide a structured way to compare the relative cost-effectiveness of projects. They also help users to structure projects, set long-term targets, assess risks and measure the efficiency of projects. Unless funding agencies demand more detailed and consistent information about prospective and ongoing projects, however, the complexity of the tools tested means that they are unlikely to be used widely by CBOs. For greater uptake, the tools may need to be redesigned so that they are more appealing to non-experts, and take into account spin-off benefits and values that are difficult if not impossible to quantify using current approaches. Such re-designed tools could be of great value to community groups planning or contributing to Predator-Free New Zealand initiatives.

The work is funded by a Landcare Research Senior Research Fellowship and by the Ministry of Business, Innovation and Employment (contract C09X0503).

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A sooty shearwater chick in the sooty shearwater enclosure near Stony Bay.

A yellow-eyed penguin - Banks Peninsula is its northern breeding limit.

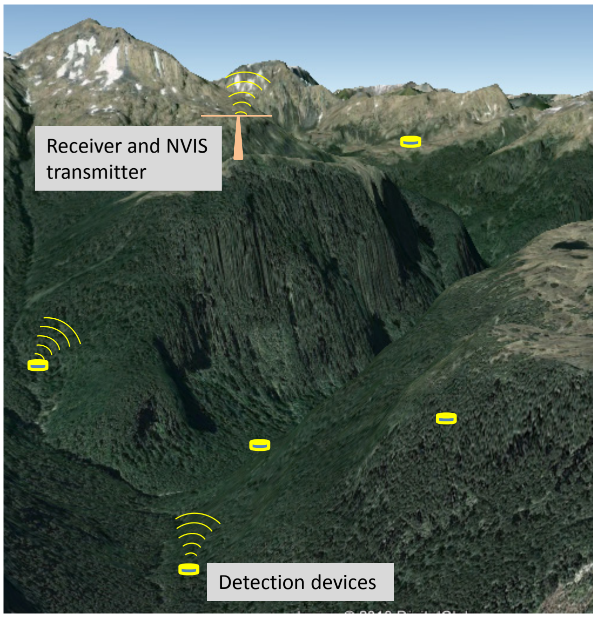
Remote monitoring of traps and vertebrate pests

Current technologies associated with the pest control industry such as traps, chewcards, wax blocks, or trail cameras all require manual checking, either daily (e.g. leghold traps), weekly (e.g. chewcards) or longer (e.g. kill traps and trail cameras). Because trapping and monitoring is often carried out over large, remote areas, any physical checking is expensive both in terms of travel and staff time. This is especially so for areas that are or are planned to be made pest-free in the future as they will require ongoing surveillance to detect invaders and trigger an immediate and targeted response.

The University of Canterbury Wireless Research Centre (WRC) was commissioned by Landcare Research to investigate potential methods for remotely monitoring traps and other detection devices that could significantly reduce servicing costs and provide near-real-time information from the field.

The application of wireless technology in forested terrain has almost been left behind by modern developments in communication, which strive for high data speeds and high density coverage (viz. cellular networks). But the cellular network does not have national coverage and may not work well in forested and mountainous terrain. If wireless technology is to be useful for communication in remote forested areas, there are two major technical issues to overcome: (1) radio waves do not travel easily through foliage, and (2) monitoring devices need to have low power requirements to enable a long operational life.

This project was carried out by two engineering students, Thomas Harding and Richard Jeffcote, as part of their masters degrees, under supervision and technical guidance from the WRC. One project focused on transmitting the status of field-laid traps (i.e. still set or sprung), while the other looked at transmitting images that might be taken by infrared-sensing trail cameras. Each system was designed to send the information back to a central collection point that could be easily accessed remotely.



Detection devices transmitting information to a base receiver that sends the data to a computer for near real-time monitoring.

Thomas and Richard investigated the most suitable frequencies for radio propagation in forest, and sought a compromise between very low frequencies that transmit well through and over obstacles and the need to have aerials of a length practical for field use. As an example, a frequency of 6.2 MHz has a wavelength of 48 m and an optimal aerial length of 24 m. Although this frequency is very effective in forest, such aerial lengths are impractical. With testing of propagation performance, and taking account of portability, expected costs, durability, and ease of use, the students found 27 MHz provided a good compromise between transmission efficiency and practicable aerial length (c. 5 m) for transmitting data through at least 500 m of forest (*Fig.*).

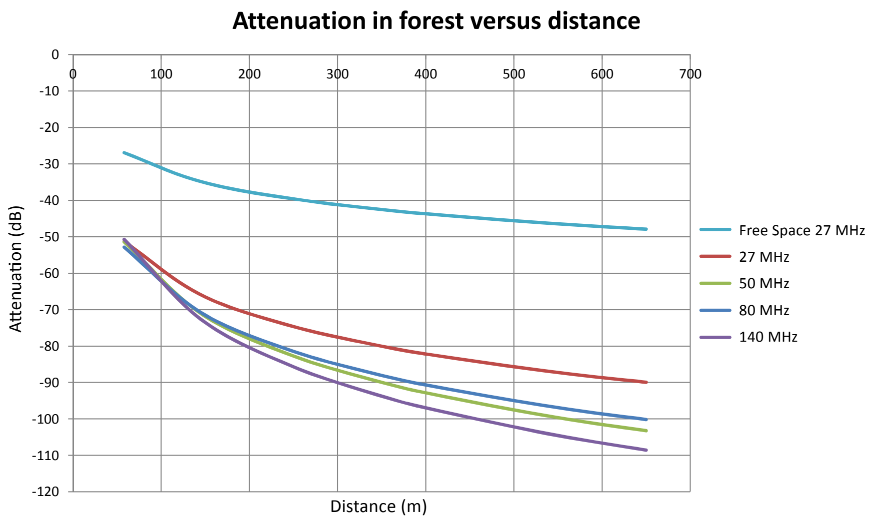


Fig. *Decline (attenuation) in radio signal strength through forest with increasing distance from a transmitter of four frequencies compared to transmission through free space (i.e. with no vegetation).*

For monitoring the status of traps, Richard developed an innovative method using prime numbers to separate data on the status of multiple traps being received by a single receiver. The transmitter developed used very little power, with an AA battery servicing the unit lasting 800 days – a key requirement for field application in remote areas.

Thomas looked at options for transmitting images and selected an existing analogue slow-scan TV mode, which is low speed but has high sensitivity. Pictures take 1–2 minutes to be transmitted, depending on resolution, but such speeds are more than adequate for monitoring remote sites for the presence of invasive species.

Future work will look at how best to link networks of traps or monitoring devices to receiving stations (*Photo*) and how to get the information from remote locations (e.g. the middle of Fiordland) to office-based computers so that devices can be monitored in near real-time. One possibility for accessing remote sites that are out of cellular network range is to use the low frequency Near Vertical Incidence Skywave (NVIS) system (i.e. the system used for New Zealand's mountain radio service).

This work was funded by the Ministry of Business, Innovation and Employment.

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Trapping stoats and ship rats – a low-cost option for their control

Over the past decade more community-based groups have been carrying out pest control in New Zealand, but they are constrained in the amount of control they can do with available funding. Consequently, there is a demand for low-cost tools that community groups can use. Additionally, there is an increasing acceptance that all vertebrate pest control programmes must meet national welfare standards. For traps, there is now a guideline in place for testing their welfare performance. The Victor® Easy Set® rat trap is one trap that meets both these requirements for use against ship rats, but has potential to also be a low-cost trap for controlling stoats.

In 2011–12, Grant Morriss and colleagues made some minor modifications to the Victor® Easy Set® trap to make it more suitable for catching stoats, and tested the modified trap against stoats and ship rats in pen trials. To increase the likelihood of the trap killing stoats consistently, the treadle trigger was changed to a pull trigger and a plastic shroud was added to direct and align the animal at the front of the trap to ensure it was struck lethally and consistently across the top of its head. The modified trap was tested in vertical (*Fig. 1*) and horizontal sets (*Fig. 2*) against both stoats and ship rats. The vertically aligned trap was set 20 cm above the ground to minimise access by ground birds such as kiwi whereas the horizontally set trap (on the ground) was placed inside a purpose-built corrugated plastic tunnel that also limited the access of non-target species. During trials, the trap had to render each of 10 animals captured irreversibly unconscious within 3 minutes to meet the trap-testing welfare guidelines for kill traps. In the first trials, some stoats were struck on the neck and escaped, so the shroud length and trigger design were modified and the trap retested. The further-modified trap then passed the welfare standard for both species in both set types.

The modified Victor® Easy Set® trap provides a low-cost, low-weight, humane trapping option for community groups to control stoats and ship rats. The two setting options (vertical and horizontal) minimise the risk of capture of non-target species such as kiwi and weka. Though community groups could make their own modifications to the Victor® Easy Set® trap, two NZ suppliers of pest control products are currently investigating making modified traps commercially available.

This research was funded by the Ministry of Business, Innovation and Employment (Programme C09X1007 Strategic Technologies for Multi-Species Pest Control).

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Sam Brown, Jane Arrow and Bruce Warburton

Fig. 1 *The Victor® Easy Set® trap set vertically with a shroud to ensure the targeted animal is positioned correctly for a humane kill and that non-target animals are excluded.*

Fig. 2 *The same trap set horizontally and fully covered to protect non-target avifauna.*

Using radio frequency identification technology to measure possum interaction rates with traps

All possum control and monitoring devices require possums to interact with them if they are to function as intended. In the field, it is obvious when a possum is captured, but not how often an individual visits a trap but avoids capture. Increasing the number of visits that result in capture is of obvious practical importance. To answer this question, Samantha Brown and her colleagues have been researching encounter and interaction rates of possums with traps and monitoring devices set in areas containing both uncontrolled (naïve) and controlled (potentially shy) populations.

The probability of capturing a possum is determined by the likelihood of it encountering a trap and then interacting with it. The probability of a possum encountering a trap is principally determined by trap density within that animal's home range. Samantha focused her research on the probability of a possum interacting with a trap or monitoring device once it has encountered it and what can be done to ensure successful interactions follow encounters.

Initial research focused on how to increase the probability of capturing a possum in a leghold trap following an encounter. The study was conducted on farmland in South Canterbury that had been subject to infrequent, low intensity possum control. Sixteen possums were trapped and fitted with active RFID (radio frequency identification) collars. Collared possums were detected by an RFID scanner (developed by Landcare Research) and a PIR (passive infrared) movement sensor when they were 12 m and 3 m away from modified leghold traps set at 21 sites throughout the study area, and when they triggered the traps. The traps were locked open so possums were unable to be caught, which allowed them to make repeated visits to multiple trap sites. The behaviour of possums around traps was observed using motion-activated trail cameras. The interaction probability and behaviour of collared possums was compared between standard trap sets (i.e. that met the National Pest Control Agencies' (NPCA) monitoring protocol); hazed (side fenced) trap sets, and covered trap sets.

All three types of trap sets had similar encounter rates; on around 60% of the occasions that possums came within 12 m of a trap, they came closer to investigate it (*Table*). The average number of trap encounters each night was 1.6, but individual possums visited traps up to 5 times per night. Eighty-one percent of the collared possums encountered traps within 3 nights of them being laid and set.

The number of nights between a possum first encountering a trap and being 'captured' varied between 0 (i.e. caught on its first visit) and 6 (*Fig.*). However, the majority of possums (77%) got 'caught' on the first or second night they encountered a trap. The two possums that got 'caught' 4 and 6 nights after first encountering a trap (see *Fig.*) both visited the same trap on three different nights before 'capture'.

A possum fitted with an RFID collar at one of the trap sites.

Trap set	Probability of an encounter given a detection at 12 m (Encounter / Detection)	Probability of a capture given an encounter (Interaction / Encounter)	Probability of a capture given one or more encounters per night (Interaction / Encounter night)
Standard NPCA protocol 	0.66 (79/119)	0.21 (6/29)	0.33 (6/18)
Hazed (fenced) 	0.63 (95/151)	0.34 (10/29)	0.43 (10/23)
Covered 	0.60 (73/121)	0.40 (10/25)	0.48 (10/21)

Table. *Encounter and interaction probabilities for standard, hazed and covered leghold trap-sets.*

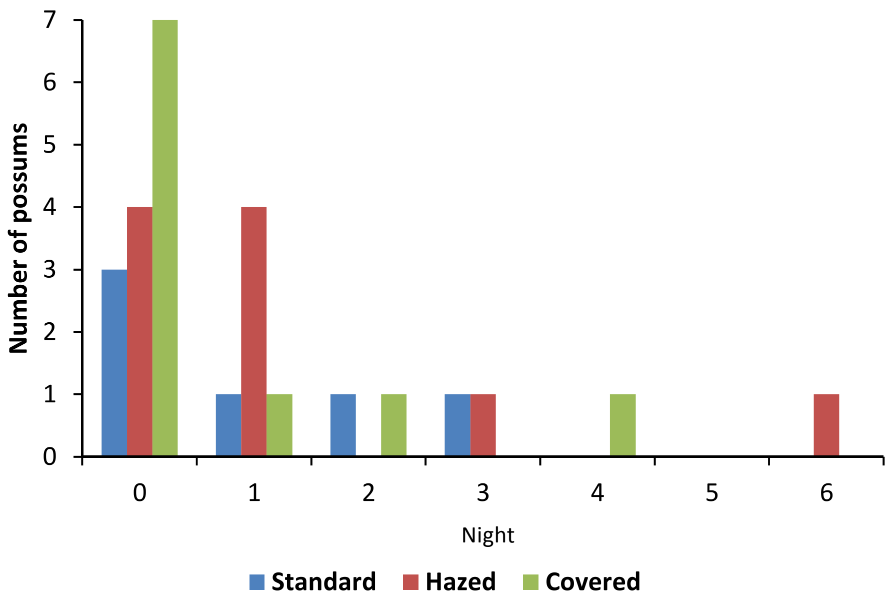

Fig. *Number of nights between first encounter and first 'capture'.*

The capture rate for each trap-set includes all encounters up to a possum's first 'capture'; subsequent 'captures' are ignored as in reality possums would not have the opportunity to be recaptured. Hazing and covering the trap increased the capture rate from 0.21 for standard sets to 0.34 and 0.4 for hazed and covered traps, respectively (*Table)*. However, because of the small sample sizes these differences were not statistically significant and further trials are underway to test this relationship more rigorously. For a trapper, it is unimportant whether a captured possum has one or more encounters on any one night as long as it is caught, but taking multiple encounters before a capture into account still showed that hazed and covered traps had a higher capture rate than standard sets (*Table*).

Many possum visits to trap sites do not result in a capture, but altering the trap-set by hazing or covering it may increase the capture rate. Further work to better understand possum behaviour when encountering and interacting with detection and trapping devices will improve the cost effectiveness of control and minimise numbers of device-shy animals. Future trials will look at the effect of population density on capture rates; i.e. do encounter and interaction probabilities change when possum densities are reduced. The new information on improving capture and detection rates, particularly at low population densities, will contribute significantly to achieving the aspiration of Predator-Free New Zealand.

This study is funded by the Ministry of Business, Innovation and Employment.

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Single or multiple-capture traps – what should you buy?

Funding is the most significant limiting factor on pest control, and will be a major issue for national initiatives like Predator-Free New Zealand, so improvements in cost-effectiveness of current control methods are always welcome. Trapping possums, rodents, and mustelids is expensive because most traps only capture a single animal and require frequent checking to clear and reset. As a consequence, multiple-capture traps have recently become available, but are currently more expensive (NZ$150–$170) than single-capture traps (NZ$9–$30). Deciding what is the most cost-effective option requires an understanding of how many captures a trap might have at a single site over the time between checks.

Multiple-capture traps seem a good idea when pest densities are high, but when there are few animals (as is the case when pests are being maintained at low densities), spending scarce operational funds on traps that can kill 10–20 individuals might not be justified. Bruce Warburton and Andrew Gormley used an individual-based simulation model to determine, for a given density of possums, ship rats, and stoats, what trapping capacity would be needed to maximise the proportion of the population captured using established operational practices. Such information will enable pest controllers to make choices between using multiple-capture traps and multiple single-capture traps, and help developers of multiple-capture traps to optimise the capture capacity of their traps to avoid redundant (and possibly expensive) capacity.

In the model, an area of *c.* 1000 ha was established with spacing between traplines and between traps along lines based on established operational practices for each target species. The model simulated 30 consecutive nights of trapping, with captured animals 'removed' from the population each night. The number of animals captured per trap was recorded. For single-capture traps, traps were 'removed' after capture of a single animal, whereas multiple-capture traps remained in service until their capacity was reached (i.e. 6 or 12 captures), or the trapping period ended. The researchers assumed the single- and multiple-capture traps had equal capture efficiency and that a similar lure was used for both.

Possums

At low densities, increasing the number of possums an individual trap could capture (trap capture capacity) had little effect on the proportion of the possum population captured (*Fig. 1*), with greater than 98% captured when densities were 0.5 possum/ha. Efficacy of single-capture traps decreased with increasing density with only 60% being caught at a density of three possum/ha. When trap capture capacity was at least three possums, greater than a 97% kill was achieved for the entire range of possum densities tested (*Fig. 1*). Increasing trap capacity to 12 resulted in only a small gain in kill percentage (viz. 98.6%). So, three single-capture traps set at each trap site would potentially be a cheaper option than setting one multiple-capture trap.

Stoats

At low densities, increasing the trap capture capacity had little effect on the proportion of stoats captured, with more than 98% captured when densities were 0.02 stoats/ha (*Fig. 2*). Efficacy of single-capture traps greatly decreased with increasing density, with only 47% of the population caught in single-capture traps at the highest stoat

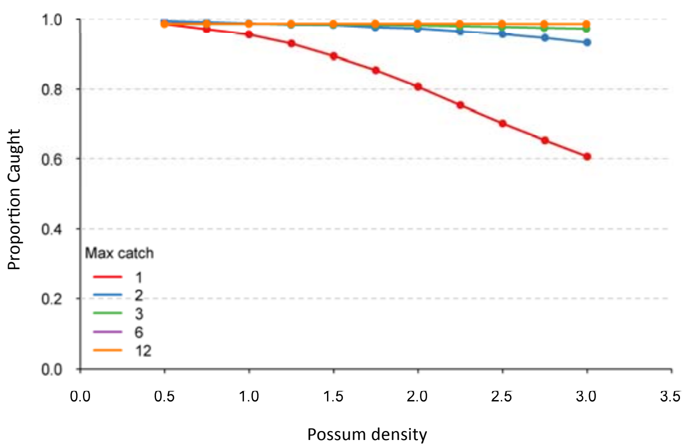

Fig. 1 *Proportion of the simulated possum population captured by traps with capture capacities of 1, 2, 3, 6, and 12. (The line for 6 is obscured by 12)*

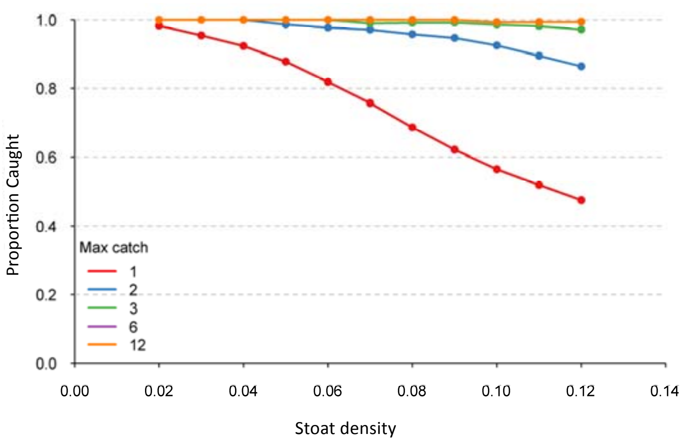

Fig. 2 *Proportion of the simulated stoat populations captured by traps with capture capacities of 1, 2, 3, 6, and 12. (The line for 6 is obscured by 12)*

densities tested. When trap capacity was increased to at least three stoats, a kill of greater than 97% was achieved for the entire range of densities tested (*Fig. 2*). Increasing trap capacity to 12 resulted in only a small gain in kill percentage (>99% at 0.12 stoat/ha). When the low-cost stoat trap described by Grant Morriss (p19) becomes available, it will support the use of multiple single-capture traps over a single multiple-capture trap.

Ship rats

Assuming no immigration, at the lowest rat densities simulated, increasing the trap capture capacity, slightly increased the proportion of rats captured, from 83% with single-capture traps to 87% with multiple-capture traps (*Fig. 3a*). Efficacy of single-capture traps decreased markedly with increasing density, with only 32% of the population caught in single-capture traps at the highest densities. When trap capture capacity was at least three rats, a kill of more than 75% was achieved for the range of densities tested (*Fig. 3a*). Increasing trap capture capacity to 12 resulted in a 16% gain in kill percentage (87% at 11 ship rats/ha). The maximum kill of 87% achieved in these simulations suggests the trap spacing used was too wide, with some rats not encountering traps.

Rat populations recover quickly after control so immigration was modelled with rats from an adjacent uncontrolled area doubling the population on the controlled area over 30 days if no control took place. This resulted in the percentage of rats captured in traps of all capacities being reduced, but traps with a capture capacity of 12 were little better than those with a capture capacity of 6 except at the highest densities (*Fig. 3b*).

Conclusion

For maintaining possums and stoats at low densities, Bruce and Andrew's simulations suggest three or four low-cost single-capture traps set at one place provide a more cost-effective option than using the currently expensive single multiple-capture traps. For ship rats, even at relatively high densities (i.e. 10 rats/ha) 6 low-cost single-capture traps could be more cost-effective than one multiple-capture trap. The simulations ran for only 30 days, and if traps and lure remained effective for longer periods then a higher-capture-capacity trap might have more benefit for controlling rats since they occur at higher densities and have higher immigration rates than possums and stoats. For possums and stoats the results suggest that where a control programme aims to maintain both species at low densities, managers should consider establishing sites with multiple traps as a practical alternative to using single multi-capture traps. Future trials will compare the operational costs of using multiple single capture traps with those of multiple-capture traps.

This work was funded by the Ministry of Business, Innovation and Employment.

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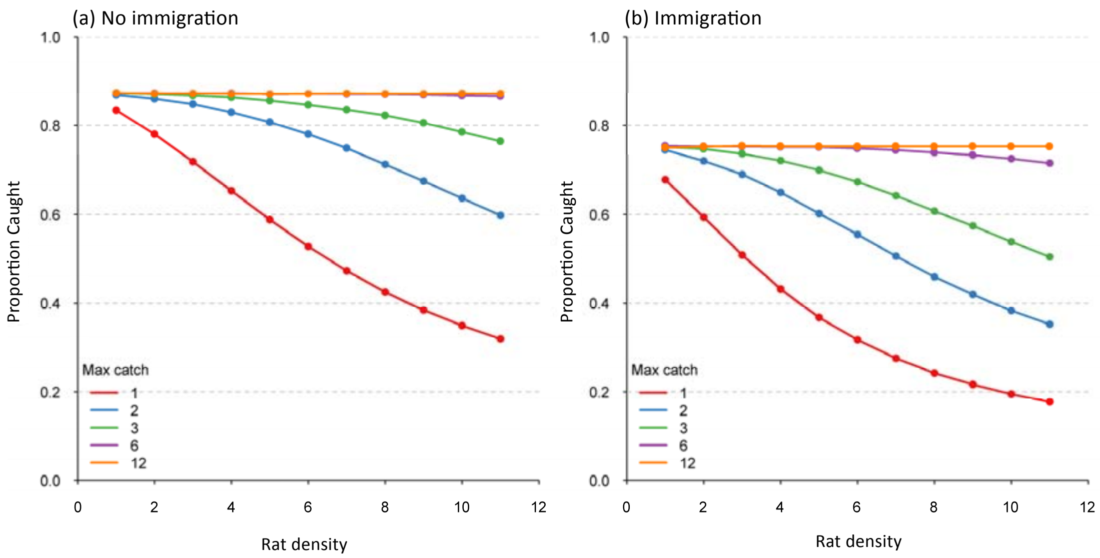

Fig. 3 *Proportion of the simulated ship rat populations captured by traps with capture capacities of 1, 2, 3, 6, and 12, assuming (a) no immigration and (b) immigration.*

Some recent vertebrate-pest-related *publications*

Ballesteros C, Sage M, Fisher P, Massei G, Mateo R, De La Fuente J, Rossi S, Gortázar C 2012. Iophenoxic acid as a bait marker for wild mammals: efficacy and safety considerations. *Mammal Review 43:* 156–166.

Barron MC, Nugent G, Cross ML 2013. Importance and mitigation of the risk of spillback transmission of *Mycobacterium bovis* infection for eradication of bovine tuberculosis from wildlife in New Zealand. *Epidemiology & Infection 141:* 1394–1406.

Clayton RI, Byrom AE, Anderson DP, Edge K-A, Gleeson D, McMurtrie P, Veale A 2011. Density estimates and detection models inform stoat (*Mustela erminea*) eradication on Resolution Island, New Zealand. In: Veitch CR, Clout MN, Towns DR eds 2011. Island invasives: eradication and management. IUCN, Gland, Switzerland. Pp. 413–417.

Cowan P, Forrester G 2012. Behavioural responses of brushtail possums to live trapping and implications for trap-catch correction. *Wildlife Research 39:* 343–349.

Etherington TR, Holland EP 2013. Least-cost path length versus accumulated-cost as connectivity measures. *Landscape Ecology:* 1–7.

Glen AS, Atkinson R, Campbell KJ, Hagen E, Holmes ND, Keitt BS, Parkes JP, Saunders A, Sawyer J, Torees H 2013. Eradicating multiple invasive species on inhabited islands: the next big step in island restoration? *Biological Invasions*. Published online at: doi: 10.1007/s10530-013-0495-y

Glen AS, Pech RP, Byrom AE 2013. Connectivity and invasive species management: towards an integrated landscape approach. *Biological Invasions.* Published online at: doi: 10.1007/s1053001304396

Holland PE 2012. Inferring changes in foliar mass and area from foliage cover: A mechanistic model. *Austral Ecology 38:* 121–130.

MacLeod CJ, Greene T, MacKenzie D, Allen R 2012. Monitoring widespread and common bird species on New Zealand's conservation lands: a pilot study. *New Zealand Journal of Ecology 36:* 300–311.

MacLeod CJ, Tinkler G, Gormley AM, Spurr EB 2012. Measuring occupancy for an iconic bird species in urban parks. *New Zealand Journal of Ecology 36:* 398–407.

Matthews A, Ruykys L, Ellis B, FitzGibbon S, Lunney D, Crowther MS, Glen AS, Purcell B, Moseby K, Stott J, Fletcher D, Wimpenny C, Allen BL, Van Bommel L, Roberts M, Davies N, Green K, Newsome T, Ballard G, Fleming P, Dickman CR, Eberhart A, Troy S, McMahon C, Wiggins N 2013. The success of GPS collar deployments on mammals in Australia. *Australian Mammalogy 35:* 65–83.

Nugent G, Whitford EJ, Hunnam J, Wilson P, Cross M, de Lisle G 2011. *Mycobacterium avium* subsp. *paratuberculosis* infection in wildlife on three deer farms with a history of Johne's disease. *New Zealand Veterinary Journal 59:* 293–298.

Nugent G, Whitford EJ, Yockney IJ, Cross ML 2012. Reduced spillover transmission of *Mycobacterium bovis* to feral pigs (*Sus scrofa*) following population control of brushtail possums (*Trichosurus vulpecula*). *Epidemiology and Infection 140:* 1036–1047.

Nugent G, Whitford EJ, Yockney I, Perry M, Tompkins DM, Holtslag N, Cross ML 2013. Percutaneous interdigital injection of *Mycobacterium bovis* as a model for tuberculous lesion development in wild brushtail possums (*Trichosurus vulpecula*). *Journal of Comparative Pathology 148:* 33–42.

Parkes JP, Anderson D 2011. What is required to eradicate red foxes (*Vulpes vulpes*) from Tasmania? In: Veitch CR, Clout MN, Towns DR eds Island invasives: eradication and management. IUCN, Gland, Switzerland. Pp. 477–480.

Paterson RA, Lal A, Dale M, Townsend CR, Poulin R, Tompkins DM 2013. Relative competence of native and exotic fish hosts for two generalist native trematodes. *International Journal for Parasitology: Parasites and Wildlife 2:* 136–143.

Rouco C, Norbury GL, Smith J, Byrom AE, Pech RP 2012. Population density estimates of brushtail possums (*Trichosurus vulpecula*) in dry grassland in New Zealand. *New Zealand Journal of Ecology 37*. Published online at: http://www.nzes.org.nz/nzje/new_issues/NZJEcol37_1_RoucoIP.pdf

Scroggie MP, Parkes JP, Norbury G, Reddiex B, Hayward R 2012. Lagomorph and sheep effects on vegetation growth in dry and mesic grasslands in Otago, New Zealand. *Wildlife Research 39*. Published online at: http://dx.doi.org/10.1071/WR11209

Sinclair ARE, Metzger KL, Fryxell JM, Packer C, Byrom AE, Craft ME, Hampson K, Lembo T, Dureant SM, Forrester GJ, Bukombe J, Mchetto J, Dempewolf J, Hilborn R, Cleaveland S, Nkwabi A, Mosser A, Mduma SAR 2013. Asynchronous food-web pathways could buffer the response of Serengeti predators to El Niño Southern Oscillation. *Ecology 94:* 1123–1130.