What's happening with stoat research?

Fifth report on the five-year stoat research programme

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Dedication

This volume is dedicated to Dr Nigel Barlow, who died on 4 June 2003 after a courageous battle with cancer. He was only 53. Nigel moved to New Zealand in 1979 after completing his PhD at the University of East Anglia in 1977. He made an enormous contribution to a range of issues in wildlife management in Australasia, and was at the forefront of contributions in each of the topics he studied. He published over 100 refereed scientific papers, as well as many other significant publications.

Nigel was developing models to assist the evaluation of lethal versus fertility control for control of animal pests (including stoats). The models were of wide application to many species and demonstrated that although lethal control could produce large reductions in pest abundance in the short term, in the long term both methods produced similar results. His work was providing more soundly based assessments on the feasibility of biological control options and of the likely levels of control necessary to achieve given reductions in stoat density.

Nigel will be sadly missed, but he will not be forgotten, and his work will continue to be relevant for many years to come.

Cover: Dog stoat in tussock, Otago Peninsula. *Photo: Department of Conservation collection.*

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Stoat research programme

A stoat control research programme was initiated in July 1999 with an injection of funds from the New Zealand Government of $6.6 million over five years.

The programme aims to find more cost-effective and sustainable approaches to controlling stoats, which are a critical threat to many of our native wildlife.

The stoat research programme is guided by the vision:

'That stoats will no longer be a threat to indigenous biodiversity'

The four key objectives of the programme are:

- To make stoat control more cost-effective where it is already successful
- To develop new techniques so that control can realistically be undertaken in more and larger areas
- To expand the arsenal of methods to ensure that stoat control, and the consequent benefits to biodiversity, are sustainable
- To seed new, longer-term projects that have the potential to dramatically increase the effectiveness of control

A stoat technical advisory group has been established to develop and oversee this research programme. The group is composed of representatives from the Department of Conservation—Elaine Murphy (Programme Manager), Craig Gillies, Darren Peters, Elaine Wright, Harry Keys, Ian Flux, and Fiona McKay; from Michigan University, U.S.A.—Graham Hickling; and from Auckland University—Mick Clout. Funding for the first year was $338,000, which increased to $1.406 million in the second year (2000/01). Funding for the third year and subsequent two years was $1.631 million annually.

This is the fifth report in a series of progress reports on the programme. The first report was an outline of the programme, published in January 2000; the second report covered the first year of operations and appeared in November 2000; the third report in November 2001 and the fourth report in November 2002 covered the second and third years of the programme, respectively.

Overview

The New Zealand Government announced in July 1999 that an extra \$6.6 million over five years would be given to the Department of Conservation (DOC) to fund an integrated stoat control research programme. Stoats were introduced from Britain to New Zealand in the 1880s (along with ferrets and weasels) in an attempt to control rabbits, but were quickly implicated in the decline of native birds. Stoat control in New Zealand will have to be on-going if some endemic species, such as kiwi and kaka, are to survive on the mainland. Currently, stoat control relies largely on labour-intensive trapping—new, more cost-effective, and sustainable approaches to controlling stoats are urgently needed. The extra funding means that there is a real opportunity to make a significant start on finding cost-effective solutions for managing stoats.

The stoat programme in the first year (1999/2000) concentrated on reviewing what was already known about stoats and assessing potential directions for research. The second to fourth years concentrated on finding more effective baits, lures, and traps, as improvement in these areas will bring quick gains in the short term. A highlight in the fourth year was the passing of two user-friendly traps developed by Ian Domigan (Lincoln Ventures) as 'Class A' under the draft National Animal Welfare Advisory Committee guidelines. One of these traps, (the 'Hammer') won in the prototype category in the Straight Furrow Inventors Awards at the New Zealand National Field Days at Mystery Creek—beating 49 other entrants, some of whom were Crown Research Institutes and major companies.

The development of a new, humane, predator toxin heralds a new age in the use of toxins for controlling pest species, and is likely to be of value internationally, as well as in New Zealand.

The work on controlling stoats on islands in Fiordland has also been a real success. Planning is now underway to remove stoats from Secretary Island (8000 ha). I was lucky enough to visit this island earlier this year, but was appalled at the lack of birdlife. Secretary Island has no rodents, and stoats appear to have an even bigger impact on the birdlife there than on the nearby mainland. Ridding the island of stoats will provide a huge conservation benefit.

As well as focusing on improving more traditional methods of control, the programme has funded some longer-term, higher-risk projects, because a variety of methods are likely to be needed if stoat control is to become sustainable in the longer term. Linkages have been made with the Pest Animal Control Cooperative Research Centre in Australia, to take advantage of the experience they have gained in investigating biotech options for pest species. Linkages have also been made with Russian and Finnish scientists, and a project has been funded in Finland to test a new approach for the fertility control of stoats.

Elaine Murphy
Stoat Research Programme Manager
Department of Conservation

1. Year Four of the stoat research programme

Year Four? The first report in this series pre-dated the start of the five-year programme, so the second report actually covered **Year One** of operations, not **Year Two** as it stated. Reports for the following years (third and fourth reports) mistakenly continued to equate the number of the report with the year of the stoat research programme. We apologise for this confusion. (See the last paragraph in the Box on p. 4 of this issue for details of the actual coverage of these reports.)

So, welcome to the fifth report of the stoat control research programme! Since July 1999, when the programme was initiated, a total of 79 projects have been funded. Some of these projects will now be completed in Year Six (2004/05). Forty research projects were funded in the last financial year (2002/03). Of these, 15 were completed and the remainder will be completed over the next 1–2 years. Eight new proposals are so far in the process of being funded for Year Five (2003/04). This annual report provides:

- A brief insight into the findings from research completed in 2002/03
- A progress report on on-going research
- A summary of research initiated this year (2003/04)

1.1 LINKAGES WITH OTHER RESEARCH AGENCIES

The stoat programme has given DOC the opportunity to broaden its relationships with other key agencies, both within New Zealand and internationally. These linkages are vital to ensure best use is made of the knowledge and expertise available, and are likely to have flow-on effects to our other research programmes.

A Memorandum of Understanding (MOU) has been signed with the Pest Animal Control Cooperative Research Centre (PAC CRC) in Australia. This has resulted in invaluable advice being provided to the programme, particularly concerning the potential offered by research into biocontrol techniques. Linkages have also been made with Russian and Finnish reproductive biologists and a project has been funded to test a new approach for the fertility control of stoats—initially using American mink as a surrogate species. One of the scientists involved, Sergei Amstislavsky (Siberian Division of the Russian Acadamy of Sciences), has published extensively on mustelid reproduction and has had experience in successfully breeding captive stoats. A MOU is being prepared between the Russian, Australian, New Zealand, and Finnish parties to establish the wish to conduct joint research projects.

Dr Yulia Ternovskaya at the Ternovskaya farm, Siberia, Russia. *Photo: Sergei Amstislavsky*

The Siberian mustelid embrace! *(Right)* Sergei Amstislavsky at the Ternovskaya farm, Siberia, Russia. *Photo: Vladislav Amstislavsky*

2. Research summaries

2.1 TRAPS

The National Animal Welfare Advisory Committee (NAWAC) has developed draft guidelines for evaluation of kill-traps for humaneness. The draft guideline identifies three classes of traps: Class A (animals rendered irreversibly unconscious within 30 seconds), Class B (animals rendered unconscious within 3 minutes) and prohibited traps (unable to render the animal unconscious within 3 minutes). For kill traps to be acceptable either 10 of 10 or 13 of 15 target animals must be rendered irreversibly unconscious within 3 minutes of capture. If 15 animals are chosen for the test and one or two animals fail to be rendered irreversibly unconscious within 3 minutes, they must still be rendered irreversibly unconscious within 5 minutes. Consciousness is determined by using the blinking reflex, which stops when the animal has lost consciousness. Prototype traps currently being developed will be tested to ensure they meet the NAWAC specifications and, if they do, will then be tested in the field.

The most common kill-trap used for stoats is the Fenn trap, which comes in two sizes—Mk 4 and Mk 6. Recent trials undertaken by Landcare Research have shown that Fenn traps do not meet all the requirements of the draft NAWAC guidelines, so it is important to develop alternatives that do.

2.1.1 Research completed during 2002/03 (Year Four)

The Hammer Class A ferret/stoat/rat trap

The Hammer ferret, stoat and rat trap has been developed as a cost-effective multi-species kill trap by Ian Domigan (Lincoln University and Lincoln Ventures). It has been tested by Landcare Research Ltd and has achieved the highest standard of humane kill (10/10 stoats, 10/10 ferrets and 10/10 rats, all killed in less than 30 seconds). This trap has met the Class A requirements in terms of the draft NAWAC guidelines for humane kill-traps.

An animal's view of a Hammer trap.

The Hammer is different from most traps in that it targets the animal's head, rather than the neck/chest. The trap mechanism is based on two trigger systems. The primary trigger, activated by the animal itself, releases a spring-powered arm. This in turn activates the blank-charge which produces a large amount of gas that drives the captive bolt down onto the animal's head. The result is a very quick and effective kill.

The trap is reset by sliding the top cover back to allow replacement of the blank charge and this action also resets the trigger and impact bar. Once the top cover is put back into the closed position the trap becomes loaded. The trap does not require an additional wooden box as the mechanism is self-contained.

The Hammer was entered into the Straight Furrow Inventors Awards at the New Zealand National Field Days at Mystery Creek, and won in the prototype category—beating 49 other entrants, some of whom were Crown Research Institutes and major companies.

Additional information on this trap can be obtained from NZTRAP@Yahoo.co.nz

The Thumper tunnel stoat/rat trap

Ian Domigan has also developed another kill trap, for stoats and rats—the Thumper. It is easy to use, safe, and requires a very small setting force. This trap has also met Class A requirements in terms of humaneness. The Hammer and Thumper are the only traps so far to achieve this for stoats.

Stewart Dowding setting a Thumper trap.

The Thumper incorporates the following three attributes which were considered to be essential in the design of a successful trap:

- Consistent strike location on the targeted animal
- Low force, yet stable trigger
- Sufficient strike force to kill the animal humanely

The triggering mechanism is stable, and can be easily adjusted to the level required. The materials used in the trap have been tested in terms of durability in the field, with all pivots being made of stainless steel. The trap has no floor (which makes cleaning easy) and is placed directly on the ground. The trap cover can be changed in terms of colour and construction materials to suit particular environmental or climatic conditions. Replacement components can be purchased separately and the entire trap can be stripped in the field using only a pair of pliers.

More information on this trap can be obtained from NZTRAP@Yahoo.co.nz.

Production of an alternative kill trap for stoats

Phil Waddington developed a prototype mustelid kill trap (Waddington Back Cracker) as an alternative to the Fenn trap. Pen trials to test the effectiveness and humaneness of the trap were undertaken by Landcare Research Ltd using the draft NAWAC guidelines. The first seven stoats tested were killed rapidly by a head strike, however the eighth stoat received strikes to the neck and shoulders only and this resulted in the animal remaining conscious well after 3 minutes. Although the trap showed potential, it was decided not to continue with further development at this stage. Phil Waddington subsequently developed a trigger for the new DOC 200 trap.

Trials to test a prototype kill-trap for stoat control

Malcolm Thomas (Pest Control Research Ltd) developed a prototype kill-trap based on a more powerful version of the Victor Professional snapback trap. The Victor design was chosen as a potentially useful trap for stoat control because of its low cost, light weight and portability. Measurements of humaneness were undertaken using the draft NAWAC guidelines. Three striking positions were tested (head, neck and body). Only the head and neck strikes rendered the stoats unconscious within the 3 minutes as required. The results indicated that a more powerful version of the snapback trap could have potential to be a humane and cost-effective method for controlling stoats provided that head and neck strikes were achieved.

Self-resetting mustelid eradicator

Frank Greenall and co-worker Keven Johnston were funded to develop a cost-effective, humane, self-setting/self-clearing mustelid kill-trap. Preliminary testing indicated that the device would be able to deliver approximately 20–25 humane kills before resetting was required. Unfortunately, difficulties with the prototype have led to the suspension of this programme.

Improving stoat trapping efficiency: A pilot study exploring the usefulness of existing data sets

Jenny Christie, along with Ian Westbrooke and Elaine Murphy (DOC), initiated a pilot project exploring data from stoat-trapping operations across New Zealand. The aims of this pilot study were to:

- Establish which stoat trapping operations have data suitable for exploratory statistical analysis
- Explore statistically at least one of the data sets
- Identify ways to improve data collection and storage generally
- Report on the need for and direction of an extended project

The stocktake of data trapping operations and their data recording proved to be a valuable exercise. Of the total 51 stoat trapping operations identified from throughout New Zealand (covering about 100 000 ha in total), at least 13 had data with enough detail for an extended analysis. This included all of the larger-scale operations. Methods of data collection and storage were highly variable with four types of spreadsheet formats identified. Staff doing stoat trapping operations were very interested in information on best practice for data recording, and a new data entry template has been developed for trial.

Analysis of trapping data from the Hurunui Mainland Island indicated that statistical modelling, incorporating spatial techniques, was a useful tool for ascertaining factors that influence trap success. The variable 'month' had the strongest association with trap success—which fits in with the highly seasonal nature of stoat prevalence. Other findings built on previous unsubstantiated presumptions that there was an increased probability of capturing a stoat in a tunnel, if a rat was caught at the same time. Traps that caught a rat were approximately twice as likely to catch a stoat, as those that had not. Traps that had caught a stoat recently were also found to have more chance of capturing another stoat. These findings suggest that double rather than single trap sets might be more effective for stoat control.

Further work extending this study to encompass both data collection and analysis was recommended. Identification of the most effective techniques such as trap placement, trap layout, and timing of trap checks or bait change should improve trapping efficiency and stoat trapability.

Conservation benefits from the use of colour as an attractant for tracking and trapping stoats

Stoats rely partially on visual cues for prey detection; however, the practical impact of these visual cues on the effectiveness of lures and attractants is poorly understood. Billy Hamilton (Ecological Networks Ltd) compared the effects of colour on catch rates. Different coloured trap covers were tested (red, yellow, green, and black) at two sites bordering yellow-eyed penguin colonies in Otago.

Stoats appeared to favour the yellow covered traps compared to the green or black covered traps. There was no evidence for a difference in trap catch between the red coloured trap covers and the other three colours. There appeared to be no difference between the sexes in terms of colour preference although females were caught more often in brighter coloured traps when compared with duller traps.

Note this was a preliminary study only, and further work is needed to verify the results.

2.1.2 On-going research

Evaluating a low-intensity stoat control regime on large inshore islands

Murray Willans, Keri-Anne Edge, and Graeme Elliott (DOC) are conducting a four-year study to assess the likelihood of success of stoat eradication programmes on Resolution and Secretary Islands through pilot study trials on smaller, but similar islands.

The first stage of this project was to eradicate stoats from Anchor Island (1280 ha). Trapping was initiated in July 2001 and 19 stoats were successfully trapped. The traps were next checked in November 2001 and 3 stoats were found caught. No stoats have been captured on Anchor Island since November 2001 which indicates that the intensity of trapping is appropriate. Stoats are unlikely to re-colonise this island, as the islands which they would have used for stepping stones are now all trapped. Anchor Island is now considered to be free of stoats. Tieke (South Island saddleback), mohua (yellowhead), and robins have since been transferred to the island, with other species such as kakapo also being considered for transfer.

The second stage of this project was to eradicate stoats and implement an on-going low-intensity trapping regime on Bauza Island. Bauza Island is approximately 480 ha and lies near the entrance of Doubtful Sound. It is closer to the mainland than Anchor Island and, therefore, provided a better opportunity to test an on-going low-intensity trapping programme as a means of sustained stoat control. Stoat control began on Bauza Island during the winter of 2002. Based on the results from Anchor Island, it is likely that all stoats were removed from the island by November 2002. Six stoats have been caught on Bauza Island since then and it is likely that these stoats have re-invaded from either Secretary Island (a distance of 200 m) or the mainland (a distance of 500 m). This was expected, and is desirable to test the effectiveness of the on-going trapping regime which provides protection to tieke, which were transferred to the island in March 2003.

Eradication of stoats from Anchor Island and eradication and control on Bauza Island have been very successful, and planning is underway to use this technology on Secretary Island (8000 ha) in Fiordland.

This project will be completed by June 2005.

Comparison of three stoat trapping set designs

Rhys Burns (DOC) compared three different stoat trapping 'sets'. Trapping sets are used to direct stoats over the trap, and to reduce the by-catch of non-target species. A direct comparison of the sets will determine relative preference by stoats.

Of the three trap sets tested, two were conventional (wooden tunnels and wire cage tunnels covered in clear plastic) and one was more unconventional (buried corflute tunnels). The field testing was carried out in northern Te Urewera National Park, in areas where the highest number of stoats was trapped during

2001/02. The trap sets were grouped within a 5 m radius in 150 different groups at 150 m intervals along ridges, streams and spurs. All sets used Fenn traps (Mark IV) with a white hen egg as a lure. The lures were replaced four-weekly.

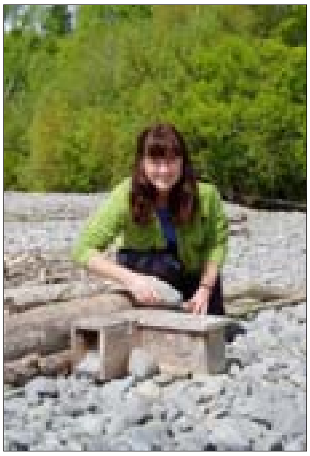
A total of 38 stoats were caught from November to March at these sites. Of these, 21 (55%) were caught in the wire tunnels, 9 (24%) in wooden tunnels and 8 (21%) in buried tunnels. From a preliminary analysis, the capture rate by the wire tunnels was significantly higher than expected at the 5% level (Chi-squared test), but a more detailed analysis is on-going.

This project will be completed by February 2004.

2.1.3 New research funded for 2003/04 (Year Five)

Field testing three new stoat traps in different habitats

Elaine Murphy, Ian Westbrooke, and Fraser Maddigan (DOC) will co-ordinate trials of the three new stoat traps that have passed the draft NAWAC guidelines. The trials will take place at 11 sites around the country. Trap catch data will be compared and trap performance, durability, functionality and acceptability will also be measured to give us confidence the traps are satisfactory under a broad range of requirements.



Elaine Murphy sets a stoat trap in the Waimakariri River bed.

This project will be completed in June 2005.

Improving stoat trapping efficiency: Can we learn more from trapping data?

Jenny Christie (DOC) is analysing stoat trap catch data from a selection of large-scale mainland trapping operations to describe conditions which maximise stoat capture rates. This project builds on the completed pilot study (see 2.1.1).

Stoat trap catch data from mainland trapping operations will be analysed to determine conditions which maximise capture rates. Regression models will be used to correlate trapping success with environmental, ecological and equipment predictors. Standardised data collection will enhance the ability to use data for meaningful comparisons, such as between sites or over time. A spreadsheet has been developed to record predator trapping information. This spreadsheet is currently under trial, and has been disseminated to DOC operational staff for testing.

The results of this project have potential to improve trap success, and have wide application for managing both new and existing stoat trapping operations.

This project will be completed in December 2004.

Kiwi chick survival in relation to stoat trap density and pattern

Derek Brown and Jenny Christie (DOC) are going to explore whether there is a relationship between trap layout (density and pattern) and survival of individuals from a protected population. An ecological model created using spatial and statistical tools will be used to investigate this question. This type of model could be applied to a number of species, such as kiwi, kaka or takahe. A pilot analysis on kiwi at one of the Kiwi Sanctuaries will be undertaken. This will involve creating a spatial-statistical model looking at chick location/survival rate, modelled against variables such as trap density, time of year, 3D distance to trapping area boundary, and density patterns of rat and stoat capture.

Potential outcomes from this model include:

- Identifying appropriate trap layout, pattern and density
- Mapping the survival probability of a protected species across a trapped area
- Identifying high-risk predation areas

This project will be completed in June 2004.

2.2 BAITS, LURES, AND TOXINS

2.2.1 Research completed during 2002/03 (Year Four)

Prey odours as lures for stoats

Andrea Byrom and co-workers Eric Spurr and Cheryl O'Connor (Landcare Research) have developed long-life lures, based on natural prey odours, which have been encapsulated into slow-release matrices.

Prey odours or the combination of odours from natural prey were tested on captive stoats. Two separate methods for extracting rodent odours were tested. The first method encapsulated ground-up, freeze-dried laboratory rats within a PVC matrix. The second method involved using gas chromatography and mass spectroscopy for the identification of volatile chemical compounds produced by live ship rats. Four promising volatile chemical compounds were then incorporated into a PVC matrix.

Pelletised PVC lures. *Photo: Andrea Byrom*

The chemical rat and freeze-dried rat lures incorporated into PVC matrices were compared against fresh dead rat in terms of attractiveness to 18 captive stoats. The results showed that the freeze-dried rat lure was significantly more attractive than either the chemical rat lure or fresh dead rat. The chemical rat lure was at least as attractive as fresh dead rat for most of the stoat behaviours observed, indicating that this lure may also have promise as a lure for attracting wild stoats to devices in the field.

Further work is needed to fine tune the lures to get the right combination of longevity and attractiveness. Field trials also need to be undertaken.

MNT toxicity to stoats and risk assessment for non-target species

Currently no toxic baits are registered for stoat control. Although 1080 in hen eggs has been used previously to control stoats, its use is controversial due to its lack of target specificity. Any new toxin registered for stoat control would need to demonstrate efficacy, humaneness, and target specificity if it is to achieve public acceptability.

In conjunction with the Victorian Department of Natural Resources and Environment (Australia), DOC and Landcare Research are developing a promising toxic compound to which mammalian predator species may be highly susceptible. Designated 'Mustelid New Toxin' MNT for confidentiality, it is being tested for effectiveness in mustelid control.

Penny Fisher and Cheryl O'Connor (Landcare Research) evaluated this new toxin in terms of its potential for stoat control. Laboratory trials indicated that this product is highly toxic to stoats when delivered by oral gavage. However, results from Australia indicated a potential technical problem with the delivery of this toxin in a bait, and some formulation issues need to be overcome.

The toxicity information indicates that should this toxin be used on stoats, then the non-target species most at risk will be dogs and cats.

2.2.2 On-going research

Testing the attractiveness, palatability and longevity of novel stoat lure and bait formulations

The aim of this research is to search for new, highly attractive, long-life lure and bait formulations. Kay Clapperton and co-workers Lloyd Robbins, Tony Woolhouse, and Dick Porter are comparing different food lures (e.g. rabbit, rat, and sparrow) and novel odours in a range of possible bait matrices for their attractiveness, palatability, chewability, and longevity in terms of attracting stoats. These could be used as long-life attractants to lure stoats to a trap, or entice stoats to eat poisoned bait or bait containing a vector for biological control.

In terms of attractiveness, a low-level response was observed when the odour of cracked egg was offered. The next trials confirmed the attractiveness of rabbit, rat, mouse and sparrow to stoats. Whole animals were offered so that all sources of possible odour were present. Further trials indicated that rabbit flesh and gut were more attractive than skin. Tests using dried pet food indicated that this material held no attraction for stoats. Further bait trials used rabbit and mouse as the active ingredient as these are the most readily available. The success of sparrow should be kept in mind though, especially when targeting possible 'rogue' animals tuned into the scent of birds.

A series of trials tested the attractiveness of highly processed forms of prey and single chemical prey odours. Of all the items tested, spiralina and male anal sac secretion showed the greatest potential as stoat attractants, but even those elicited only low levels of response.

Attractiveness and palatability trials using formulations of rabbit and mouse were conducted on captive stoats in 2002/03. Freeze-drying and salting the bait marginally reduced rabbit meat attractiveness. But salted rabbit was preferred over more highly processed baits. This was consistent with the previous trials which indicated that highly processed commercial products are not attractive to stoats. The stoats also initiated early attacks on salted rabbit in the palatability trial which confirmed its attractiveness. The low bait consumption score suggests that salted rabbit would not be a useful poison bait, but its high score on time spent chewing suggests a possible role as a bio-control delivery system as well as a trap lure.

Wax/tallow and gelatine/bran/wax rabbit baits were investigated and both were chewed and eaten. Freeze-dried rabbit was investigated and chewed, but was less palatable than the wax/tallow formulation.

The softer of two dairy-product matrices produced by Fonterra and containing rabbit meat as the active ingredient also showed considerable promise as a long-life, chewable bait, but there are difficulties with supply of this product. Polymer baits were tested for palatability, but were not promising.

While freeze-dried mice have been used in the field as trap lures, in terms of palatability it was observed that stoats were deterred from eating them after the first mouthful. Emphasis was placed on finding softer formulations to make them more palatable. Soaking the freeze-dried mice in a softening agent such as fat or oil resulted in the stoats licking off the coating. However, injecting the freeze-dried mice with a softening agent made them more palatable and further trials are underway to test gelatine-injected mice against rabbit baits and egg.

Foam baits have been used on other species as covers for virus capsules. The captive stoats chewed the coatings off the outside of foam baits but seldom chewed hard on the foam itself even if it was soaked in palatable rabbit/oil/egg mixtures. The stoats did chew the baits for extended periods, but it was unclear if this amount of nibbling would have broken a virus or immuno-contraceptive capsule.

The most promising lure and bait formulations identified above (salted rabbit, wax/tallow/rabbit, gelatine-injected freeze-dried mice) will be aged to simulate field conditions, and the bait longevity assessed.

This project has been extended to be completed by November 2003.

Developing a multi-sensory bait/lure system for controlling stoats

Kay Clapperton with co-workers Lloyd Robbins and Dick Porter are investigating the development of a multi-sensory stoat bait/lure system to attract bait-shy or trap-shy animals. This is an extension of their research investigation into novel bait and lure combinations. Preliminary trials indicated that visual characteristics such as shape, sound, or movement may be important determinates of bait attractiveness. These stimuli, once determined, could be added to stoat lure/bait formulations to improve their attractiveness and/or palatability and acceptance. Bait consumption and video recordings were used to assess the effectiveness of each lure or combination of lures. The olfactory stimuli were limited to rabbit and mice only and tested with a range of visual cues such as shape and colour along with sound and movement.

Preliminary trials indicated that the stoats were attracted to the mouse-shaped baits with confectionary eyes, however this was not repeated in a subsequent shape trial where the stoats failed to discriminate between simple mouse-shaped (including stylized eyes, ears, and tail) and roughly circular shapes offered. In this trial the stoats tended to eat more of the nondescript blobs over the mouse shapes, possibly because they have been conditioned in captivity to eating a ‘blob’ of food. The lack of discrimination in initial investigation of the baits suggests that the stoats are not showing a neophobic response to the mouse-shaped baits and that it is more likely that prey discrimination is based on more subtle cues.

There was also a lack of discrimination between novel coatings on baits and uncoated baits, and this may suggest that fur is not an essential component of prey recognition. Preference for freeze-dried rabbit coating over fur suggests that the olfactory cue was more important than just visual appearance. This was supported by the lack of deterrence by the green spirulina.

A moving bait proved promising as an attractant, however it needs to be developed further to attract the stoat from a distance. The movement of the bait did not induce an attack or biting response, suggesting that its value may be more in terms of a lure rather than an edible bait.

Observations to date on how stoats eat the baits may have implications for the design of baits. Further tests on the shape of baits, e.g. baits with narrow ends simulating a head/neck area are planned in order to determine which features stoats use to orientate for the kill bite. This will include looking at the importance of eyes and other facial features.

The small nibbling style of eating shown by stoats also has management implications in terms of maximising the effect of the bait. Soft paste type baits are likely to be suitable as carriers of toxins, micro-encapsulated poisons or viral-transmitting capsules.

This project will be completed by June 2004.

Toxic micro tabs and a bait for stoats

Jeremy Kerr (Feral R&D Ltd) has developed micro-sized toxic tablet formulations (tabs). Trials have been undertaken on stoats with tabs containing lethal doses of 1080 (Lloyd Robbins) and on ferrets with Zinc Phosphide (Kay Clapperton).

It is envisaged that toxic tabs would be delivered in a feeder on the ground. The micro tabs will be coated with palatable material and presented to the stoat in a bait matrix that will ensure the micro tabs are swallowed, thereby delivering a lethal dose of toxin to the stoat in one micro tab. This will minimise the chance of the stoat consuming a sub-lethal dose.

Three synthetic lures were obtained from a fragrance manufacturer in France: rabbit meat, rat musk, and rabbit aroma. These lures were refined and synthesised from New Zealand samples that were shipped frozen to France. Lloyd Robbins and Kay Clapperton undertook the lure trials with captive stoats. The rabbit meat lure clearly outperformed the other two lures and was also preferred against the control bait. As a stoat lure, this material clearly has potential to either enhance existing edible baits or form part of a matrix for a lure to attract stoats onto traps. Further work is needed to choose an optimum feed-base material for a bait incorporating the lure.

This project has been extended to be completed by November 2003.

Development of a long-life toxic bait for stoat control

Ray Henderson (Pest Tech. Ltd) and co-workers Chris Frampton and James Ross are building on their previous work which looked at the development of a long-life toxic bait for stoats. A prototype stoat bait has been developed which was eaten in moderate amounts by captive stoats. However the ‘hardness’ of the bait was thought to be a factor that limited the amounts eaten. The focus of this research is to look at how the palatability of the bait can be improved.

Results to date have indicated that the inclusion of animal extracts (referred to as 'digests') improved the palatability of bait more than including amino acids in bait. Of the amino acids tested, only alanine, phenylalanine, and arginine slightly improved the palatability. Monosodium glutamate (a salt routinely added to pet foods) was found to have no effect on how palatable baits were to stoats.

Throughout the study, extruded baits have not been as palatable to stoats as bait formed on an orbital pelleter. It is believed the key difference between baits formed using the different manufacturing technologies has been the 'hardness' of bait. The hardness of extruded baits can be reduced by adding substances that remain fluid at normal extrusion temperatures. As yet not all stoats will readily eat prototype baits. Therefore, further trials are planned, using new bait formulations and different means for increasing bait palatability.

This project has been extended to be completed by December 2003.

Pen trials of small-volume toxic baits for stoats

Carolyn (Kim) King (Bioengineering, HortResearch, Ruakura) along with Murray Potter and Paul Barrett (Massey University) are investigating the reactions of captive stoats to lethal doses of 1080 presented in small (1 g) baits of two different formulations. Previous trials have confirmed that stoats will consume a lethal dose of 1080, diphacinone and cholecalciferol when presented in hen eggs, but the toxin is much less concentrated in an egg than it is in a 1 g bait.

The first bait used was one which was known to be acceptable in a non-toxic form, the second has not been tried before, but there was no difference between them in acceptance rates. So far 12 of the 14 stoats offered the baits have taken them and died within 4 hours (average 2.5 hours) of eating the bait.

This study will be completed by December 2003.

Control of stoat dens after location by trained predator dogs at Trounson Kauri Park

Scott Theobald, supported by Natasha Coad and Craig Gillies (DOC), demonstrated that trained predator dogs can have a useful role in locating natal stoat dens, which can then be controlled. The use of trained predator dogs provides another method for actively searching out and controlling stoats. This method is proactive and targets the females who can be harder to trap, or those known individuals which may be avoiding traps and/or toxins.

Control of the dens once they were found, however, was not so straight-forward. Both the pilot study and the 2002 season indicated that the main cause of den control failure was the fact that not all entrances could be located and blocked. Of the 10 dens that were attempted to be controlled this season, 7 were unsuccessful because of concealed entrances. Magtoxin is only effective in a sealed area and thus has limited application for den control. Other possible control methods such as carbon monoxide fumigation of dens is currently being trialled in Australia and this is being investigated as an option to use here.

Stoat kits 2 weeks old in their den. *Photo: John Dowding*

Young stoats (about one month old) were also located by using a dog after a sighting in a bracken patch—four were controlled and a


Stoat kit 2 weeks old. *Photo: John Dowding*

further two were trapped the following day. Over the last two seasons, the use of dogs has resulted in the removal of at least 27 stoats, including two adult females known to have killed kiwi chicks.

Once effective den-control techniques are available, the use of trained dogs in this manner will have important value at on-going managed sites, sensitive species sites, offshore islands, predator exclosure sites, and also for contingency work.

This project is to be completed by June 2004.

2.2.3 New research funded for 2003/04 (Year Five)

Trials of fresh and freeze-dried rabbit against hen eggs as stoat bait in a Northern forest environment

Stoat numbers have traditionally been controlled using Fenn traps set in tunnels baited with hen eggs, however in Northland, some evidence suggests that fresh rabbit is more attractive than eggs. Fresh rabbit however, has the disadvantage of quickly decaying, especially in damp sites, requiring more frequent replacement than eggs. This increases labour costs and limits the number of traps able to be serviced by an operator. However, this increased cost may be justified if fresh rabbit performs significantly better than other baits.

Nigel Miller (DOC) will trial the relative attractiveness of fresh rabbit replaced twice weekly at Mimiwhangata against fresh eggs. This will identify the most attractive bait irrespective of the cost associated with its maintenance. At Whananaki, freeze-dried rabbit will be compared with fresh eggs, both replaced fortnightly, while traps are checked weekly. State of decay will be recorded for all captured mustelids at Whananaki, so that relative changes of attractiveness between baits over the fortnightly period can be assessed.

This project is to be completed by June 2005.

Paired trial of salted rabbit versus egg as stoat baits in a Northern forest environment

Steve Allan, with support from Clea Gardiner (DOC), will trial the relative attractiveness of salted rabbit replaced fortnightly against fresh hen eggs. Salted rabbit appears to be working as an effective long-life bait in the Whangarei Kiwi Sanctuary and this trial will measure its performance against the more standard bait (hen eggs).

Salted rabbit has the advantage over fresh-meat baits of being an inexpensive long-life bait which appears to be attractive for at least 2 weeks. This decreases labour costs and increases the number of traps able to be serviced by an operator, so may allow the expansion of the managed area.

This project is to be completed by June 2005.

PTF (Predator Toxin Formulation) bait development

Jeremy Kerr (Feral R&D Ltd), with collaborators Andy Lavrent and Lloyd Robbins, aim to produce an effective humane method of poisoning mustelids and feral cats, providing a valuable tool to help achieve conservation objectives.

This work builds on the 'Toxic micro tabs and a bait for stoats' project (see 2.2.2 On-going research), but will focus on refining the formulation of the new toxin for delivery.

This study will be completed by June 2004.

Registration of 'Stoat-B-Gone'

Phil Ross (Golder Associates (NZ) Ltd) is collating the information required to register the new vertebrate pesticide compound above (PTF) for use in New Zealand. The collected information will be used to classify the compound to determine the subsequent registration requirements of ERMA (HSNO).

The specific tasks to be conducted include:

- A literature search to determine the hazardous properties (as defined under the HSNO Act) of the compound
- To classify the hazardous properties of the compound according to the ERMA classification system
- Listing the standard controls that will be placed on the compound by ERMA
- Determining what studies would be needed to fill the gaps, and the possible cost of doing the study

This study will be completed by June 2004.

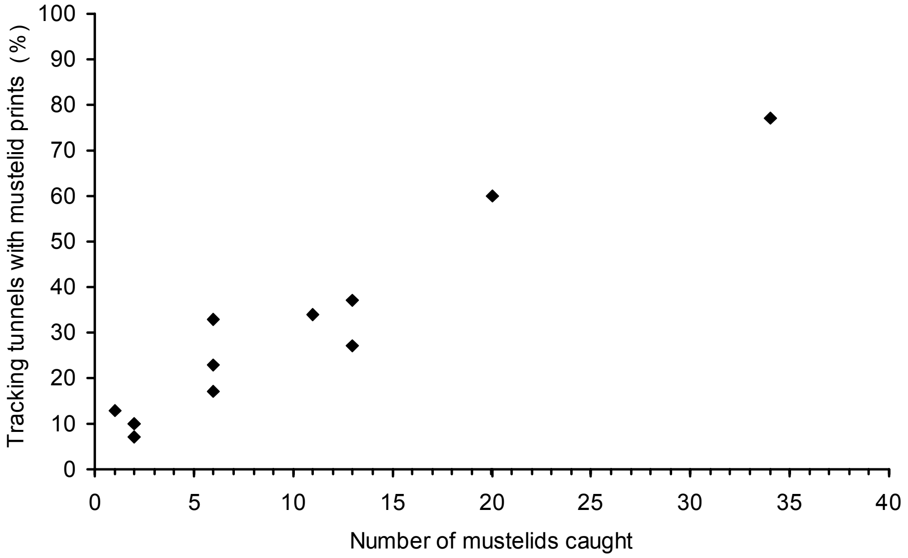
2.3 ECOLOGY

2.3.1 Research completed during 2002/03 (Year Four)

Evaluating the use of tracking tunnels to monitor mustelids as well rodents

Ink footprint tracking tunnels are now commonly used at many mainland conservation sites to monitor the effects of pest control operations on rodent activity and abundance. Craig Gillies and Peter Dilks (DOC) investigated whether or not it was possible to make changes to the existing rodent tracking tunnel protocol used by DOC staff that would allow the same tunnels to also be used to provide an index of relative abundance of mustelids. Several DOC managers from different sites—Boundary Stream, Whirinaki and the Dart, Caples, and Eglinton Valleys—helped with the assessment. The results from that work indicated that the technique could prove to be a useful stoat management indicator for some control operations and also provide a coarse index of mustelid relative abundance. A revised protocol for DOC staff has been put together and an electronic link to this protocol has been posted on the DOC Intranet best practice pest control page.

To calibrate the mustelid tracking tunnel index, tracking rates were compared against the numbers of mustelids caught in live traps at four sites: North branch of the Hurunui, Hollyford Valley, Craigieburn, and Waimanoa. At each site 6 tracking tunnel lines were used, each consisting of 5 tunnels, spaced 100 m apart, baited with fresh rabbit meat and opened for 3 nights. Live trapping was carried out over 9 or 10 days using 35 or 36 live traps, spaced at 200 m intervals along a line or circuit running through the same area as the tracking tunnels.



The percentage of tracking tunnels containing mustelid prints, plotted against the number of mustelids caught in live traps set, for nine days either immediately before or immediately after the tracking surveys.

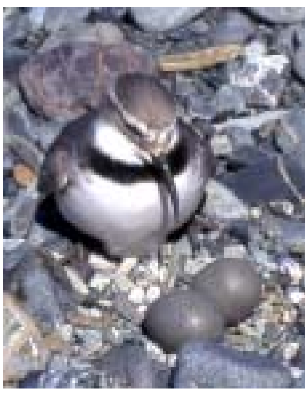
The tracking data were compared with the corresponding live trapping data for each survey.

There was a strong positive correlation between the proportion of tracking tunnel lines with tunnels containing mustelid prints and the number of stoats caught (not counting recaptures) in the live traps over nine days (Spearman's $r = 0.843$, $p = 0.001$). The percentage of all tunnels in the survey that contained mustelid prints correlated even more strongly with the number of stoats live trapped (Spearman's $r = 0.908$, $p < 0.0001$). The results indicate that tracking tunnels can be used as a coarse index of mustelid abundance.

Ecology of stoats in a South Island braided river valley

John Dowding (DM Consultants) and co-worker Mike Elliott undertook a two-year radio-telemetry study of the ecology of stoats in the Tasman River valley, Mackenzie Basin. Elaine Murphy and Fraser Maddigan (DOC) helped with the diet and den analysis. South Island braided rivers provide important breeding habitat for a number of threatened endemic ground-nesting birds such as black stilt, wrybill, and black-fronted tern. These birds are present in large numbers in spring and mostly absent in autumn. While the ecology of stoats is well-documented for forested and coastal areas, less is known of these braided river systems.

A wrybill at its nest, Tasman River. *Photo: John Dowding*



Live-capture and radio-tracking of stoats in and around the Tasman River was undertaken to gain information on stoat home range size, activity patterns, and habitat preferences. The home ranges of male stoats were found to be significantly larger than those of females, with wide variation in home range size recorded. One male had a very large range in spring (estimated at 810 ha and 7.1 km in length). Home ranges of stoats were found to overlap, with more stoats overlapping in spring than in autumn.

Contents of a stoat den, Tasman River. Whole spur-wing plover (left), banded dotterel wings and eggs (centre and top), two wrybills, both colour banded (bottom). *Photo: John Dowding*

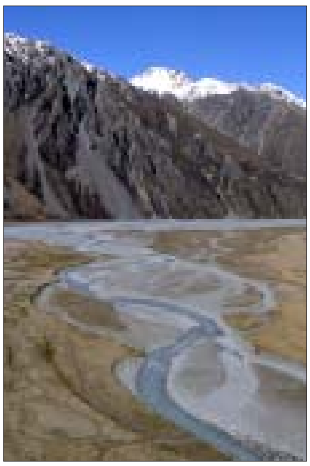
Stoat, ferret, and rabbit indices all showed a consistent annual pattern with numbers peaking in late summer–autumn and numbers declining through winter and then increasing in spring (rabbits) or summer (mustelids) following breeding. House mice were the only rodent present and were at very low densities throughout the study. No rats were recorded at all in the study area. Banded dotterels were the most common shorebird nesting in the valley, followed by spur-winged plovers and wrybills.

Sequential den use by different stoats was recorded during this study on a number of occasions. Sequential den use by stoats and ferrets was also recorded. These findings may have implications for the transfer of disease or biocontrol agents within and between mustelid species.

Analysis of scats showed that stoats in this system mainly ate lagomorphs (mostly rabbits), birds, and invertebrates. Other minor components of the diet included mice, lizards, fish, and hedgehog. The remains found in den contents tended to be larger items such as rabbits and birds. Twenty-four species (13 native and 11 introduced) of birds were identified in den contents or scats. The most common bird identified in den contents was the banded dotterel. The presence of wrybill remains in 8% of all stoat dens suggests that stoats are having a significant local impact on the wrybill population in this system. The remains of 24 adult wrybills found in dens constitute roughly 20–24% of the wrybill population in this river. The presence of black-fronted tern remains in 10 stoat dens, with a minimum of 25 adults counted, suggests that where stoats are at the densities encountered in this study, they must be considered a serious threat to black-fronted terns as well.

Mortality of stoats was higher in autumn 2002 than in previous seasons and trapping indices were much lower than usual in spring 2002, suggesting that stoat numbers in the study area were declining. The reasons for this decline are not clear, but may signal natural long-term changes in stoat density in this habitat. Further investigation is needed to inform effective and proactive conservation management for this area. In the Mackenzie Basin, stoats appear to be common only in the Tasman and Godley River valleys, which are both high-altitude rivers close to the main divide. Stoats have the ability to disperse over large distances and it is possible that the forests west of the main divide provide a reservoir of stoats for repopulating the upper braided rivers of the Mackenzie Basin.

The Hooker River, Tasman Valley. *Photo: John Dowding*



Dispersal of juvenile stoats in the Mackenzie Basin

John Dowding (DM Consultants) and co-worker Mike Elliott initiated a project investigating the dispersal of juvenile stoats in the Mackenzie Basin. The study area was chosen because it was well-known from a previous study (outlined above) and stoat densities were known to be relatively high.

Very little is known about the distances young stoats disperse and the timing of dispersal, partly because studying dispersal in stoats is difficult. The aim of this study was to trap and radio-collar females, follow them through pregnancy and mark the kits in the dens before they became independent. However stoat mortality was high in autumn of 2002 and stoat density in the valley declined. Few female stoats were collared in spring 2002 and mortality of those that were collared was high. As a result the dispersal aspect of this project was abandoned for the 2002/03 season. Tracking tunnel indices were continued however, so that if stoat numbers recovered in autumn 2003 (through local productivity, immigration or both), the dispersal study could be carried out in the 2003/04 season. However, stoat densities in the Tasman valley continued to decline during 2003, which resulted in the termination of the dispersal study.

Reasons for the decline of stoats in this area are not known, although it does appear to be specific to stoats. Annual peak rabbit densities have been the same for the past three years and ferret densities, while more variable, have clearly not declined in the same way. The decline in stoat densities over the last three years may indicate the existence of a cycle of stoat numbers in this system, although it is not clear what is causing this cycle. Factors from outside the valley may play a part.

Dispersal and survival of juvenile stoats in a South Island beech forest

Andrea Byrom (Landcare Research) initiated a project to investigate dispersal and survival of juvenile stoats in South Island mountain beech forest at Craigieburn. Reinvasion of stoats (primarily juveniles) into stoat control areas is a major problem for conservation managers. While young stoats are thought to be particularly mobile, dispersal and survival patterns of young stoats remains largely unquantified.

Andrea Byrom setting a stoat trap at Craigieburn. *Photo: Caroline Thomson*

This research was initiated in August 2002 in the mountain beech forest of Craigieburn (inland Canterbury) which seeded heavily early in that year. Stoats were expected to respond indirectly to this seedfall during spring/summer 2002/03 as a result of the predicted increase in rodent numbers in winter/spring of 2002. The aim of this project was to compare dispersal and survival patterns of juvenile stoats in a heavy seedfall year (2002/03) with a year of predicted low seedfall (2003/04).

Two approaches were used to find juvenile stoats for this study. Firstly, adult females were trapped in late winter 2002 with the aim of radio collaring them to find their nests and young in spring and subsequently radio-collar the juveniles. Secondly, juvenile stoats were targeted directly by trapping in late spring of 2002.

A total of only six individual stoats (2 females and 4 males) were trapped, of which one adult female was recaptured at Craigieburn between August and December 2002. The stoats were captured close to where stoat footprints were observed in tracking tunnels which suggested that all the stoats present were caught.

Thus despite mountain beech seeding moderately at Craigieburn in autumn of 2002, and the corresponding increase in mouse numbers, stoat numbers did not increase as expected in spring 2002. Only one adult female and two juvenile stoats (one of each sex) were radio-collared. This study was terminated in January 2003 because of the low numbers of stoats.

2.3.2 On-going research

Effects on ship rat and stoat abundance of reducing possum densities

Peter Sweetapple and Graham Nugent (Landcare Research) are looking at the effects of possum control on ship rat and stoat abundance. Aerial use of 1080 typically kills greater than 80% of both the possum and ship rat population and an unknown proportion of stoats. Possums in large control areas typically recover from a 90% reduction within a decade, while rats can recover from any direct effects of poisoning within a year. However, there is some anecdotal evidence that decreased possum numbers allow rats and perhaps stoats to reach much higher densities than before the 1080 control. This increase may be the result of a reduction in competition from possums for fruit and seeds.

This study will try to determine whether rats and stoats do increase as a consequence of reduced possum density, and if so, how long the effect lasts. Two study sites were selected: Minginui and Mokau—each contains a treatment and non-treatment area.

At the Minginui study area, pre-possum control indices of possum, rat, and stoat abundance were found to be similar in both the treatment (Okahu) and non-treatment (Whirinaki) blocks, with possum densities high and rat and stoat densities low. Ground control of possums at the Okahu Valley (treatment site) was initiated in August 2001 and completed in February 2002.

It has now been two years since possum control was carried out in the Okahu Valley (treatment site) and possum trap-catch rates have remained low. At the non-treatment site possum trap-catch rates have also declined during the last year. Rat tracking rates were similar in both blocks before and immediately after possum control and have increased in both blocks since possums were controlled in 2001. However, rat tracking rates increased faster in the possum control block (treatment site), and by April 2003 were significantly higher than in the non-treatment block. Poisson transforming tracking data to convert this index to a linear index of abundance indicates that in April 2003 rats were 2.5 times more numerous in the possum control block (treatment site) than the non-treatment block. There appears to be no correlation to date, between rat and stoat tracking rates, in either block.

The results to date from Minginui, support (but do not prove) the hypothesis that rat densities increase when competition from possums is reduced. However, they do not provide evidence that stoat abundance is linked to the abundance of rats in these podocarp-hardwood forests. Work at the Okahu site will be completed by June 2004.

The second study area (Mokau) was established in February 2002 with funding from FRST. Aerial possum control (1080) was undertaken during the winter of 2002 and monitoring post control animal abundance trends will continue until June 2005.

Modelling the immigration rate of an island stoat population

Murray Willans, Keri-Anne Edge, and Graeme Elliott (DOC) are undertaking a four-year study looking at the re-invasion rate of stoats to islands in Fiordland.

All the islands included in this study are within stoat swimming distance but are unlikely to support resident stoat populations.

The information obtained from this study will be used to construct a predictive model to show the relationship between invasion rates and topographical and population parameters. This predictive model would then be used to implement control regimes based on an estimate of the invasion rates and persistence times for specific islands being considered for the conservation of endangered species.

The m.v. *Renown* in Fiordland waters. *Photo: Bob Walker*

Twenty-eight islands in Doubtful, Breaksea, and Dusky Sound, and Lakes Te Anau and Manapouri have been selected for this study. The islands range in size from 2 ha to 200 ha and also range in distance from the shore, but all are within the known swimming range of stoats. A trapping regime has been set up on all the islands. The traps are serviced twice a year (May and December) and baited with hen eggs. The first servicing took place in December 2000.

To date this study has continued to build evidence that islands closer to the mainland are visited more regularly by stoats. Data will continue to be collected and at the end of the study will be used to develop a predictive model

This study will be completed by June 2004.

Modelling the dynamics and control of stoats

This project was being undertaken by Nigel Barlow (AgResearch), but will now be completed by Mandy Barron after Nigel's tragically early death.

Results to date indicate that, in the short term, culling is more effective than fertility control, but the difference is less for stoats than for other key pests. This is partly because of their high rate of increase, particularly in beech forests. In the long term, culling and fertility control have been shown to be equally effective, with fertility control being more effective in beech than in non-beech forests. This makes stoats a potentially good target for vectored immuno-contraception, other things being equal, since it offers a way of achieving the necessary proportion of sterile animals.

The results of this modelling study will provide more soundly based assessments of the feasibility of biological control options, and of the likely levels of control necessary to achieve the given reductions in stoat density.

This study will be completed by June 2004.

Kiwi Sanctuaries: Ecological consequences of mustelid control to benefit kiwi

Ian Flux (DOC) is leading a project which will monitor the abundance, and look for interactions, between rodents and mustelids at the five kiwi sanctuaries. The nesting success of birds such as fantail (which are primarily threatened by predation, and possibly competition with, rats and possums) is also being monitored. This will provide information on some of the wider ecosystem effects of the current management of kiwi sanctuaries, and go some way to answering the question: What happens to other pest and prey populations when one pest guild is intensively managed?

Rodent and mustelid monitoring lines have been established and quarterly tracking sessions run. Site treatments, as well as site geographic situations and vegetation, vary widely and it is, therefore, not surprising that mammal monitoring produced widely divergent results. A consistent pattern of elevated ship rat indexes in areas with stoat control, compared to non-treatment sites, has emerged. It will be important to maintain monitoring over 1–2 further seasons to see whether this effect is maintained over time. Data on general bird abundance was also collected at each site, as a long-term indicator of change; 153 fantail nesting attempts (together with an assortment of nests from other species) were monitored to assess breeding success or cause of failure. Success of breeding attempts ranged from 39% at Bream Head to 69% at Okarito and was not correlated to November rat indexes.

This project will be completed by June 2004 and is co-funded with the kiwi sanctuary initiative.

The relationship between stoat and rodent relative abundance in North and South Island forests

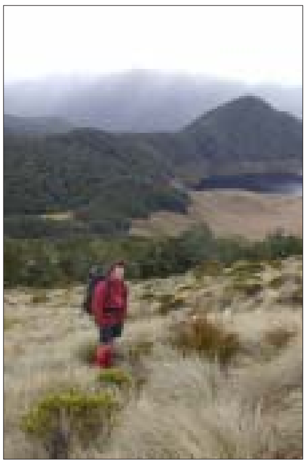
Craig Gillies with co-workers Elaine Murphy, Peter Dilks, and Fraser Maddigan (DOC) have established, or assisted DOC staff to establish, a network of permanent standardised tracking tunnel lines at a range of sites throughout New Zealand. This is to help determine the relationship between stoat and rodent indices of abundance, and complements the work being undertaken by Ian Flux in the kiwi protection zones (see above). As part of this study, tracking tunnel indices of rodent abundance are also being compared with standardised snap trapping indices at a number of the study sites.

To date, surveys of stoat and rodent relative abundance using standardised tracking tunnel protocols have been undertaken at 30 sites during November 2002, February 2003, and May 2003. Six snap trapping and tracking tunnel survey comparisons have also been carried out, and indications are that the two indices of abundance behave similarly.

This project will be completed by 2004 and links in with the Ian Flux study above.

Movement and abundance of stoat in an alpine grassland/ beech forest habitat: Inter-annual variations and the impact of control

Des Smith (University of Otago) near the Borland Saddle, November 2002. *Photo: Deb Wilson*



Des Smith (a PhD student, Department of Zoology, Otago University) is building on his previous MSc research which has shown that stoats are resident in alpine grasslands during the summer months and that stoats in the valley floor and alpine habitats may be insular in their relationship to each other. Stoat populations are resource-dependent. Alpine grasslands (*Chionochloa* spp.) show a strong annual variation in flowering, with seed production being exceptionally high in some years relative to others. However, it is unknown whether there is a relationship between stoats and *Chionochloa* flowering in alpine habitats, as there is with beech masting in forest habitats.

This research will:

- Establish whether there is a change in stoat abundance and dispersal as a result of an increase in food resources associated with the *Chionochloa* mast
- Determine whether stoats inhabiting alpine grasslands act as a source for re-invasion into beech forest, and whether the opposite occurs

Des Smith with a stoat captured at 1335 m a.s.l., note the flowering *Chionochloa* in the foreground. *Photo: Scott Davidson*

- Determine at what stage in the *Chionochloa*/*Nothofagus* seed-fall cycle a population of nesting birds, inhabiting alpine grasslands, is most at risk from predation by a stoat population

The Borland Valley (south-eastern Fiordland) is the study area for this work. This area is a long-term *Chionochloa* monitoring site and is typical of much of eastern Fiordland and other parts of the Southern Alps.

The first field season of this work commenced in January 2003. Four live trap lines (two in beech forest and two in alpine grasslands) were set up. Two five-day trapping sessions (January and March) yielded 15 stoats from the beech forest and 9 from the alpine grasslands. All stoats (except 2 that died) were ear-tagged and released and 5 stoats caught from the alpine grasslands were radio-collared. However, home-range data from only one stoat was obtained because of a technology failure of the collars. Landcare Research recorded a moderate *Chionochloa* flowering for the Borland area and beech seed-fall trays put out in the area indicate that beech seed-fall has been insignificant.

This project will be completed by September 2005.

Inter-annual variation in pest densities in alpine grassland and strategies for limiting pest effects

Deb Wilson (Landcare Research) will look at the inter-annual variation in pest densities in relation to the production of seed in periodic masts (responding to high temperatures in the previous summer) by alpine tussock grasses (*Chionochloa* spp.). As in forests where rodents increase in numbers in response to masting, mammalian pests may respond numerically to these seeding events also, by breeding at enhanced rates. Mice and possibly hares are most likely to follow this pattern, and stoats may respond indirectly as a result of the increased abundance of mice and other prey.

This research will:

- Look at how mice, stoats and hares vary in abundance in alpine grasslands, in relation to temporal variation in fruiting of tussock grasses over two summers
- Look at the abundance of these mammals in the alpine zone and in adjacent beech forest in relation to temporal variation in fruiting of beech trees over the same period
- Predict whether the presence of these mammals may result in periods of heightened threat to native species in the alpine zone

Study plots were established in January 2003 and consist of three zones in alpine tussock and three in the adjacent beech forest. Mice have been caught in live- and kill-traps in both beech forest and alpine tussock. The stomach contents of the mice have yet to be analysed. Stoats were tracked in only the beech forest sites in February but in both beech and alpine tussock sites in May. Few hare droppings were found on plots in May, and only in the alpine tussock sites. There appeared (from a preliminary analysis of the data) to be a moderate fruiting of *Chionochloa* tussocks, but a poor fruiting of beech near the tree line. Data analysis is still being undertaken, and conclusions will depend on data to be collected in November 2003 and February 2004.

This study will be completed by June 2004.

2.4 BIOLOGY

2.4.1 On-going research

Stoat reproductive biology

Development of an effective fertility control for stoats requires a thorough understanding of stoat reproduction, about which little is presently known. Cheryl O'Connor and Janine Duckworth (Landcare Research) are undertaking a three-year study of stoat reproductive biology. The aims of this study are to:

- Monitor reproductive biology, stress physiology, immunology, and behaviour of wild-caught stoats during and following acclimatisation to captivity
- Alter photoperiod (light-dark cycle) to examine control of oestrus, seasonal breeding and the prolonged 10-month period of embryonic diapause
- Develop techniques to assess and manipulate the reproductive state of stoats during oestrus and pregnancy
- Optimise husbandry and welfare of stoats leading to the establishment of a captive-breeding colony of stoats that will benefit research in many areas of stoat control

A captive-stoat breeding facility has been established at the Landcare Research Animal Facility. It utilises the best husbandry practices for the acclimatisation and care of wild stoats, developed in the course of this project. During the 2001/02 breeding season one litter of 2 kits was produced from one of the 6 female stoats in the captive breeding trial. These were the first stoats known to be born in captivity in the Southern Hemisphere. During the 2002/03 breeding season, two litters of 3 kits were born in the breeding facility. The first kit (a female) that was born in captivity in October 2001 was mated at 6 weeks of age, but did not produce any kits. At least 9 adult females and the 2 female kits born in 2003 came into oestrus and were mated November/December 2002. These females will be offered a wide variety of high-protein foods during late pregnancy to investigate whether level of nutrition will influence implantation and litter size. Offspring are expected to be born in October/November 2003.

A captive-bred stoat kit. *Photo: Susie Scobie, Landcare Research*

The development of 'out of season' mating techniques is another priority of this study. Successful manipulation will enable the reproductive cycle of stoats to be shortened by several months and allow young to be produced in captivity out-of-season. This has implications for reproductive (and future biocontrol) research allowing it to be undertaken throughout the year. The seasonal reproductive cycle of stoats is controlled by photoperiod (i.e. the changing ratio of light to dark hours). In 2002, 12 stoats (6 male, 6 female) were exposed to a photoperiod that changed gradually, similar to natural photoperiod, but was 6 months out of step (i.e. summer day lengths in winter and vice versa). No obvious changes in behaviour or reproductive function were observed. Because the response of seasonal mammals to changes in day length is directly related to the magnitude and rate of such change, this year the light treatment was more extreme and abrupt. In order to advance breeding activity, from May 2003 6 male and 6 female stoats have been exposed to long 'summer' photoperiod. Their reproductive function is being monitored and during 2003/04 will be compared to 6 male and 6 female stoats kept under natural photoperiod.

This project will now be completed by June 2004.

Stoat artificial reproductive technology

Susana La Falci and Frank Molinia (Landcare Research) are developing artificial reproductive technologies (ART) for the stoat, so that their reproduction may be controlled and manipulated in captivity to generate gametes, embryos, blastocysts, and ultimately, live young on demand. This research will significantly broaden our knowledge of the key features of stoat reproduction, enhance our ability to breed stoats in captivity, and assist in the identification, development and testing of unique reproduction-based targets for biocontrol.

Susana La Falci has replaced Andy Glazier who left Landcare Research last year. As recommended by an external project review by DOC in April 2003, the scope of the project has been extended to consolidate the most promising research directions. Key tasks for the 2003/04 year are to:

- Perform hormone treatments, mating-induced ovulation and/or artificial insemination of stoats to produce eggs, embryos and blastocysts both during and outside the breeding season
- Validate the technique for cryopreservation of stoat sperm by studying the biological competence of frozen–thawed sperm so that functional sperm can be made available all year round
- Define media and conditions required to maintain the viability of stoat blastocysts in *in vitro* culture

Following the outcome of hormone treatments performed during the breeding season reported last year, work in the coming year will focus on achieving the same success outside the breeding season. To increase the likelihood that stoats are receptive to hormone treatment, animals are currently being kept under long-day photoperiod conditions (refer to stoat reproductive biology research above). Hormone treatments will commence in September 2003, and a comparative trial will be undertaken during the normal 2003 breeding season.

The first blastocyst produced *in vitro* from two cells. *Photo: Susana La Falci*

A method for frozen- and liquid-storage of stoat sperm has been developed. This involved a rigorous evaluation of media, cryoprotectants, dilution rates, and pH for sperm samples collected from recently euthanased males. Sperm samples diluted in Tris-based media containing egg yolk and glycerol at pH 7.0 maintained 65% motility in liquid-storage at 4°C for 4 days. The same media and cooling regime was used before pellet-freezing sperm samples on dry ice then storing at –196°C in liquid nitrogen. After thawing samples at 37°C, more than one third of the sperm population were motile and 60% had intact acrosomes, both key indicators of functional survival. A series of trials will be conducted during the 2003 breeding season to validate that these sperm are biologically competent. Success will mean that functional sperm will be available all year round, avoiding the need to maintain males in reproductive condition for the future development of control strategies.

Stoats carry blastocysts for up to 10 months of the year, making them a logical target for biocontrol. Work in the coming year will focus on defining the media and conditions required to maintain their viability in *in vitro* culture, to facilitate screening of agents that may interfere with the blastocyst.

This project will now be completed by June 2004.

Monitoring hormones of stoat reproduction

Susana La Falci and Frank Molinia (Landcare Research) are establishing a non-invasive, non-radioactive endocrine monitoring technique to measure the hormones of reproduction of captive stoats. Little is currently known about the major hormones associated with reproduction in stoats (testosterone in males, oestradiol and progesterone in females), and this research will provide much-needed information for the work currently underway in stoat reproductive biology and artificial reproductive technology. Once the benchmark values for the natural reproductive cycle are established, the effects of artificial manipulations of the breeding cycle can be assessed. Knowledge of the reproductive hormones is essential if biocontrol through interruption or manipulation of the breeding cycle is to be contemplated in the future.

Susana La Falci has replaced Andy Glazier who left Landcare Research last year. As recommended by an external review by DOC in April 2003, the scope of the project has been extended to consolidate the most promising research directions. Key tasks for the 2003/04 year are to:

- Complete enzyme immunoassays of hormones for monitoring testicular (testosterone) and ovarian (oestradiol and progesterone) function from stoat faecal samples
- Establish biological validation of these methods by:
  — Comparing faecal hormone measures against those from existing matched serum samples
  — Demonstrating faecal hormone measures reflect reproductive status of animals
  — Confirming that faecal hormone measures change after exogenous hormone ‘challenges’ or removal of gonads
- Determine what hormone metabolites the immunoassays are measuring by performing HPLC analysis of stoat faecal samples

A series of laboratory validations of the method for measuring testosterone from stoat male faecal samples are nearing completion. The first of these was development of an extraction method that gave high recovery of testosterone from faecal samples. The procedures documented for other carnivores resulted in low extraction of testosterone because of the large proportion of feathers present in stoat faeces. Ultimately a combination of methods resulted in an extraction efficiency of over 80%. Secondly, ‘parallelism’ experiments were performed to determine whether the samples behaved immunologically in a similar manner to testosterone standards. Preliminary results indicate that testosterone was present in measurable quantities, and reacted with appropriate antibodies in a predictable fashion. The final validation is a recovery check and determines the degree to which the measured concentration corresponds to the true concentration of a substance. These experiments are underway for the testosterone assay. The same validations are currently being undertaken for measuring oestradiol and progesterone from stoat female faecal samples.

These laboratory validations in conjunction with the biological validations (detailed above) and HPLC analysis for hormone metabolites will produce robust assays for measuring testosterone, oestradiol, and progesterone from stoat faecal samples.

This project will now be completed by June 2004.

2.4.2 New research funded for 2003/04 (Year Five)

Vomeronasal organ as a potential target in stoat control

Mike Legge (University of Otago) will initiate an investigation into the role of the vomeronasal organ to determine whether this may provide a unique target for stoat control. The vomeronasal organ (VMO) is a chemoreceptive structure situated at the base of the nasal septum. It has a similar structure to the main olfactory system mediated by the olfactory bulb. This organ is used to gain direct and specific contact with chemical cues released by congeners and in biological fluids. The chemosensory cues provide information about the emitter and facilitate interactions such as reproduction, social structure, food, and homing. The VMO operates independently of the main olfactory system and complements the chemical cues received by this system.

Current evidence indicates that the VMO primarily detects non-volatile odours whereas the main olfactory system is cued by volatile odours. In small mammals the VMO has been identified as having a significant role in puberty acceleration, oestrous induction, pregnancy blocking, initiating diapause, mate selection, and maternal and neonatal behaviour. Removal or blocking of the VMO has been shown to stop or significantly modify one or more of these behaviour patterns. Understanding the role of the VMO in stoats may provide a unique target for stoat control. It has the potential to deliver a range of specifically targeted agents to stoat populations to influence reproductive and social interactions.

This research will investigate the isolation and characterisation of changes in cellular structure and seasonal changes of the stoat VMO and look into the VMO proteome. This project will be completed by August 2004.

Assessing the potential for orally ingested dopamine antagonists to cause precocious implantation in a stoat

Clive Marks (sub-contracted by the Pest Animal Control Cooperative Research Centre, Australia) and co-workers Heli Lindeberg (Institute of Applied Biotechnology, University of Kuopio, Finland) and Dr Sergei Amstislavsky (Russian Academy of Sciences, Institute of Cytology and Genetics) are going to investigate the potential of orally delivered dopamine antagonists (DA) to cause precocious embryo implantation in mustelids.

Drs Sergei Amstislavsky, Heli Lindeberg, and Clive Marks. *Photo: Aleksei Krasnov*

The reproductive strategy of the stoat stands apart from other species in New Zealand—the breeding cycle is highly seasonal, and uses a long period of embryonic diapause. These attributes may represent an Achilles heel that can be exploited to produce species-specific control techniques. In American mink, a DA antagonist has previously been shown to produce precocious implantation. This may be possible to achieve in stoats, using bait-delivered dopamine antagonists.

American mink are an ideal model for preliminary screening of DA antagonists as they are closely related to stoats, have a short period of delayed implantation and are readily available in fur farms. This trial seeks first to identify the most potent and orally active DA antagonist that causes sustained elevations in prolactin, and then will test to see if this causes precocious implantation in mink.

This project will be completed by October 2005.

2.5 BIOTECH/BIOCONTROL

2.5.1 Research completed during 2002/03 (Year Four)

Incidence and diversity of* Bartonella *in stoats and other wildlife

Robbie McDonald (Queen's University, Belfast) with co-workers Richard Birtles (University of Liverpool) and Michael Day (University of Bristol) conducted a histopathological survey of disease in major organ systems in free-living stoats in New Zealand, along with culture and polymerase chain reaction (PCR) techniques to determine the incidence of the arthropod-borne bacteria *Bartonella*. These findings were compared to an earlier survey of stoats collected in Great Britain. Diseases identified in free-living stoats may be useful as potential agents for the biological control of stoats.

The histopathological survey examined samples from 60 stoats and 34 individuals of a further 9 species. A high proportion of stoats (63%) exhibited inflammation of the lung tissue, mostly associated with local or diffuse interstitial pneumonia and, in some cases this had advanced to bronchopneumonia. Thirty percent of the stoats showed signs of inflammatory liver disease. No evidence of nematode parasitism in the lungs or livers of stoats was found, and parasitism of the intestines was comparatively rare (7%). In 27% of stoats there were no significant pathological lesions at the microscopic level.

Bartonella spp. were not detected in the 168 specimens tested using culture and PCR analysis. Two samples showed signs of infection by a bacterium closely related to *Yersinia pestis* and a further stoat exhibited similar signs, but did not yield enough material for sequencing.

Two principle contrasts were drawn from this survey and that conducted on stoats in Great Britain. The high incidence of pneumonia among stoats in New Zealand suggests that their pulmonary immune system may be compromised in some way. This may offer an opportunity in terms of the development of a form of biological control which exploits this weakness. The apparent absence of *Bartonella* suggests that this organism remains a candidate vector organism for some form of immunocontraceptive, since there would be no competition between the introduced vector and endemic bacteria. This would be contingent on the ability to introduce a non-native bacterium, and on the means of transmission among stoats being available.

It was recommended that further investigation be carried out on the:

- Identification of the organisms causing such a high prevalence of pneumonia among New Zealand's stoat using culture and PCR techniques
- General investigation of the pulmonary immune system of stoats
    - Identification of infectious agents affecting the respiratory system of stoats
    - Investigation into the epidemiology of *Bartonella* and its arthropod vectors to help determine if this bacterium may be a suitable candidate vector for immunocontraceptives

Captive-bred stoat kits.
Photo: Susie Scobie, Landcare Research

2.5.2 On-going research

Biological control of stoats using a vaccine strain of canine distemper virus

Tao Zheng, with co-worker Bryce Buddle (AgResearch), is in the third year of an investigation for the use of a vaccine strain of canine distemper virus as a lethal agent for the biocontrol of stoats. Previous studies have shown that stoats and other mustelids are susceptible to the canine distemper virus and vaccine strains of this virus have caused mortality in ferrets.

This project is focusing on the development of the distemper virus into a preparation suitable for biocontrol of stoats, by passaging the virulent distemper virus in eggs. Two strains of virulent CDV have been obtained from the United States. Historically, distemper virus has been attenuated by passage on chorio-allantoic membranes of eggs. However, passaging in this manner resulted in no macroscopic changes during passaging and the canine distemper virus genome was not detected on the membrane. This was because the titres of viable distemper virus were low in the original inocula.

To test the distemper virus stocks from the United States, a further trial was undertaken. Two ferrets were inoculated with one of the virus stocks and another two with the other. A sentinel ferret was also housed in the same room as the inoculated ferrets. The two ferrets inoculated with the virus died on day 9 and 18 and the sentinel ferret died on day 31. For the other two ferrets that received the strain with a lower titre of viable distemper virus, one was euthanased at day 14 when it became moribund. However in the remaining ferret no distemper symptoms were observed.

By passaging canine distemper virus through ferrets, higher titre distemper virus preparations could be obtained, which could then be used as inocula to be passaged in embryonated eggs. Passaging canine distemper virus in ferrets may also reduce its virulence to dogs, but increase its virulence in ferrets, and this approach is also being pursued.

An attempt to isolate a New Zealand strain of distemper virus was also undertaken. Two ferrets were inoculated with liver and spleen preparations from a captive ferret (from Woodville) suspected of having canine distemper. Neither of the two inoculated ferrets demonstrated any signs of distemper and the virus was not detected.

Further work is now being undertaken on passaging and in sourcing a more virulent vaccine from manufacturers in the United States. Findings to date have shown that viable distemper virus titre in the original imported virulent distemper inocula was low. However, the ferrets used in the studies were susceptible to distemper virus infection and the virus was transmissible from inoculated ferrets to a sentinel ferret.

This project will be completed by June 2004.

Identification of zona pellucida antigens of the stoat and assessment of their potential for immunocontraception

Janine Duckworth and Frank Molinia (Landcare Research) and researchers associated with the Pest Animal Control Cooperative Research Centre in Canberra, Australia, are investigating the potential of a fertility control method as a long-term solution for the control of stoats. The process of developing a fertility control agent is complex and long term. The identification of potential antigens is the first stage. Previous studies with mice and rabbits have indicated that zona pellucida antigens can be effective as immunocontraceptives when delivered by recombinant species–specific viruses. Direct immunisation of these antigens can also be undertaken to assess their potential for affecting fertility.

This project will assess the immune responses of stoats to a heterologous reproductive antigen—porcine zona pellucida C—and examine the function of the zona pellucida proteins in ovarian follicular development as well as during diapause and implantation. In parallel studies, a stoat ovarian cDNA library will be prepared and the stoat zona pellucida genes cloned. Once full-length cDNAs have been identified and sequenced, recombinant proteins will be expressed for use in immunisation trials in captive stoats (at the Landcare Research facility in New Zealand). Eventually (beyond the scope of this project), the effective proteins could be inserted into delivery systems for use in the field.

This study was to form the basis of a PhD doctorate, however the project team was unsuccessful in attracting a student to undertake this work. As a result progress has been delayed. The project has been re-organised and the research will now be done by Pestat Ltd and CSIRO Sustainable Ecosystems in Australia, and Landcare Research in New Zealand.

To date, recombinant porcine zona pellucida protein has been synthesised in a mammalian gene expression system and prepared for use, and research material has been transported, under permit, between New Zealand and Australia. Landcare Research has commenced *in vivo* studies of captive stoat response to zona pellucida antigens and staff (of CSIRO Sustainable Ecosystems) have begun the *in vitro* work on mustelid zona pellucida genes/proteins.

The completion date for this work has now been extended to April 2005.

Proof-of-concept studies to determine feasibility of controlling stoats using a species-specific technique

Landcare Research will investigate a potent, species-specific, humane, and environmentally clean technique as a control for stoats. The ultimate aim of the project is to develop an orally available stoat/mustelid-specific pesticide that can be incorporated into a readily distributed bait.

To date progress has been made identifying and isolating target sites and designing pesticide agents for stoat-specific control. A stoat gut cDNA library is now available for use by other DOC-related programmes if required.

This study will be completed in June 2004.

Screening of viral disease in stoats from New Zealand

Robbie McDonald (Queen's University, Belfast), Malcolm Bennett, and Richard Birtles (University of Liverpool) are examining the range of viruses present in stoats in New Zealand. They are undertaking a screening study of the seroprevalence of key virus groups in the sera of stoats.

Samples for this project were collected opportunistically during a previous study funded by DOC (see 2.5.1 Incidence and diversity of *Bartonella* in stoats and other wildlife). Sera from approximately 60 stoats are available, hence a major hurdle for the project has already been cleared.

The serum samples will be screened using specific assays for the following carnivore virus groups: morbillivirus (distemper), parvovirus (antigenically similar to mink parvoviruses such as Aleutian Disease Virus and Mink Enteritis Virus), coronavirus, orthopoxvirus and lymphocytic choriomeningitis virus (an arenavirus). A range of exploratory screening tests will also be conducted for cat and dog viruses that are less likely to be cross-reactive with mustelid viruses, including: feline herpesvirus, feline calicivirus, canine adenovirus, and canine herpesvirus.

This study will be completed by May 2004.

2.6 MISCELLANEOUS

2.6.1 Research completed during 2002/03 (Year Four)

Social acceptability of control options for stoats

Potential biological control techniques for stoats that involve the use of exotic diseases, viral vectors and genetic modification are likely to be contentious. Any new methods are only likely to be used if they are socially acceptable.

Gerard Fitzgerald (Fitzgerald Applied Sociology) looked at the social acceptability of new stoat control techniques as well as the acceptability of the existing trapping and poisoning techniques. Roger Wilkinson, formerly of Landcare Research, has been collaborating on aspects of the project.

The first phase of the research involved conducting seven focus groups, covering the public, iwi and various special interest groups. The groups were selected to capture the range of views about stoats, their impacts, and the acceptability of current and potential future control methods. The results were published in *Science for Conservation 207*. The qualitative information gained from these focus groups was used to design the second (quantitative) phase of the work: a national telephone survey of a random sample (1000 members) of the New Zealand public.

The telephone survey, like the earlier focus groups, confirmed that there was widespread support for controlling stoats in order to protect native birds, especially kiwi, from stoat predation. There was also widespread support for improving stoat control methods. However, analysis revealed that this support only clearly extended to research and the development of more effective kill traps. People were uncomfortable about using poisons to control stoats, even when the poison was delivered via a bait station. In terms of biological control, people did not support the use of diseases that could affect other animals and this view was held regardless of whether the disease was already present in New Zealand. There was clear opposition to the use of canine distemper virus. Potential new forms of biological control whose function would be to reduce the fertility of the stoat were marginally acceptable in theory, especially because they could be humane and specific to stoats. However, the use of genetic engineering/modification of organisms to develop and/or deliver the fertility control was less supported by the public. These findings are similar to those of previous studies on pest control methods.

The level of support for existing and potential new forms of stoat control reflect the concerns of people about its specificity (the degree to which the control is confined to stoats), its humaneness (the extent of pain or discomfort caused to the stoat), and its effectiveness. Cost is not an issue for most people.

The findings from this study indicate that the New Zealand public, at this time, is unlikely to support the development of biological controls for stoats, including controls that make use of genetic engineering. The most socially acceptable and sustainable option would be to focus stoat control development on trapping, while seeking to understand how fertility control can be achieved through means other than genetic manipulation.

2.6.2 On-going research

Genetic tagging for estimating stoat population parameters in the field

Dianne Gleeson and Andrea Byrom (Landcare Research) are looking at using recently developed genetic (DNA) markers (micro-satellites) which, when combined with traditional statistical methods and novel tissue capture techniques, will provide new opportunities for measuring population densities and behavioral parameters in the field. Initially this project is aimed at determining the probability of identifying individual stoats in the field. To achieve this, both wild populations and captive stoats are being used. The results from this study will provide both an overview of the genetic variability and population structure of stoats in New Zealand.

Olivia Holland, an MSc student, analysing the stoat DNA data. *Photo: Dianne Gleeson*

To date 18 populations of stoats have been sampled throughout New Zealand. Of these, mitochondrial DNA sequence data and microsatellite DNA profiles have been derived from 14 populations. Initial results using microsatellite DNA analysis have revealed significant genetic variability throughout New Zealand populations of stoats. This is of interest because the mitochondrial DNA results from the 70 individuals sequenced, suggest that only 3 maternal lineages have persisted in New Zealand following initial colonisation (one haplotype common to all populations and two restricted to the southern half of the South Island). Temporal sampling from one region (Otago peninsula) has shown that there is no significant variation in the genetic structure of this population at different times of the year.

Further analysis of known parent/offspring from captive stoats and through blastocyst sampling will take place during 2003/04 to determine more precisely the statistic parameters required to achieve significant probabilities of individual identification in the field.

This project will be completed by June 2004

Measuring stoat movements across a control boundary using genetic markers

Andrea Byrom and co-workers (Landcare Research) are looking at identifying individual stoats using genetic markers to determine movements of stoats into

A hair tube set to 'capture' hair from stoats passing through. *Photo: Paul Horton, Landcare Research*

or within areas of high conservation value. Attempts to mitigate the predation impacts of stoats by kill-trapping in areas of high conservation value may be compromised either by high reinvasion rates, or the survival of too many resident stoats, or both. Despite stoat control (Fenn Traps over a 10 000 ha core area), high predation rates on juvenile kiwi were observed in Okarito Forest, South Westland, throughout the summer of 2002/03.

This study will look to identify individual stoats both inside and outside a kill-trapped area at Okarito, using genetic markers to 'capture', 'mark' and 'recapture' individuals. This will allow the following parameters to be measured:

- Movement across a stoat density gradient at one stage of the stoat annual cycle (April–June 2003). This is after the main period for juvenile dispersal, and will determine whether kill-trapping in the stoat control area has a 'source sink' effect by continuing to attract stoats to immigrate into vacant territories. Hair will be collected from the stoats and individuals identified using DNA typing.
- Mark-and-recapture of stoats will allow an estimate of population density within and outside the kill-trapped area.
- Identification of individual stoats at first 'capture' and subsequent 'recapture' will allow any movements to be measured. Of particular interest is the movement of individuals into the kill-trapped area.

Three study grids have been established at Okarito. One is located within the area in which DOC undertakes stoat control, while the other two study areas are located to the north and south of the stoat control area. Two 7-night sampling sessions were undertaken in April and June 2003.

Analysis of the hair samples obtained to date from the 'captured' samples in the DOC stoat control area suggests most of the stoats caught in this area by conventional methods appear to be immigrants and not residents. DNA analyses are still needed to confirm this observation.

This project will be completed by February 2004.

Close-up of stoat hairs attached to the glue on the rubber band. *Photo: Paul Horton, Landcare Research*

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Stoat being weighed, Eglinton Valley. *Photo: John Dowding*

Appendix 1

NEW STOAT RESEARCH PROJECTS TO BE INITIATED IN YEAR FIVE (2003/04)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Vomeronasal organ as a potential target in stoat control	Mike Legge	University of Otago
Trials of fresh and freeze-dried rabbit against hen eggs as stoat bait in a Northern forest environment	Nigel Miller	DOC
Paired trial of salted rabbit versus egg as stoat baits in a Northern Forest Environment	Steve Allan and Clea Gardiner	DOC
Kiwi chick survival in relation to stoat trap density and pattern	Derek Brown and Jenny Christie	DOC
Assessing the potential for orally ingested dopamine antagonists to cause precocious implantation in a stoat	Clive Marks (Heli Lindeberg and Sergei Amstislavsky)	Pest Animal Control CRC, Australia (University of Kuopio, Finland & Russian Academy of Sciences)
PTF (Predator Toxin Formulation) bait development	Jeremy Kerr (Andy Lavrent, Kay Clapperton and Lloyd Robbins)	Feral R&D Ltd
Registration of 'Stoat-B-Gone'	Phil Ross	Golder Associates
Field testing three new stoat traps in different habitats	Elaine Murphy, Ian Westbrooke and Fraser Maddigan	DOC

Appendix 2

ON-GOING STOAT RESEARCH PROJECTS INITIATED IN YEAR TWO (2000/01), YEAR THREE (2001/02) AND YEAR FOUR (2002/03)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Evaluating a low-intensity stoat control regime on large inshore islands	Murray Willans, Keri-Anne Edge and Graeme Elliott	DOC
Comparison of three trapping set designs	Rhys Burns	DOC
Testing attractiveness, palatability, longevity of stoat lure and bait formulations	Kay Clapperton (Lloyd Robbins, Tony Woolhouse and Dick Porter)	Private
Developing a multi-sensory bait/lure system for controlling stoats	Kay Clapperton (Lloyd Robbins and Dick Porter)	Private
Development of a long-life toxic bait for stoat control	Ray Henderson (Chris Frampton and James Ross)	Pest Tech Ltd
Pen trials of small-volume toxic baits for stoats	Kim King (Murray Potter and Paul Barrett)	HortResearch (Massey University)
Effect of reducing possum densities on ship rats and stoat abundance	Peter Sweetapple (Graham Nugent)	Landcare Research
Modelling the immigration rate of island stoat populations	Murray Willans, Keri-Anne Edge and Graeme Elliott	DOC
Modelling the dynamics and control of stoats	Mandy Barron (completing work of Nigel Barlow)	AgResearch
Kiwi Sanctuaries: Ecological consequences of mustelid control to benefit kiwi	Ian Flux	DOC
The relationship between stoat and rodent relative abundance in North and South Island forests	Craig Gillies (Elaine Murphy, Peter Dilks and Fraser Maddigan)	DOC
The movement and abundance of the stoat in an alpine grassland/beech forest habitat: Inter-annual variations and impact of control	Des Smith	University of Otago
Inter-annual variation in pest densities in alpine grassland and strategies for limiting pest effects	Deb Wilson	Landcare Research
Stoat reproductive biology	Cheryl O'Connor and Janine Duckworth	Landcare Research
Stoat artificial reproductive technology	Frank Molinia and Susana La Falci	Landcare Research
Monitoring hormones of stoat reproduction	Frank Molinia and Susana La Falci	Landcare Research

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PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Biological control of stoats using a vaccine strain of canine distemper virus	Tao Zheng (Bryce Buddle and Lindsay Matthews)	AgResearch
Identification of zona pellucida antigens of the stoat and assessment of their potential for immunocontraception	Janine Duckworth and Frank Molinia	PAC CRC, Australia and Landcare Research, NZ
Proof of concept studies to determine feasibility of controlling stoats using a species-specific technique	Brian Hopkins	Landcare Research
Genetic tagging for estimating stoat population parameters in the field	Dianne Gleeson and Andrea Byrom	Landcare Research
Measuring stoat movements across a control boundary using genetic markers	Andrea Byrom and Dianne Gleeson	Landcare Research
Improving stoat trapping efficiency. Can we learn more from trapping data?	Jenny Christie	DOC
Screening of viral disease in stoats from New Zealand	Robbie McDonald, Malcolm Bennett and Richard Birtles	Queen's University, Belfast/ University of Liverpool, U.K.
Toxic micro tabs and a bait for stoats	Jeremy Kerr	Feral R&D Ltd
Control of stoat dens after location by trained predator dogs at Trounson Kauri Park	Scott Theobald (Natasha Coad and Craig Gillies)	DOC

Appendix 3

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR FOUR (2002/03)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
The 'Hammer' Class A ferret/stoat trap.	Ian Domigan	Lincoln Ventures/ Lincoln University
The 'Thumper' tunnel stoat trap	Ian Domigan	Lincoln Ventures/ Lincoln University
Production of an alternative kill-trap for stoats	Phil Waddington	Private
Trials to test a prototype kill-trap for stoat control	Malcolm Thomas	Pest Control Research Ltd
Self-setting mustelid eradicator	Frank Greenall	Private
Improving stoat trapping efficiency: A pilot study exploring the usefulness of existing data sets	Jenny Christie (Ian Westbrooke and Elaine Murphy)	DOC
Prey odours as lures for stoats	Andrea Byrom (Eric Spurr and Cheryl O'Connor)	Landcare Research
MNT toxicity to stoats and risk assessment for non-target species	Penny Fisher and Cheryl O'Connor	Landcare Research
Evaluating the use of tracking tunnels to monitor mustelids as well as rodents	Craig Gillies (Peter Dilks)	DOC
Ecology of stoats in a South Island braided river valley	John Dowding (Mike Elliot)	DM Consultants
Dispersal of juvenile stoats in the Mackenzie Basin	John Dowding	DM Consultants
Dispersal and survival of juvenile stoats in a South Island beech forest	Andrea Byrom	Landcare Research
Incidence and diversity of *Bartonella* in stoats and other wildlife	Robbie McDonald, Michael Day and Richard Birtles	Universities of Waikato, Bristol, and Liverpool
Conservation benefits from the use of colour as an attractant for tracking and trapping stoats	Billy Hamilton	Ecosystems Consultants Ltd/ Ecological Networks Ltd
Social acceptability of the various control options for stoats	Gerard Fitzgerald (Roger Wilkinson)	Fitzgerald Applied Sociology

Appendix 4

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR THREE (2001/02)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Automatic stoat trap pilot study	Ian Domigan	Lincoln University
Effectiveness of a low-cost kill-trap system for stoats	Bruce Warburton (Nick Poutu)	Landcare Research
FeraCol® for stoat control	Jeremy Kerr (Andy Lavrent)	Feral Control R&D Ltd
Paired trial of long-life stoat baits in northern coastal environments	Nigel Miller and Pete Graham	DOC
Comparison of hen eggs, freeze-dried laboratory mice and freeze-dried feral rats as lures for trapping stoats	Rhys Burns and Pete Shaw	DOC
Control of stoat dens with magnesium phosphide (magtoxin) after locating with trained dogs	Scott Theobald and Nastasha Coad	DOC
The movement and diet of stoats in an alpine-beech forest habitat	Des Smith (Ian Jamieson)	University of Otago
Quantifying stoat /rodent population parameters in podocarp/ broadleaf for predictive modelling	Wendy Ruscoe and Andrea Byrom	Landcare Research
Review of potential 'Archilles heel' characteristics of the stoat	Clive Marks	sub-contracted by PAC CRC, Australia
Potential technique for marking stoats to determine optimum spacing of tracking tunnels, bait stations and traps	Henrik Moller and Billy Hamilton (Chris Jones)	Ecosystems Consultants Ltd/ Ecological Networks Ltd
Current stoat control practice at 16 sites nationally: identifying long-term cost-effective approaches for killing stoats	Kerry Brown	Ecological Consultants
Risk assessment of possible stoat control methods	John Parkes and Elaine Murphy	Landcare Research/ DOC

Appendix 5

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR TWO (2000/01)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Develop a prototype kill-trap for stoat control	Malcolm Thomas	Pest Control Research Ltd
Gotcha electronic trap	Warren Agnew (Mark Chitterden, Eric McCall and Geoff Moon)	Private
Development of a long-life bait for the control of stoats	Ray Henderson (Chris Frampton and James Ross)	Pest Tech Ltd
Meat- and rodent-scented lures as attractants for stoats	Tom Montague	Roe Koh and Associates Ltd
Bait marker for stoats	Eric Spurr (Cheryl O'Connor)	Landcare Research
Evaluation of new toxins for mustelid control	Cheryl O'Connor (Charlie Eason)	Landcare Research
Microsite factors affecting stoat trap success	Barry Lawrence and Bruce McKinlay	Private/DOC
Cost-effectiveness of exclusion fencing for stoat control	Tim Day (Lindsay Matthews)	AgResearch
'Find out' project	Warren Agnew (Eric McCall and Geoff Moon)	Private
Mustelid bibliography on-line database	Kim King	Waikato University

Appendix 6

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR ONE (1999/2000)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
A review of overseas studies relevant to stoat control	Robbie McDonald and Serge Larivière	University of Bristol, U.K.
Scoping review: feasibility of immunocontraception for managing stoats in New Zealand	Lyn Hinds (Kent Williams, Roger Pech, Dave Spratt, Tony Robinson and Gerhard Reubel)	CSIRO, Australia
A review of mustelid studies from the former Soviet Union	Artyom Polkanov	Private
Preliminary modelling of stoat control options	Nigel Barlow and David Choquenot	AgResearch/ Landcare Research
Colonisation of new areas by stoats: time to establishment and requirements for detection	David Choquenot	Landcare Research
Disease and pathogens in stoats in Great Britain	Robbie McDonald (Michael Day and Richard Birtles)	University of Bristol, U.K.
Development of a protocol for the identification of pathogens from sick stoats in New Zealand	Joseph O'Keefe and David Tisdall	MAF
Evaluation of cholecalciferol as a new toxin for stoat control	Craig Gillies (Elaine Murphy and Eric Spurr)	DOC/Landcare Research
Testing the efficiency of current stoat control during the predicted stoat population irruption in southern beech forest ecosystems	Peter Dilks and Barry Lawrence	DOC