

Kararehe Kino

Vertebrate Pest Research

Issue 25 / March 2015



RESEARCH UPTAKE AND IMPACT



Landcare Research
Manaaki Whenua

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CONTACTS AND ADDRESSES

The lead researchers whose articles appear in this issue of *Kararehe Kino – Vertebrate Pest Research* can be contacted at the following addresses:

Lynn Booth

Phil Cowan

Andrew Gormley

Chris Jones

Graham Nugent

Roger Pech

Bruce Warburton

Landcare Research

PO Box 69040

Lincoln 7640

ph: +64 3 321 9999

fax: +64 3 321 9998

Ingrid Gruner

Department of Conservation

Private Bag 701

Hokitika 7842

ph: +64 3 756 9100

fax: +64 3 756 9188

Al Glen

Landcare Research

Private Bag 92170

Auckland 1142

ph: +64 9 574 4100

fax: +64 9 574 4101

Carlos Rouco

Dan Tompkins

Landcare Research

Private bag 1930

Dunedin 9054

ph: +64 3 470 7200

fax: +64 3 470 7201

ADDRESS CHANGES

Please let us know if your address has changed, you no longer wish to receive this newsletter or if you would like to be added to the hard copy mailing list.

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Editors: **Jim Coleman**

colemanj@landcareresearch.co.nz

Caroline Thomson

thomsonc@landcareresearch.co.nz

Thanks to:

Judy Grindell

Christine Bezar

Layout:

Cissy Pan

Published by:

Landcare Research

Manaaki Whenua

PO Box 69040

Lincoln 7640, New Zealand

ph: +64 3 321 9999

fax: +64 3 321 9998

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Some recent vertebrate-pest-related publications





Rod Dickson

Landcare Research, like all Crown Research Institutes, has agreed a set of national 'outcomes' with Government. In pest management, desired outcomes are to improve the protection of New Zealand's terrestrial ecosystems and biodiversity and to increase the ability of New Zealand industries to meet market and community requirements. Our job as scientists is to ensure that our research is useful in achieving these outcomes. We do this through transfer of technology and knowledge in partnership with key stakeholders. In this issue of *Kararehe Kino*, our scientists highlight some recent examples of research that have helped our stakeholders improve their management of pest animals – and ultimately, helped halt the decline of New Zealand's native biodiversity and increase agricultural production. It's no coincidence that many of the articles in this issue are co-authored by pest managers.

Pest managers make decisions based on evidence, but what sorts of evidence do managers actually use? How reliable or accurate does it need to be? What else guides management decisions? If managers want to use evidence from research, does it exist, can they easily obtain it, and how do they judge its reliability? Evidence-based management is about making decisions through the conscientious, explicit, and judicious use of four sources of information: practitioner expertise and judgement, evidence from the local context, a critical evaluation of the best available research evidence, and the perspectives of those people who might be affected by the decision (Briner et al. 2009). Working partnerships and the consequent dialogue between researchers and pest managers are therefore a sure way to maximise the application and benefits of research.

Research can contribute to improved stakeholder decision making in diverse

ways. The 'Proof of TB Freedom' framework developed by Graham Nugent and colleagues working with TBfree New Zealand staff enables evidence-based decision making by TBfree New Zealand on when to declare areas free of bovine TB, and is a key tool in the strategy to eradicate TB from New Zealand. Similarly, better understanding of the relationship between thar numbers and their impacts on alpine tussock grasslands by Jennyffer Cruz and colleagues is assisting DOC pest managers adjust the intensity of thar control to ensure the desired outcome of reduced tussock damage is achieved.

Such decisions can also significantly affect the costs of pest management, and pest managers are always interested in cost savings because funding is the biggest factor limiting their ability to achieve outcomes. Much of our research is therefore aimed at reducing the costs of current control. Carlos Rouco and

Grant Norbury describe how that can be achieved by exploiting new information about habitat use by possums to better target control. Research by Bruce Warburton and colleagues details how the use of fixed-wing aircraft rather than helicopters can reduce the costs of aerial poisoning targeted at possums and rodents. Andrew Gormley and DOC collaborators applied sophisticated statistical analysis to existing data to show how the cost of monitoring possums as part of DOC's National Biodiversity Monitoring and Reporting System could be reduced without loss of information.

Pest managers also need evidence to address issues raised by people who might be affected by their decisions. Farmers in rabbit-prone areas are often concerned that predator control will result in increased rabbit numbers and damage by these pests. Research by Chris Jones and colleagues in collaboration with Hawke's Bay Regional Council clearly shows that this is generally a misconception, as predators are usually 'passengers' rather than 'drivers' in the ups and downs in rabbit numbers. Extensive use of toxins is a feature of New Zealand pest animal control and, not surprisingly, concerns are often expressed about potential impacts on the environment

and native wildlife. The internationally-accredited Landcare Research toxicology laboratory, managed by Lynn Booth, provides a range of analyses not only to assure pest managers that the control products they use meet manufacturing specifications but also, through analysis of water, soil and animal tissue samples, that environmental contamination by pest control products remains within acceptable limits. Sometimes pest managers need additional evidence. Dan Tomkins and his team describe how their research addressed concerns raised – after approval from the Environmental Protection Agency for their release – about exotic dung beetles as potential spreaders of infectious diseases of livestock and people.

Finally, research can help pest managers make decisions about the future. New Zealand's success at eradicating animal pests from islands has started people thinking about mainland pest eradications. Al Glen and Rod Dickson discuss not only how Landcare Research's involvement in the Hawke's Bay Cape to City project will help the regional council deliver region-wide biodiversity benefits through predator control, but also how the research and trialling in that project may contribute to the longer term aspiration of a Predator-

Free New Zealand. In a similar vein, research described by Roger Pech and colleagues on how climate change may alter the frequency of mast seeding of native plants, and thus rodent and predator dynamics, will allow pest management agencies to better plan pre-emptive pest control to reduce impacts on native biodiversity.

The last issue of *Kararehe Kino* mentioned the Biological Heritage National Science Challenge. This has now been approved and teams are hard at work drafting the research plans. A key feature of the challenge will be the kind of collaborative and interactive partnerships between researchers, stakeholders and end-users highlighted in this issue of *Kararehe Kino*.

This article was funded by the Ministry of Business, Innovation and Employment, Science and Innovation Group, contestable programme C09X1007 (Strategic Technologies for Multi-Species Pest Control).

Phil Cowan

cowanp@landcareresearch.co.nz

Reference:

Briner RB, Denyer D, Rousseau DM 2009: Evidence-Based Management: Concept Cleanup Time? <http://amp.aom.org/content/23/4/19>



Rod Dickson

Feral cat captured in a predator control operation.



Wide-scale predator control for biodiversity in Hawke's Bay



Red Jackson

Introduced predators are implicated in the extinction of 33 terrestrial vertebrate species since European settlement in New Zealand. A further 77 native bird species are currently listed as threatened, while an unknown number of invertebrate species have been lost. To prevent further extinctions, predator control must be undertaken on a scale sufficient to allow populations of native animals to recover.

Hawke's Bay Regional Council (HBRC) is breaking new ground in the battle to save New Zealand's native species. Predators have been successfully controlled across 8000 ha of Hawke's Bay farmland since 2011, resulting in the significant recovery of native lizards and invertebrates (see Jones et al., this issue). While the land area is not in itself significant in terms of pest management, what is potentially transformational is the very-low-cost farmland maintenance control practice being developed by HBRC for predators. The proposed *Cape to City* Project (Fig.) aims to control predators such as stoats, ferrets and feral cats across 26,000

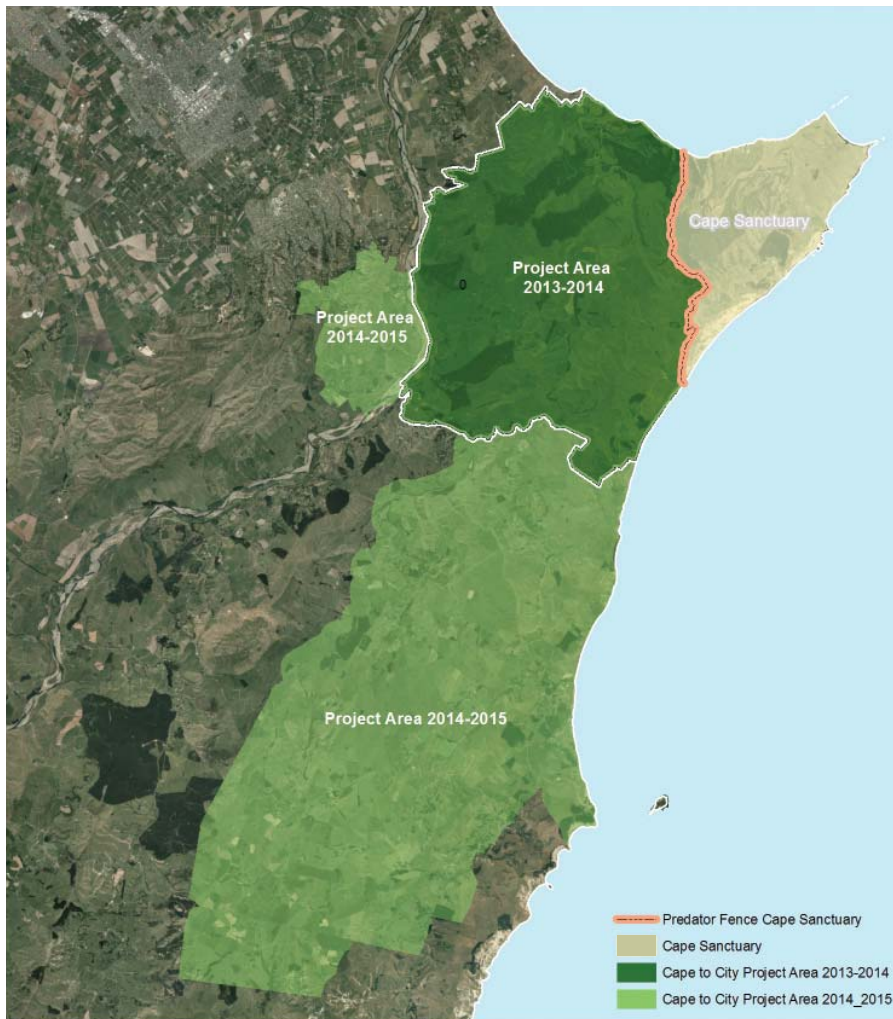
ha of fragmented rural and semi-urban land between Cape Kidnappers and the city of Hastings. As well as protecting remnant populations of native species in this landscape, it is hoped the project will also encourage rare native birds to disperse from the fenced Cape Sanctuary and recolonise the adjacent landscape.

A major challenge for any wide-scale pest control programme is keeping costs affordable. Encouraged by the success of their regional possum control programme and by recent trials on Rangiora and Opouahi stations (see Jones et al., this issue), HBRC is confident that predators can be controlled across the *Cape to City* landscape for a few dollars per hectare. As with all conservation work, monitoring is essential to determine whether the desired results (lower numbers of predators) and outcomes (greater abundance of native species) are being achieved. Landcare Research staff will monitor predator abundance for HBRC using motion-activated cameras and use a range of monitoring techniques to

determine how native species respond to predator control. Weta houses will be used to monitor invertebrates, tracking tunnels to monitor native lizards, and five-minute bird counts to monitor the abundance and diversity of bird species.

Another challenge for the *Cape to City* project is the large number of properties and different land uses within the project area. Much of the proposed predator control will be on private land. Predictive modelling carried out by Cecilia Latham and colleagues suggests that at least 80% of landholders will have to participate for the project to be effective, so corresponding buy-in will be critical.

From HBRC's perspective, the *Cape to City* project provides the opportunity to potentially transform the benefits its community gets across economic and environmental outcomes. This is because the project is a model for how future predator control targeting possums, feral cats, mustelids and hedgehogs could be



achieved over the remaining 500,000 ha of the HBRC possum control programme. Critically, the project also provides the opportunity to test operational-scale solutions relevant to wide-scale predator management. This includes trap monitoring using wireless technology, motion cameras to monitor pre- and post-control predator populations, and disease surveys to determine whether the incidence of toxoplasmosis in the area can be reduced to deliver tangible economic benefits to sheep farmers.

The *Cape to City* project promises not only to benefit native biodiversity in Hawke's Bay, but also, in combination with Landcare Research, to develop knowledge and techniques valuable for the long-term aspiration of a Predator-Free New Zealand.

This work is funded by Hawke's Bay Regional Council as well as core funding from the Ministry of Business, Innovation and Employment.

Al Glen
 glena@landcareresearch.co.nz

Rod Dickson (HBRC, Napier)

Fig. The Cape to City project areas controlled for predators in 2013–14 and 2014–15.



Al Glen

Rod Dickson (HBRC) sets a motion-triggered camera to monitor predator abundance.



A feral cat photographed by a motion-triggered camera in Hawke's Bay farmland.



Rowan Buxton

'Mega-masts', climate change and the management of invasive mammals

It is well known that many New Zealand plants periodically have years with very high seed production (called masts) and that, for beech forests, populations of invasive rodents increase substantially in mast years. This, in turn, leads to a build-up of populations of stoats and increased predation on indigenous species by rodents and stoats. For example, research by DOC scientists has shown that outbreaks of ship rats result in severe impacts on orange-fronted parakeets and native bats, and that populations of yellowhead in the South Island are unlikely to persist through periodic irruptions of stoats.

Currently the management solution to mast-generated outbreaks of invasive species is pre-emptive control operations, usually with aerially-sown 1080 baits distributed over large areas of forest. Although using 1080 is an effective method of pest control, baiting large areas of forest is costly. For beech forest, planning begins as soon as there is heavy flowering by beech trees. Because flowering occurs a year in advance of seed production there is, in principle, ample time to check on the seed crop and the abundance of rodents. However, it is feasible to do this only at a few locations such as high-priority conservation areas with remnant populations of predation-sensitive indigenous species. Until recently there were no easy, affordable methods for estimating the spatial extent of a beech mast and therefore the appropriate size of pest control operations.

In 2013, Dave Kelly and colleagues, including several from Landcare Research, published a simple model for predicting masts using climate data. According to their 'delta T' (ΔT) model, the likelihood of masts by several species, including beech and tussocks, is positively correlated with the difference between average summer temperatures in successive years: a high positive value of ΔT (i.e. last summer warmer than the preceding summer) corresponds to a high likelihood of a mast in the coming year. In a follow-up paper, Pen Holland and colleagues have shown that ΔT can predict directly the probability of outbreaks of house mice after beech masts.

Roger Pech and his colleagues used the ΔT model to consider the following questions. (1) Are some areas in New Zealand more prone to masts? (2) Do masts always occur over very large areas? (3) How often have widespread 'mega-masts' (e.g. >50% of beech forest predicted to mast) happened in the past and (4) will they occur more frequently in the future? (5) How do mega-masts affect the cost of controlling invasive mammals?

Mandy Barron used temperature data from the National Institute of Water and Atmospheric Research's (NIWA) Virtual Climate Station Network to calculate ΔT values for each 5 x 5 km grid cell across New Zealand for the last 40 years (Fig. 1). The model predicts that in some areas, for example on the west coast of the South Island, beech forest is likely to mast once every 3 years; this compares with an average of once every 5.4 years

at the five sites with long-term datasets used by Dave Kelly and his colleagues. Previous modelling by Dan Tompkins suggested that very frequent beech masts 'will lead to populations of stoats and ship rats becoming less irruptive and being maintained at appreciably higher abundances, while the ability of both current and in-development management approaches to suppress invasive mammals will be compromised.'

Mandy also calculated the percentage of the total area of beech forest predicted to have masted each year since 1974. Most masts are localised (e.g. since 1974, there have been 11 years when masts covered <10% of beech forest), but some were much more widespread (Fig. 2). Mega-masts were predicted on eight occasions: over the last four decades there has been a moving average of 5.2 mega-masts per 25 years. In cooperation with colleagues at NIWA, ΔT values to 2100 were predicted for four standard scenarios representing a range of possible future levels of greenhouse gas emissions: an optimistic scenario with peak CO₂ concentrations around 2025 followed by a substantial decline (labelled RCP 2.6); CO₂ increasing initially then declining after 2050 (RCP 4.5); CO₂ increasing until 2060 then declining slowly (RCP 6.0); and a pessimistic scenario with rapidly increasing greenhouse gas concentrations (RCP 8.5). Compared to the reasonably likely mid-range scenario RCP 4.5, the number of mega-masts with subsequent high-cost pest control is estimated to decrease for *all* other RCPs over the 21st century.



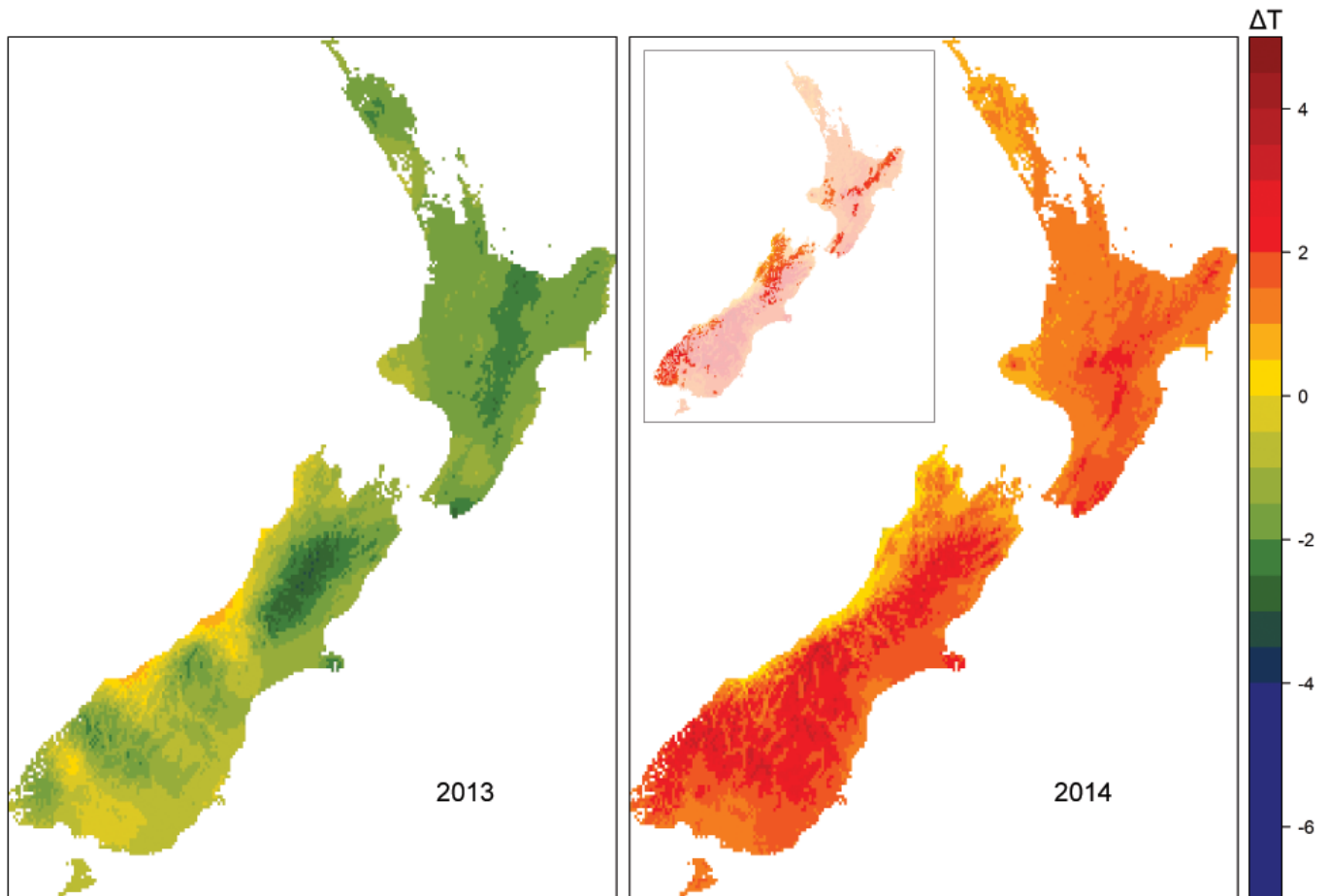


Fig. 1 Examples of ΔT maps illustrating differences between regions and years for all of New Zealand. The inset shows the high ΔT values for beech forest that generated the forecast of a mega-mast in 2014 (85% of the area of beech forest affected) and contributed to planning for DOC's 'Battle for our Birds' programme.

Mega-masts are particularly important for at least two reasons. Firstly, widespread outbreaks of rodents and their predators are likely to result in widespread impacts on indigenous species. This has potential to severely reduce connectivity between remnant populations of endangered species. Secondly, the cost of pest control following a mega-mast can be prohibitive. In its 'Battle for our Birds' programme, DOC has implemented a massive boost in pest control in response to the 2014 mega-mast (Fig. 1). Based on data for the period 2003 to 2013, it would cost DOC approximately \$65 million to conduct aerial 1080 baiting over the entire 3,632,500 ha of beech forest predicted by the ΔT model to mast in 2014. Clearly, episodic pest control on this scale would require major financial and logistical planning.

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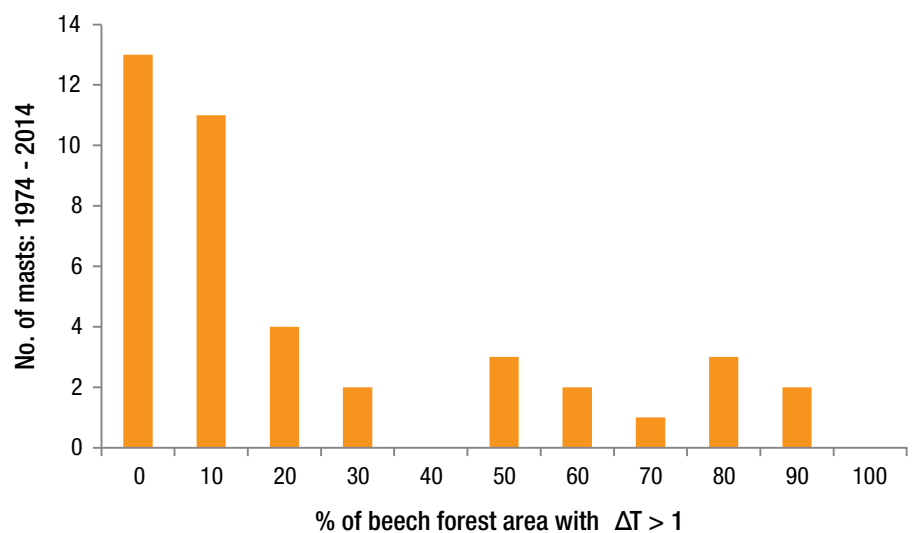


Fig. 2 Number of years over the last four decades with no masts (first column) or with masts (in 10% incremental size classes).

Roger Pech
pechr@landcareresearch.co.nz

Mandy Barron, Andrea Byrom, Dan Tompkins
Jenny Christie (DOC)
Andrew Tait (NIWA)



Quantitative assessment of TB freedom in possums

Sometimes, inspired ideas have to wait before they can be implemented. For example, the value of having a quantitative tool for assessing the probability that bovine tuberculosis (TB) had been eliminated from possums in a local area was recognised 8 years before that tool was first used in 2012. This article summarises the key roles current and former Landcare Research staff have played in developing that tool, in collaboration with key TBfree New Zealand staff (Mark Bosson and Paul Livingstone) and overseas researchers (Tony Martin, Western Australia).

Declarations of 'TB freedom' are largely based on a calculated probability that there is a less than 5% chance the possums are still infected (i.e. $P_{\text{Free}} > 0.95$). These calculations are made within a 'Proof of Freedom' data model developed by Dean Anderson and others in about 2010. That

model is initialised with predictions from a Possum-TB model developed by Dave Ramsey and Murray Efford and refined by Mandy Barron. In essence, the Possum-TB model provides a quantitative statement of belief that previous possum control has been sufficient to eradicate TB from an area (Fig. 1).

Once the possum-model-predicted P_{Free} reaches an agreed trigger level (currently $\geq 80\%$), surveillance is initiated to provide empirical evidence that TB is indeed absent from a possum population. The greater the survey effort undertaken without finding TB, the greater the confidence an area is TB-free. Surveillance data can be derived not only directly from possums, but also from surveys of 'sentinel' species such as deer, pigs, and ferrets.

The underpinning data and theory span

Bayesian probability and classical sampling theory, TB epidemiology, population dynamics, home range utilisation and movement patterns of possums and sentinel species, and, for possums, their trappability or detectability. Most of the underpinning research was conducted without Proof of Freedom in mind, highlighting how current research can have unforeseen additional uses.

Qualitative 'stopping rules', developed by TBfree New Zealand to decide when they could stop local possum control, underpinned the development of a quantitative Proof of Freedom model beginning in 2004 with a workshop between TB managers, Landcare Research, AgResearch, Environment Waikato and others. Some key points discussed were:

- The desirability of using actual surveillance to quantify confidence that TB was absent.
- The difficulty of surveying a large sample of possums given that in well-managed areas possum densities were very low
- Whether simply knowing that enough possum control had been done would suffice; e.g. would achieving $>95\%$ kills on three occasions over 10 years guarantee local eradication of TB from possums?

By 2006, Graham Nugent, Dave Ramsey and Peter Caley had produced a discussion document that showed how all three issues could be combined into a workable tool. This included the development of a new concept of spatially explicit surveillance based on 'TB-detection kernels' for sentinels (Fig. 2). The kernels from different species could be added together to predict where in the landscape TB was least likely to be.

Over the next few years, a major review was undertaken by the funders of the TB programme to decide whether the objectives of TB management should be to control the disease at some low level

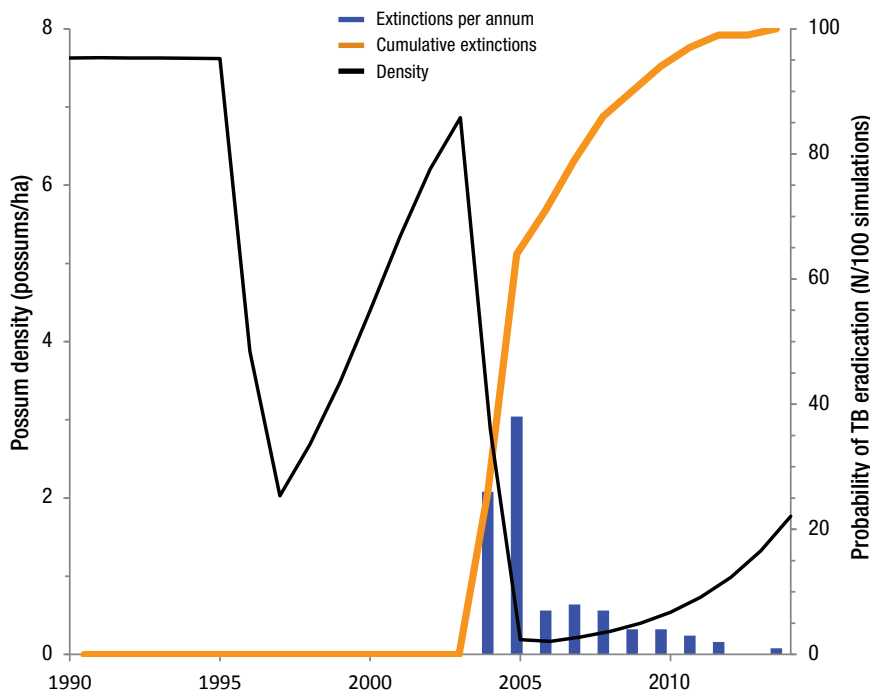
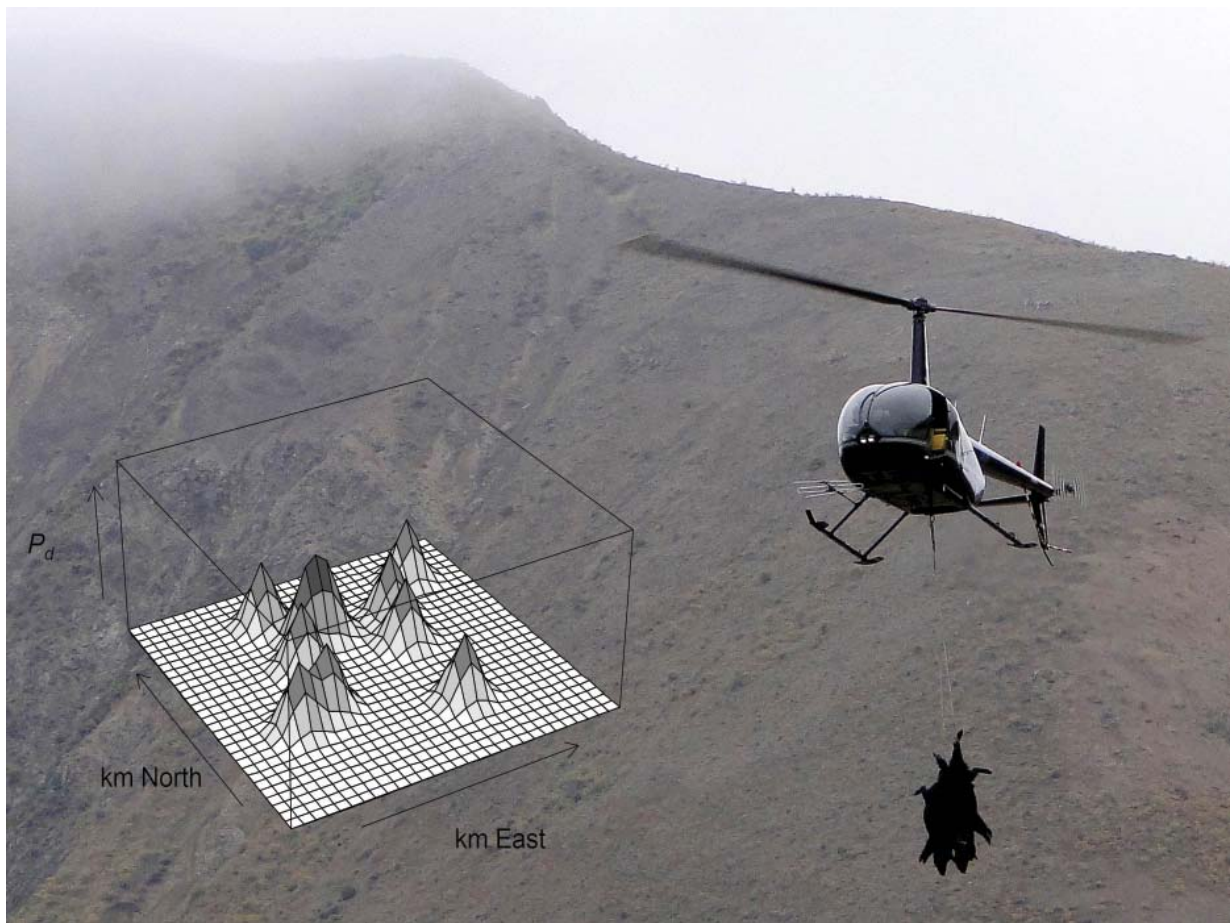


Fig. 1 Increasing probability of TB eradication from the Hokonui Hills, Southland, as predicted by the Possum-TB Model, and based on possum control history involving aerial baiting in 1996 (80% kill) and 2004 (97% kill), and ground control in 2005 (10% kill). The black line shows the predicted changes in possum density over time, the blue bars the number of the 100 simulations in which TB went extinct in possums in each year, and the orange line how the number of extinctions accumulates over time. Under these assumptions, and assuming even control, the model predicts there was minimal chance eradication had occurred before 2004, but a very high probability it had by 2011.



Graham Nugent

Fig. 2 Spatially explicit sentinel surveillance. For each pig necropsied, a TB-detection kernel is created in a GIS, as depicted graphically, with the radius of the kernel related to average home range size and the height of the kernel to the probability of TB detection by pigs.

or push for eradication. Agreement was eventually reached that eradication would indeed be a key objective in the National Pest Management Plan (NPMP) for TB, and the development of a Proof of Freedom tool by researchers began in earnest in 2009 – leading to its first formal application in early 2012. As at June 2014, TBfree New Zealand had declared 830,000 ha, or 33% of the 2.5 million ha proposed for TB eradication by 2026 in their NPMP, as TB-free. This means that 8% of the 10.5 million ha that was defined as containing tuberculous wildlife at June 2011 is now free of infected possums.

In summary, development and adoption of the Proof of Freedom framework as a major new paradigm in TB management

took almost a decade, partly because it inevitably takes time to ‘sell’ new concepts to users, but mainly because the need for such an approach only became a priority when local eradication of TB became a formal management goal. There is now a strong focus on refinement and extension of the framework and associated software. An example is the development of a new theory by Dean Anderson that would allow inclusion of data from livestock TB testing and slaughterhouse inspections to help increase confidence that TB is absent from possums in farmed areas. Currently that information is used only qualitatively and does not affect the calculated probabilities of TB freedom.

By providing an objective measure for

comparing progress between areas, the Proof of Freedom tool has enabled a shift away from focusing on possum control toward the true objective of TB management – the elimination of TB from possums. In doing so, it has led Andrew Gormley and Graham Nugent to explore new strategic concepts about when to start TB surveillance. These concepts have the potential to greatly shorten the cost and duration of possum control required for TB freedom.

This work was funded by TBfree New Zealand.

Graham Nugent

nugentg@landcareresearch.co.nz



Reducing the cost of DOC's biodiversity monitoring



Caroline Thomson

traps spaced at 20-m intervals, giving a total of 40 traps per sampling location (*Fig. 1*). Such trapping data also provide information on site occupancy by possums and are supplemented by data from surveys of 120 faecal pellet plots per sampling location.

A phased implementation of the Tier 1 programme was conducted at 85 forest locations and 79 non-forest locations in the 2011/12 and 2012/13 field seasons, during which time traps were set over two fine nights and checked daily. Andrew Gormley (Landcare Research) and Dave Forsyth (Arthur Rylah Institute (ARI)/DOC) analysed these trap-catch data to assess the consequences of reducing trapping to only one night. They found that estimates of possum occupancy were not affected, due in part to the amount of information obtained from pellet plots remaining unchanged (*Fig.2*). However, estimates of possum abundance were slightly affected, with slightly more possums estimated in forest habitats and greater uncertainty. Greater uncertainty also affects the level of change that could be detected reliably, albeit very slightly. For example, if all forest locations were sampled, two nights of trapping would detect a 5.4% change, whereas one night of trapping would detect a 5.7% change.

The outcomes of Andrew and Dave's research have led to DOC reducing possum monitoring from two nights to one night in Tier 1 of the BMRS. One night of possum monitoring has the potential to reduce the number of field days per field season from 813 (i.e. 3 days across 271 locations per year) to 542, resulting in potential savings of 6% per sampling location, due to a 20% reduction in the costs of labour, food and field allowances. However, the need to monitor other taxa and changes to the organisation of field teams means that actual savings are likely to be less than this. Another benefit of fewer field days is that it gives greater opportunity to select more suitable weather windows and therefore increased likelihood that all 271 locations will be sampled during the field season.

Robust biodiversity monitoring programmes are expensive and time-consuming, especially when conducted at large scales. As such, it is important to identify ways of monitoring more quickly and more cheaply without a loss in the quality of information collected.

The Department of Conservation (DOC) is implementing a systematic approach to Biodiversity Monitoring and Reporting (BMRS) to enable reporting on three indicators of ecological integrity: species occupancy, indigenous dominance and ecosystem representation. The BMRS is composed of three tiers of information, which operate at different scales with varying levels of detail and coverage (see <http://tinyurl.com/doc-bmrs>). The Tier 1 component involves measuring a variety of taxa (i.e. native and exotic plants and birds, and pest mammals) at 1354 systematically located sites on public conservation land over a 5-year rolling period, with 271

locations sampled each field season (i.e. October–March).

An initial pilot study at 18 locations in 2008/09 determined that the two nights required for possum monitoring was a major determinant of costs, time investment and availability of adequate technical expertise. DOC is particularly interested in whether reliable estimates of possum abundance could be obtained from one night of monitoring. Field teams would only need to stay 2 days (rather than 3 days) at each sampling location and so be able to cover more locations in a season. This means fewer people would need to be trained in possum monitoring protocols.

Possums are measured using the Trap-Catch Index (number of possums captured every 100 trap nights), which measures relative abundance and reflects actual possum abundance. Possum monitoring consists of 4 × 200 m trap lines, each with 10 leg-hold

The research gave DOC confidence that reducing the sampling effort would compromise neither the quality of the data nor the inferences that could be made using those data.

The implementation of Tier 1 of the BMRS is a template for other large-scale biodiversity monitoring programmes: the pilot study enabled potential savings to be identified, while the phased implementation allowed key data to be collected and benefit-costs analysis to be performed before the programme was fully implemented in 2013/14.

This work was funded by the Department of Conservation.

Andrew Gormley

gormleya@landcaresearch.co.nz

Dave Forsyth (ARI/DOC), **Elaine Wright,**
Meredith McKay, John Lyall, Mike Elliott,
Mark Martini, Benno Kappers (DOC) and
Mike Perry (Landcare/DOC)

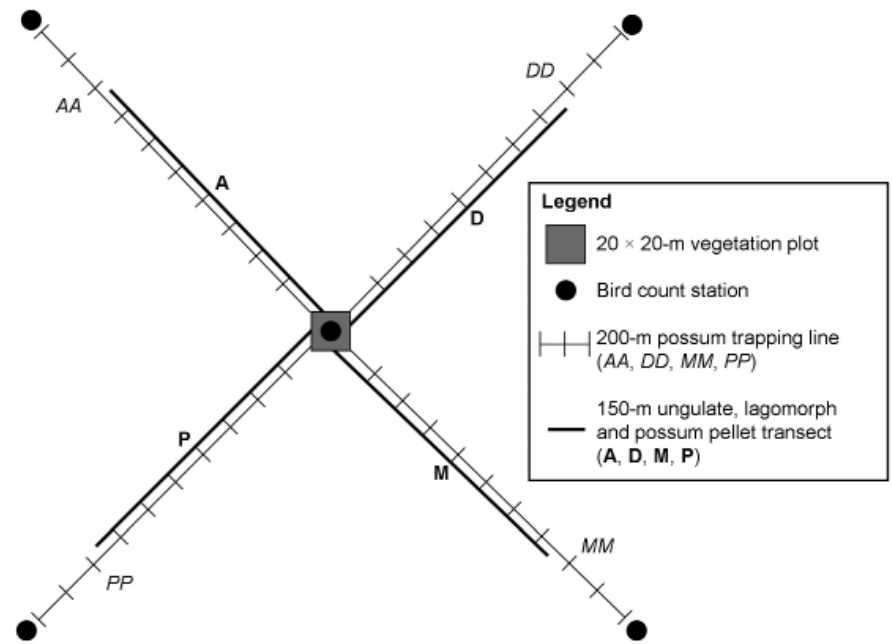


Fig. 1 Spatial design of monitoring conducted at each sampling location. Possum trapping occurs along each of the four 200-m trap lines (AA, DD, MM and PP) and the presence or absence of possum faecal pellets is recorded on each of the 30 plots located along the four 150-m ungulate/rabbit/hare pellet transects (A, D, M and P). Birds are monitored at each of the bird monitoring stations, and vegetation is monitored on the central 20 x 20-m vegetation plot.

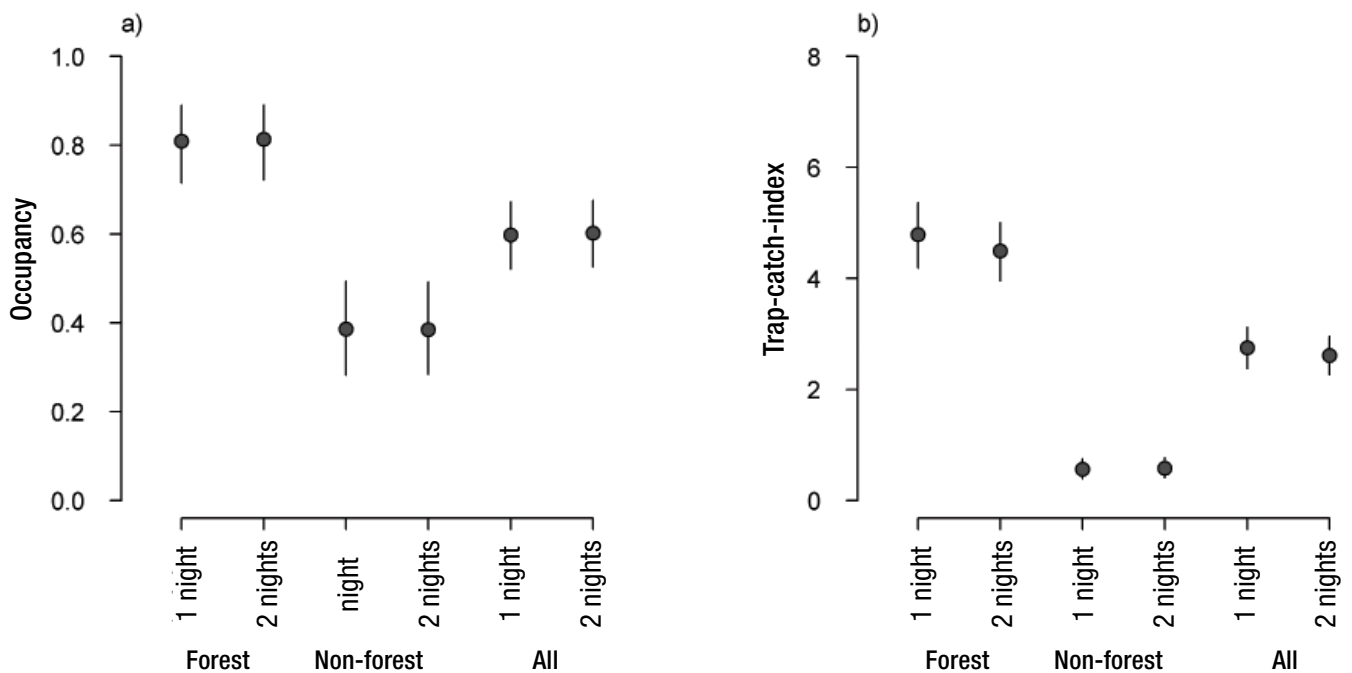


Fig. 2 Effects of reducing sampling effort on estimated possum occupancy (a) and relative abundance (b). There were 85 sampling locations in forest habitat and 79 sampling locations in non-forest habitat. Vertical bars indicate 95% credible intervals.





Jan Kely

Predator control benefits native species but not rabbits

Landcare Research scientists have been working with Hawke's Bay Regional Council (HBRC) to measure the effectiveness of the council's predator control operations in protecting native biodiversity, and to review the evidence around a potentially contentious pest control issue concerning landowners in the region.

Since November 2011, HBRC has been controlling invasive predators on two pastoral properties adjacent to Boundary Stream Reserve – a large conservation area containing populations of rare native animals. The wide-scale trapping programme, which covers 8000 ha on Rangiora and Opouahi stations, is part of the larger *Poutiri Ao ō Tāne* project (www.poutiri.co.nz), a collaboration between HBRC, community groups and the Department of Conservation. The aim of the programme is to test whether predator control can benefit native biodiversity in a pastoral landscape with fragments of native bush. It is also hoped that trapping adjacent to Boundary Stream will reduce predators reinvading the reserve.

Before trapping began in 2011, Landcare Research scientist Al Glen and colleagues began monitoring predators and native species in the predator control area (see

Glen & Dickson, this issue). This work is ongoing. For comparison, monitoring is also done on neighbouring Toronui Station, where no predator control has been or is being undertaken. Pest mammals are monitored using footprint tracking tunnels and motion-activated cameras (camera traps). The tracking tunnels also detect native skinks. Invertebrates are monitored using weta houses, while the diversity and abundance of birds are monitored using electronic bird song recorders.

Tracking rates of skinks have increased in the predator control area from zero in 2011 to 50% in February 2014. No skink tracks have been detected in the non-treatment area. Populations of native invertebrates are also more abundant where predators are controlled; the weta houses in the predator removal area consistently have around 30% more invertebrates than those in the non-treatment area. Further monitoring and analysis will determine whether pest control has also benefited native birds.

As programmes to enhance indigenous biodiversity expand, some landholders with overabundant rabbits believe that predator control on adjacent lands has exacerbated their rabbit problems. Because control is costing more, they are seeking subsidies

from regional councils or the Department of Conservation. This issue will become increasingly complex and contentious as new technologies and ambitious visions of pest eradication over very large areas gain traction. Public perceptions are critical: many landowners and members of the general public believe intuitively that if predators eat rabbits they must be regulating rabbit numbers. However, predator-prey population dynamics are rarely that simple. As a first step, Grant Norbury and Chris Jones reviewed the published scientific literature covering predator effects on rabbit populations, both in New Zealand and overseas.

The review found that, in New Zealand, there is no compelling experimental evidence that predator removal increases rabbit abundance. Predators have relatively little effect on rabbit numbers compared with other forms of mortality, such as disease or flooding and collapse of burrows. In Australia, rabbit numbers are driven primarily by climate and its effects on food abundance and quality, and disease. However, where rabbit numbers are low, predation can limit population recovery. Similar patterns have also been described in parts of Europe. Overall, predation appears to be less important than the effects of



climate, food, disease and habitat on rabbit numbers. Predator abundance (especially for species that specialise on rabbits) can usually be predicted by rabbit abundance, but the reverse is not necessarily true.

For areas of New Zealand that are highly favourable for rabbits (e.g. dry central South Island) predator control is less likely to result in higher rabbit numbers than in areas of higher rainfall where other forms of rabbit mortality prevail. Any increases in rabbit numbers subsequent to predator control, however, are likely to be small compared with the effects of climate, food, disease and habitat.

In circumstances where predator control might lead to more rabbits, we do not know whether the factors involved can be identified with enough certainty to predict where and when rabbit population increases are likely to occur, and if so, by how much? The researchers suggest a robust and consistent rabbit, predator and disease monitoring programme be instigated at sites adjacent to or overlapping predator control operations so that data on changes in rabbit populations can be collected alongside data on changes in disease prevalence and predator abundance. These data could be combined with local data on climate and other conditions to investigate the most likely conditions for rabbit populations to increase.

For the success of the council's predator control programme, it is crucial for the community to understand that predators are 'passengers', not drivers, in predator-rabbit population dynamics, and Landcare Research efforts are helping generate this appreciation. The common misconception that predators drive rabbit abundance has the potential to damage the community uptake of voluntary predator control programmes in the future.

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Chris Jones

jonesc@landcareresearch.co.nz

Grant Norbury, Al Glen

Rod Dickson (HBRC)



Rod Dickson

Trapper Pouri Rakete-Stones checking a mustelid trap in Hawkes Bay.



G. Dickson

Two ferrets, a stoat and a weasel (top to bottom) all trapped during HBRC predator control operations.

Impact of Himalayan thar on snow tussock grasslands in the Southern Alps



Vegetation plot in the Zora catchment (1999). In each measurement, the condition of at least 20 individual tagged tussocks is assessed, along with overall cover of all plant species present. Thar activity around each plot is assessed using faecal pellet counts.

Following their introduction into New Zealand in 1904, Himalayan thar (tahr) colonised over 8000 km² and their population grew to over 50,000. However, during the 1970s, aerial commercial hunting reduced their numbers to less than 5000. In 1983, commercial hunting was temporarily banned allowing thar populations to partly recover. Since 1993, thar have been managed under the Himalayan Thar Control Plan. This specifies intervention (control) densities above which thar impacts were thought to be ecologically unacceptable. These intervention densities are based on expert opinion, but the Plan also calls for further research and monitoring to enable periodic reviews of the appropriateness of the intervention densities.

In response to this recommendation, Landcare Research and the Department of Conservation (DOC) set up a programme in the early 1990s to determine ecologically acceptable thar densities from population assessments undertaken in parallel with vegetation monitoring. Eight catchments were selected where thar densities were well below, at, or far above specified intervention densities. Snow tussocks were

chosen as the key indicator species as they constitute a large part of thar diet, but not of the diets of sympatric possum or chamois populations. Variably-sized permanent plots containing at least 20 adult snow tussocks were subjectively placed in areas used by thar.

Measurements for each individual tussock included basal live diameter (cm), maximum height of the extended live leaves (cm) and the amount of crown death estimated to the nearest 10%. The percentage of each plot covered with vegetation (of all plant species) was also measured to assess impact of thar on the overall vegetation present in the tussock grasslands. The level of thar activity was assessed near the plots using the proportion of 1-m² plots containing faecal pellets (assumed to be mainly from thar since few other ungulates were present).

In the 20 years, the vegetation plots have been remeasured several times, and ungulate activity around the vegetation plots and thar numbers in the study catchments assessed. The monitoring was initially by Landcare Research, and later by

DOC (see *photo*). Landcare Research was commissioned to review the data up to the latest measurements in 2004 and again in 2014.

The 2004 review indicated that tussock condition was improving in catchments where thar were held below intervention densities but not in those where thar exceeded the thresholds. Unfortunately, the methodology used for assessing thar densities was not consistent, and in some years it was only possible to derive the minimum number of thar known to be alive. Reliable comparisons of thar density over time and across sites were thus impossible. Furthermore, relating plot data to catchment-wide thar counts involved introducing pseudo-replication into the design. Therefore, the 2014 review focused on comparing snow tussock condition and overall vegetation cover with thar activity immediately around the vegetation plots. This review used a mixed-effects linear model with tussock condition (i.e. height) as the response variable, and thar activity, elevation and aspect of the plot, year of sampling, live diameter and percentage of crown death of adult tussocks as

explanatory (fixed) variables. To evaluate the effects on overall vegetation cover, a generalised linear model with Poisson error was used to account for the skewed distribution of vegetation cover. This second model included plot elevation and aspect, year of sampling and thar activity as explanatory variables. The main results suggest that (1) tussock condition decreased over time and continues to be negatively affected by thar (Fig. 1), and (2) although vegetation cover increased over time, it was also negatively impacted by thar at sites with high thar use (Fig. 2).

The latest review by Landcare Research identified a key shortcoming in the monitoring, namely inconsistency in the

methods used to collect data relating to thar densities. Because of this, it is impossible to address the key question behind the original study, i.e. what are ecologically acceptable thar densities? This observation highlights an issue for long-term studies in general, in that the initial intent, management and data requirements of such studies risk being relaxed or forgotten over time, thus greatly reducing their value.

Nonetheless, results from the latest review demonstrate that current levels of thar control are not sufficient to maintain the status of tussock grasslands, let alone enable their recovery. This is not surprising, as the intervention densities specified in

the Thar Control Plan were exceeded at all eight study sites monitored (based on minimum numbers of thar known to be alive). Thar management is now being reviewed to achieve better conservation outcomes in the future.

This work was jointly funded by the Department of Conservation and Landcare Research.

Ingrid Gruner (DOC)
igruner@doc.govt.nz

**Jennyffer Cruz, Caroline Thomson,
John Parkes
David Forsyth** (Arthur Rylah Institute)

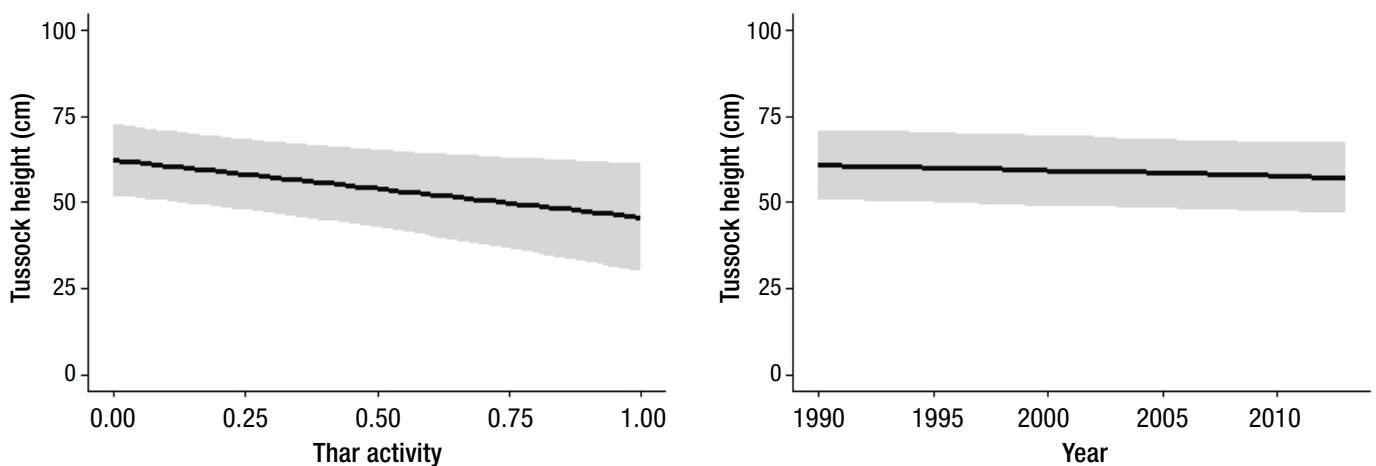


Fig. 1 Predicted mean relationships between tussock height and thar activity, and between tussock height and year of monitoring. Shaded areas are the 95% confidence intervals.

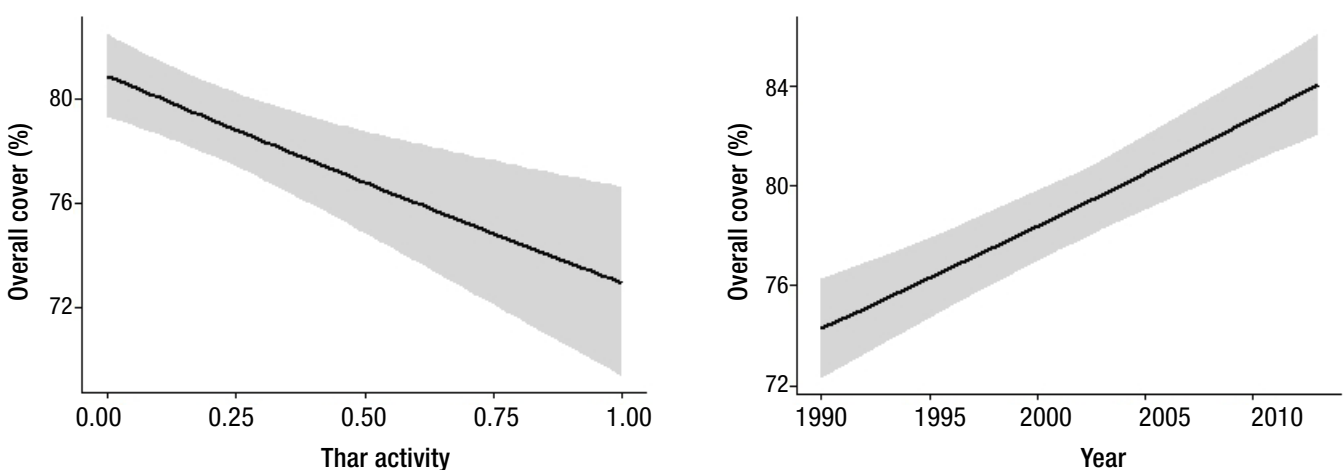


Fig. 2 Predicted mean relationships between overall vegetation cover and thar activity, and between vegetation cover and year of monitoring. Shaded areas are the 95% confidence intervals.



Improving possum ground control in the southern South Island

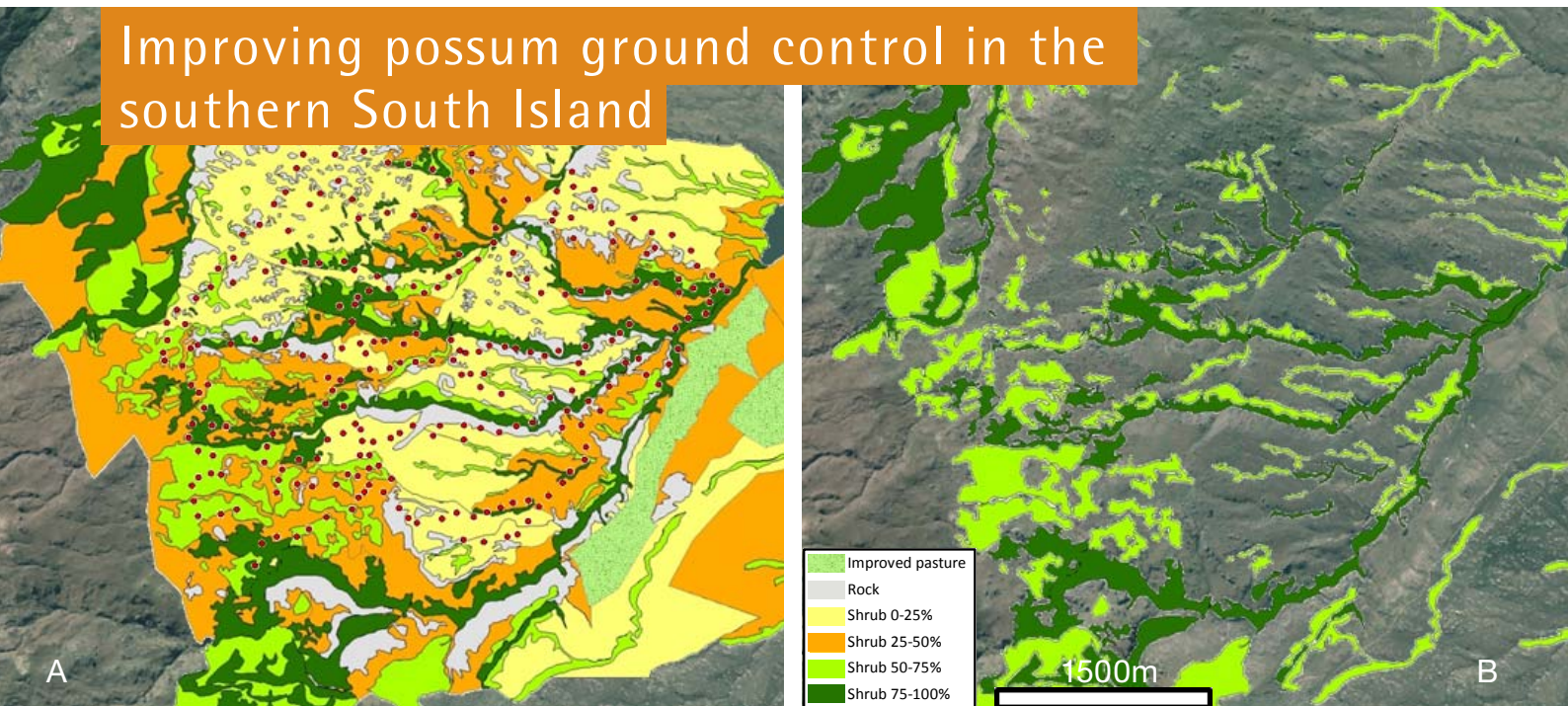


Fig. 1 A. Map of the study site showing different habitat types. Red dots represent chewcard locations. B. Map showing the habitats most preferred by possums (based on chewcard records) and likely to yield the most possums in maintenance possum-control operations.

Brush-tail possums are the main wildlife reservoir of bovine tuberculosis (TB) in New Zealand, and are primarily responsible for the transmission of TB from wildlife to livestock. Intensive control of infected possum populations undertaken under the New Zealand National Bovine Tuberculosis Pest Management Strategy has led to substantial reductions in the number of infected cattle and deer herds. However, such possum control costs about \$80 million a year. In addition, possum grazing reduces farm production by about \$35 million a year. Improving the efficacy of possum controls is therefore a national priority.

Nineteen percent of New Zealand's land area is dryland habitat, consisting mostly of grassland and shrubland. Such lands include some of the most threatened native ecosystems and species in New Zealand, and are poorly represented in reserves. Possums do not use these landscapes randomly but instead concentrate their activities in particular habitats such as shrublands and rocky outcrops. This being so, habitats such as open grassland could be omitted from ground-based possum control operations, with little loss of control efficiency. In addition, possums may vary

their movements and use of habitats throughout the year depending on the availability of favoured foods and their breeding behaviour. Understanding this seasonality will help managers decide on the timing and location of possum control, and increase control efficiency. Further, habitat use by possums in uncontrolled, high-density populations may differ from that of possums at low density following control. This can affect the way managers target control for initial versus maintenance (follow-up) operations. For example, after control, surviving possums may concentrate their home ranges in the very best habitat, or they may aggregate depending on the availability of surviving conspecifics. On the other hand, post-control possum distribution may simply reflect the level of difficulty control teams face when accessing different terrains.

This project enables spatially-targeted control of possums to be applied to southern South Island (SSI) habitats by providing critical information on habitat types preferred by possums and its seasonality of use.

Carlos Rouco and Grant Norbury monitored an uncontrolled possum population living

at a range of elevations in a diverse array of rock outcrop, grass and shrub habitats between Alexandra and Cromwell. The site was representative of typical dryland habitat across the SSI. The team set out 260 chewcards spaced at 100-m intervals over 900 ha for 4 days. The habitat type at each card location was derived from a habitat map (Fig. 1A) based on aerial photographs using ArcGIS 10 software (ESRI, Redlands, California, USA). Cards were deployed during summer, autumn, winter and spring for a year, before the possum population was controlled to 30% of its pre-control density (i.e. c. 70% decline). Chewcards were then redeployed for eight seasons (24 months) and the data analysed using Jacobs' (1974) index to quantify possums' preference for each habitat type.

The chewcard data showed that possums in the SSI prefer dense shrub (75–100% coverage), followed by less dense shrub (50–75% coverage) and rock outcrops (Fig. 2). Improved pastures were avoided. Before control, preference for shrubs and rock outcrops was most evident in winter when there was unusually high snow cover. After control, preference for all shrublands and rock outcrops increased in all seasons, presumably because lowering the density

of possums reduced competition for preferred habitats. This greater preference for shrub and rock habitats should benefit maintenance control operations provided contractors target these habitats (Fig.1B).

Possum control takes place over 3.5 million ha of Vector Risk Area (infected wildlife habitat) in the SSI, therefore, more targeted

control in preferred habitat will have substantial cost savings.

This work is part of a larger project funded by the former Animal Health Board entitled *Improved efficiency and effectiveness of ground-based possum control and monitoring in the southern South Island (R-10737)*.

Carlos Rouco

roucoc@landcareresearch.co.nz

Grant Norbury

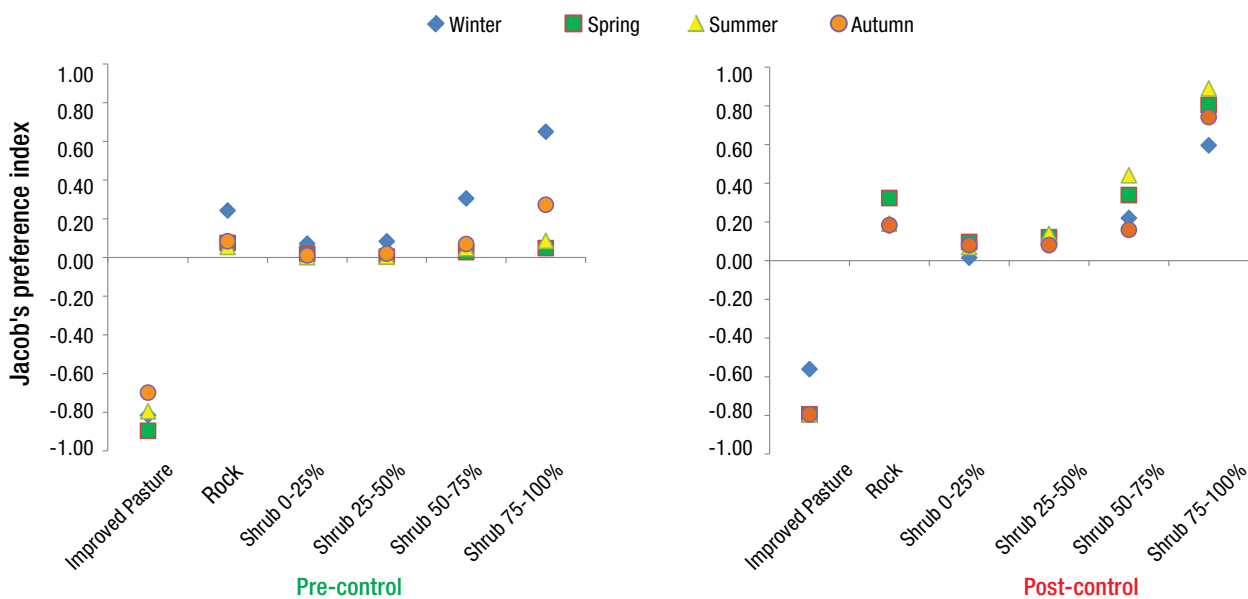


Fig. 2 Habitat selection by possums, indicated by chewcards after one night before and after control at the study site. Positive values indicate habitat preference and negative values indicate habitat avoidance relative to availability. There was high snow cover during the winter before control (blue diamonds, pre-control).

The Landcare Research Toxicology Laboratory

– analyses and advice for vertebrate pesticide testing

The Landcare Research Toxicology Laboratory was established in 1989 and specialises in analysing environmental samples for traces of vertebrate pesticides such as 1080, cyanide and various anticoagulants. Some test methods available are accredited under International Accreditation New Zealand (IANZ) and the Ministry of Primary Industries laboratory approval scheme (LAS).

Laboratory staff deal with a range of sample types – water, bait and meat testing are the most common, while other matrices include plants and various biological samples from animals, such as wool, milk, honey, internal organs and bodily fluids. Test results provide important data critical to understanding, monitoring and managing risks around the use of 1080 and other poisons for possum and rodent management. The laboratory provides analytical and formulation

support for research projects conducted within Landcare Research, and also has a strong commercial function in carrying out accredited testing for a range of clients including local authorities, private pest control companies, other laboratories, government departments and universities.

Recently staff have worked with the Department of Conservation in developing toxic baits with bird repellents to protect



kea and other native birds during pest control operations. Staff developed and validated assays for two bird repellents, then conducted extended trials with baits containing the repellents to determine the longevity and therefore usefulness of these repellents in baits. This project is ongoing.

Testing for 1080 in waterways, catchment areas or in wastewater samples can make up a large proportion of the winter samples sent to the laboratory. The method used can detect 1080 in water at concentrations as low as 0.1 parts per billion (ppb). Since 1990, over 2900 water samples have been tested from areas where 1080 bait has been aerially applied. Over 96% of these samples had no detectable 1080, supporting field research that shows 1080 is biodegradable and does not persist or accumulate in the natural environment.

Laboratory staff also provide a fast-turnaround service where test results are needed quickly, such as following the accidental spill of toxic bait on Anchor Island, Fiordland, in June 2010. These

baits contained the anticoagulant toxin brodifacoum, which is widely used for rodent control. Brodifacoum is known to persist in some animal tissues, so it was obviously important to monitor for residual concentrations of this compound in the environment after the spill. Staff can also monitor for potential environmental contamination from other vertebrate toxins following pest control operations to ensure residues have not entered the food chain, e.g. monitoring for brodifacoum in fish and shellfish after the removal of rats from Ulva Island. Tests for traces of brodifacoum (or other anticoagulants) can be carried out on various samples ranging from water, sediment, fish, invertebrates and birds. The results determine whether continued monitoring is needed or whether harvesting fish and shellfish can resume from a control area.

Quality assurance data are provided to a variety of organisations, including pest control companies, contractors, regional councils, TBfree New Zealand, and the Department of Conservation. Laboratory

staff check that baits and formulations are at the expected nominal concentrations prior to the operations, and also provide a service for analysing weathered baits after an operation so that farmers know when it is safe to return stock to their paddocks after poisoning operations.

Stability testing on new bait products, or new formulations of existing products for registration purposes, ensure they meet their registration criteria.

For further information about available tests and prices please contact Laboratory Manager Lynn Booth or refer to the following website:
<http://www.landcareresearch.co.nz/resources/laboratories/toxicology-laboratory/tests-and-methods>

Lynn Booth

boothl@landcareresearch.co.nz

Penny Fisher

Understanding infectious disease risks of dung beetle releases into New Zealand

Eleven exotic species of dung-burying beetles were approved for release into New Zealand's agricultural pastures by the Environmental Protection Agency (EPA) in 2011, to join four previously introduced species (Fig. 1). These beetles are part of the natural nutrient recycling mechanism for dung produced by wild ruminants. They are expected to bring multiple ecosystem service benefits, including reduced nutrient runoff and waterway pollution from agricultural pastures and reduced greenhouse gas emissions and parasitism of livestock, due to the rapid transport of

cattle dung underground as the beetles create brood balls.

The decision to apply for permission to release dung beetles was led by the Dung Beetle Release Strategy Group (DBRSG), a landowner-driven organisation with support from the Ministry of Business, Innovation and Employment (MBIE), the Ministry of Primary Industries (MPI), DairyNZ and Environment Southland. Despite the formal risk assessment process conducted by the EPA, the decision to grant approval for unconditional release was

publicly questioned. Concerns included the spread of infectious diseases affecting both livestock and public health. Landcare Research worked with DBRSG Project Manager Andrew Barber (Agrilink NZ) to address these concerns.

A team led by Dan Tompkins sought to improve our knowledge in regard to three perceived disease risks: (1) that contaminated dung beetles may potentially transport *Mycobacterium bovis* (the causative agent of bovine TB) away from either cattle or possum dung; (2) dung





Fig. 1 Mexican dung beetle – one of the beetles introduced in 1956 into New Zealand pastures.

beetles on pasture could be a food source for possums or encourage their bush-to-pasture movements and, potentially increase rates of TB transmission between wildlife and cattle; and (3) dung beetle tunnelling activity could potentially increase freshwater microbiological loading via increased groundwater contamination.

To understand the risk of dung beetles disseminating *M. bovis* away from either cattle or possum dung, the team investigated two key components – first whether TB-infected cattle produce *M. bovis*-contaminated dung to which dung beetles could be exposed, and second whether dung beetles utilise possum dung (the possum being the primary wildlife host of TB in New Zealand). For the first component, the team showed that dung samples collected from 12 tuberculous cattle (at least three of which had sufficiently generalised TB for their carcass to be condemned) failed to yield any positives upon gold-standard bacteriological culture for *M. bovis*. For the second component, no-choice host range tests showed that possum dung is rarely explored, let alone used, by dung beetles (Fig. 2). The team concluded that there is a negligible current risk of dung beetles acting as TB transport hosts in New Zealand.

To understand the risk of possums increasing their bush-to-pasture movements, the team first used captive feeding trials with nine possums to investigate whether they would forage for and eat dung beetles. With all of the dung beetles included in cages with possums being accounted for after 2 days' exposure, and no evidence of any possum foraging for the beetles, these trials demonstrated that possums are unlikely to forage for and eat dung beetles. To further understand this risk, the team conducted a diet survey of free-living possums in an area of high dung beetle availability in Northland. No dung beetle remains were found in the stomach of any of 30 possums examined. With the possums clearly foraging on pasture (evident from high stomach grass contents), the team concluded that there was negligible risk of altering possum foraging behaviour and hence negligible risk of additional dung beetle species potentially increasing rates of TB transmission between wildlife and cattle.

Finally, to understand the risk of dung beetle activity increasing microbial percolation through soil, the team conducted leaching experiments with soil cores in six undisturbed barrel lysimeters (three containing fresh cow dung and dung beetles, and the other three as dung-only controls). After leaving them for 11 days to allow beetles sufficient time to construct

burrows and brood chambers, the soil cores were irrigated for 2 days using a drip-type rainfall simulator during which leachate was collected hourly. Testing the leachate for the indicator microbe *Escherichia coli* (a highly labile microbe expected to be influenced by any changes in microbial-bypass-flow process in soil) showed no pattern of greater microbial loading in the leachate from the soil cores containing dung beetles. The team concluded that the risk is negligible of dung beetles increasing freshwater microbiological loading via increased groundwater contamination.

On the basis of this work, and on evidence addressing other perceived risks, the Technical Advisory Group to the DBRSG recommended that planned releases of new dung beetle species onto New Zealand pastures should proceed. The first release was subsequently conducted in Southland in late 2013.

This work was funded by Core funding from the Ministry of Business, Innovation and Employment to Landcare Research, and Northland Regional Council Envirolink Advice Grant #1296-NLRC161.

Dan Tompkins

tompkinsd@landcareresearch.co.nz

Andrew Barber (Dung Beetle Release Strategy Group; Agrilink NZ)

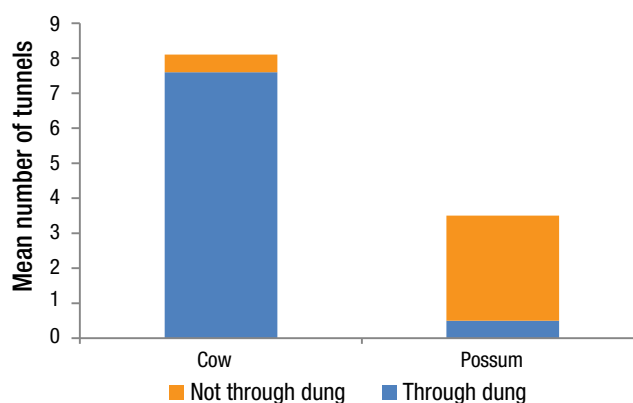


Fig. 2 Mean numbers of tunnels through the dung and not associated with dung, for dung beetles given access to either cow or possum dung.

Back to the future – using fixed-wing aircraft for aerial application of 1080 baits



Grant Morriss

The Cresco aircraft (modified by Ravensdown Aero Work) used in this trial being loaded with bait.

Aerial application of 1080 bait is the only cost-effective option for controlling possums and ship rats over large areas of remote forest in New Zealand. However, even with aerial application, the total area that can be treated is limited as the cost per hectare is high (about \$20/ha). To make limited control budgets go further, Landcare Research staff have been investigating different aerial application strategies for reducing the amount of bait sown and the flying time required to sow it (see *Kararehe Kino* Issue 22). To further decrease costs, Bruce Warburton and Grant Morriss have been working with Ravensdown Aero Work to re-engineer and test the suitability of a Cresco fixed-wing aircraft for sowing bait at low rates compared with helicopters that have dominated the pest control industry over the past decade.

Potential savings result from fixed-wing aircraft sowing bait at twice the speed of helicopters (120 knots compared with 55–60 knots respectively). Although fixed-wing aircraft were used to sow 1080 bait before helicopters, helicopters eventually became the preferred option due to developments in sowing bucket technology

and knowledge. Up until recently it was believed that, to obtain high kills of possums and rats, bait had to be distributed uniformly over the landscape. As fixed-wing aircraft could only sow bait in swaths (lines) 25–30 m wide, they had to fly along parallel lines about 30 m apart across the entire control area to achieve complete coverage, resulting in a high number of flying hours. Conversely, some helicopters equipped with underslung buckets with 'spinners' can throw the bait horizontally out to 200 m (depending on bucket design), allowing these helicopters to fly along parallel lines 200 m apart (i.e. about 15% of fixed-wing flying patterns).

Research on bait application strategies showed that high kills of possums and rats could be achieved if baits were sown along lines as strips or clusters, and that these strips could be 100 to 150 m apart (*Kararehe Kino* Issue 22). With this new knowledge, it became apparent that fixed-wing aircraft could again be used because their narrow bait swath was essentially applying bait in a strip. As long as bait density within the strip was sufficient, high kills of pests could be obtained.

The research and success of the re-engineered Cresco aircraft (*photo*) led to TBfree New Zealand partnering with Muzzle Station (North Canterbury) in August–September 2014 to apply bait in strips to control possums over 10,000 ha in the Clarence catchment. The operational area comprised steep semi-arid hill country from c. 500 m to 2000 m elevation, with a predominant ground cover of matagouri and sweet briar interspersed with scree and rock outcrops. Open areas at lower elevation were vegetated by short tussock oversown with introduced grasses, while at higher elevation tall tussock, spaniards and flax were present.

In one block totalling 6025 ha, the aircraft sowed bait on lines 100 m apart, and in two blocks totalling 1901 ha, bait was sown on lines 150 m apart. The remainder of the area (1980 ha) was sown by helicopter (*Fig.*) to eliminate any possibility of sowing bait outside the control area. In the blocks with bait lines 100 m apart, non-toxic 2-g prefeed and 12-g toxic RS5 cereal baits were sown at 0.5 kg/ha. In the blocks with lines 150 m apart, the same bait was sown at 0.33 kg/ha. Because the flow rate of bait

was the same in both treatment blocks, the bait density was the same on each bait line. The percentage kill of possums was estimated from 37 possums collared with mortality-sensing radio transmitters in the blocks with lines 100 m apart, and from 46 possums spread across the blocks with lines 150 m apart.

The results were excellent with 100% of radio-collared possums killed in the blocks with lines 100 m apart and 98% killed (one survivor) in the blocks with lines 150 m apart.

The mean flying time per 100 ha at a flight line spacing of 100 m for the Cresco (2.7 min) was 45% of the flying time for a squirrel helicopter (5.9 min). The reduced sowing time not only reduced flying costs but also reduced the fuel used and potentially the carbon footprint of aerial control operations.

This new knowledge on possum control and aircraft re-engineering resulting from the team's research is an excellent example of the rapid implementation of research results making a real difference

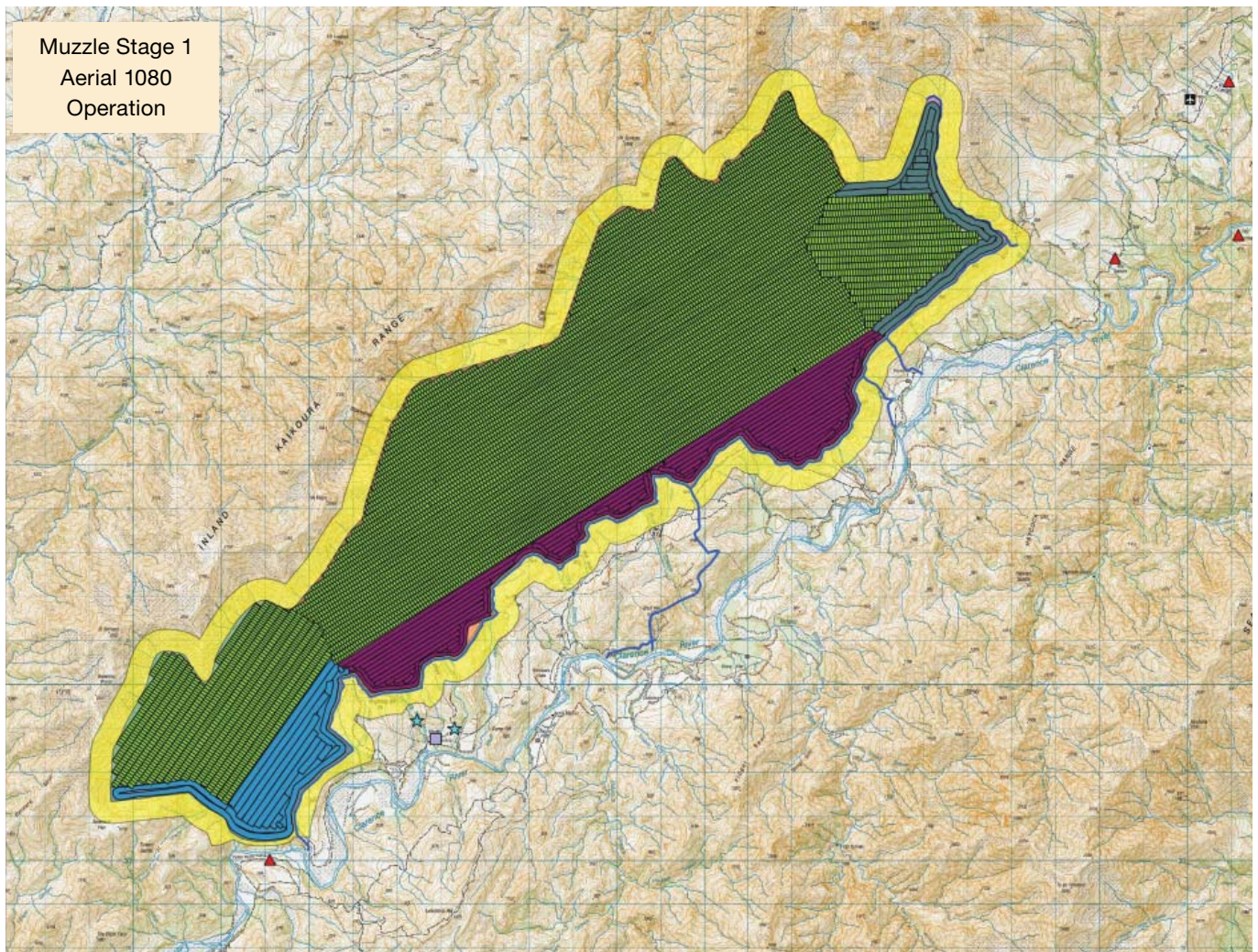
to operational practice. We are now working with industry to make additional modifications to other fixed-wing aircraft to reduce costs even further.

This work was funded by the Ministry of Business, Innovation and Employment (C09X1007) and TBFREE New Zealand.

Bruce Warburton

warburtonb@landcareresearch.co.nz

Grant Morriss, Graham Nugent and Ivor Yockney



Muzzle Stage 1 Aerial 1080 Operation - From 1 September 2014
Produced by Vertebrate Pest Management For Toxic Application 3 September 2014
TopoMap references BS27, BT27 and BT26

Fig. The sowing patterns of the modified Cresco fixed-wing aircraft on Muzzle Station (green), showing the blocks sown using line spacings of 100 and 150 m. The other colours were sown by helicopter and the yellow band is the consented buffer.

Some recent vertebrate-pest-related *publications*

- Buxton RT, Anderson D, Moller H, Jones CJ, Lyver PO'B 2014.** Release of constraints on nest-site selection in burrow-nesting petrels following invasive rat eradication. *Biological Invasions*: [early view online]. <http://dx.doi.org/10.1007/s10530-014-0807-x>
- Byrom AE, Craft ME, Durant SM, Nkwabi AJK, Metzger K, Hampson K, Mduma SAR, Forrester GJ, Ruscoe WA, Reed DN, Bukombe J, Mchetto J, Sinclair ARE 2014.** Episodic outbreaks of small mammals influence predator community dynamics in an east African savanna ecosystem. *Oikos* 123: 1014–1024. doi: 10.1111/oik.00962
- Cowan P, Brown S, Forrester G, Booth L, Crowell M 2014.** Bird-repellent effects on bait efficacy for control of invasive mammal pests. *Pest Management Science*: [early view online]. doi: 10.1002/ps.3887
- Delibes-Mateos M, Ferreira C, Rouco C, Villafuerte R, Barrio IC 2014.** Conservationists, hunters and farmers: the European rabbit *Oryctolagus cuniculus* management conflict in the Iberian Peninsula. *Mammal Review* 44: 190–203. doi: 10.1111/mam.12022
- Dickman CR, Glen AS, Jones ME, Soulé ME, Ritchie EG, Wallach AD 2014.** Strongly interactive carnivore species: maintaining and restoring ecosystem function. In: Glen AS, Dickman CR eds *Carnivores of Australia: past, present and future*. Collingwood, Australia, CSIRO. Pp. 301–322.
- Forgie SA, Dymock JJ, Tompkins DM 2014.** No evidence that brushtail possums (*Trichosurus vulpecula*) forage on dung beetles (Coleoptera: Scarabaeidae) in New Zealand. *New Zealand Journal of Zoology* 41: 95–102.
- Glen AS 2014.** Fur, feathers and scales: interactions between mammalian, reptilian and avian predators. In: Glen AS, Dickman CR eds *Carnivores of Australia: past, present and future*. Collingwood, Australia, CSIRO. Pp. 279–299.
- Glen AS, Dickman CR eds 2014.** *Carnivores of Australia: past, present and future*. Collingwood, Australia, CSIRO. 438 p.
- Glen AS, Dickman CR 2014.** The importance of predators. In: Glen AS, Dickman CR eds *Carnivores of Australia: past, present and future*. Collingwood, Australia, CSIRO. Pp. 1–12.
- Glen AS, Dickman CR, Letnic M 2014.** Carnivore communities: challenges and opportunities for conservation. In: Glen AS, Dickman CR eds *Carnivores of Australia: past, present and future*. Collingwood, Australia, CSIRO. Pp. 405–415.
- Holland EP, James A, Ruscoe WA, Pech RP, Byrom AE 2014.** Climate-based models for pulsed resources improve predictability of consumer population dynamics: outbreaks of house mice in forest ecosystems. *PLoS ONE*: (in press).
- Kelly D, Geldenhuis A, James A, Holland EP, Plank MJ, Brockie RE, Cowan PE, Harper GA, Lee WG, Maitland MJ, Mark AF, Mills JA, Wilson PR, Byrom AE 2013.** Of mast and mean: Differential-temperature cue makes mast seeding insensitive to climate change. *Ecology Letters* 16: 90–98.
- Masuda BM, Fisher P, Beaven B 2015.** Residue profiles of brodifacoum in coastal marine species following an island rodent eradication. *Ecotoxicology and Environmental Safety* 113: 1–8. <http://dx.doi.org/10.1016/j.ecoenv.2014.11.013>
- Norbury G, Hutcheon A, Reardon J, Daigneault A 2014.** Pest fencing or pest trapping: a bio-economic analysis of cost-effectiveness. *Austral Ecology* 39: 795–807. <http://onlinelibrary.wiley.com/doi/10.1111/aec.12147/pdf>
- Norbury G, Jones C 2015.** Pests controlling pests: does predator control lead to greater European rabbit abundance in Australasia? *Mammal Review* 45: 79–87.
- Rouco C, G Norbury, Ramsey D 2014.** Kill rates by rabbit hunters before and 16 years after introduction of rabbit haemorrhagic disease in the southern South Island, New Zealand. *Wildlife Research* 41: 136–140.
- Russell JC, Innes JG, Brown PH, Byrom AE 2015.** Predator-free New Zealand: Conservation country. *BioScience*. doi: 10.1093/biosci/biv012
- Tompkins D, Forgie S, Aislabie J, Nugent G, Gourlay H, McGill A, McLeod M, Yockney I, Paynter Q, Fowler S, Hayes L 2012.** Informing the infectious disease risks of dung beetle releases into New Zealand. Landcare Research Internal Report LC908 (available online at www.dungbeetle.org.nz).
- Tompkins DM, Byrom AE, Pech RP 2013.** Predicted responses of invasive mammal communities to climate-related changes in mast frequency in forest ecosystems. *Ecological Applications* 23: 1075–1085.
- Whitford J, Rouco C, Tompkins D, Nugent G. 2014.** First direct estimate of the detection probability of bovine tuberculosis in possums by possum transmission. *European Journal of Wildlife Research*, 60: 827–830. doi: 10.1007/s10344-014-0834-z
- Wood JR, Dickie IA, Moeller HV, Peltzer DA, Bonner KI, Rattray G, Wilmshurst JM 2015.** Novel interactions between non-native mammals and fungi facilitate establishment of invasive pines. *Journal of Ecology* 103: 121–129. <http://dx.doi.org/10.1111/1365-2745.12345>