Kararehe Kino
Vertebrate Pest Research

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Manaaki Whenua
Landcare Research

Impacts of Feral Pigs on D'Urville Island's Invertebrates

Pigs were first released in New Zealand in the late 18th century and now occupy about 93 000 km^2 or 35% of the country. Feral pigs feed mostly on plants but animals form an important part of their diet, providing their only real source of essential protein. Earthworms are often eaten in large numbers, but pigs are also considered to be a potential cause of the decline of *Powelliphanta*, a genus of indigenous giant carnivorous land snail.

Between 1996 and 2002, Morgan Coleman, John Parkes (Landcare Research) and Kath Walker (Department of Conservation) investigated the impacts of feral pigs and birds on giant snails and other forest invertebrates. The study was carried out on D'Urville Island, which is free of possums that also prey on *Powelliphanta hochstetteri obscura* and could have confounded the trial results.

Two study sites were established on Mt Attempt in areas where feral pigs and giant snails still coexist. At each site, a 50 x 50 m area was fenced to exclude pigs, and 10 (5 x 5 m) 'snail plots' established both inside and outside the fence. Each November, the number and size of live snails and empty snail shells on the snail plots were recorded, and the likely cause of death of all empty shells noted. Four soil samples were also taken

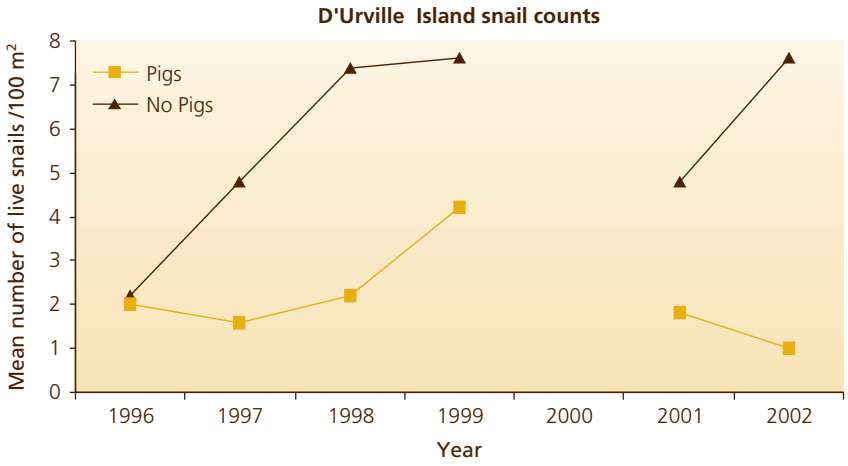


Fig. *Mean number of live* Powelliphanta hochstetteri obscura *snails at two sites in the presence of feral pigs (lower line) and where pigs were excluded (upper line), Mt Attempt, D'Urville Island, 1996 – 2002. No data were collected in 2000.*

alongside each snail plot, and all soil invertebrates present were counted, identified, and their total biomass recorded. Stomach samples from 31 pigs shot on the island were also collected for analysis.

Over the six years, snail numbers increased significantly within the pig exclosures but remained at similar densities outside them (see Fig.). The increase in snail densities in the fenced plots was due largely to increased numbers of juvenile snails. Outside the exclosures, feral pigs were responsible for 72% of all observed snail mortality, but the real mortality rate may have been significantly higher – few small empty shells were found with evidence of pig predation, and Morgan and the team believe pigs swallow smaller snails whole. Thrushes and weka were also important predators of snails. Thrushes ate only small snails, and accounted for 78% of dead snails on the plots within the exclosures, while weka ate all sizes of snails both within and outside the fence. No bite marks from the rodents present (kiore and house mice) were found on dead snail shells, although two live snails were found with clear rodent bite marks on their shells.

Photo: Kath Walker

A Powelliphanta *snail, similar to the species found on D'Urville Island.*

Generally, the biomass of soil invertebrates fluctuated widely during the study both inside and outside the exclosures, and the effect of excluding pigs on soil invertebrates was less clear-cut than on giant snails. There were more centipedes within the exclosures, and numbers of tipulid larvae (crane flys) increased more rapidly where pigs were excluded. Surprisingly, earthworms, a highly favoured food of feral pigs, did not appear to benefit from the fence. Seven of the pig stomach samples contained earthworms, but few pigs had eaten other invertebrates (only 4% of samples). However, the general abundance of clover in the stomach samples analysed indicates that most of the pigs shot fed mainly on pasture, and thus their diets were not representative of pigs living in forest habitat similar to that at the study sites.

Although snail numbers outside the exclosures over the six years of the study did not decline, the proportionately higher number of dead snails there and the lower overall numbers of live snails compared with those inside the exclosures, together with the small geographic range of the species, indicate it would be prudent to provide some degree of protection to giant snail populations from pigs. Conversely, giant snails on D'Urville Island seem to be able to withstand the predation pressures of birds.

This work was funded by the Department of Conservation.

Morgan Coleman

John Parkes

Kath Walker (not shown)

Density of Prey Matters in Pest Control

One of the national objectives of conservation is to stop the decline of populations of endangered species. Success can be assumed when the rate of increase (r) of the population of the target species is above zero. This objective is often accompanied by a subsidiary question: how little pest control is needed to achieve a positive rate of increase (and prevent the further decline) of the endangered species?

Kākāpō moved to some predator-free islands have increased their population densities whereas on the mainland they are close to extinction.

The answer to this question, investigated by Tony Sinclair (Landcare Research 2003/04 Hayward Fellow) for many years, is complicated, and really depends on where the target (endangered species) population density lies relative to its maximum density. In general, a population at low density has maximum per capita resources (e.g. food, territories, and nest sites) and so maximum production and minimum mortality, and is capable of increasing close to its maximum rate (r_{max}). However, as the population increases, its resources are used at a faster rate and food supply declines, followed by declines in reproduction and increases in mortality until reproduction and mortality reach a balance. This balance is called the 'carrying capacity' of the population (K), and any change in reproduction or mortality is therefore 'density dependent'. This leads to population stability, although a stable point is rarely discernable due to random environmental fluctuations. There is nothing mysterious about this process; it is simply the demographic consequence of declining per capita resources.

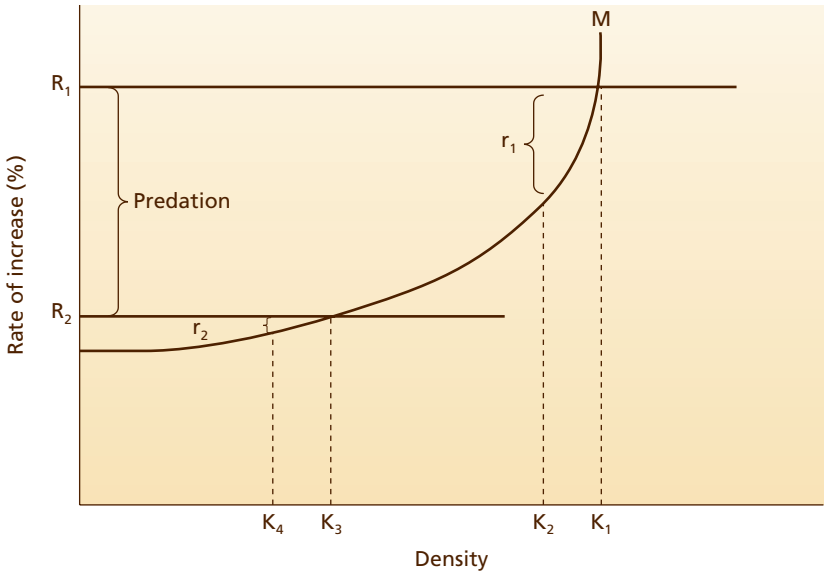


Fig. *A drop in population near maximum density (K_1) results in a greater capacity for compensation (r_1) than a similar drop (K_3 to K_4) at low density (r_2).*

These proportional rates are illustrated in the figure, where for simplicity, net recruitment is shown as a constant percentage (R_1) when plotted against population density. The percent mortality (M) is shown as a curve, being flat at low density (little density dependence) and steep at high density (strong density dependence). Where the two curves (R_1 and M) cross, the percentages are equal and the potential equilibrium is indicated as K_1.

So what has this to do with pest control? Tony suggests using the figure to illustrate an example in which a rare target species existing at K_1 with no (or little) predation

from, say, stoats or rats is suddenly reduced to K_2 (perhaps through a temporary surge of predators or a wet winter). Now at K_2, population losses from normal mortality of the target species from starvation are significantly less than gains from reproduction due to the steepness of the mortality curve. This difference (labelled r_1) is the rate at which the population can *compensate* for the disturbance and increase again.

Alternatively, if the target population started at low density (K_3), as a consequence of the dead weight of severe, persistent predation, net recruitment is only R_2. Again imposing the disturbance listed above, the target population drops by the same proportional amount to K_4. Now the difference between net recruitment and mortality is very small (r_2) because the mortality curve is flat. Here there is almost no compensation because the population is already operating at its maximum rate and so cannot increase after a sudden decline. The precise shapes of the curves for reproduction and mortality are not essential for these conclusions to hold.

Therefore, if a target population is held at low density through limited pest control, the population not only remains vulnerable to extinction but has almost no inherent compensation ability. In contrast, if the target population is allowed to increase to a higher density, it has substantial ability to compensate for disturbance, and so increase rapidly even if under constant predation. In fact, the population is doing much of the work for itself that managers would have to do instead at lower density.

So what is this compensation? Essentially there are three ways a population can compensate for a drop in density, say from a pulse of predation. It can increase its reproduction, decrease its mortality, or decrease its dispersal of juveniles. These factors respond best to a disturbance at higher population density, and not at all at low population density. Therefore, it would pay managers to get target species up to high density before reducing pest control.

Tony believes that very little is known about the nature of these compensation mechanisms in endangered New Zealand birds and reptiles because these species have not occurred at high density for at least a century. He suggests that experiments be undertaken to create very local high densities of endangered species, and to measure the various demographic parameters and the compensation that follows. New Zealand is an unusual island, isolated from mammalian predators for at least 50 million years and more, and its endangered species may respond surprisingly differently to pest management compared with similar species elsewhere in the world.

Tony Sinclair

Can Rabbit Populations Be 'Re-set' after RHD Has Failed?

Since its introduction to New Zealand in 1997, rabbit haemorrhagic disease (RHD) has successfully reduced rabbits to very low levels in some areas and held them there. In these areas, most of the surviving rabbits are older, immunised animals (i.e. ones that have caught the disease and survived) and RHD or predation (or both) kill most of their offspring each year.

In other areas the disease either did not reduce the rabbit populations during the initial epidemics or the rabbit numbers have recovered to unacceptable levels despite annual epidemics. Even this is not a problem if survivors are susceptible to the disease (i.e. have no antibodies from previous exposure and survival) and most die if exposed to the virus. However, it becomes a problem when farmers have both too many rabbits and too many of

them immunised against RHD. In this case, the farmers have to reinstate conventional rabbit control by poisoning or shooting. The question is whether removal of the 'problem' rabbits re-sets the disease-host system so that RHD will work next time on a new susceptible population of rabbits.

Farmers and regional councils have recently been forced to poison rabbits in several areas. Where they also have estimates of changing rabbit abundance, continued counts of rabbit numbers and their serology at these sites after the poisoning will show whether RHD fails again to control the rabbits. If it always fails at some sites, this would indicate that there is something about that area or the rabbits there that undermines the disease. If it succeeds, it will suggest that previous failures were due to some event in the past that is currently absent (perhaps the timing of the early epidemics).

John Parkes, Environment Canterbury staff, and individual farmers have identified several sites in Canterbury and Otago where RHD failed and where aerial 1080 control was conducted subsequently, mostly in the winter of 2002 or 2003. Results from most sites will have to wait future monitoring, but data from Tiromoana in North Canterbury, poisoned in the winter of 1998 after the initial RHD epidemic failed, provides some initial insight.

Rabbit numbers at Tiromoana were at modest levels prior to 1997, but exploded to very high densities in spring 1997, before RHD arrived in North Canterbury (see Fig.). RHD epidemics broke out at the site sometime in late 1997 or early 1998, but rabbit densities remained very high at that time and 73% of the survivors had caught RHD but survived and were immunised. The area was aerially poisoned with 1080 in the autumn of 1998 and over 95% of the rabbits were killed. Environment Canterbury has subsequently monitored the rabbit numbers and their immune status with annual counts and shot samples (see Fig.).

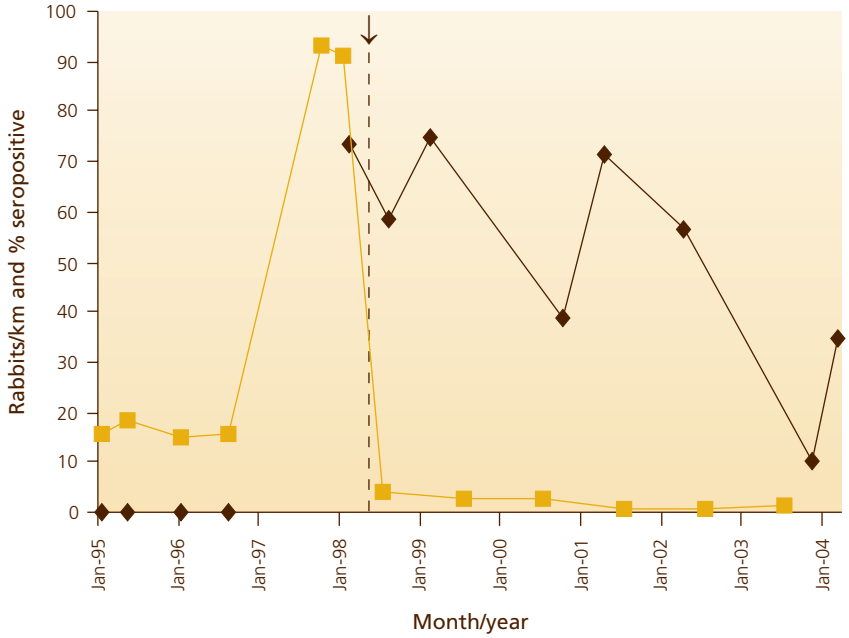


Fig. *Changes in rabbit density indices (■) and the percent of rabbits seropositive to RHD virus (◆) at Tiromoana, North Canterbury. The timing of the 1080 poisoning is indicated (↓).*

The good news from Tiromoana is that the 1080 poisoning has re-set the populations and RHD has persisted and continued to suppress the population. Rabbit numbers have, if anything, continued to decline and although the proportion of immune survivors has remained quite high, this is not a problem as rabbits cannot pass the immunity on to their offspring in the short term.

Of course a sample of one site does not prove the point about re-setting. Better inference will have to await similar monitoring at sites poisoned in 2002 and 2003.

This work was funded by Environment Canterbury and the Foundation for Research, Science and Technology.

John Parkes

Magpies Are Not Serious Pests

Magpies occupy a unique and ambivalent place in New Zealanders' hearts and minds. Some people like magpies because of their morning carolling, and perhaps because of their feeding on invertebrate pasture pests such as grass grubs. However, other people dislike magpies because they chase other birds, including native ones, and sometimes kill them, and occasionally attack humans. How frequently such attacks occur and whether they impact on native bird populations have been the subject of a combined study between Landcare Research and Waikato University over the last 4 years. Nine regional councils funded the project to help them resolve whether or not to include magpies in their regional pest management strategies. John Innes, Eric Spurr, Corinne Watts and Greg Arnold coordinated a large-scale trial in which regional councils controlled magpies in five 900-ha blocks. All birds were counted in these blocks and in five paired non-treatment blocks in which magpies were not controlled.

On average, regional councils removed 550 magpies from each treatment block each year, and magpie counts subsequently declined by 62% compared with non-treatment blocks. At the same time, counts of blackbirds, kererū, mynas, skylarks, song thrushes, and starlings increased significantly in the treatment blocks relative to the non-treatment blocks (see Fig.), with 2-fold increases being typical. However, the number of kererū counted in all blocks was extremely small, making the statistical outcome for that species unreliable. Tūī (not shown) responded differently in different blocks, with a large increase in one treatment block only, and fantails (not shown) declined slightly for reasons unknown. All these increases may have been due simply to there being more birds present after magpie control, or they may simply reflect the birds being more conspicuous.

Magpies were introduced from Australia in the 1860s.

Concurrently, Dai Morgan from Waikato University reviewed available published and public accounts of magpie attacks on other birds, and found that they attacked 43 species, killing individuals of 28 species. Killings occurred only during the magpie breeding season (July to January), and only 17% of the birds killed were eaten. Dai also observed both territorial and non-territorial magpies near Hamilton each month for a year, and determined that territorial magpies chased individuals of most species passing within 50 m but only 6% of the total number of individual birds, and no case of direct contact was observed. Non-territorial magpies made fewer attacks, and only on harriers. Birds seemed to recognise the threat, however, because while they frequently flew past a feeding magpie, they avoided landing within 50 m of one. Taken together, these observations suggest that

reports are greatly biased towards sensational events, and magpie attacks are much rarer than most people believe.

Dai also filmed with video cameras at 21 nests of common rural birds such as blackbirds, song thrushes and greenfinches, to see if magpies raided their nests. Harriers and cats were frequent predators, but magpies visited no nests, indicating they are not important predators of eggs or nestlings.

Neither the large-scale magpie control trial nor Dai's observations of magpie interactions with other birds indicate magpies are a serious threat to other rural bird populations. Particular magpies may chase native birds away from important small feeding or nesting areas. The likely cost of this aggression for other birds is a small (50–100 m) displacement until the chase ends, although in landscapes with fragmented native forests there may be more serious consequences for such species as tūī and kererū if they are forced to travel to the next forest remnant.

Magpies presumably are perceived by many humans to be important pests because they are noisy, easily seen, and chase other birds. Key mammal predators of birds such as ship rats could not be more different – they are small, silent, raid nests at night, and are virtually unobservable to humans. In contrast to the numerous accounts of magpie attacks, there are no published eyewitness scientific accounts of ship rat predation on forest birds, even though video footage proves that rats are the most frequent predator of small forest-birds in New Zealand.

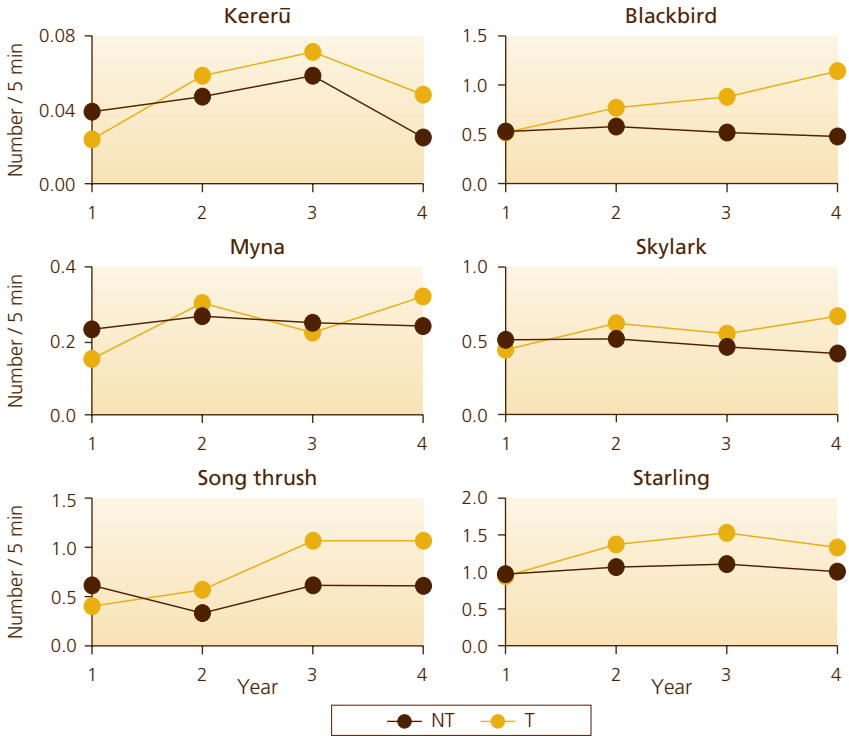


Fig. *Mean numbers of those birds that increased significantly after magpie control counted per 5-minute count per annum for all blocks. Year-1 counts were before magpie control started, and year-2 counts were the first post-control counts. (NT = Non-treatment, T = Treatment)*

John, Eric and Dai recommended that regional councils should not attempt large-scale control of magpies in pastoral land because it is expensive, and because the benefits to native birds and other indigenous biodiversity are likely to be small, in comparison with the control of pest mammals in native vegetation remnants. There may be particular sites where magpie control enables tūī and kererū to feed or nest freely without significant harassment, but more research is needed to verify this and to determine what features create this situation. The research has thus found no evidence that magpies are serious pests, and has refined the context in which magpies may be worth controlling.

John Innes

Eric Spurr

Dai Morgan

Possum Nematodes – a Promising Vector for Biological Control Agents

To be useful as a vector for a transmissible form of biological control for possums, an organism must have several key characteristics. Apart from infecting only possums, it must also infect a large proportion of all possums and either be persistent or readily reinfect possums. For several years Phil Cowan from Landcare Research and Mark Ralston and Warwick Grant from AgResearch, have been assessing the extent to which a possum-specific intestinal nematode, *Parastrongyloides trichosuri*, possesses these characteristics. The results of their work suggest that this parasitic worm is likely to be a very effective vector for biological control agents. Although there is some seasonal variation in the level of infection, with lowest levels in winter and spring, even then more than 50% of possums, on average, had worms. Juvenile possums had lower levels of infection, but infection was consistently high (>70%) in possums more than 2 years old. Levels of infection in the North Island vary from place to place, but within large tracts of native forest, such as the Tararua Range, there was little spatial variation in prevalence – seven populations sampled over a 24-km transect had a range of infection varying from 40% to 70%.

Although the parasite is common throughout the North Island, it is naturally absent from the South Island except for an area in coastal Southland from the Longwood Range across to the Maclennan Range in south-eastern Otago. This

Fig. *Spread of a parasitic nematode from release point in Northwest Nelson.*

distribution is puzzling, since possums have been spreading out from the Longwood Range for about 150 years (the site of the first successful introduction of possums to New Zealand), and Phil would therefore have expected the parasite to occur more widely by now. The lack of spread is not due to a peculiarity of possums in the South Island, however, as the team has shown that these can be readily infected experimentally. So to assess whether there was an issue about the ability of the parasite to spread between possums in the South Island, nematodes were released into a parasite-free possum population in Northwest Nelson. About 60 possums in a 9-ha area there were live-trapped and artificially infected by having parasite larvae applied to their skin. Within 3 weeks all but one of the artificially infected possums recaptured was shedding parasite eggs in its faeces.

For the last 3 years the team has tracked the gradual spread of the parasite in Northwest Nelson (see Fig.) and compared the dynamics

of infection there in artificially and naturally infected possums. To date, the parasite has spread to infect possums over an area of about 8000 ha. Patterns of infection and numbers of worms were similar in both the artifically infected and naturally infected possums, and in two sites where infection was monitored in detail, the seasonal patterns of infection were similar to each other and to the patterns shown in the earlier study of infection in North Island possums. The team is thus confident there are no issues about the ability of the parasite to spread that might compromise its suitability as a biological control vector, despite the apparent failure of the parasite to spread in Southland and Otago. In these areas, it appears that rather than having been present for 150 years, the parasite is a relatively recent introduction, perhaps brought there with someone's pet possum. Possums in most of this area have now been reduced to very low densities for bovine Tb management, so the opportunity to investigate this hypothesis further has been lost.

This work was funded by the Foundation for Research, Science & Technology and the Ministry of Agriculture and Forestry.

Phil Cowan

Mark Ralston & Warwick Grant (not shown)

Mouse Population Dynamics in Mixed Forest

Although it has long been known that periodic seeding (masting) in beech (*Nothofagus spp*.) forests drives house mouse (*Mus musculus*) eruptions, no similar relationships have been recorded previously between seeding and mouse numbers in other New Zealand forest types. However, this is no longer the case, as there is now evidence that heavy seeding of rimu *(Dacrydium cupressinum*) is also a precursor of mouse population eruptions in a forest containing a mixture of beech and podocarp species.

Wendy Ruscoe measuring a captured mouse in Waitutu forest.

Since 2001, Wendy Ruscoe and her team have been studying mouse population ecology in Waitutu Forest, Southland. In the absence of any significant seedfall between February 2001 and June 2002, they trapped only two mice despite considerable trapping effort. However, in winter 2002, rimu seeded heavily in Waitutu Forest and, to the surprise of the team, led to a local mouse population eruption. Clearly, the sudden increase in a resource that allows mice to attain reproductive condition and females to sustain pregnancy and lactation underpins population eruptions in both beech- and podocarp-dominated forests.

Subsequent chemical analysis has shown that rimu seed from Waitutu

Lake Hauroko – immediately north of the Waitutu study site.

Seed fall trap to identify masting events.

Forest is a good source of energy, protein and other major nutrients. The amount of protein (nitrogen) in mountain beech (*N. solandri* var. *cliffortioides*) seed (33%) from Craigieburn Valley and in rimu seed (23%) from Waitutu Forest exceeded the level estimated as required for survival and successful reproduction in rodents. Laboratory trials revealed that mice easily broke open the rimu nuts and ate the nutritious seed. Rimu seeds from Waitutu Forest also had higher calorific value than seeds of European beech (*Fagus* sp.) and many other tree species from temperate North America and Europe that are susceptible to rodent predation.

So what are the benefits mice receive during rimu seeding years? An average mouse needs approximately 91 kJ/day for survival. Based on measured calorific values of 30 kJ /g dry weight of rimu seed, a mouse needs to eat approximately 3 g of rimu seed per day. This equates to eating about 950-1000 rimu seeds if they are not eating anything else, and mice are able to achieve this total, since other trials show that they can eat up to 1100 beech seeds in 24 hours.

Wendy and her team argue that there are two major conservation implications arising from these findings. Firstly, house mice in New Zealand eat more than just beech seed in mixed forests. While beech and rimu populations may survive high seed predation due to the large amounts of seed produced during 'mast' years, other plant species that do not produce large amounts of seed or that also only seed in mast years may be suffering levels of seed predation that limit any seedling germination. Secondly, there is now clear evidence that mouse population eruptions lead to stoat population eruptions, and eventually to increased predation of native birds. In forests dominated by beech, this occurs irregularly every few years, with years of high bird predation interspersed between years of low seedfall, low mouse and stoat abundance, and consequently higher bird survival. In mixed forests, where various tree species 'mast' asynchronously, the result is more frequent years of high pest numbers. In these forest systems, native bird populations appear to be faced with high predation more often, and with fewer intermediate years in which their populations can recover, and their numbers may be consequently lower.

This work is funded by the Foundation for Research, Science and Technology and Landcare Research.

Wendy Ruscoe, Deb Wilson & Rob Allen (not shown).

Lisa McElrea

Gary McElrea

Richard Heyward

An Automatic Radio-tracking System for Monitoring Wildlife – an Electronic Breakthrough to Replace an Outdated System

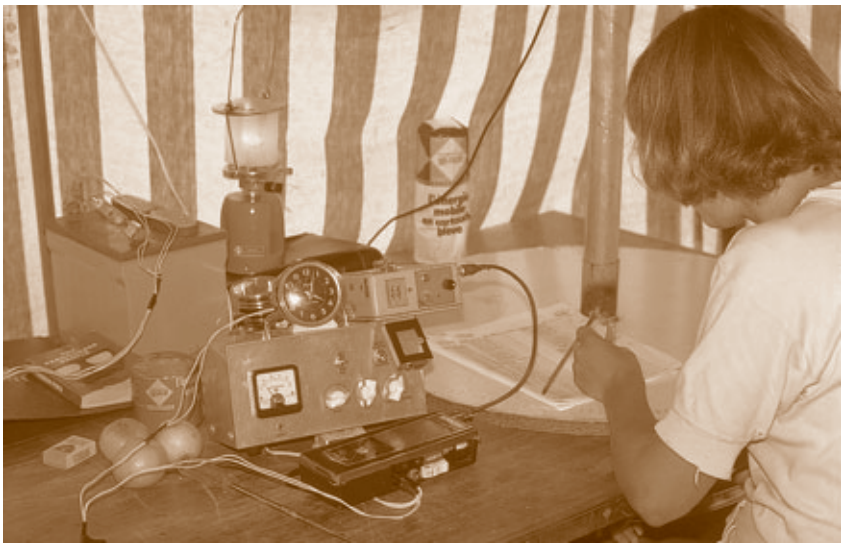
The well-established practice of radio-tracking animals using manually operated tracking towers has at last been replaced with an automatic system ideal for long-term studies. Until now these have been cost-prohibitive because of the huge number of person-hours required to gather the data.

The new system was jointly designed and developed in Canterbury by Graham Digital Design and Data Beam Systems, and has been successfully tested by Landcare Research (for results, see *Kararehe Kino 2*: 10–12). It is suitable for use in remote locations, being powered by lead acid batteries and solar panels. Its memory can hold a total of 10 900 locations from up to 50 transmitters each on a unique frequency, before being directly downloaded to a laptop PC, or sent by cellphone modem to an office-based PC.

One tower of the new system, including, from the top, a whip radio aerial and double yagi (that feed into the dual receiver), UHF whip aerial, solar panel, electronic control unit, a second solar panel (for additional charging), and heavy-duty batteries.

The new system consists of three receiving 'stations' or metal towers, which hold the double-yagi antenna, electronics, and solar panel. Three stations are used to permit unambiguous triangulation from three bearings. Two stations can be used, but the precision of the estimated position of the transmitter is reduced. The stations (which are identical in construction) are set up as 'Master', 'Slave 1' and 'Slave 2'. The master station communicates with the slave stations via an ultra high frequency (UHF) transceiver and 'tells' each slave which frequency to scan. Each tower rotates the aerial through 360 degrees, to identify the general direction of the transmitter, and then slowly sweeps the selected sector to refine the original bearing. After the sweep, the master requests the bearing obtained by each slave and stores all the results in its memory. The time taken to determine the bearing to a transmitter and to gather the results from the slave stations is about 3 minutes, so about 20 transmitters can be tracked each hour.

The electronics include a Control unit, Dual-receiver and UHF transceiver. The control unit for the entire system is set up by the operator either directly or by downloading a preprogrammed set-up from a laptop PC via a serial port. The frequencies of the transmitters are programmed into the system along with the start and end-time and number of times



A manually operated tracking station being used in the 1970s.

the frequency list is to be scanned each session.

The spacing between the towers can be up to 2 km, but is determined by the terrain. The UHF transceivers work best when there is a direct line of sight between the towers, and these are normally arranged in a triangle. However, the pattern can be altered to best suit the location.

The range over which a good bearing can be obtained is dependent on several factors and is best when there are few obstacles between the transmitter and receiver. Generally, if the signal can be heard with a handheld receiver, the tracking station will locate it.

Bearing accuracy will be reduced with weak or noisy signals, and if the system cannot locate a signal, this is indicated on the display and in the record. Bearing resolution is in one-degree steps; bearing accuracy for a fixed transmitter is typically ± 1 to 2 degrees, and for a collared animal typically ± 2 to 3 degrees (given a reasonably detectable signal).

A typical record from the automated system contains channel number, frequency, time, date, gain setting for each station, transmitter pulses-per-minute, master battery voltage, and bearing (Azimuth) data for Master, Slave 1 and Slave 2 stations. A windows-based PC program is used to both set up the system and read back the records.

Further information on the availability and cost of the new system can be obtained by contacting Autotracker@landcareresearch.co.nz

Paul Horton

Various radio-collared animals likely to be tracked using the new system.

Wild Deer in New Zealand: a Revision of Their Ranges

The Department of Conservation is currently considering changes to the legislation that covers deer farming. These changes are likely to involve revised standards for perimeter fences and a clearer definition of where deer farming of each deer species is either permitted or prohibited. As part of this process, Wayne Fraser and Steve Ferriss, assisted by Don Mckenzie and Leigh Honnor from DOC's Northland Conservancy, have updated the distribution maps of the seven deer species that occur in New Zealand and the database of new location records for deer. The work was based on reviews by wild animal management staff in all DOC conservancies and some regional councils of maps showing the 1996 distribution of each deer species and information on where distributions had expanded or contracted. Information was also obtained on the 157 new location records for deer documented in 1996 and on any others identified between 1996 and 2004.

Red deer are present in many parts of the South Island but are still absent from some areas of the North Island.

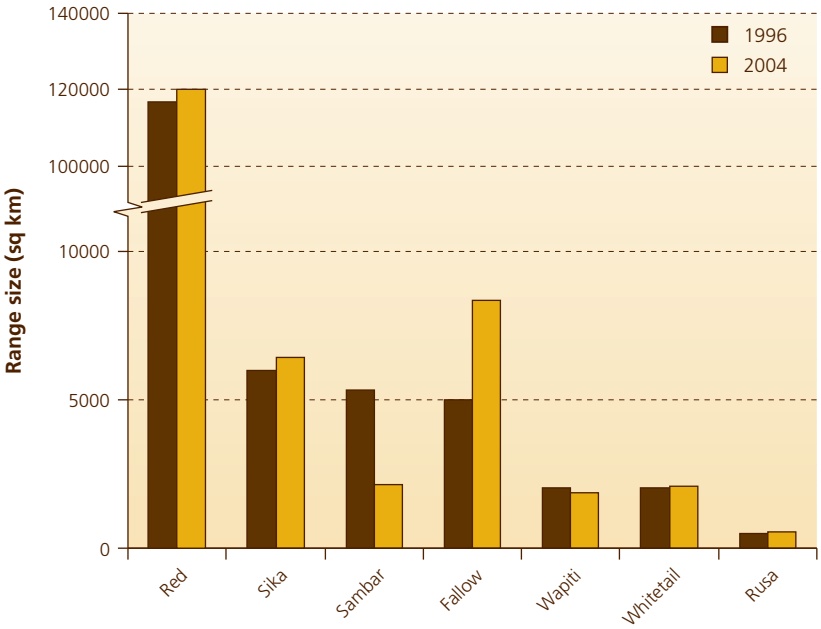


Fig. *Comparison of range sizes in 1996 and 2004 for the seven deer species present in New Zealand.*

Wayne and his team found that there has been relatively little change in total range size for most deer species between 1996 and 2004 (Fig.), except for a significant decrease in range for sambar deer and a significant increase in range for fallow deer. However, the contraction of sambar deer range is an artefact of the system used to store, analyse, and display species range information. While the 1996 ranges were already in a Geographic Information System, current ability to integrate these data layers with other information layers such as habitat type means that the team can now exclude areas that are clearly not deer habitat. In the case of sambar, this meant excluding large areas of farmland within the boundaries of the Manawatu-Wanganui herd, which deer cross when moving between patches of favourable

Table. *New location records for all deer species reported in 1996 and 2004.*

Conservancy	Number of location records in 1996*	Status of the 1996 new location records in 2004			Number of location records added in 2004	Total number of current location records
		Eradicated or probably eradicated	Still present	Unknown		
Northland	27	26	1	0	0	1
Auckland	42	3	30	9	14	53
Waikato	17	4	5	8	26	39
Bay of Plenty	2	2	0	0	5	5
East Coast/Hawke's Bay	9	2	6	1	8	15
Tongariro/Taupo	5	0	3	2	1	6
Wanganui	15	1	12	2	24	38
Wellington	13	0	6	7	7	20
Nelson/Marlborough	7	2	4	1	7	12
West Coast	0	0	0	0	3	3
Canterbury	14	2	6	6	6	18
Otago	5	0	4	1	7	12
Southland	1	0	0	1	1	2
Total (all NZ)	157	42	77	38	109	224

** This differs from the previously published total of 166 (9 records were found to be either duplicates or misinformation).*

habitat. The apparent expansion of fallow deer range, on the other hand, is real and reflects both improved range details of where fallow deer were present in 1996 together with recent increases in the distribution of this species following farm escapes and illegal liberations. The team has also mapped 109 location records identified since 1996 for four of the seven deer species. Sixty-one (56%) of these records related to fallow deer, and there are new fallow deer herds in 11 of the 13 DOC conservancies with 12 new herds in the Wanganui Conservancy alone.

The current status of the new location records reported in 1996, together with the number of new location records added in 2004, indicates there are almost a hundred new sites or areas recorded since 1996 where deer now occur (Table). However, some of these were probably already present in 1996 but were unreported. One of the most notable changes has been the eradication of all but one of the herds recently established in the Northland Conservancy. This has resulted from the concerted deer eradication programme funded by DOC, the Animal Health Board, and Northland Regional Council. There, local systems, including a toll-free number (0800 FIND DEER), have been established to ensure the early notification of farm escapes and illegal liberations, so that such deer are quickly recaptured or shot. A similar programme is underway in Taranaki.

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A Selection of Recent Vertebrate-Pest-Related Publications

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