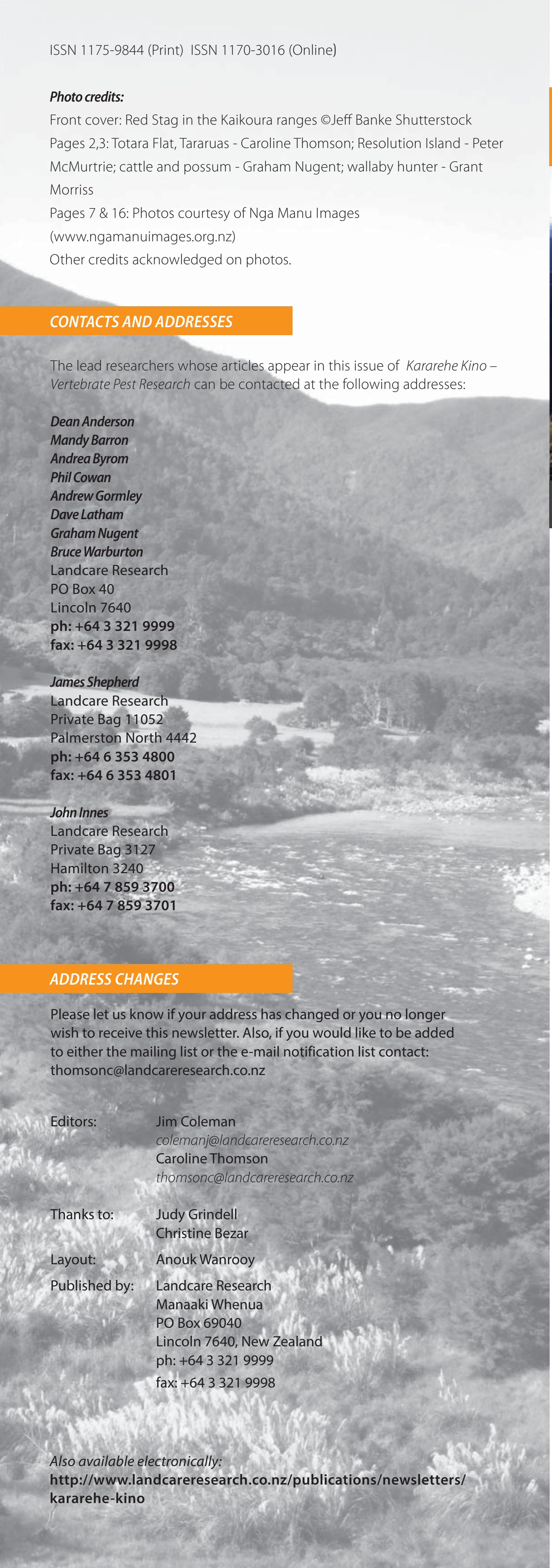
Kararehe Kino

Vertebrate Pest Research

Issue 23 / February 2014

ANIMAL MOVEMENTS

Landcare Research
Manaaki Whenua



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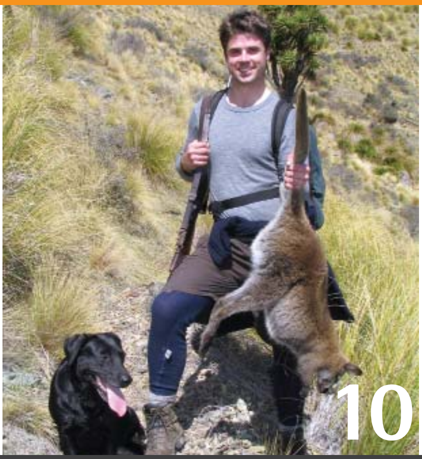

Editorial

Managing animal movements

In 2008, the Department of Conservation began the eradication of stoats from Resolution Island, Fiordland. Five years later, stoats still persist on the island because of repeated reinvasion from the South Island mainland, only half a kilometre away (see page 5–7). In 2011, bovine TB was detected in the Rolleston Range, Canterbury, a long way from the nearest source of infection. One strong possibility is that TB was carried there across the Southern Alps by a dispersing deer (see page 8–9). These two examples clearly demonstrate why failure to prevent dispersal and reinvasion is one of the main reasons both eradication and sustained control of pest species are often unsuccessful. However, there are also situations where managers want to promote animal movements into controlled areas. Where pest species have been removed or their numbers drastically reduced, the aim is often to promote the re-establishment of native animals by facilitating their migration and settlement (see page 12–13).

Understanding animal movements is fundamental to many aspects of pest management. Animal location data provide essential information on how animals behave and how they interact with each other, their environment, and the baits, traps and devices used to control them. Using such knowledge will help managers improve the efficiency and effectiveness of control and better understand key ecological questions about pest population dynamics, pest-native species interactions and pests as disease vectors. The ability of researchers to collect detailed animal movement data has increased hugely through the growing use of global positioning systems (GPS), telemetry and remote sensing devices such as animal-to-animal contact loggers and remotely-triggered trail cameras. Recognising the growing significance of this area of research for pest management, Landcare Research has recently established an Animal Movements research group (**http://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/animal-spatial-ecology**) which brings together its wildlife biologists, pest researchers, modellers and database experts to maximise the information that can be obtained from animal movement data.

The present issue of Kararehe Kino features examples of the six main areas where research to improve information on animal movements will aid pest management outcomes. First, there are pest species for which better basic information on movements and dispersal behaviour will improve management strategies and tactics (ungulates, page 19–20; wild dogs, page 18–19). Second, there are species with currently limited distributions where the management aim is to prevent range expansion and where movement outside of the current range must be detected as quickly as possible (ungulates, page 19–20; wallabies, page 10–11). Third, more information on triggers for dispersal and dispersal behaviour, including settlement rules, will help manage problems of pest reinvasion after control or eradication (stoats, page 5–7; rats, page 16–17). Fourth, predictive spatial models of pest populations at local and national scales used by managers to plan control will be improved by the inclusion of new information on habitat-related differences in home range size and changes in movement behaviour of survivors of control and of animals in adjacent uncontrolled areas (possums, page 14–15; rats, page 16–17). Fifth, management strategies such as buffer zones to prevent or contain pest dispersal will be enhanced by formal assessment of their effectiveness (buffers, page 14–15). Sixth, strategies to prevent the spread of diseases and parasites carried by pests are critically reliant on good information about pest movements, both of the disease vectors themselves and also of the other potential disease hosts with which they interact (bovine TB, page 21–23).

Much, however, remains to be learned about pest animal movements. Researchers know little, for example, about the detail of how animals use their home ranges – if they did, managers might improve the effectiveness of ground-based control methods. Further, researchers have little knowledge of what triggers animals to disperse from their natal areas and what decision processes they use in choosing a new location in which to settle – if they did, the ability of managers to manage pest animal spread and reinvasion would undoubtedly be improved. But thanks to GPS and contact logger technology and new methods of analysing movement data, researchers should now be able to address questions fundamental to the design of large-scale control operations such as how landscape features in the real world and intra- and inter-specific interactions among pests influence pest animal movements.

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Eradication or control to zero density on near-shore islands?

Lessons from a stoat-removal operation on Resolution Island, Fiordland

The problem of reinvasion: animal movements on land and water

The number of successful pest eradication programmes on islands is growing internationally and resulting in important increases in native biodiversity. Most of these successes have been on isolated islands where reinvasion can only occur with human assistance. Attention is now turning to near-shore islands, which are at high risk of invasion or reinvasion. A common perception is that once an island is cleared of pests, the 'job is done' and management can shift from intensive control to periodic surveillance. Eradication on near-shore islands challenges this expectation. It is still possible to achieve ambitious biodiversity outcomes, such as the reintroduction of threatened fauna, but it requires a different mind-set because it involves long-term investment. In this article, Dean Anderson and colleagues use a case study to demonstrate the biological and management complexity associated with removal of invasive pests from near-shore islands. Because of the inherent reinvasion risks and the required long-term commitment for management, they use the concept of 'control to zero density' in place of 'eradication'.

In July 2008 the Department of Conservation (DOC) began a project to eradicate stoats from Resolution Island, Fiordland (*Fig.1*), to create a sanctuary for endangered species such as kākāpō. Resolution Island is approximately 20,800 ha and 550 m from the mainland. Stoats first swam across in the early 1900s. Stoats continue to persist on the island despite more than 2500 traps having been checked and reset three times a year (January, July and November) since 2008. Given these results, the current management questions are (1) is control to zero density feasible and (2) what effort is required to achieve success? Trapping data collected by DOC were analysed in a two-stage modelling approach. First, data on the number and locations of stoats trapped on the island were used to estimate population size at each stage of the operation, and to estimate immigration rate, population growth rate, and the probability of capturing a stoat. Second, forward-prediction modelling was used to simulate different management scenarios to identify the effort required to achieve control to zero success. The probability of sustained zero density (i.e. no stoats on the island for the final five years of the simulation (2016–2020)) was quantified for each simulated scenario. Immigration was allowed during this time, but for control to zero to be successful new immigrants had to be captured in the subsequent trapping session.


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Stoats persist on the island despite continued trapping.

How can control to zero density be achieved?

A total of 556 stoats have been captured in 18 trapping sessions between July 2008 and July 2013. Analysis estimated that 340 (95% CI: 316–366) or approximately 1.6 stoats/km^2 were present on the island prior to the onset of trapping. The mean annual immigration rate was estimated to be 0.71, or approximately 7 stoats every 10 years. The mean annual population growth rate was 8.45, which was much higher than the expected rate of 3.7 reported in the literature. This high rate indicates a female-biased sex ratio that could be maintained by differential trapping, immigration or survivorship rates of females and males.

The predictive simulation of the current trapping regime showed that there was a 17% chance of successful sustained zero density from January 2016 through November 2020 (*Fig. 2A*). If the trapping programme was stopped, the stoat population would rebound to its starting population size within 2–3 years. If the July trapping session in each year was discontinued, because of funding cuts for example, the population would steadily increase to high levels unsuitable for reintroductions of endangered species (*Fig. 2B*).

The probability of sustained zero density could be increased by increasing the trapping effort (more traps or trapping sessions), reducing reproductive potential of the population, decreasing immigration rate, or increasing trap success. A scenario in which 264 additional traps were placed in large gaps between trapping lines resulted in a 30% chance of sustained zero density from 2016 to 2020. An alternative increase in trapping effort was simulated by adding an annual trapping session in March, which increased the chance of sustained zero density to 53%. These substantial increases in trapping effort failed to reach high probabilities of zero density (e.g. >90%) because of the persistent risk of immigration. However, the predictive simulations showed that addressing immigration alone would not provide the desired outcome. A 50% reduction in immigration would result in a 43% chance of sustained zero density (*Fig. 2C*), likely due to high reproductive rates and insufficient trappability. The reproductive potential of the population could be reduced by capturing a disproportionate number of females. A 50% reduction in the population growth rate increased the chance of sustained zero density to 32% (*Fig. 2D*). Increasing the trappability of both sexes by doubling trap attractiveness resulted in a 47% chance of sustained zero density (*Fig. 2E*).

Increasing the chance of sustained zero density to 90% or higher was only obtained when three additional management actions were combined; namely. a reduction in immigration, an increase in trappability, and either the addition of an extra trapping session or a reduction in the reproductive potential of the population. For example, when immigration and population growth were both reduced by 50%, and trap success was doubled, the chance of sustained zero density was 90% (*Fig. 2F*).

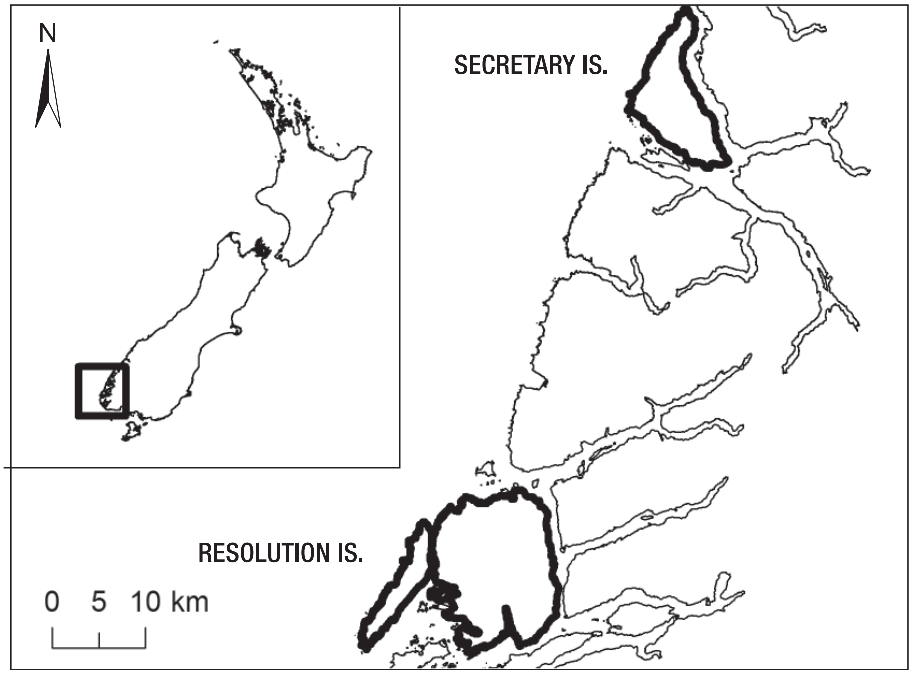

Fig. 1 *Location of Resolution and Secretary islands in Fiordland.*

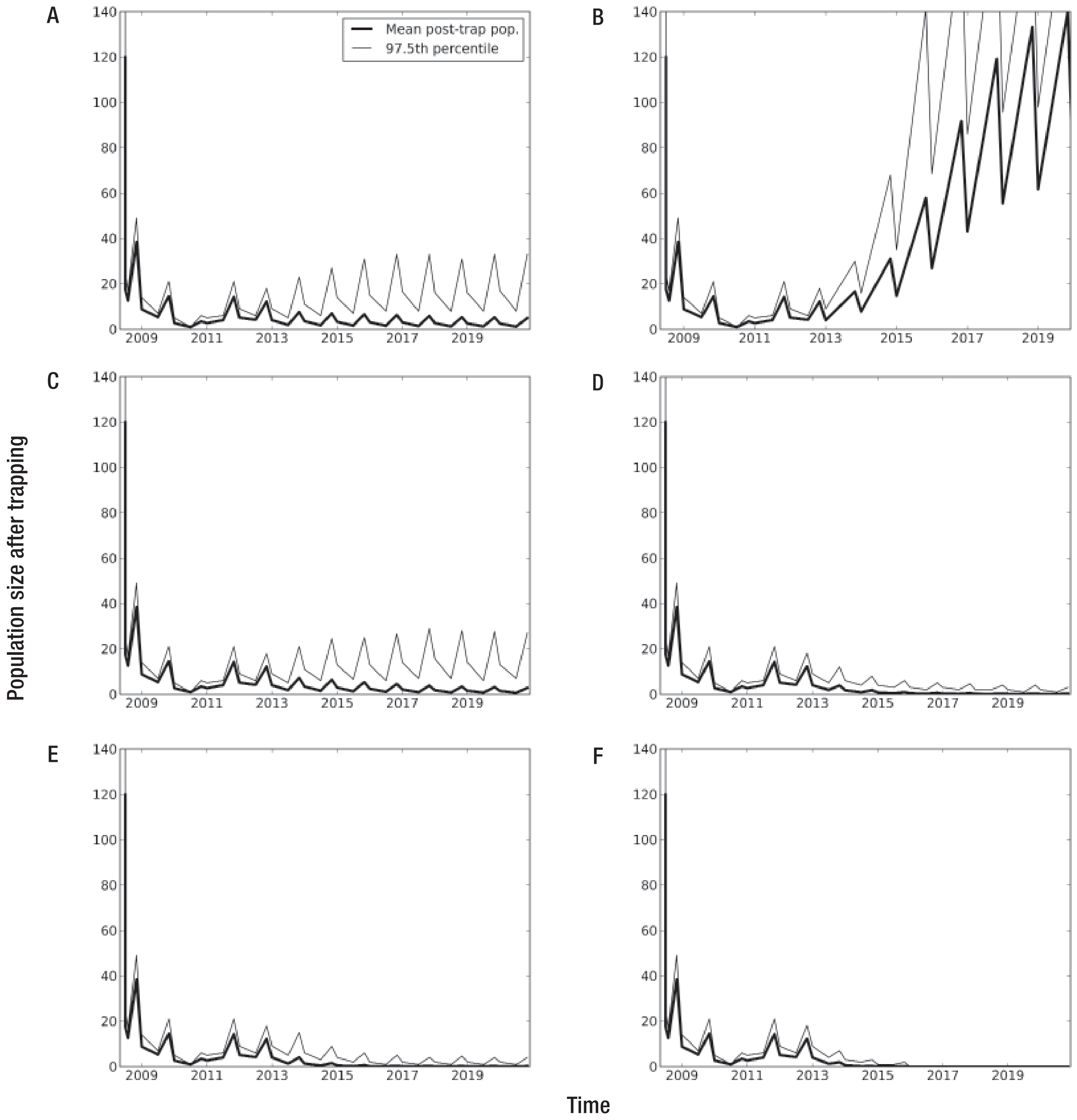

Fig. 2 *Results of six simulation experiments in which the post-trapping stoat-population size is plotted over time, showing the effect of: (A) the current trapping programme; (B) stopping the July trapping session; (C) reducing the immigration rate by 50%; (D) reducing the mean population-growth rate by 50%; (E) increasing the trappability of both sexes by doubling trap attractiveness; and (F) reducing immigration and population growth by 50% and doubling trap attractiveness.*

Conclusions

Near-shore pest management is complicated by reinvasion, but may benefit native fauna. For control to zero density to be feasible, the following three rules must be met: (1) all pest animals must be put at risk; (2) pests must be removed faster than they reproduce; and (3) immigration must be stopped or new invaders captured before they reproduce. Our predictive-simulation results for Resolution Island indicated that only the first condition has been met. Control to zero density of stoats on Resolution Island is feasible but will depend on a concerted effort to reduce immigration, increase trappability, and include either an additional trapping session or specific targeting of females to reduce the population growth rate. Until such time as threatened or endangered species are reintroduced onto Resolution Island, the programme offers the opportunity to act as a long-term research project into how to conduct and learn from near-shore control to zero operations.

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Dispersal of a non-motile species: the story of bovine TB's spread in New Zealand


Graham Nugent

A fatal curiosity; how TB could spread from an infected possum (with pus on its fur) to cattle.

Dispersal is easy for most land mammals. They walk to wherever they need to go. In contrast, parasitic bacteria such as *Mycobacterium bovis* (the cause of bovine tuberculosis; TB) have to rely on their hosts for dispersal. *M. bovis* is part of a broader group of related bacterial species that cause different forms of tuberculosis. This group has been extremely successful in dispersing around the globe – the single progenitor of the group is believed to have developed as a disease of humans in Africa perhaps 40,000 years ago and subsequently spread with humans when they first colonised the Middle East. There it split into two main lineages, one carried by humans and the other mostly by animals. The shift to animal hosts is likely to have occurred with the domestication of animals about 13,000 years ago. It is now accepted that humans gave tuberculosis to animals, the reverse of that once believed.

Since then, *M. bovis* has spread around the world as people colonised new lands and took their livestock with them. Without doubt, *M. bovis* arrived in New Zealand from Europe early in the 1800s – by 1880 4–7% of cattle slaughtered in Wellington were considered to be infected. Efforts to control TB in cattle in New Zealand were largely ineffectual until the mid-1900s. Between 1930 and 1951 ~35,500 cattle annually were classed as tuberculous at slaughter (compared with just 270 per year in recent years). Oddly, even though *M. bovis* has a very wide host range, the disease did not appear to spread to wild mammals during this time.

Tuberculosis was first recorded in New Zealand wildlife (a wild deer) in 1954, then in a wild pig in 1964. Although possums are now the main host of *M. bovis* in New Zealand, TB in possums was not recorded until 1967. This is unexpected given that possums had lived alongside infected cattle for nearly a century. Curiously, despite the long initial lag, the jump from livestock to possums then appears to have occurred independently in numerous places in both the North and South Island between 1967 and 1981. By 2004, *M. bovis* had become established in wildlife populations in ~10 million hectares or ~40% of New Zealand.

It was inevitable, after it first established


Graham Nugent

Possum with TB infected and infective lymph nodes.

in possums, that most of the subsequent spread of *M. bovis* would be the result of direct (possum–possum) or indirect (possum–other wildlife host–possum) transmission between possums. Paul Livingstone analysed the locations at which TB was found in possums during the 1980s. The spatial patterns indicated that infection was spreading within the wildlife populations in contiguous forest or bush habitats, and to farmland along the edges of rivers and from bush–pasture margins. By analysing the pattern of new outbreaks of infections in cattle that appeared to have been caused by possums, Paul estimated that TB was spreading in extensive forest lands by 1.6–2.3 km per year. In less rugged country with a mixture of native and exotic forest, the disease was spreading by 1.4–4 km per year, and by 2.5–5.0 km per year in more open or tussock-covered country.

Because forest-dwelling possums have home ranges only a few hundred metres wide, and because the frequency of transmission between possums is quite low, these rates of spread suggest that the principal mechanism of TB spread is likely to have been through dispersal of infected animals in a series of migrations. Infected possums dispersed, establishing infection in new possum populations, which then triggered further waves of expanding infection. Additionally, or alternatively, infection may also have been spread through indirect transmission from possums to far more wide ranging species such as wild deer, feral pigs or ferrets, which later transmitted the disease back to possums in distant uninfected areas. In North Canterbury during the 1990s, for example, wildlife TB appears to have spread southward too rapidly to have been solely due to possums, suggesting ferrets or wild pigs were probably also involved. It is possible that pig hunters may have inadvertently contributed by discarding offal from infected carcasses in another (previously clean) area on their way home.

The continued spread of *M. bovis* has been largely halted by intensive control of possums at the fringes of infected areas. However, there is a recent exception. In 2011, *M. bovis* was detected in the Rolleston Range, Canterbury, a long way from any known infected possum population. Although the source of the outbreak is unknown, it is possible that *M. bovis* was carried across the Southern Alps by a dispersing deer. Another possibility is that hunters illegally released pigs (to create a hunting resource) they had obtained from an infected area, accidentally introducing TB.

Even though the relative importance of the various mechanisms by which *M. bovis* spreads to new possum populations may never be known, the bacteria is very effective in finding ways of piggybacking on mammals. Without continued intensive efforts to prevent the spread of TB, it is highly likely that *M. bovis* would spread through all possum populations in New Zealand within a few decades.

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Inspecting offal from a wild pig for signs of TB.

Grant Morriss

Bennett's wallabies: do they provide any lessons for eradicating invasives?

Bennett's wallabies were introduced from Tasmania into the Hunters Hills near Waimate in 1874 to provide animals for recreational hunting. Although early records are unclear, recent DNA analysis suggests that 3–5 pairs of animals were released. Whatever the number, the species established and increased, both in distribution and numbers over the next 4–5 decades. The estimated distribution of wallabies since establishment shows that they spread at a rate of about 46 km^2 per year between 1916 and 1975 (*Fig. 1*).

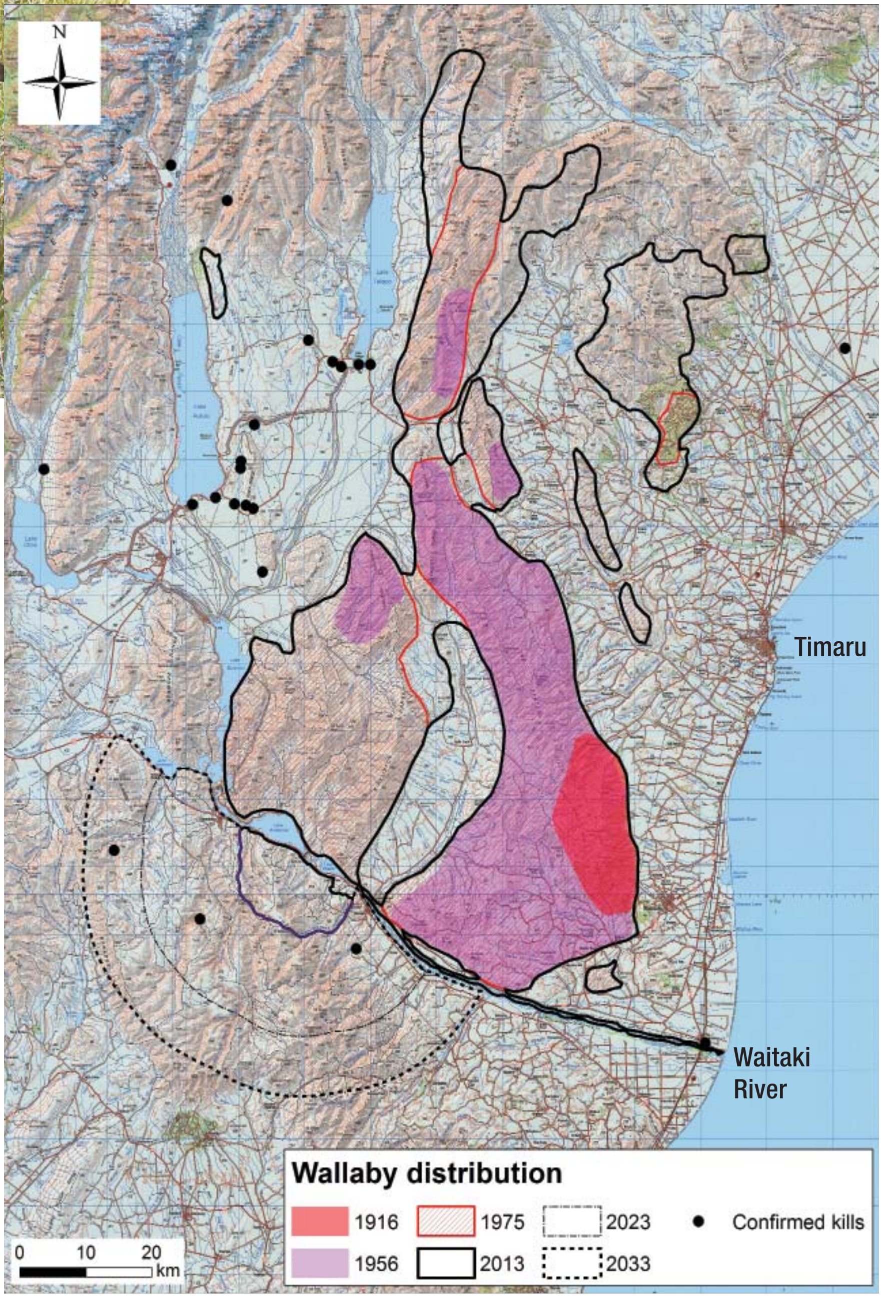

Fig. 1 *Historical and current distribution and recent confirmed kills of Bennett's wallabies. Predicted limits of the distribution of wallabies south of the Waitaki River in 2023 and 2033 are shown by the dotted lines.*

By the 1950s, the impact of wallabies on farm production was such that farmers were calling for Government intervention to control them. Since then, there have been various agencies involved, beginning with the Department of Internal Affairs, then the New Zealand Forest Service, and later still wallaby boards (similar to the rabbit boards). When the Biosecurity Act 1993 came into force, managing vertebrate pests in Canterbury became Environment Canterbury's (ECan) responsibility. Their Regional Pest Management Strategy included wallabies. Environment

Canterbury's latest strategy has two requirements pertaining to this pest:

(1) Landowners have to ensure wallaby densities do not exceed Level 3 on the Guilford Scale (a subjective method for scoring the abundance of wallabies) on land within the Wallaby Containment Area (*Fig. 2*).
(2) Land occupiers must notify ECan within 10 working days of becoming aware of wallabies on any of their land outside the containment area, to prevent wallabies establishing there.

The first requirement (i.e. to ensure wallaby densities are kept at low levels) is standard pest control practice, and generally requires either the application of poisons (either 1080 or more recently Feratox® cyanide pellets) or shooting. However, ensuring requirement two is met is considerably harder because, at the edge of the species' distribution, wallaby numbers are low so often difficult to detect, and the cost of their removal is high.

A recent update of the distribution of Bennett's wallabies (*Fig. 1*) shows that this species has 'escaped' from the containment area into several new sites. One area of special concern is the south bank of the Waitaki River. Given the availability of suitable habitat for wallabies in this area and their rate of dispersal, it is likely that (without control) a further 740 km^2 of farmland could be occupied by 2023, and 1480 km2 by 2033 (*Fig. 1*).

To successfully eradicate the wallabies south of the Waitaki River, four requirements must be met:

(1) Further dispersal from north of the Waitaki River must be stopped.
(2) The current distribution of wallabies south of the river must be known.
(3) All animals within this area must be able to be put at risk from either poisoning or shooting.
(4) It must be possible to objectively determine if eradication has been achieved.

Although this will be challenging for ECan, it will provide an opportunity to learn how best to meet the four requirements.

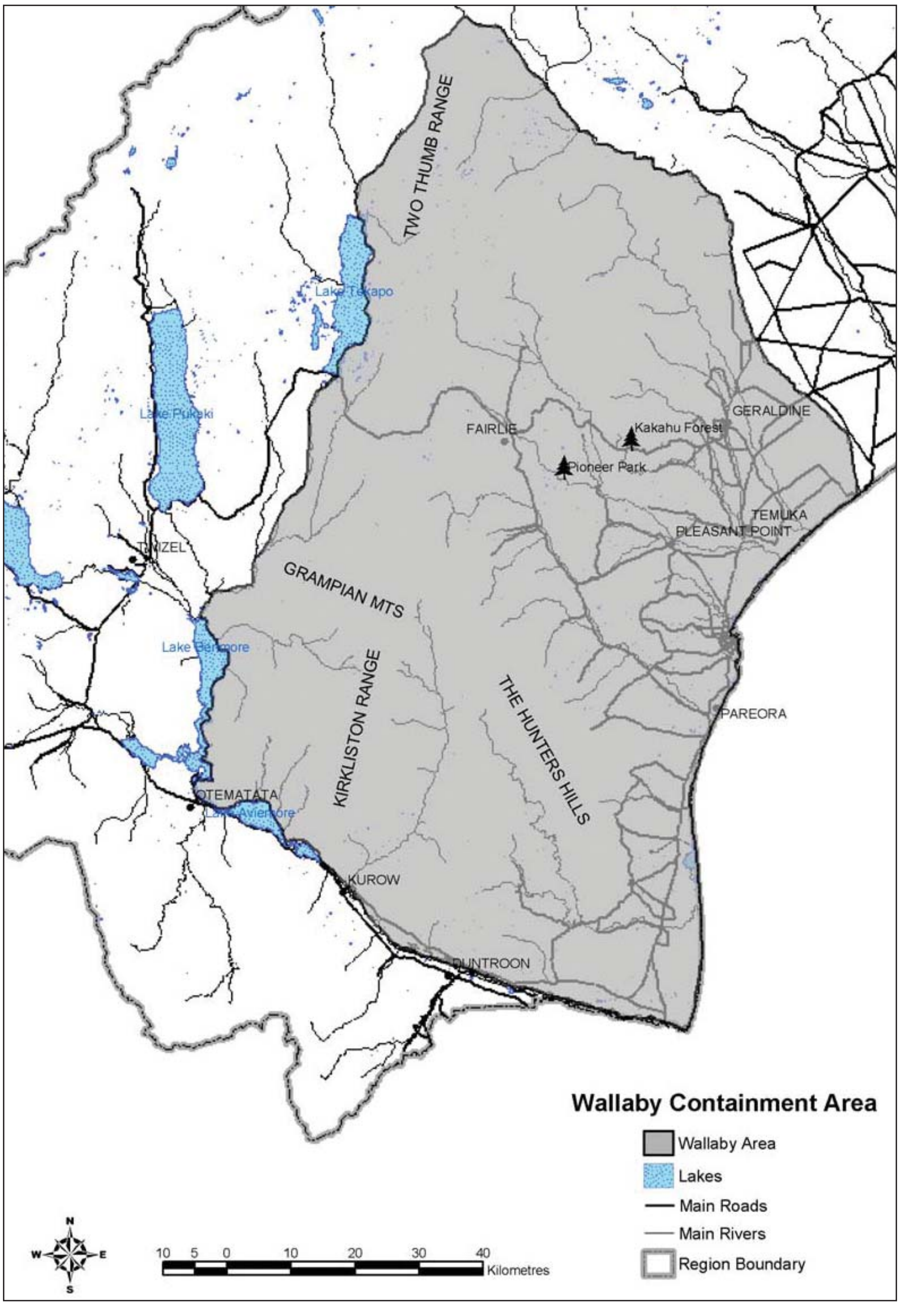

Fig. 2 *Bennett's wallaby containment area in South Canterbury (from Environment Canterbury's Pest Management Strategy, 2011).*

The lessons learnt will be applicable to eradication of other pest species with restricted distributions. The lessons from this case study will also be useful to test the technological and social challenges posed by the aspirational goal of a predator-free New Zealand.

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Movements of tūī in the Waikato

While reinvasion by pests is unhelpful during or after control programmes, one common objective of pest control is to get valued native species to reinvade places where they were formerly abundant. Translocation may be required if the nearest desired colonists are hundreds of kilometres away, or where inhospitable landscapes provide a barrier to colonisation. On the other hand, some species are intrinsically very mobile and readily colonise new sites by themselves, as managers of many sanctuaries are currently discovering.

Tūī is one such mobile species. When nesting, tūī home ranges are only a few hundred metres across. But in the spring and winter when nesting is finished they undertake much larger journeys, frequently travelling up to 20 km to access seasonally available nectar of species such as coastal *Banksia*, camellias, eucalypts and kōwhai.

For the last decade, Neil Fitzgerald, John Innes and team have studied tūī in Waikato in two different contexts. First, working with Waikato Regional Council and Hamilton City Council, they showed that pest control in forest fragments 8–15 km from Hamilton has increased the number of tūī visiting the city in winter about 15-fold since 2007. Tūī are also reasonably common nesters in the city so some are resident all year round (see Kararehe Kino 20, June 2012, pp. 8–9). Second, Neil and John have monitored tūī 'spillover' from Maungatautari, a pest-free (except for mice) sanctuary in the central

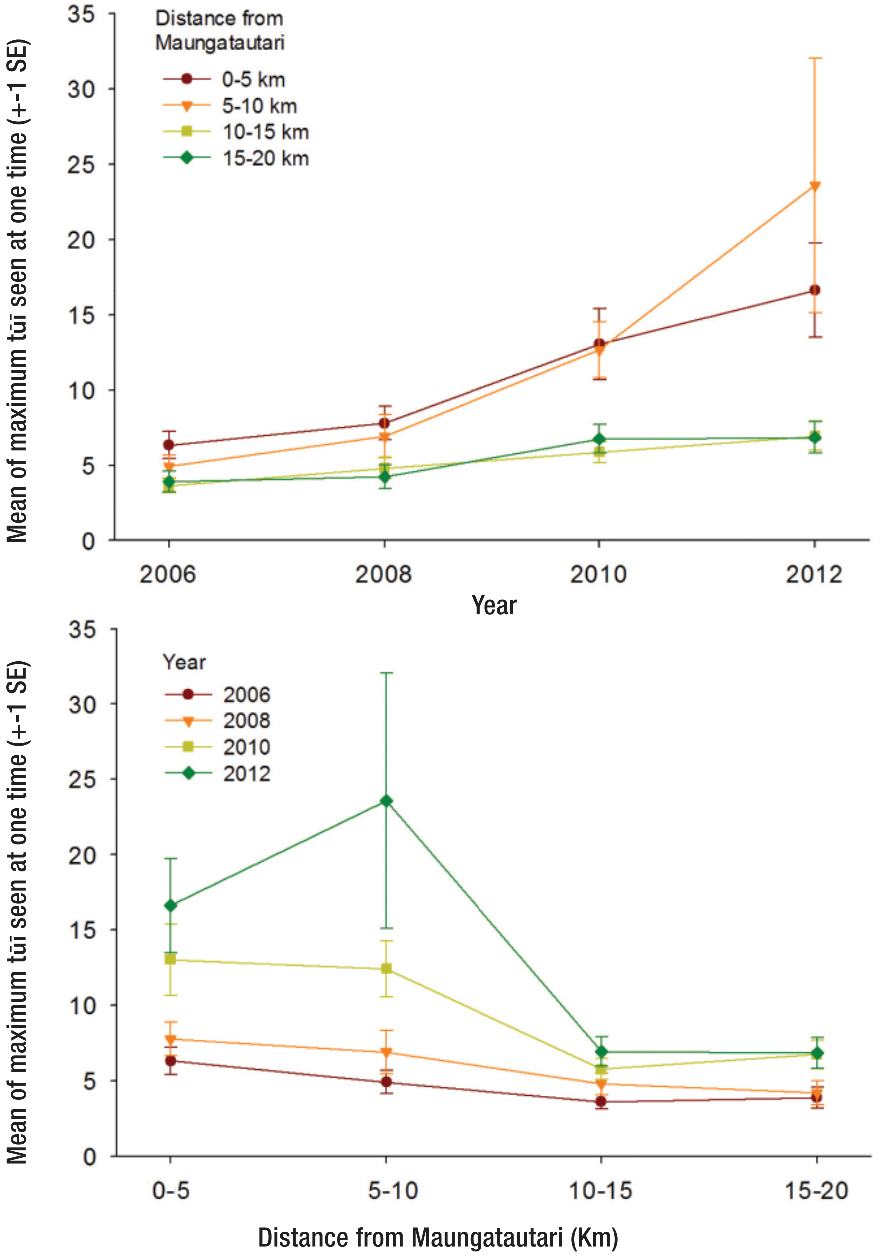

Fig. 1 *Average of 'most tūī seen at one time' by residents in 5-km bands around pest-fenced Maungatautari Reserve, central Waikato, from 2006 to 2012, arranged by year (top) and distance (bottom).*

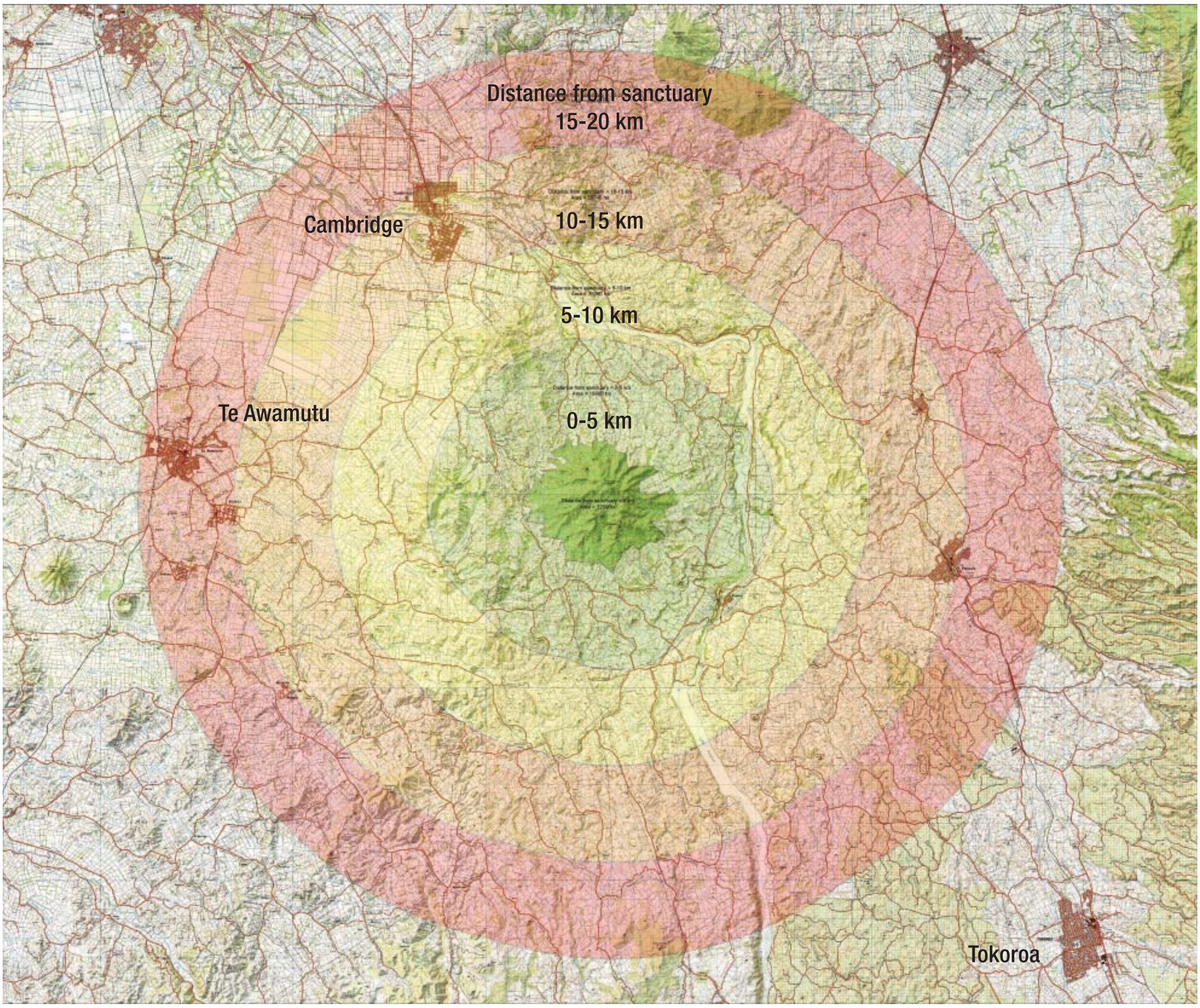

Fig. 2 *Five-kilometre bands around the pest-fenced Maungatautari Reserve in which residents were surveyed about tūī 'spilling over' from the sanctuary. The edge of Hamilton City is just visible at top left.*

Waikato, and it is this work that is described here.

Maungatautari is a 3400-ha reserve of tawa-dominated forest, protected by 47 km of pest- fence, and has been largely pest-free since late 2006. Landcare Research monitoring at Maungatautari shows that mean tūī counts doubled from 2 to 4 per count station between 2002 and 2011. Neil and John also investigated whether tūī have increased outside the sanctuary. The landscape around Maungatautari was divided into four 5-km bands (*Fig. 2*) and the residents were asked two questions: What was the most tūī you saw at your property at one time last winter? Do you think that tūī at your property have decreased, stayed the same or increased in the last 2 years?

Questionnaires were delivered to about 2000 properties in late 2006, with the number of questionnaires scaled to the area of each zone. The survey was repeated biennially (2008, 2010, and 2012) with identical questions put to the 307 initial respondents and 218, 199 and 161 responses respectively received.

Results showed that tūī increased greatly outside the sanctuary as well as inside it (*Fig. 1*), with average maxima increasing between 2006 and 2012 from 6.3 to 16.6 in the 0–5 km band, from 4.9 to 23.6 in the 5–10 km band, from 3.6 to 6.9 in the 10–15 km band and from 3.9 to 6.9 in the 15–20 km band.

Most residents' subjective opinions about tūī increases agreed with these data. Over all zones and years, 55% of respondents thought that tūī had increased since the previous survey; 31% thought they had stayed the same; 9% thought they had decreased and 5% were unsure.
The team's results show that Maungatautari is one of several managed sites in the Waikato that are improving nesting success of tūī, and that there is a spillover band at least 10 km wide around the sanctuary in which this species has greatly increased. There is much to learn about how widely other species will range from the many kinds of sanctuary now being developed on the New Zealand mainland and its near-shore islands, and which native species will disperse to production and urban landscapes.

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Neil Fitzgerald

How do forest buffers help control the spread of bovine tuberculosis?

Removing possums from strips of forest (buffers) adjacent to farmland is the main strategy for reducing the spread of bovine tuberculosis (TB) to livestock from uncontrolled possum populations in large areas of forest hinterland (*Fig. 1*). These buffers are created by aerial baiting followed by ground-based control, and they are usually about 5 km wide. They result in gradients in possum population density: high in untreated forest, medium along the forest boundary of the buffer (where some possums with home ranges overlapping the buffer are removed), and low inside the buffer. Such a gradient might influence the direction of movements of possums in forest immediately adjacent to buffer areas, and their movements may also be influenced by topographic features such as rivers and ridgelines.

Do possums cross buffers?

To assess the effectiveness of buffers in preventing the spread of TB to farmland, Andrea Byrom, with colleagues Roger Pech, Dean Anderson, Caroline Thomson and Morgan Coleman, investigated the movements of possums in podocarp-broadleaved forest immediately adjacent to buffers on five sites on the West Coast. The team set out to answer a series of questions, including (a) were there any consistent types of movement exhibited by possums, (b) are movement types associated with particular age/sex classes of possums, and (c) are movements influenced positively or negatively by major topographic features such as rivers and hills? To help TBfree New Zealand choose optimal buffer widths, field observations were modelled to determine the probability of infected possums crossing buffers of varying widths and arriving on farmland over the 6-month period of highest known dispersal (January to June). Also the model was used to predict how the likelihood of an infected possum arriving on farmland might vary if the density of possums is very low or very high in the untreated forest, and whether that risk increases if such populations have a high prevalence of TB.

Observations of possum movements

Each study site had a large river passing through the buffer and steep ridges in the untreated forest. In January, just before the peak dispersal period for subadult animals, possums were captured in untreated forest close to the buffer. GPS collars – placed on a mix of subadult, adult, male and female possums – were configured to provide 2–3 locations for each possum each night. In total, 79 possums yielded useful data for up to 4½ months.

Possums had four types of movement (*Fig. 2*): long-distance dispersal, exploratory moves, home-range displacement, and settled home range. The results suggest that long-distance dispersal is a relatively rare event and involved only 3 of 29 subadult possums. Two subadult males and 2 subadult females displayed exploratory movements and 6 possums (1 adult male, 2 adult females and 3 subadult males) were displaced. The remainder (83.5%) had settled home ranges. Dispersal and exploratory movements were not biased toward buffers even though these had few residual possums and the habitat was just as suitable as untreated forest. Instead, the possums settled in river valleys near waterways. There was no evidence that forested ridges changed movement patterns of possums or that possums crossed major rivers.

Predictive model for buffers

Computer simulations showed that the probability of an infected possum moving across a buffer to farmland was influenced by the width of the buffer (500–3000 m in the model), possum population density, and disease prevalence. For example, the

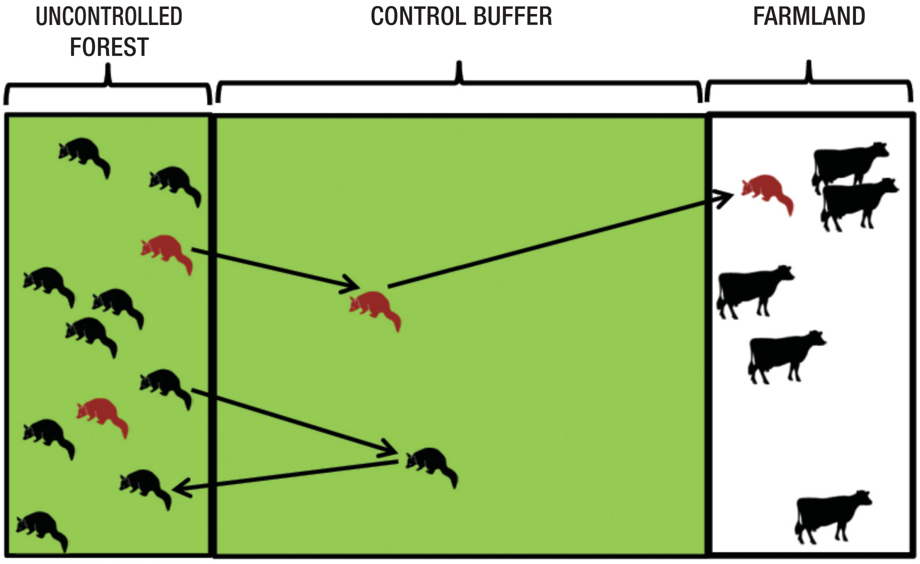

Fig. 1 *Conceptual illustration of the probability of an infected possum arriving on farmland (white) by traversing a poisoned buffer from uncontrolled forest (green). Possum silhouettes represent randomly located possums, and red silhouettes represent infected possums in an uncontrolled forest block (green). Arrows represent examples of dispersal and exploratory movements by possums.*

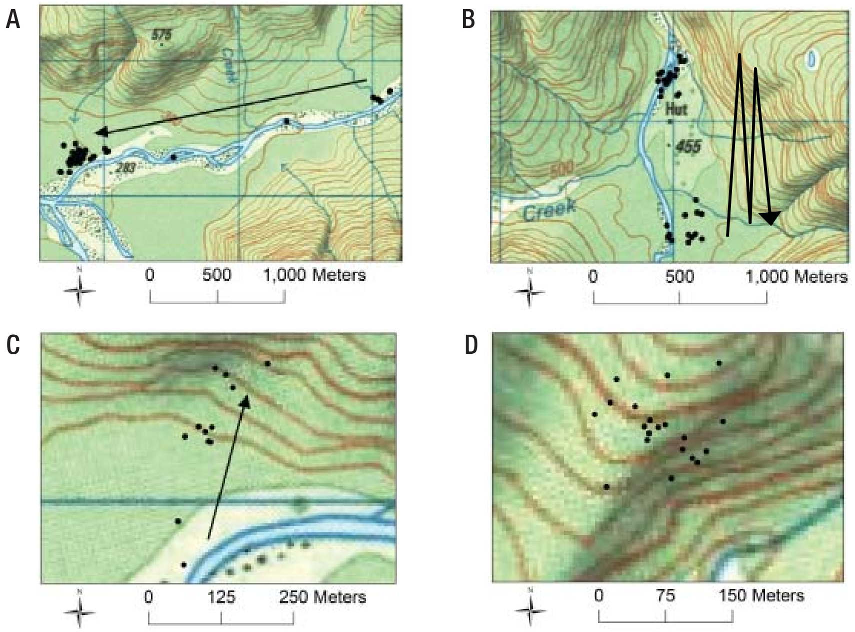

Fig. 2 *Examples of movements by (A) a subadult male dispersing long distance, (B) an exploratory subadult male, (C) an adult female displacing home range, and (D) an adult male showing a settled home range. The arrows indicate the major types of movement.*

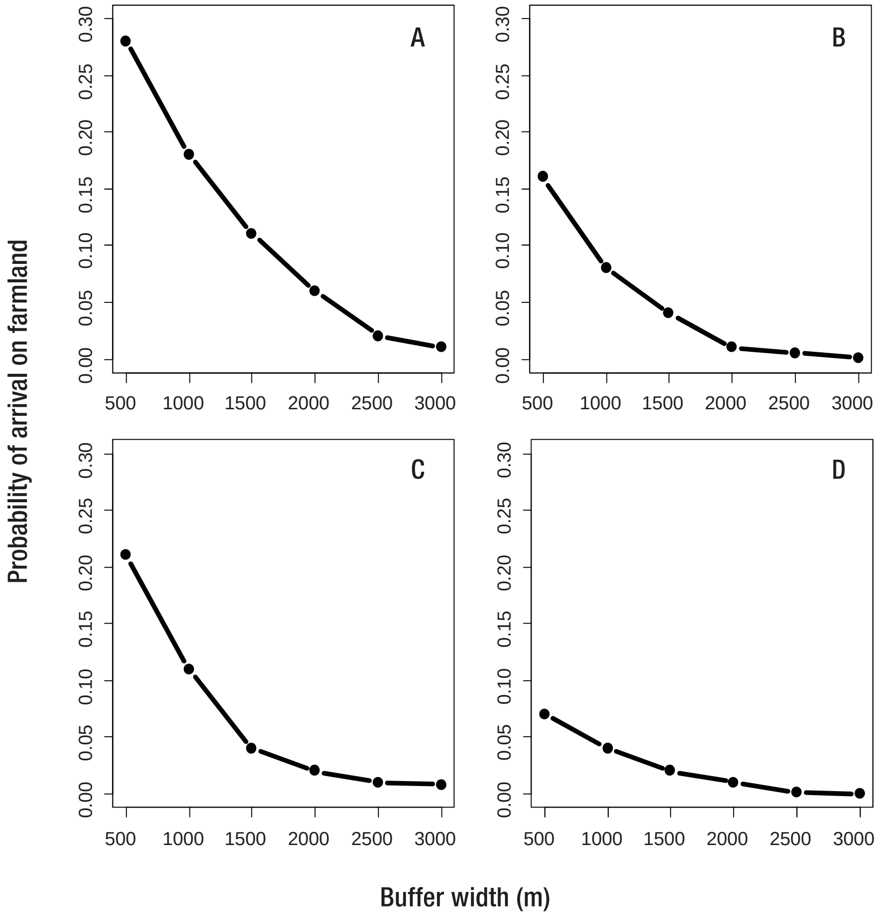

Fig. 3 *Predicted probability of an infected possum crossing a forest buffer to farmland. Simulations were run with buffer widths ranging from 500 to 3000 m and with the following combinations of population density (number per hectare) and disease prevalence in untreated forest (in brackets): (A) 9 (0.1); (B) 2 (0.1); (C) 9 (0.02); and (D) 2 (0.02).*

predicted probability of an infected possum reaching farmland was 0.28 (or just over a quarter of all infected possums) with a buffer width of 500 m, population density of 9 possums/ha and disease prevalence of 0.10 (10%). The lowest probability of arrival was 0.0001 (or 1 in 10,000) and occurred with a buffer width of 3000 m, and low population density and disease prevalence (*Fig. 3*).

Implications for management

Buffers can provide short-term protection from disease incursions but the risk of a diseased possum moving to farmland will increase over time as (potentially infected) possums invade the buffer. The current 5-km buffer width generally applied to containment areas may be overly conservative, given the maximum observed dispersal distance of subadult possums of ~2.5 km. Buffer widths of just 2–3 km may be sufficient to prevent dispersing possums coming into contact with livestock, although the most cost-effective width will also depend on other factors such as the frequency of control. The results confirm that large rivers are barriers to possum movement and that it would be advantageous to concentrate follow-up possum control in riverine habitat.

This research was undertaken under contract to TBfree New Zealand.

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How rapidly do rat populations recover after control with 1080?


Nga Manu Images

An aerial 1080-bait poison operation usually results in an immediate reduction in the number of possums and rats inside the baited area. But two critical questions are how far does this control extend and how fast do pest numbers recover across the entire control area? Landcare Research and the Department of Conservation (DOC) have been looking at these issues using data collected from DOC's Project Kaka (the forest restoration initiative in Tararua Forest Park, controlled in November 2010) and from Greater Wellington Regional Council's Hutt Water Collection Area (at the southern end of the Tararua Range, controlled in September 2009). Two to four times a year since the control operations, 65 lines of rodent tracking tunnels have been opened for one night and baited with peanut butter. The proportion of tunnels in a line of 10 with rat tracks in them is used as an index of rat abundance. Mandy Barron (Landcare Research) and James Griffiths (DOC) have been analysing these data for different patterns in the rates of rat recovery with respect to distance from the control zone boundary.

Overall, the 1080 operations achieved good kills of rats within the first 4 km of the control zone (–4 to –1 km) (see Fig.), with median tracking rates of zero recorded in the 6 months following control. The benefits did not, however, extend beyond the control zone; tracking rates on the border of the control zone (0 km: Fig.) remained high.

Recovery rates showed a consistent spatial pattern: rat tracking rates on lines just inside the control zone (–1 km) increased 6–12 months after control. Lines located 1–2 km and 2–3 km into the control zone showed delayed recovery rates at 1–1.5 years and 1.5–2 years respectively. Tracking on most interior lines (3–4 km) only recovered 2–2.5 years after control (Fig.).

Analysis confirmed a significant interaction effect – of time-since-control with distance from control-zone edge – on rat tracking rates, as illustrated in the figure. The analysis also showed that season has an effect on rat tracking rates – spring followed by winter had the highest rates. Lines at lower elevations generally had higher frequencies of rat tracking than lines at high elevations, but as this effect is similar to the effect of forest type (e.g. silver beech forest occurred at the highest elevations and harboured the lowest numbers of rats), the exact mechanism is unclear. There was also an unexplained ('random') effect of different years on rat tracking rates, which could have been due to year-to-year variation in fruiting or seedfall affecting rat productivity or yearly variation in weather affecting rat survival.

The spatial pattern of rat recovery observed, i.e. fastest at the control margins and slowest in the control interior, strongly suggests that such recovery was initiated by rats immigrating into the control zone from untreated parts of the forest where rats remained abundant. The alternative explanation, that productivity of rats surviving control was higher at the control margins and slower or delayed in the interior, seems unlikely given the control area boundaries were arbitrary and did not align with any changes in habitat or topography likely to affect productivity of rats.

The next step in the analysis is to look at the response of native species to changes in rat abundance. DOC has been monitoring birds in the control zone (using five-minute bird counts) and Landcare Research has been monitoring tree weta (using wooden 'hotels' nailed to trees), stick insects and tree weta (using frass collected in seedfall traps), and ground weta, beetles and spiders (using pitfall traps). The implications of the spatial patterns of rat recovery observed are that only species in the very interior of control zones are afforded long-term (>2 years) relief from rat predation.

The 1080 aerial baiting operation for the Project Kaka area was repeated in early December 2013 and further monitoring should show if the patterns observed after the second control operation are consistent with the first.

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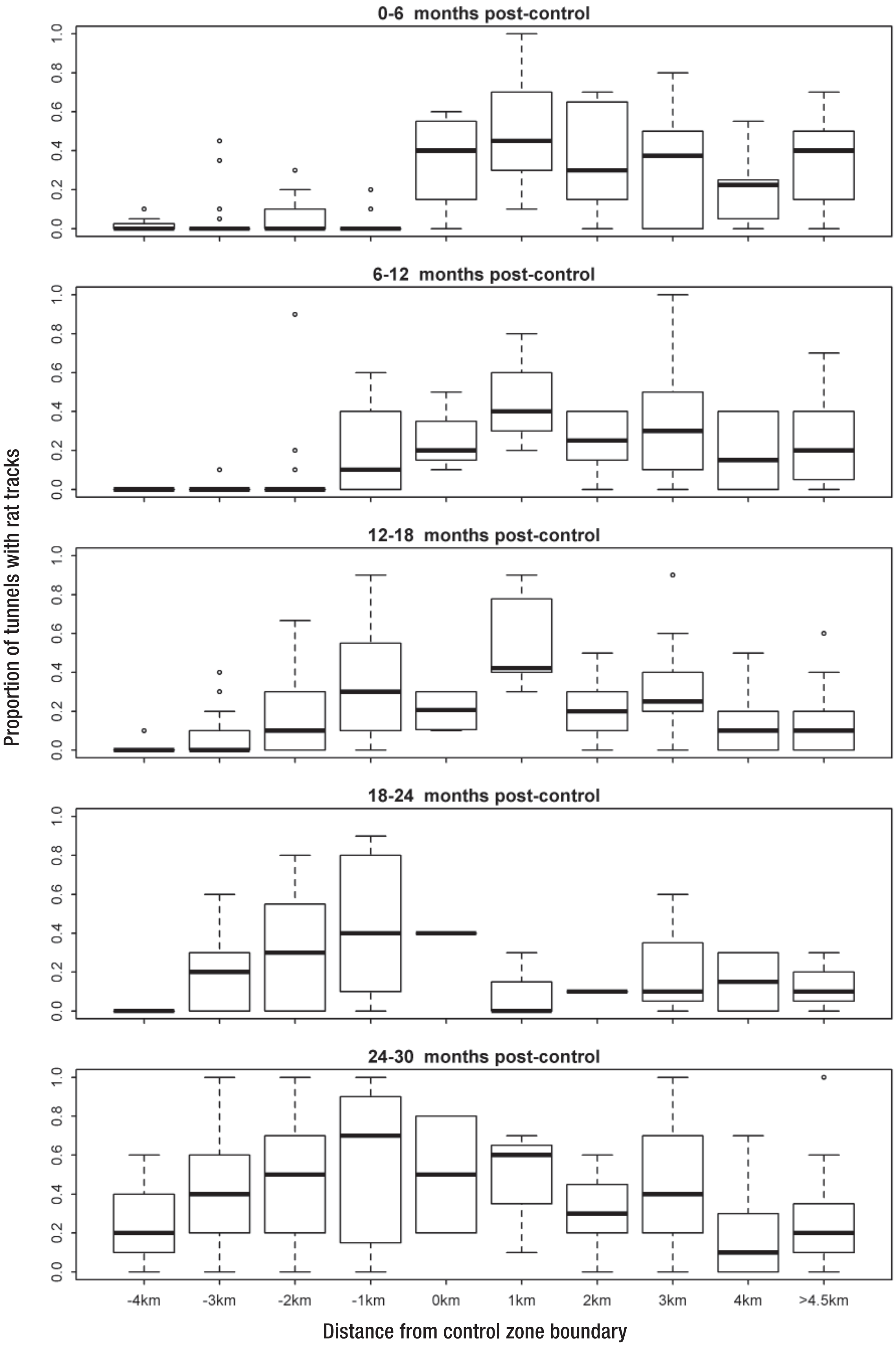

Fig. *Rat tracking rates with time since 1080 control and with distance from the control zone (negative distances are inside control zone, positive distances are outside it). Boxes show interquartile ranges of tracking rates with medians indicated by a dark band and outliers by hollow circles.*

Dispersal movements by wild dogs in eastern Victoria, Australia

Alan Robley

Wild dog fitted with a GPS collar.

Wild dogs (dingoes, feral dogs and their hybrids) are an important apex predator throughout Australia. However, they also cause economic and social distress to farming communities because they injure and kill livestock, causing an estimated A$48.5 million in damage annually. To reduce the incidence of attacks on livestock, wild dogs are controlled (usually with buried toxic baits) on land adjacent to areas with livestock, with baiting concentrated within 3 km of pastoral land.

Several studies have investigated wild dog movements in temperate and semi-arid land. However, little is known about their movements around heavily forested environs of south-eastern Australia. Andrew Gormley and Alan Robley used collars fitted with GPS receivers to investigate the movements and habitat use of wild dogs on Nunniong Plain in eastern Victoria, in an area that contains sheep and cattle grazing areas adjacent to public land. Nine wild dogs were captured and had collars fitted, with the GPS devices programmed to gather location information every 30 minutes for 3 months, then every 8 hours for the next 6 months, at which time the collar was set to automatically fall off. The aim of the project was to investigate patterns of wild dog movement and habitat selection at the home range scale, and to see whether features with suspected high relative use (e.g. roads and watercourses) could be identified in order to better target wild dog control operations.

Home ranges varied among individuals from 30 to over 200 km^2, with males (124 km^2) having larger home ranges on average than females (45 km^2). Most collared individuals had overlapping home ranges, suggesting that they were part of a social pack.

Wild dogs displayed a high degree of memory of their home range, with individuals recorded as traversing their entire home range within days, often returning to a small number of 'high-use' locations where they would remain for a few days.

Two of the dogs, however, had unexpected long-range-dispersal movements during winter. One male travelled north for 60 km over 3 days towards the Victoria–New South Wales border, before returning to its home range on Nunniong Plain. After a further 30 days, he again headed north, this time travelling 230 km over 9 days, before again returning to his home range, stopping for a week at an intermediate location (Long Plain) along the way. Finally he again headed north, this time to Long Plain, where he remained for 3 weeks, at which point the collar fell off.

Similarly, a female left her territory in June and travelled north for 20 km over 6 days, spending a week at the new location, and then returned to her home range. A second long-range movement then occurred, which saw her travel 105 km over the next 3 months.

These two long-distance movements are unlikely to be associated with a move to lower country in winter, as all the other dogs remained on Nunninong Plain despite significant snowfall. Instead, Andrew and Alan believed that these recorded movements are initial forays into new environments followed by permanent dispersal. This type of dispersal behaviour has been previously reported in wild dogs in other land-types and is often associated with high population density and lower food availability.

The two recorded long-range movements were generally within public land reserves. However, they crossed areas that had both currently and previously been baited to control wild dogs. The fact that wild dogs are capable of moving across much larger distances than a single 100-km^2 territory may limit the effectiveness of some control frameworks (i.e. control concentrated within 3 km from the farm boundary). To better protect livestock, managers need to know how often dogs disperse across multiple territories before settling, and more specifically how often these movements take them onto private land.

This work was funded by the Department of Primary Industries, Victoria.

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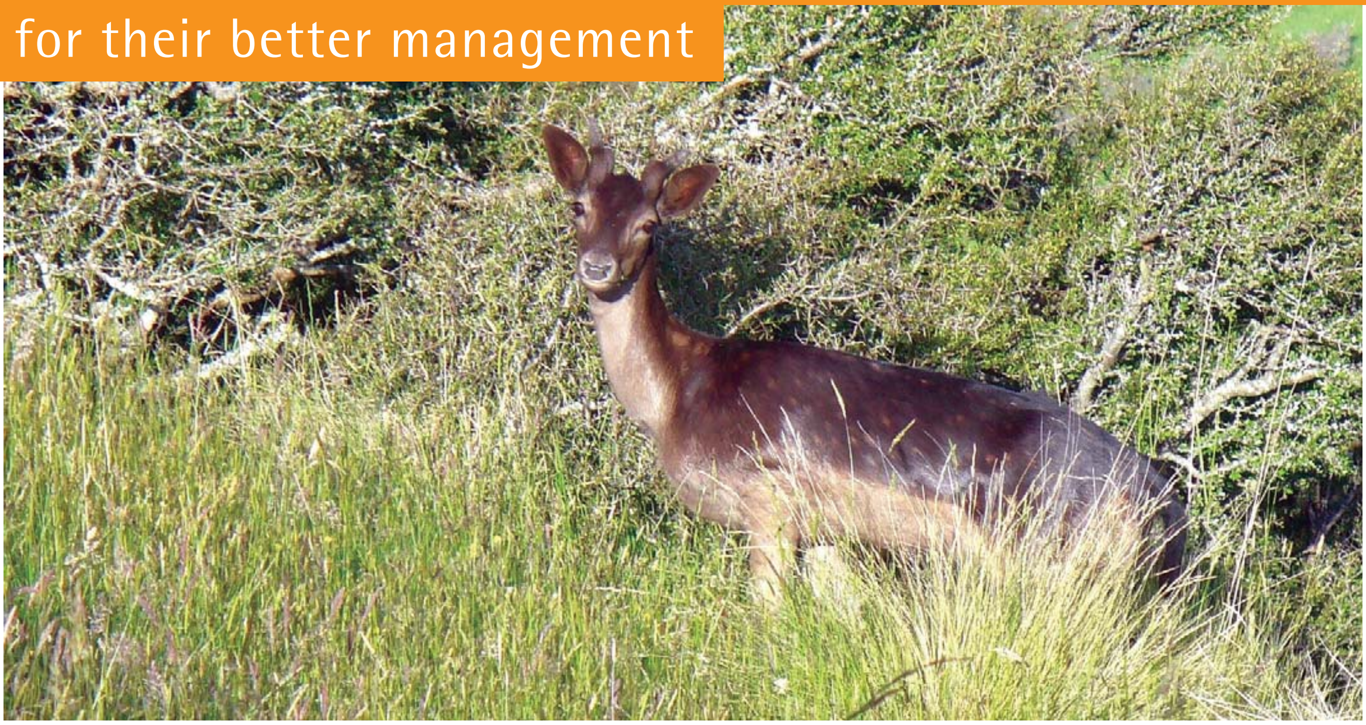
Understanding dispersal and dispersion of wild ungulates for their better management



Grant Morriss

In the mid-1990s, Wayne Fraser and colleagues reviewed the geographic distribution of 11 species of wild ungulates in New Zealand, including the various species of deer, Himalayan tahr, chamois, feral goats and feral pigs (J. Roy. Soc. NZ, 2000, 30: 419–437). The researchers identified 258 new population records and concluded that all species except Himalayan tahr were more widespread than previously documented and all were continuing to extend their ranges. Twenty years on, Dave Latham and his colleagues report that anecdotal information and limited survey data suggest that this process is continuing to occur for some of these species. For example, a survey in 2011 of selected landowners in Southland indicated that red deer, fallow deer and feral pigs are all spreading into previously unoccupied areas of the Southland Plains. Clearly if wild ungulates are continuing to expand their ranges and increase their numbers, this has implications for biosecurity and the spread of wildlife diseases, native biodiversity, and agriculture and forestry. Although wild deer and pigs are not maintenance hosts of bovine tuberculosis (TB) in New Zealand, they can sometimes spread this disease through either human-assisted translocation or long-distance dispersal. Where this results in a new outbreak of TB far from affected areas (as in the Wilberforce River valley in 2011), it can

Peter Anderson

Fitting a GPS collar onto a red deer stag for a movement study.

increase the cost and slow the currently strong progress toward local TB freedom being achieved by TBfree New Zealand (formerly the Animal Health Board).

More drastically, if foot and mouth disease (long seen as a threat to local livestock) entered the country, widespread contiguous populations of wild ungulates, particularly when adjacent to farmland, would make it difficult to manage the impacts of this disease on livestock. Further, it has been inferred (although not yet proven) that feral pigs could spread the micro-organism that causes dieback in kauri, so the occurrence of new pig populations in kauri forests is cause for concern. Similarly, many of the habitats that wild ungulates have dispersed or been liberated into are naturally occurring rare ecosystems (such as coastal wetlands and sand dunes) that may not be resilient to ungulate browsing or trampling, or rooting by pigs.

Some hunters think the spread of wild ungulates into new areas is desirable because of increased hunting opportunities. Where new populations occur on private land and landowners are amenable to hunting, this supposition appears valid. However, some landowners view wild ungulates as undesirable because they damage agricultural crops, orchards and plantation forests. Further, many new populations of wild ungulates occur on public land not gazetted for hunting (at least of large game). Often these areas are popular recreational areas for the non-hunting public or occur close to residential areas. Consequently, hunting may never be acceptable in these areas because of the risks to human safety.

Dave and his colleagues believe the current extent of wild ungulate dispersion and the occurrence of new populations need to be revised using new approaches and technologies. For example, a systematic grid survey (similar to that used in the atlas of bird distribution in New Zealand) could be useful to depict presence/absence of wild ungulates, have high repeatability and produce quantifiable changes in distributions.

Similarly, the mechanisms responsible for the ongoing spread of wild ungulates need to be reassessed. In the past, most new populations have resulted from farm escapes, illegal liberations and natural dispersal. Accurate information about how new populations are establishing is important because different mechanisms can have vastly different implications for management. For example, the best strategy for preventing deer escapes from farms is to educate farmers about the importance of sound deer fences, and to report and (if possible) recapture escapees promptly. Conversely, the clandestine nature of illegal liberations makes it more difficult to prevent the establishment of new populations. For example, we know that fallow deer have low dispersal rates and yet there are now many new populations of fallow deer, often considerable distances from the nearest source population. These types of illegal actions are likely best addressed through hunter education programmes coordinated by the Game Animal Council.

Relative to farm escapes and illegal liberations, natural dispersal has resulted in far fewer new populations in recent decades. However, understanding the dispersal process can be crucial for wild ungulate management strategies. For instance attempted eradication of animals from a specific site is likely to be hampered by reinvasion. This might occur because neighbouring populations are able to interact with each other despite being separated by artificially or naturally fragmented habitats. Alternatively, survivors of an eradication programme might disperse to adjacent habitat following disturbance, establish viable populations and subsequently pose a reinvasion threat to the area from which they were initially removed.

Dispersal studies can provide information about the prevalence of dispersal within populations, the attributes of dispersing individuals, and the corridors, habitats or other landscape features that most favour dispersal. Recent GPS technology, coupled with environmental data in a GIS framework, can be an excellent method of quantifying dispersal. However, this approach is only useful if some radio-tagged individuals disperse from a population. Where anticipated dispersal is low, more animals need to be tagged to quantify this process. That said, the cost, both of GPS units and of deploying them, is likely to be prohibitively high.

Revising the work of Fraser et al. will allow managers to estimate the numbers of new populations and changes in the distributions of species. Regionally, much of this information already exists but it needs to be collated and summarised to provide a nationwide picture. This would enable managers to identify new locations and likely sources of new populations, determine which populations must be removed to mitigate unwanted impacts, and so develop species management plans. Similarly, understanding how and why animals disperse, particularly around the interface of areas where wild ungulates are permitted and areas where they are not, will also be key for effective management and biosecurity.

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

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Bruce Warburton

Forecasts and ‘nowcasts’ of possum distribution in New Zealand

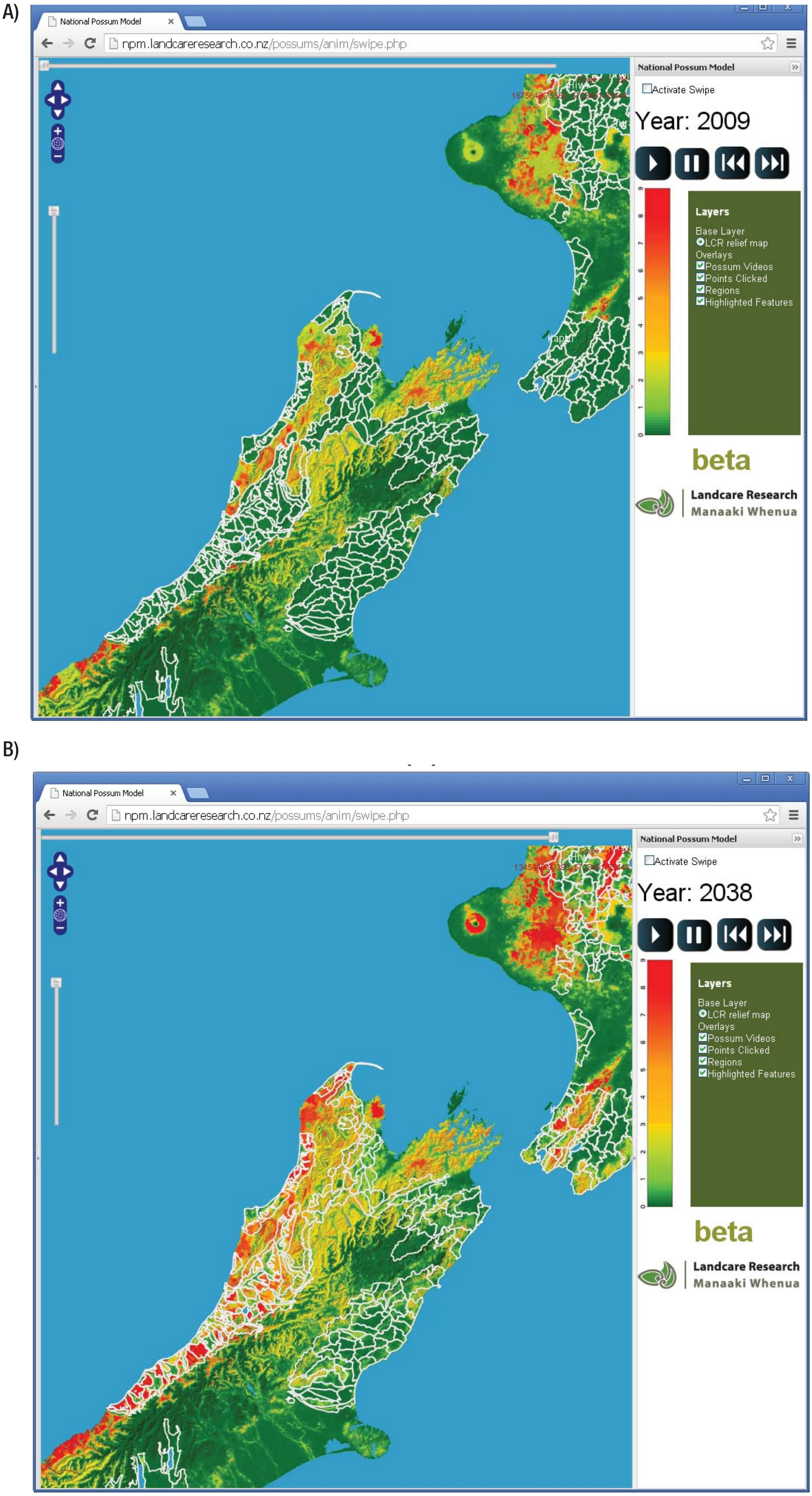

Caroline Thomson

Since their arrival in New Zealand in the mid-19th century, possums have colonised almost all areas of suitable habitat. Is there anything new to say about their distribution? The answer is yes: the abundance and distribution of possums in New Zealand changes continuously as a result of natural fluctuations in food supply, control programmes, and reinvasion and re-establishment of populations in previously controlled areas.

In the future, possum distribution is likely to change even more as regional councils expand control programmes across large areas (e.g. the Poutiri Ao o Tane project and the Cape to City proposal in Hawke’s Bay) or if the ‘Predator-Free New Zealand’ initiative gains traction. On the other hand, if TBfree New Zealand achieves success in eradicating bovine tuberculosis (TB) from many parts of the country, the need to suppress possum populations over large areas might have lower priority.

Recently, Bruce Warburton, James Shepherd and Phil Cowan estimated that control operations conducted by the Animal Health Board (now TBfree New Zealand), the Department of Conservation and regional councils had reduced New Zealand’s possum population, estimated at 48 million in 2009, by about one-third to a total of 30 million (see *Kararehe Kino* Issue 17, pp. 22–23). This assessment used habitat maps and the estimated carrying capacity of possums (i.e. the maximum density of possums in each habitat), taking into account suppression of possums through recent control operations. Keeping track of changes in possum distribution and abundance across New Zealand to provide up-to-date ‘nowcasts’ is possible through mapping data from repeated surveys. But these maps soon become outdated, either due to range contraction after habitat modification, pest control and eradication; or due to range expansion, for example via natural recolonisation of treated areas or deliberate or accidental releases in new areas.

In the case of possums, there are substantial demographic data and knowledge of ecological processes that drive population dynamics. So, current national maps of abundance and distribution can be combined with models of population dynamics to create dynamic maps showing future population trajectories. Murray Efford and Dave Ramsey (formerly with Landcare Research), and more recently Mandy Barron, designed a ‘spatial possum model’ that simulates the birth, movements and death of individual possums to predict the rate of recovery of entire populations after control. Currently this model can simulate changes in possum populations up to about 100,000 individuals (i.e. over areas of about 10,000 ha) but above this number computational speed is slow, so the model is unable to deal with very large areas, e.g. at regional and national scales. James Shepherd and colleagues have overcome this difficulty by rewriting the model’s computer code in a more efficient programming language and running model simulations with every possum represented individually for the entire North or South Island. This implementation, called the ‘National Possum Model’, is designed to run



☐ Activate Swipe

Layers

Base Layer
● LCR relief map
Overlays
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☑ Regions
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Fig. *Static output from the beta version of the National Possum Model for central New Zealand showing vector control zones for managing bovine TB. (A) Possum abundance in 2009, and (B) predicted possum abundance in 2038 under a 'no control' scenario (population density ranges from 0 to 9 per hectare: red = high; green = low).*

on a clustered computing system (i.e. many linked computers running in tandem) and takes advantage of the large-scale parallel processing and memory that this system makes available.

Other innovations make the dynamic maps intuitive so that they will be easy to use when the National Possum Model is made publically accessible via the Internet. Data are colour-coded so that areas of high and low possum density are easily distinguished. Maps consist of small 'tiles' and each of these tiles is sub-sampled at a number of different resolutions. Then the appropriate tile and resolution is chosen as the user zooms and pans around the map. To display changes over time, each tile at each resolution is turned into an animation showing an entire time series of the 'most likely' number of possums. Extra frames are introduced to make the animation look smooth enough for dynamic display. The result is a dynamic map predicting future changes in possum distribution and abundance anywhere in New Zealand and at any scale. Graphical overlays, such as vector control zones used by TBfree New Zealand, can be selected to provide additional spatial context and to generate outputs for areas of interest (*Fig.*).

The National Possum Model is still being developed to provide more functionality for managers. For example, one aim is to use it to compare scenarios with alternative management regimes (e.g. different control frequencies). Other developments will improve the model's ecological realism by (1) using the recently-released land cover database (LCDB v 3.3; **http://lris.scinfo.org.nz/layer/401-lcdb-v-33-land-cover-database-version-33/**) to update the underlying habitat map, (2) accounting for the most recent possum control operations conducted by TBfree New Zealand and the Department of Conservation, and (3) including new knowledge of possum movement patterns. For example, in a separate article in this issue Andrea Byrom describes recent results on rates of reinvasion of forest habitat by possums. Also, research in progress in dryland ecosystems by Carlos Rouco and Grant Norbury, and forest ecosystems by Peter Sweetapple, Dean Anderson and Graham Nugent, is quantifying how possums that survive control operations aggregate in favoured habitats or form social groups.

Ultimately, the aim of the National Possum Model is to improve strategic planning for possum control at regional and national scales. Also this model serves as a template for future dynamic maps of other species.

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Sam Gillingham, Mandy Barron, Tim Heuer, Andrea Byrom and **Roger Pech**

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