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Manaaki Whenua
Landcare Research

Predicting Extinction Proneness and Recovery in Grand and Otago Skinks

Grand and Otago skinks (*Oligosoma grande* and *O. otagense;* see photos) are critically endangered, most likely due to a combination of habitat loss and predation by cats, ferrets and other exotic predators. To clarify the causes of population decline in both species, a mark-recapture study at Macraes Flat, eastern Otago, was undertaken from 1996 to 2002, to determine abundance trends and collect demographic data from seven skink populations. As cats eat skinks, a cat control operation (that also caught ferrets) was carried out over all study populations from May 1999 to May 2002 to test whether predator control assists skink population recovery.

Four of the five grand skink populations and both Otago skink populations declined during the study, with population 'growth' (Lambda) estimates between 1996 and 2002 varying from 0.81 to 0.97 (values <1 indicate a declining population). With the possible exception of a single population of each species, predator control did not reverse the downward population trends. This suggests that the recovery of both species on mainland New Zealand may only be possible within predator-exclusion fences.

*Grand (top) and Otago (bottom) skinks.*

But what are the demographic targets required to avoid extinction? Population modelling was used to help answer this question.

Otago skinks live up to 13.5 years in the wild, produce their first offspring at about 5 years of age, have female-biased sex ratios, and low recruitment (c. 50%) of juveniles into the reproductive population. In any given year, 64% of females of reproductive size produce an average litter of about two (1–4).

In contrast, grand skinks live up to 18 years in the wild, produce their first offspring at 4 years of age, have a variable sex ratio, and up to 71% of reproductive females bear young each year. Litter sizes average two (1–4), and again, only half of all juveniles survive to reproductive size.

The robustness of these demographic data to predict observed population trends were tested using a stage-structured model with environmental and demographic stochasticity (random variation). Density-dependence in survival at nominal low and high population densities was included. There was no allowance for potential inbreeding or bottleneck effects.

The model was used to predict likely extinction probabilities, and investigated
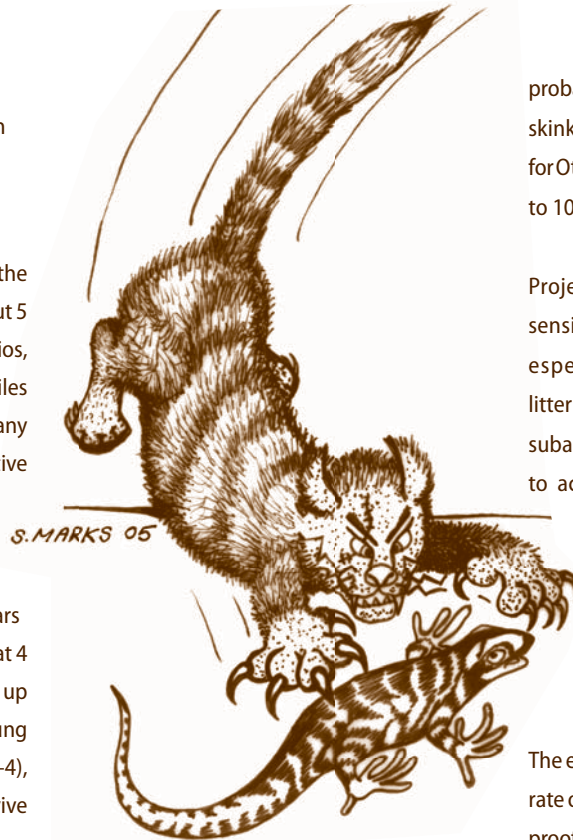
scenarios for survival and litter size that led to population growth (Table). The founder population size required for a given rate of recovery in predator-proof enclosures was also determined.

The model satisfactorily recreated the population trends generated by mark-recapture data (observed vs predicted lambdas for each site: $r^2 = 0.46$, $P = 0.06$). At current annual survival (0.54 for subadults and adults), litter size (c. 2), and population size (c. 60 individuals), there is a 59%

probability of extinction in 10 years for grand skinks, and an 88% probability of extinction for Otago skinks. These probabilities increase to 100% in 20 years for both species.

Projecting population recovery is most sensitive to changes in survival (Table), especially of subadults. With current litter sizes, an increase in survival of both subadults and adults to 0.80 is required to achieve greater than 90% probability that populations of both species will exceed 100 individuals in 20 years. For grand skinks, necessary survival is lower (0.70) if litter size is increased to three.

The effect of founder population size on the rate of population recovery inside predator-proof enclosures was modelled. With survival of at least 0.80 expected in the absence of predators, a minimum population of 15 adult grand skinks is needed to ensure a 97% probability that there will be more than 100 individuals in 20 years. For Otago skinks, at least 30 adults are required to achieve 80% probability of recovery (Fig.). If pest removal is able to improve survival beyond 0.80, fewer founders are required.

If nothing is done to reduce predator impacts, these species appear to be doomed to extinction in the wild in a very short time. Modelling indicates that the biggest gains in population recovery will be made through management techniques that boost survival rates by at least one-third. These techniques are urgently needed. Predator eradication and habitat restoration inside predator-proof enclosures are being implemented now, although only on a very small scale. Time will tell whether these efforts will be enough to reverse the decline to extinction of these iconic reptiles.

Table. *Probabilities of various survival rates and litter sizes leading to populations of more than 100 skinks in 20 years from starting populations of 60 skinks.*

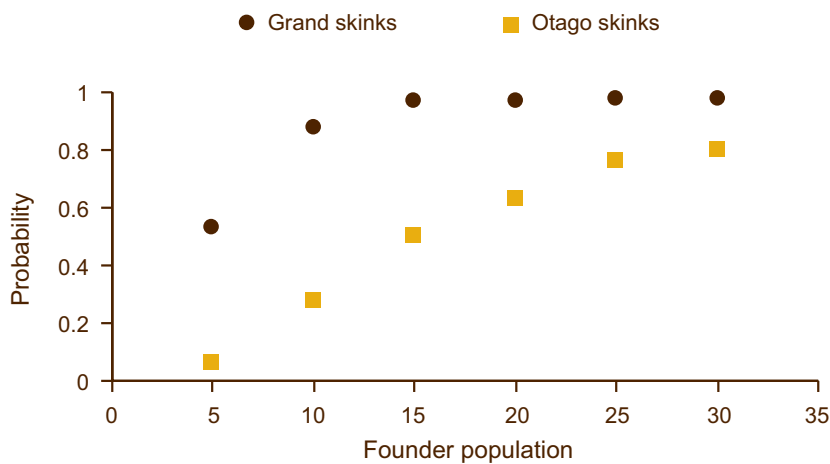| Species	Litter size	Survival		
		0.6	0.7	0.8
Grand skinks	2	0	0.84	0.98
	3	0.19	0.94	0.98
	4	0.71	0.94	0.97
Otago skinks	2	0	0.58	0.96
	3	0.01	0.85	0.95
	4	0.10	0.90	0.97

Fig. *Founder population size inside a predator-proof enclosure and predicted probabilities of populations recovering to more than 100 skinks in 20 years.*

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Hokonui Hills: from Problem Possums to a One-Hit Solution?

Current possum control aims to reduce and maintain populations below target densities at which they adversely affect conservation values or sustain infections of Tb in wildlife and associated livestock. Such control is most commonly achieved by aerially sowing toxic bait throughout targeted areas at intervals of 3–5 years, and, for the control of Tb populations particularly, carrying out annual or 2-yearly ground-based control.

Historically, one-off or infrequent control of possums provided only short-term relief before both conservation and livestock values were again at risk. However, the outcomes of recent changes in aerial baiting strategies suggest possum populations can be reduced to levels so close to zero that they take many years to recover to levels requiring further control.

The first example of this is the Hokonui Hills, Southland, which have a history of infection of Tb in possums and of possum control going back to the early 1970s. In

spite of past control or perhaps because of it, contractors undertaking control in the forest often failed to meet operational performance targets (as indicated by Residual Trap Catch Indices; RTCIs). Such failures were, they argued, due to the avoidance (shyness) by possums of toxic bait and traps. While the failure of contractors to routinely achieve good kills in the Hokonui Hills was undeniable, and indicated local aerial control was also likely to produce a sub-optimal kill, the reasons for such failures were unclear. Jim Coleman and colleagues were therefore contracted in 2003 to investigate this lack of effectiveness and to develop a solution to it. The failure of ground control meant aerial control was strongly favoured as that solution.

The research team developed and field tested an 'overkill' strategy of enhanced aerial baiting that extended the methods traditionally used, to improve the chances of achieving successful aerial control. First, a bait acceptance trial was undertaken to

identify whether RS5 cereal or carrot bait was most acceptable to the possums in the Hokonui Hills. Two pre-feedings and a non-toxic baiting dyed with rhodamine B were conducted in separate 100-ha forest blocks in the Hokonui Hills. Aerial sowing rates were increased to 5 kg/ha from the standard 2–3 kg/ha to overcome bait hoarding by the high numbers of rats present and to ensure all possums encountered the bait in the dense scrub present. Ground searches confirmed good bait coverage throughout. The standard lure, cinnamon essence, was changed to Jaffa orange to overcome any shyness towards cinnamon. Following baiting, each block was trapped, and all possums captured were examined for evidence of dye. Both bait types were eaten by all possums (contrary to the predictions of ground hunters), but possums from the RS5-sown block were most heavily marked and had eaten most bait. These results were confirmed by further acceptance trials using penned possums. RS5 bait, Jaffa orange lure, 5 kg/ha sowing rate, and

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two pre-feeds were thus proposed for the planned control operation.

This overkill, double pre-feeding, baiting protocol was then put to the test in an aerial control operation over 12,975 ha in the Hokonui Hills in 2004. Control success was measured on 54 randomly located trap lines monitored for three fine nights. No possums were taken on any of the trap lines. The kill clearly exceeded the target RTCI of 2% and indicated the possibility of local eradication.

This outstanding result prompted the Animal Health Board and Environment Southland to confirm that all possums had in fact been killed. Jim, Graham Nugent, and others designed a novel monitoring approach involving the use of grid trapping, wax tags, and faecal pellet searches along continuous transects spanning the entire area controlled. While 206 possums were trapped in this exercise and further evidence of possum presence was obtained from the wax tags and faeces, 167 possums and most 'sign' came

from outside or on the periphery of the area aerially baited. This confirmed that very few possums survived the operation. The finding also added further weight to evidence that normal RTCI monitoring conducted immediately after poisoning can sometimes miss survivors when their numbers are very low.

Building on this result, a similar baiting strategy has recently been trialled by AHB and DOC over almost 80,000 ha of the Hauhungaroa Forest, central North Island, again with great success (only 6 possums taken in 15,358 trap nights post- control). Graham and colleagues now plan on mapping where the few surviving possums are, and how quickly they recover.

Jim and colleagues believe that there is now enough evidence to support a strategy built around the most palatable bait and pre-feeding to provide a real breakthrough in extending the interval between successive aerial control operations to maintain infected possum

populations below Tb threshold levels, in reducing the time required to eliminate Tb from infected populations, and in reducing the overall cost of possum control.

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

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Morgan Coleman, Craig Reed (not shown).

Eradication of Bovine Tb at Molesworth

Control and eventual eradication of Tb from Northern South Island High Country (NSIHC) poses some major challenges, particularly in deciding which species to control and where. The region is remote, mountainous, and mostly unforested. Little is known about the numbers, distribution, or habitat use of local Tb vectors such as possums, ferrets, or feral pigs, or of their respective roles in the Tb cycle.

The physical characteristics of the area make it extremely costly to apply vector control, so to reduce the cost to

affordable levels, managers need help to know which species and areas to target first. Andrea Byrom, Graham Nugent and colleagues, along with Joanna MacKenzie (Massey University), have been tackling this problem on the 183,000-ha Molesworth Station, focusing on the following questions:

• Which vector species should be controlled?
• Which combination of vector species and habitat types poses the greatest risk of Tb persistence?
• What habitats should be highest priority for vector control aimed at

reducing livestock reactor rates?
• Is there a minimum set of habitats that must be controlled to eliminate Tb from livestock?

The researchers are addressing these questions by (1) comparing possum abundance in different habitats and at different altitudes to identify which habitats harbour too few possums to sustain Tb; (2) characterising seasonal movements of possums and ferrets to determine whether their local control may be compromised by animal movements; (3) confirming if possum

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control alone is sufficient to break the Tb cycle or if pig or ferret control is also needed for Tb eradication. The overall goal is to combine results and data on the distribution and abundance of possums and ferrets with landscape and habitat features and cattle grazing location data, to produce a Geographic Information System (GIS) decision support tool that will help managers prioritise areas for vector control.

Possum abundance in areas of different altitude and habitat have been measured on 42 trap lines 1–3 km long randomly located across Molesworth Station. Trap-line catches of possums varied from 1.2% to 35.8%, with the highest catch rates on the eastern boundary of Molesworth, and declining westwards. Both possums and ferrets were captured on lines at 600 to more than 1500 m a.s.l., but possum catch rates declined from 13% at 600 m to 5% above 1000 m, and to <5% above 1500 m (see Fig).

Thirty-eight possums and 25 ferrets have been radio-collared on two different sites on Molesworth. Early indications are that possums remain relatively sedentary, with home ranges similar to those in typical forest habitats in New Zealand. Ferrets appear to move widely (several kilometres),

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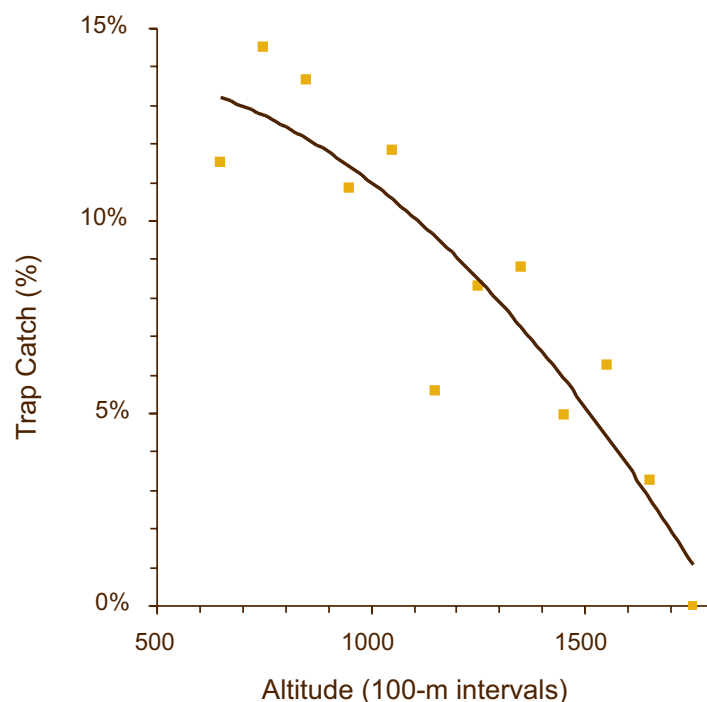
Airlifting out ferret traps and animals for necropsy.

Fig. *Trap-catch rates of possums with altitude on Molesworth Station.*

particularly in autumn, so there is more potential for them to transport Tb between controlled and uncontrolled habitats.

The effectiveness of pig-only and ferret-only control in reducing Tb levels, relative to the effect of aerial poisoning of possums (that also kills some ferrets and pigs), is being measured at several sites. These different management treatments have not been in place long enough to detect an effect, but baseline surveys have confirmed high Tb prevalences in ferrets, and very high prevalence in pigs – in some areas, all adult pigs are infected. To confirm that this high prevalence was not a result of pig-to-pig transmission, five Tb-free pigs (sentinels) have been held in a 1-ha enclosure with two heavily infected feral pigs from Molesworth. Only one of the Tb-free sentinels became infected during a cumulative total of about 14 years of exposure across all of the sentinels held at an effective density of 200 infected pigs per square kilometre. The experiment indicates that Tb transmission between pigs is likely to be a rare event in the wild.

With a year still to run on the project,

preliminary results are providing some important insights into landscape-scale management of Tb vector species in the NSIHC. Importantly, the long-held belief that possums are the only true Tb maintenance hosts in New Zealand remains unchallenged.

In the NSIHC, the greatest risk of Tb transmission to livestock is on the southern and eastern side of Molesworth, which holds the greatest number of possums and therefore the highest likelihood of Tb persistence. Also, there appears to be little benefit in spending money on aerial possum control above 1500 m, as possum numbers there are below 5% (the widely accepted threshold level of the disease) and possums are thus unlikely to maintain Tb provided they are controlled efficiently at lower altitudes. Furthermore, Andrea has not observed large-scale movements of possums, so such movements are unlikely to compromise Tb control efforts in the NSIHC.

These initial results provide little support for concerns that ferrets might be more important in maintaining Tb in the NSIHC than elsewhere, or that pigs are likely to maintain Tb long-term in the absence of infected possums.

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

Andrea Byrom

The Macrae Hut, Molesworth, was used as a base for some of the trapping lines.

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Joanna McKenzie** *(not shown)*

Cannibalism and Contact: Post-mortem Transmission of Tb in Possums

Tuberculosis abscesses or lesions in possums often occur only in the lymph nodes of the axilla (armpit) or groin. This does not fit well with the belief that the main route of infection in possums is respiratory (i.e. through inhaling Tb-laden aerosol droplets breathed out by infected possums) and results in lesions in the lungs. One possible explanation is that many possums become infected through the deliberate inspection and eating of infective material.

In a series of studies, Graham Nugent and colleagues have obtained video footage of repeated episodes of possums feeding on deer, pig, and even ferret carcasses. Graham has also gathered and collated about 30 reports from researchers, possum trappers, and farmers documenting cannibalism and other close-contact interactions between healthy and dead or dying possums, and he seeks further reports of such behaviours.

If you have observations or records of any of the following behaviours: (1) meat eating by possums, including cannibalism; (2) fur-raking of cyanided possums (carcasses attacked by another possum); and (3) aggressive or other interactions between healthy and dead or dying possums, please notify Graham at nugentg@landcareresearch.co.nz. The place, habitat type, and time of year of the observation would also be useful, and assessment of how common the particular behaviour was.

Reducing Non-target Interference with Feratox®

Feratox® baits contain encapsulated cyanide pellets and are an important tool for the control of possums. However, interference with Feratox by rats can substantially reduce the availability of the bait to possums, while the potential for deaths of weka or livestock that access

baits limits how and where Feratox can be used. To minimise interference with Feratox by rats, weka and livestock, Landcare Research has developed two prototype Feratox delivery devices – one 'spring-based' and the other 'suspended'. Both are simple, lightweight designs that

seek to exclude all non-target species, while allowing possums access to Feratox pellets.

Grant Morriss and colleagues have tested both devices, using non-toxic pellets and peanut butter or liquorice lure. Preliminary

trials showed that captive possums had no problem accessing the pellets in both devices, while captive ship rats were unable to access them. Subsequent field trials, using movement-activated video cameras to record the interactions of free-ranging weka with non-toxic pellets presented in both devices, revealed weka were attracted to the excluder devices but were unable to access the baits in them.

Further testing of the devices was carried out with domestic deer, sheep and cattle. All of the liquorice-baited suspended devices were eaten by deer but none were touched by cattle or sheep. Livestock were unable to extract Feratox from the spring-based devices, but in some cases rendered them inoperative through their trampling.

Both exclusion devices have demonstrated real potential in this preliminary evaluation and now need rigorous field-testing to confirm their efficacy in delivering bait to possums while effectively excluding rats, weka, cattle and sheep.

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

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**Penny Fisher, Graham Nugent,
Steve Hough, Jackie Whitford**
(not shown)

Grant Morriss

A captive ship rat used in the trials.

Grant Morriss

Weka were unable to access baits in the excluder devices.

Possum Population Dynamics in Mixed Hardwood Forests

Many possum populations are managed to protect conservation values from their browsing or predation, or to limit the transmission of bovine Tb to livestock. The cost of such work to the Animal Health Board, DOC, and regional authorities combined is approximately $60 million per year. Successful initial control requires the reduction of possum populations to levels set by conservation or disease managers, and follow-up maintenance control to slow down population recovery. The intensity and frequency of maintenance control operations depend on the natural trends in possum abundance and rates of recovery following control.

From 1965 to 2004, when proposed control of possums to manage local infections of Tb terminated the study, Jim Coleman and colleagues in conjunction with Les Pracy, formerly of the New Zealand Forest Service, annually monitored the possum population in mixed hardwood forest in the Pararaki catchment, Haurangi Forest Park, Wellington. This was the longest-running study of its kind for any vertebrate pest in New Zealand. Each year since 1965, and sporadically back to 1945, the possums were sampled from the valley floor to the ridge crest using leghold traps set on four permanent lines for three fine nights. Along with trap-catch data to provide an estimate of possum numbers, each captured possum's age, sex, breeding success, body weight, and body fat was scored to provide measures of population condition.

Possums in the Pararaki Catchment reached peak numbers of 24–30/ha in the mid- to late 1940s, 25–30 years after colonisation of the area, and then declined by 80% overall or 4% per year thereafter. Since 1965, when formal monitoring began, the population has further declined by about 2% per year indicating it has yet to reach any real balance with its environment (as reflected by a broadly stable equilibrium density) or that it has ceased to degrade local forest communities. Further, the annual trap-catch has varied erratically, with peaks at intervals of 4–6 years throughout the study but at lower amplitude from the mid-1970s onward (Fig). These trends are driven by the declining abundance of preferred foods, with the short-term perturbations apparently due to significant annual variations in food availability.

In addition to the overall pattern of possum population decline, a model of best fit of the trap-catch data indicates population crashes in 1977 and 1996, when 60–70% of the trappable population vanished, followed by variable population recovery. In both of these crashes, and in no other years, possums taken on or seen about the trap lines showed clear signs of starvation including extreme emaciation, feeding during daylight hours, and death while held in the leghold traps. The two indices of body condition taken – body fat and body weight – were also lowest in crash years and support the team's starvation hypothesis. As well, possum age declined and juveniles were under-represented in the years immediately following 1977 and 1996. Surprisingly, in both crash years, adult females continued to breed and carry pouch young. Simultaneous population crashes were recorded in another long-term monitoring study of possums in the Orongorongo Valley, about 30 km distant, where the same population regulation mechanism was thought to be involved.

Jim and his colleagues believe that this long-term monitoring study indicates that the interaction between possums and New Zealand's indigenous vegetation may in some instances take many decades to stabilise and produce a vegetation system that ceases to be degraded by possum browsing. Such a process is likely to significantly modify the ratio of palatable plant species in most forest and scrub systems.

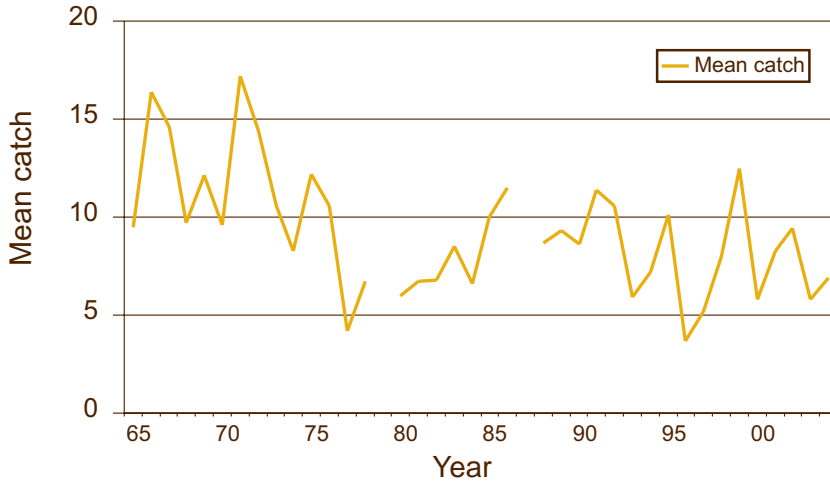*Les Pracy with possums captured in the early years of the study.*

facilitated by the recognition of the climatic clues that lead to food shortages, but these have yet to be documented. Unsustained one-off possum control mimics natural population crashes, and appears to provide similar short-term gains in forest condition or livestock health.

This work was funded historically by the New Zealand Forest Service, and later by the Foundation for Research, Science and Technology.

Fig. Mean number of possums caught per line per night from 1965 to 2004. No trapping was undertaken in 1979 or 1987.

Predicting, and taking advantage of occasional natural population crashes by integrating them with initial control operations could contribute to cost-effective possum management, and significantly extend the interval between the initial and any subsequent control operation. Similarly, predicting and taking advantage of possum condition could improve control efficacy in years when possums are in poor condition and are theoretically easier to kill. Using such natural events in this way would be

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Morgan Coleman** (not shown)

The Pararaki Catchment.

Estimating Changes in Deer Abundance Using Faecal Pellet Indices

Faecal pellet counts have been the standard method for indexing wild deer abundance in New Zealand since the 1950s, and have been widely used by land managers to make inferences about temporal changes in deer abundance. Although there have been many studies on the sampling design of faecal pellet indices in New Zealand, neither the relationships between the various indices and deer density nor the abilities of the indices to estimate changes in deer abundance have been investigated.

Dave Forsyth and colleagues examined the relationship between three faecal pellet indices and the density of deer in 20 large enclosures in the North and South islands. All enclosures were managed for hunting and all were fenced to prevent deer moving in or out. Eighteen enclosures contained mostly red deer, one mostly sika deer, and one mostly fallow deer. Deer abundances were obtained from the enclosure managers, based on known numbers released and harvested, annual musters, and direct counts from vantage points. The 20 enclosures had a median area of 478 ha (range: 41–2492 ha) and a median estimated density of 0.76 deer/ha (range: 0.10–1.95 deer/ha).

Within each enclosure, 30 randomly located transects, each 150 m long, were surveyed for the number of 'intact' pellets and the number of groups of 'intact' pellets in circular plots of 1-m radius spaced at 5-m intervals. As in previous work, intact pellets were defined as those having no recognisable loss of material, while a pellet group was judged to be one or more intact pellet(s) from the same defecation. Observers calibrated their definitions of intact pellets at the start of each year's sampling, assisted by photographs, and the sampling was conducted in January 2004 (10 enclosures) and January 2005 (the other 10 enclosures).

The team calculated three faecal pellet indices for each transect in each enclosure: (1) the total number of intact pellets ('total pellets'), (2) the number of groups with ≥1 intact pellets ('pellet groups'), and (3) the proportion of plots with one or more intact pellets ('pellet frequency'). All three indices (or variants of them) have been used previously to estimate changes in the abundance of deer in New Zealand.

Because of the uncertainty in the estimates of deer abundance by each of the enclosure managers, a Bayesian analysis was used to evaluate the relationship between each faecal pellet count index and deer density. The relationships between the three indices and deer density were all linear and positive. To evaluate the efficiency of the indices for detecting changes in the abundance of deer, the team simulated 10,000 paired sets of data using the linear model that best explained the relationship between the
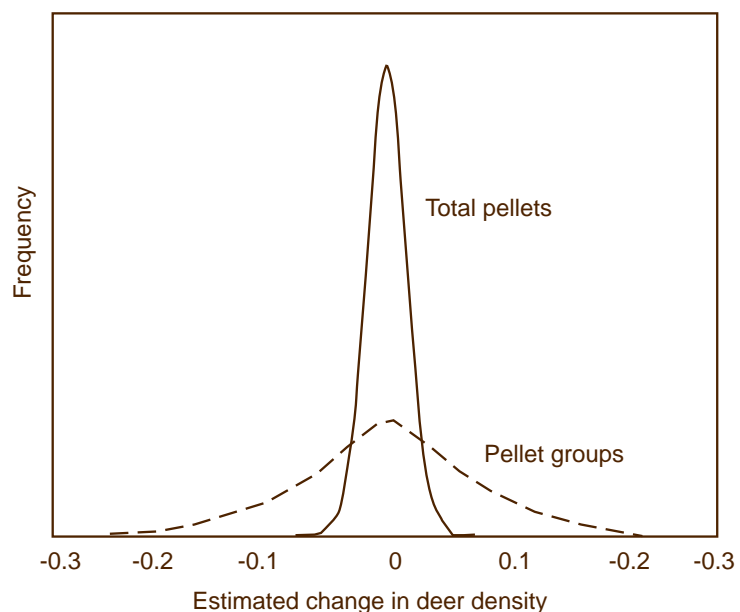

Fig. *Frequency distributions of 10,000 estimates of the change in deer density for the total-pellet and pellet-group indices assuming a linear relationship between each index and deer density. There was no actual change in the density of deer between the two surveys.*

index and deer density. Each simulation used repeat sampling of 30 transects (thus eliminating plot- and transect-effects) and assumed that the density of deer remained unchanged between successive surveys (Fig). Importantly, for pellet frequency there was no suitable estimator and this index was excluded from the simulations. The simulations indicated that 'total pellets' is a more precise and thus more efficient estimator of changes in deer density than 'pellet groups' (Fig.).

Dave and his colleagues conclude that faecal pellet indices, within the range of deer densities that they analysed, are a positive and approximately linear index of deer density, and recommend that managers make inferences about changes in deer density using total pellets rather than pellet groups or pellet frequency.

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Diphacinone Toxicity and Persistence of Residues in Pigs

Feral pigs are considered a pest by most land managers, but are also a significant resource for private hunters. However, if feral pigs eat toxic baits laid for possum or rodent control (primary exposure) or the carcasses of poisoned animals (secondary exposure), they can be exposed to the poison used. Residues of anticoagulant poisons, particularly brodifacoum, are undesirable in feral pigs, as people who eat wild pork may then also be exposed.

Bait formulations containing the anticoagulant diphacinone are currently being tested for residue profiles by Penny Fisher and her team, as an alternative to brodifacoum. Diphacinone has a lower acute toxicity to mammals and birds than brodifacoum and is less persistent in rat liver, and so is expected to pose a reduced environmental risk. To assess the potential risks of feral pigs acquiring residues following diphacinone baiting,

Penny supervised pen trials to investigate (1) sublethal doses of diphacinone in pigs, and (2) the time diphacinone persists in the liver, muscle and fat of pigs that have eaten a sublethal amount.

To determine which oral exposures were sublethal for pigs, domestic weaners were fed different doses of diphacinone to simulate different scenarios of bait intake that could occur in feral pigs. Along with their normal feed, the pigs were acclimatised to eating sweet 'dough balls', which were then used to deliver different doses of diphacinone: 12.5 mg/kg (3 pigs), 0.25 mg/kg per day for 3 days (3 pigs), or 0.5 mg/kg per day for 5 days (3 pigs). Anticoagulants such as diphacinone inhibit the production of blood-clotting factors in the liver, which then reduces the ability of the blood to coagulate and heal injuries. If sufficient anticoagulant exposure occurs, lethal haemorrhaging may occur. Tests that measure coagulation

time of a blood sample can show the effect of a dose of anticoagulant on an animal, with large increases in coagulation time indicating a toxic effect.

Two of the three pigs that received 0.5 mg/kg of diphacinone per day for 5 days became severely lame and were euthanased. Necropsy revealed that both pigs had severe haemorrhaging in or around a leg joint, indicating a toxic effect of this dose level. Significant increases in blood coagulation times were measured in all pigs 2 days after dosing but, except for the pigs euthanased, coagulation times had all returned to normal within 7 days. This indicated that a single diphacinone dose of 12.5 mg/kg or a regime of 0.25 mg/kg per day for 3 days was sublethal to most pigs.

To address the question of residual persistence, another group of 12 pigs was fed 'dough balls' containing 12.5 mg/kg

of diphacinone. This dose was roughly equivalent to a 35-kg pig eating 10 kg of bait containing 50 ppm of diphacinone. These pigs were euthanased at different intervals up to 15 days after dosing, and samples of liver, muscle and fat were analysed at Landcare Research for diphacinone residues (Fig.).

Penny then used these residues to calculate half-life values for diphacinone in pig tissue, i.e. the time required for half the measured concentration of diphacinone to be eliminated from the tissue. She found that diphacinone was persistent in pig liver for at least 15 days after dosing and conservatively estimated the elimination half-life to be 14.1 days. By 15 days, diphacinone residues were no longer detectable in muscle and fat, and half-lives of the toxin in these tissues were estimated as 3.16 days and 1.66 days respectively.

Using the half-life estimate of 14.1 days for diphacinone in liver, it would take 104 days for the highest residue measured in this study in pig liver (3.22 µg/g) to decline to below detectable concentrations (≤ 0.02 ug/g). These figures suggest that if feral pigs are taken for human
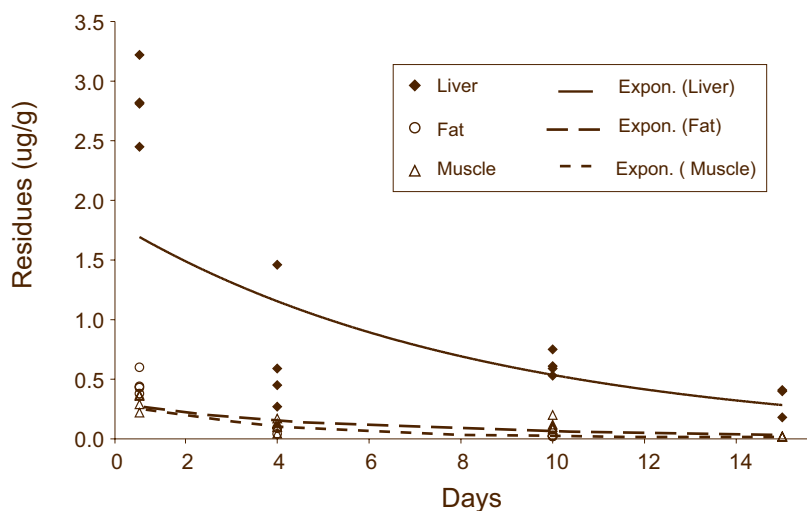

Fig. *Residual diphacinone concentrations in pig liver, muscle, and fat following an oral dose of 12.5 mg/kg. The lines represent the decrease over time of residues in each tissue, according to the calculated exponential decay curve.*

consumption in areas where diphacinone baits have been laid, the likelihood of detectable diphacinone residues (≥ 0.02 µg/g) in wild pork would be minimised by waiting approximately 160 days before harvesting pigs, i.e. using a precautionary, estimate of the withholding period. To field-check the period and extent of the risk of wild-caught pork containing residual diphacinone, muscle and liver tissue from wild pigs in areas where diphacinone baits have been used should be analysed by a suitable laboratory. This would provide additional data to support the conclusion that diphacinone is likely

to be substantially less persistent than brodifacoum in feral pig tissues, especially in liver.

The work was funded by the Department of Conservation.

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Planning Possum Control – Help in Making the Right Decisions

Vector managers, agency staff, and contractors involved in possum control have a wealth of information available to them on control tools, control strategies, possum behaviour, legal constraints to operational procedures, and the economics of control operations. Unfortunately, much of this information is found only in formally

published papers, books, or reports, and many people involved in the industry do not regularly access such information or in fact know that it exists.

While reviewing possum control plans and operations, Bruce Warburton and Jim Coleman became aware of the lack of connection between planning needs and

information on control, often resulting in ineffective or inefficient control being undertaken. To try and remedy this, Bruce and Jim along with colleague Mark Fuglestad and Jens Dietrich (Massey University) have developed an electronic web-based Decision Support System (DSS) to assist possum control managers select the most appropriate control

strategies and tactics, and to provide them with access to the most up-to-date best-practice information related to the recommendations identified by the DSS.

The DSS developed has three main components (Fig.):
- A knowledge base
- A backward-chaining inference engine (software logic that interprets the rules)
- A database of best-practice supporting information.

The knowledge base, which is essentially the rules of the system, was developed from a set of possum control scenarios that covered all possible control options that vector managers and control contractors might encounter. Each scenario was used to identify the rules a control 'expert' might follow to decide on the best control option to use.

When end-users run the system, they are provided with a set of statements that they must either confirm or refute. Each statement is linked to further information that explains its relevance. This set of statements is then submitted to the 'inference engine' (Mandarax), which uses the rules generated to provide a set of recommended control actions. Each recommended action is linked to best-practice-information web pages covering such topics as bait specifications and protocols of use, aerial and ground control, the effect of habitat on control success, non-target issues, and human and public health issues, so users can source up-to-date information relevant to particular possum management practices. These web pages are 'hyperlinked' via keywords to other related web pages and to pages that provide additional but less immediate control-based information. The user has the choice of seeking as much or as little information as he or she requires.

If users believe that the system has not recommended the most suitable action for their control operation, they are able to submit an alternative recommendation to the system manager, so the knowledge base can be reviewed and, if necessary, updated.

The DSS also has two additional components. These are checklists for vector managers and control contractors to ensure that, during operational planning, they address all potential operational constraints. Together, the complete DSS should allow the best defendable control practices to be identified for each operation and the optimal control outcomes.

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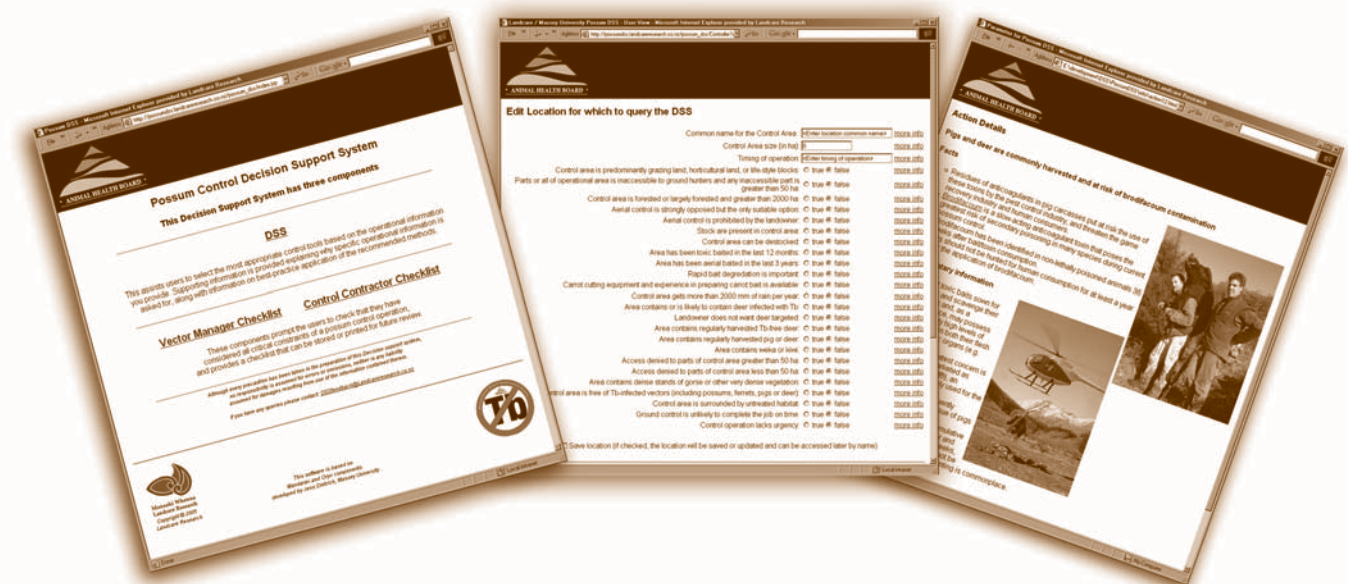**Jim Coleman, Mark Fuglestad, Jens Dietrich** *(not shown)*

Fig. *Examples of screen pages generated by the DSS. The first is the entry page giving the user a choice of either the DSS or checklists of operational contraints. The second shows the screen that users interact with to confirm or refute specific statements, and the third is an example of a best-practice information page.*

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Some Recent Vertebrate-Pest-Related Publications

Arthur, A.; Ramsey, D.; Efford, M. 2004: Impact of bovine tuberculosis on a population of brushtail possums (*Trichosurus vulpecula* Kerr) in the Orongorongo Valley, New Zealand. *Wildlife Research 31:* 389-395

Byrom, A.; Nugent, G.; Yockney, I. 2005: The role of ferrets in landscape-scale spread of bovine Tb in the high country of New Zealand's South Island. *In*: 13th Australasian Vertebrate Pest Conference : Te Papa, Wellington, 2-6 May 2005 : Proceedings. Lincoln, Manaaki Whenua - Landcare Research. Pp. 262-266.

Fisher, P. 2005: Review of house mouse (*Mus musculus*) susceptibility to anticoagualnt poisons. *DOC Science Internal Series 198*. Wellington, Department of Conservation. 19 p.

Hayes, L.; Horn, C.; Lyver, P. 2004: Taking the community with you : a process for developing acceptable pest control strategies. *New Zealand Science Review 61:* 66-68.

Innes, J.; Nugent, G.; Prime, K.; Spurr, E. B. 2004: Responses of kukupa (*Hemiphaga novaeseelandiae*) and other birds to mammal pest control at Motatau, Northland. *New Zealand Journal of Ecology 28:* 73-81

McLennan, J. A.; Dew, L.; Miles, J.; Gillingham, N.; Waiwai, R. 2004: Size matters: predation risk and juvenile growth in North Island brown kiwi (*Apteryx mantelli*). *New Zealand Journal of Ecology 28:* 241-250.

Morgan, D. R. 2004: Enhancing maintenance control of possum populations using long-life baits. *New Zealand Journal of Zoology 31:* 271-282.

Morriss, G. A.; Nugent, G.; Fisher, P. 2005: Exposure of feral pigs to brodifacoum following baiting for rodent control. *DOC Science Internal Series 194*. Wellington, Department of Conservation. 16 p.

Nugent, G.; Whitford, J.; Yockney, I.; Byrom, A.; Coleman, J. 2005: Do feral pigs play an important part in New Zealand's Tb problem? *In*: 13th Australasian Vertebrate Pest Conference : Te Papa, Wellington, 2-6 May 2005 : Proceedings. Lincoln, Manaaki Whenua - Landcare Research. Pp. 258-261.

O'Connor, C.; Warburton, B.; Fisher, M. 2005: Ethics and the killing of wild sentient animals. *In*: 13th Australasian Vertebrate Pest Conference : Te Papa, Wellington, 2-6 May 2005 : Proceedings. Lincoln, Manaaki Whenua - Landcare Research. Pp. 203-207.

Parkes, J. 2005: Eradication of exotic vertebrates and island restoration. *In*: Sinclair, A. R. E., Hodges, K., and Wingate, I. Proceedings of the workshop on the reintroduction of threatened species in Canada, held at the University of British Columbia, November 13-14, 2004. [Vancouver]. Pp. 24-27.

Spurr, E. B.; Ogilvie, S. C.; Morse, C. W.; Young, J. B. 2005: Development of a toxic bait for control of ferrets (*Mustela furo*) in New Zealand. *New Zealand Journal of Zoology 32:* 127-136.