What's happening with stoat research?

Fourth report on the five-year stoat research programme

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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 (STAG) 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), Leonie Fechney, Craig Gillies, Ian McFadden/Darren Peters, Elaine Wright, Harry Keys, Ian Flux and Fiona McKay; from Lincoln University—Graham Hickling; and from Auckland University—Mick Clout. Funding for the first year was $338,000, increasing to $1.406 million in the second year (2000/2001). Funding for the third year and subsequent two years is $1.631 million annually.

This is the fourth report in the series of progress reports on the programme. The first was published in January 2000, the second in November 2000 and the third in November 2001.

Overview

New Zealand wildlife evolved in the absence of mammalian predators and has proven to be particularly vulnerable to some of the mammals introduced since human settlement. Birds have been particularly affected, with over 40% of the pre-human land bird species now extinct. The proportion of the surviving birds classed as threatened is now higher than in any other country.

Stoats, along with ferrets and weasels, were introduced from Britain to New Zealand in the 1880s in an attempt to control rabbits. Although stoats were quickly implicated in the decline of native birds, the extent to which they still contribute to the decline of native species is only now becoming clear.

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. As a conservation pest, stoats are unique to New Zealand; they are widely regarded as the most significant predator of a number of New Zealand's most threatened and endangered native bird species. Stoat control in New Zealand will have to be ongoing 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 now a real opportunity for 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 and third years have concentrated on finding more effective baits, lures, and traps, as improvement in these areas will bring quick gains in the short-term. A number of these projects look promising and we are hoping to trial some of these in the coming year. In February, the advisory group met to review progress and to assess whether there were any major gaps in the programme. While progress on some of the work has been slower than we had hoped, other aspects have been very successful and the group is confident that we will have made real progress by the end of the programme in June 2004.

The research being undertaken on islands in Fiordland by Graeme Elliott, Murray Willans and co-workers (with invaluable support from the DOC boat m.v. *Renown*) is not only innovative, but raises the exciting prospect of being able to turn the tide on some of the island stoat invasions. The successful eradication of stoats from Anchor Island not only provides an ideal location for kakapo to breed (it has both beech and podocarp forest), but also raises the possibility in the near future of eradicating stoats from Secretary and Resolution Islands. Ongoing low-intensity trapping will ensure any re-invaders do not establish. The use of dogs by Scott Theobald (DOC) to successfully find stoat natal dens will also be an important tool in stopping re-invaders establishing, as well as being a valuable tool in ongoing mainland stoat control.

The captive-breeding of stoats by Landcare Research was also a highlight from last year. Female stoats have been kept in captivity previously in New Zealand, but despite being pregnant when caught, none had ever given birth. Landcare Research is being funded to investigate a number of key areas in stoat reproductive biology, including artificial reproductive technologies. The stoat reproductive studies are providing a solid foundation to our understanding of stoats which we will then be able to apply to a number of projects.

Although the programme is focusing on improving traditional methods of control, some longer-term, higher-risk projects have also been funded, because a variety of methods are likely to be needed if stoat control is to become sustainable. Linkages have been made with both the Marsupial Cooperative Research Centre and the Pest Animal Control Cooperative Research Centre in Australia. These will take advantage of the experience they have gained in investigating biotech options for pest species, to expand our research expertise, and to ensure co-operation and collaboration into the future.

Stoat alert! *Photo: John Dowding*

Elaine Murphy
Stoat Research Programme Manager
Department of Conservation

1. Year four of the stoat research programme

Welcome to the fourth year of the stoat control research programme. Since July 1999, when the five-year programme was initiated, a total of 67 projects have been funded (and a further 2 are pending).

In the last financial year (2001/02) 39 research projects were funded. Of these 12 have been completed, and the remainder will be completed over the next 1–2 years. A total of 11 new proposals are so far in the process of being funded for Year 4 (2002/03).

This annual report will provide:

- A brief insight into the findings from research completed in 2001/02
- A progress report on ongoing research
- A summary of research to be initiated this year (2002/03)

Expressions of interest will not be called for in the final year of the programme. It is intended to plan to field trial as many of the new baits, traps, and lures as possible and to complete the longer-term research to a proof of concept stage.

1.1 2001/02 EXPRESSIONS OF INTEREST

As in previous years, the advisory group sought expressions of interest to undertake research for year four of the stoat control research programme.

When seeking expressions of interest the following priority areas were identified:

1. Research into management and control of stoats

- Logistically feasible and scientifically meaningful monitoring methods
- New baits and lures
- Improvements to aid current best practice

2. Research into understanding the behaviour and ecology of stoats

- Stoat behaviour
- Interactions with other pest animals

3. Innovative research that has the potential to increase dramatically the effectiveness of stoat control

The advisory group received a total of 34 expressions of interest, covering a wide range of research topics. The variety and calibre of the research proposed was impressive and, regrettably, a large number were unable to be funded.

The advisory group assessed each expression of interest in terms of:

- The objectives of the stoat control research programme
- The relevant experience of the research provider
- The proposed methodology

1.2 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. Landcare Research and DOC have jointly funded two projects, which has added value to the work being done and resulted in true collaboration. DOC and Landcare Research have signed a Memorandum of Understanding with the Department of Natural Resources & Environment in Victoria, Australia, to share expertise to try and develop a humane, predator-specific toxin. 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 has also 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. We have funded a project through the PAC CRC, linking in with the Landcare Research stoat reproductive studies, for preliminary research into fertility control for stoats. DOC is also a supporting participant in the CRC's supplementary funding bid. The CRC has so far focused on exploring the use of gene technology to deliver contraceptive vaccines to wild populations of pests. Recognising that it will be quite a number of years before fertility control is developed to the stage where it can be applied in the field, the PAC CRC is seeking extra funding to expand the range of options for control of pest species by developing baits that are species-specific and not subject to the regulatory hurdles associated with recombinant technology. The Achilles heel approach underpins this new strategy.

White stoat, Craigieburn Forest, 2002.
Photo: Caroline Thomson, Landcare Research

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 may 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 2001/02 (Year 3)

Evaluation of the effectiveness of the Victor snapback trap for killing stoats

Bruce Warburton and co-worker Nick Poutu (from Landcare Research) along with Ian Domigan (Lincoln University) have tested the effectiveness of the Victor rat snapback trap as a low-cost kill-trap system for stoats. The Victor rat snapback trap has been approved in Canada as a humane method for trapping stoats (called short-tailed weasels there). Canadian stoats are considerably smaller, so the trap’s effectiveness at killing New Zealand stoats needed to be confirmed.

Captive wild caught stoats were used to test the trap, which was set with a plastic shroud to direct and align the stoat to the front of the trap. Evaluation of the trap system included measurement of the mechanical parameters (impact momentum, clamping force and kinetic energy) and pen trials to determine how well the trap captured and killed stoats. To meet the NAWAC requirements the trap needed to render at least 13 out of 15 stoats irreversibly unconscious within 3 minutes.

Seven stoats were rendered unconscious rapidly (i.e. under 3 seconds). This was a result of the high striking bar velocities which killed the stoats by fracturing the skull. However, three stoats were either not struck across the head or managed to escape because of the low clamping force of the trap (i.e. the trap did not have sufficient strength to securely hold a conscious animal). Because three captures failed to result in the stoats being rendered irreversibly unconscious within 3 minutes, the trap failed the NAWAC test.

So although the Victor professional snapback trap had the capacity to kill stoats quickly, it could not do this consistently.

Automatic stoat-trap pilot study

Ian Domigan (Lincoln Ventures, Lincoln University) reviewed possible designs for a multiple-kill stoat trap designed to meet the requirements of the NAWAC. Multiple-kill traps offer a solution to trap saturation, they require less operator input and can operate for longer periods between servicing (baiting and re-setting). Although it was acknowledged that they are likely to be more expensive.

Attributes and constraints of traps were discussed with stakeholders in addition to a review of the design solutions proposed in current patent literature accessed through the internet. The search found a number of multiple capture animal traps, but very few multiple-kill traps. Of the three multiple-kill traps found, the capture and killing mechanisms ranged from suffocation (carbon dioxide or rubber rings), electrocution power driven spikes and poison application.

When considering the design of a trap it was decided that the following specifications needed to be met. The trap needed to be:

- Humane
- Capable of killing four stoats between each service
- Affordable, portable and durable, with a simple design that may be easily produced on a large scale and easily maintained and serviced once in the field
- Species specific to exclude non-target species
- A minimum potential for injury to trappers and third parties

The development of a 'captive bolt' solution for an automatic multiple-kill stoat trap was therefore pursued. The 'Hammer' kill trap uses a captive bolt, powered by a blank charge to deliver a lethal blow to the head of the stoat. The use of blank charges as a power source has enabled a very small component to be used to deliver a very high force. The impact of a rod or plate driven by such a charge will ensure that the target animals are killed quickly, and often instantaneously. Each trap contains four individual charges, thus providing a four-kill unit, allowing the traps to be left out in the field for extended periods. It was noted that the design unit could be used as single kill traps or as multiple-kill traps. The Hammer has the potential to achieve Class A status under the NAWAC guidelines, i.e. rendering an animal unconscious within 30 seconds. The Hammer trap also has the potential to kill target species other than stoats by modifying the trap entry. It is estimated that the trap would cost less than $100 with operating costs of approximately $0.10/kill.

Pen trials are required to optimise the tunnel design and triggering system of the proposed trap to increase the chances of a stoat entering the trap and successfully triggering it. For any trap system which is to be left unattended for extended periods, it is essential that an attractive long-life bait is available.

2.1.2 Ongoing research

Multiple kill-trap testing

This is the second phase of the work initiated above by Ian Domigan (Lincoln University) in the search for, and development of, a cost-effective automatic multiple kill-trap.

The Hammer trap is now at the stage of fine tuning the mechanism to ensure that the probability of the stoat entering the trap is high and that the striking mechanism will likely result in a lethal strike. Progress to date has focused on fine tuning the charge that activates the trap and ensuring that some of the components such as springs will not stretch over time and thus limit the success of the trap. Further trials will be conducted to ensure that the springs can withstand the loading placed on them. The disarmed trap has been successfully activated by a stoat, however, due to the scarcity of stoats, further trialling with stoats will not occur until February. In the interim, the trap will be tested with rats.

The date for completion of this project is May 2003.

A new kill-trap for stoat control

Ian Domigan (Lincoln Ventures, Lincoln University) aims to develop a simple cost effective kill-trap for stoats that complies with the draft NAWAC trap testing standards.

The original trap proposed was shelved because triggering became too complicated, and a complete re-design was done on a new concept.

The new trap has been developed and patented and has been released by the researchers for comment by DOC staff. Initial feedback has been very positive with suggested modifications now being incorporated in the version for wider release and comment.

The trap has a simple setting system and should work well for both rats and stoats. A larger version is being designed for other target animals. The trap has its own housing and is powered by a 40 kg spring, ample to kill both stoats and rats. The cost of the complete trap, including casing, is comparable to a Fenn Mark VI. The trap, including casing, weighs 810 gm and can be reduced to 500 gm if an aluminium casing is used. The trap is considered completely Kiwi safe in its current form, and can be vertically or horizontally mounted. Pen testing is planned for September.

This project will be completed by May 2003.

Trials to test a prototype kill-trap for stoat control

Malcolm Thomas (Pest Control Research Limited) has developed a cost-effective, compact and efficient kill-trap. This prototype trap is based on the principles of the Victor rat trap system, but has a steel base to increase robustness and heavier springs to increase the likelihood of a humane kill. The trap has been designed so that it can be used in the tunnels that are currently being used for the Fenn trap.

Preliminary testing to ensure that the trap will kill humanely (i.e. according to the draft specifications set by the NAWAC) has been undertaken with a limited number of stoats. Difficulties have been encountered in terms of catching enough stoats to test the prototype trap. However, of the four stoats tested all were rendered unconscious within 15 seconds and death occurred within one minute. This occurred with both head and neck strikes from the trap. Although only a few stoats have been tested the results to date are favourable in terms of meeting the NAWAC guidelines for humane kill-traps, as measures of the striking and clamping force far exceed those required to humanely kill stoats. Field trials will be conducted in collaboration with DOC staff who undertake stoat control, to ensure that the traps are practical to use in the field.

Work has also been carried out in terms of securing a manufacturer who is able to produce the trap at a suitable price. A cover has been designed to ensure the trap consistently strikes the stoat on the head or neck and this will be incorporated into the manufacture of the trap.

This project will be completed by June 2003.

Production of an alternative kill-trap for stoats

Phil Waddington has developed a prototype mustelid kill-trap (Waddington Back Cracker) as an alternative to the Fenn trap. This working prototype can be stored and carried in the field in a collapsed form (an average backpack can hold at least 30 traps). The trap is assembled on site and is easily set by pulling a cord, therefore ensuring operator safety.

Pen trials to test the effectiveness and humaneness of the trap will be undertaken later this year by Landcare Research. Once the trap has passed the pen trials it will be tested in the field.

This project will be completed by June 2003.

Self-resetting mustelid eradicator

Frank Greenall and co-worker Keven Johnston have been funded to develop a cost-effective, humane, self-setting/self-clearing mustelid kill-trap. Preliminary testing has indicated that the device will be able to deliver approximately 20–25 humane kills before resetting is required. The trap will be elevated to avoid trapping ground-dwelling native birds. This trap would result in cost efficiencies by reducing the labour cost involved in resetting traps.

This project will be completed by September 2002.

Pilot project for the collation and exploration of data from DOC stoat trapping operations across New Zealand

Jenny Christie, along with Ian Westbrooke and Elaine Murphy (DOC), has initiated a pilot project exploring data from stoat trapping operations across New Zealand. The primary aim of this project is to identify factors that may be useful for catching more stoats, and therefore result in more efficient use of resources. This work will build on analyses already undertaken at some trapping operations. For example, the work undertaken by Barry Lawrence and Bruce McKinley with respect to the measurement of micro-site characteristics such as habitat type, aspect and distance to water, at individual trap locations (this work was summarized in the previous stoat report). Analyses on bait and trap types carried out for the mainland island projects at northern Te Urewera and Rotoiti Nature Recovery Programme are other examples.

Stage one of this pilot project will identify all DOC stoat trapping operations around New Zealand, and then select potential operations with suitably detailed data for exploratory statistical analysis. Ideally, the selected data sets should contain information from each time a stoat trap is checked, particularly whether a stoat was caught or not. The availability of GPS data for each trap will also be taken into account when selecting potential data sets.

Stage two of the pilot project will involve exploring the selected data sets. Trap catch data will be analysed along with information on other factors, such as site characteristics, trap specifications, time of year, and any other factors already collected or identified as useful. Patterns both within and between data sets from different sites will be looked for.

This project will be completed by October 2002.

Evaluating a low intensity stoat control regime on large inshore islands

Graeme Elliott and Murray Willans (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.

In some areas on the mainland, it is possible to reduce stoat densities to levels low enough to support some relatively endangered species. Therefore it follows that the same techniques will reduce stoats to even lower densities on large inshore islands where the stoat re-invasion rate is low. Resolution and Secretary Islands are the two largest inshore islands that are entirely managed by DOC and both currently have stoats present. If they could be managed in near stoat-free states, they could support viable populations of some of our most endangered species.

Modelling is one way of estimating the rate at which stoats can be killed against the rate of invasion of these islands. However, a pilot trial ‘eradication’ of stoats from medium-sized islands at similar distances from the mainland provides an empirical test of this approach, without the considerable expense of attempting eradication on either of the large islands. Monitoring would have to continue through at least one beech mast cycle.

Access to islands is never easy. In Fiordland the inflatable is indispensable. *Photo: Elaine Murphy*

Anchor Island has neither mice nor rats and was identified as a suitable island for the first stage of this project. An eradication plan for Anchor Island was prepared in June 2000. Implementing the eradication plan required a network of tracks to be cut, a trap line laid and pre-baiting to be undertaken. Trapping was initiated in July 2001 and 19 stoats were successfully trapped. The traps were next checked in November 2001 with another three stoats captured. No stoats have been captured on Anchor Island since November 2001 which indicates that the intensity of trapping is appropriate. If any females were left on the island after November 2001 it is expected that they or their young would have been caught in the following summer (February 2002). 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.

Now that the eradication technique has proven to be successful with Anchor Island, the last stage of this project will be initiated—the eradication of stoats and implementation of an ongoing low-intensity trapping regime on Bauza Island. Bauza Island is approximately 400 ha and lies near the entrance of Doubtful Sound. It is closer to the mainland than Anchor Island and therefore, provides a better opportunity to test the ongoing low-intensity trapping programme as a means of sustained stoat control.

The results of this project will have implications for managing larger islands such as Secretary and Resolution in the future.

This project will be completed by June 2004.

2.1.3 New research funded for 2002/03 (Year 4)

Comparison of three stoat trapping set designs

Rhys Burns (DOC) will undertake a one year project to compare 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 to be tested, two are conventional (wooden tunnels and wire cage tunnels) and one is more unconventional (buried corflute tunnels). The field testing will be carried out in northern Te Urewera National Park in areas where the highest number of stoats was trapped during 2001/02. The trap sets will be grouped within a 5 m radius in 150 different groups at 150 m intervals along ridges, streams and spurs. All sets will use Fenn traps (Mark IV) with a white hen egg as a lure. The lures will be replaced four-weekly.

This project will be completed by June 2003.

A stoat at night. *Photo: Peter Dilks*

2.2 BAITS, LURES, AND TOXINS

2.2.1 Research completed during 2001/02 (Year 3)

FeraCol® for stoat control

Jeremy Kerr (Feral R&D Limited) and Dr Andy Lavrent (Immuno Laboratories) along with Eric Spurr, Cheryl O'Connor, and Andrea Airey (Landcare Research) looked at the effectiveness of a long-life bait which they have developed. The non-toxic bait palatability trials were encouraging as all stoats in the pen trials ate some of the bait. However, in the paired bait trials more hen eggs were eaten than bait. Only two stoats out of 26 ate more than 20 g of bait per day whereas all except one stoat ate more than 20 g of egg per day. All the stoats in this trial were male, so any future trials would need to look at bait consumption by females.

Sixteen formulations were trialled at the Landcare Research facility at Lincoln. Pen trials were undertaken to test the most palatable bait formulation containing a lethal dose of the toxin cholecalciferol. In this efficacy trial, stoats ate an average of 5.5 g of toxic bait, compared to 10.6 g of non-toxic bait per day in the final bait palatability trial. It is possible that the stoats detected the cholecalciferol in the bait, or that the cholecalciferol caused the stoats to stop feeding before they ingested a lethal dose. It is known that this toxin causes bait aversion in rodents, and in possums bait consumption declined when cholecalciferol concentration approached 0.8%. Despite the low bait consumption, the results of the efficacy trial were encouraging and were consistent with the results obtained in previous efficacy trials with cholecalciferol in hen eggs. In the present trial stoats died after they had ingested an average of 43 mg of cholecalciferol whereas stoats that survived ingested an average of only 17 mg of cholecalciferol.

The study concluded that in order to increase stoat mortality either the palatability of the bait, the level of synergist or the concentration of cholecalciferol in the bait would have to be increased. The first two options are preferable as cholecalciferol is expensive and an increase in concentration may make the bait less palatable to stoats.

Paired trial of long-life stoat baits in a northern coastal environment

Nigel Miller and Pete Graham (DOC, Northland) compared the use of fresh rabbit with freeze-dried rabbit as bait in Fenn traps at two different locations—Mimiwhangata and Whananaki. Previous experience had indicated that baiting traps with fresh rabbit meat was more effective in warmer climates than baiting with hen eggs. However, the baiting of traps with fresh meat is labour-intensive, as the meat rapidly deteriorates and has to be replaced. The aim of this study is to determine whether fresh meat can be preserved (through a freeze-drying process) and yet still retain its attractiveness. For warmer climates this would present a more cost-effective means of controlling stoat numbers.

Both the total numbers caught and bait preference varied between the two study sites for stoats and total mustelid species combined (ferrets, weasels, and stoats). At Whananaki, where most mustelids were caught, significantly more mustelids preferred freeze-dried rabbit to fresh rabbit. Stoat captures mirrored

TABLE 1. THE NUMBER OF DIFFERENT MUSTELID SPECIES CAUGHT ON TWO DIFFERENT BAIT TYPES AT TWO DIFFERENT SITES IN NORTHLAND.

Significance levels (*P*) were calculated using Binomial approach (2-sided). * = significant; ** = highly significant; ns = not significant.

	MIMIWHANGATA				WHANANAKI			
	FREEZE DRIED RABBIT	FRESH RABBIT	*P*	SIG.	FREEZE DRIED RABBIT	FRESH RABBIT	*P*	SIG.
Stoat	0	5	0.06	ns	15	7	0.13	ns
Weasel	2	6	0.29	ns	10	2	0.04	*
Ferret	–	–	–	–	3	2	1.0	ns
Total	2	11	0.02	*	28	11	0.01	**

this result, but were not statistically significant. This trend was reversed at Mimiwhangata, where mustelid species preferred fresh rabbit (Table 1).

The difference in bait preference between Mimiwhangata and Whananaki may be a factor of the different checking and re-baiting regimes between the two sites. At Whananaki the traps were checked and re-baited weekly, and mustelids caught with fresh bait were more decayed when the traps were checked than those caught on freeze dried bait. This implies that the mustelids caught with fresh bait were caught soon after re-baiting, suggesting that mustelids prefer fresh bait when it is freshest, but that freeze dried bait will catch over a longer period of time. This result may explain why, under the more frequent, twice weekly trap checking and bait changing regime at Mimiwhangata, most mustelids were caught on fresh bait.

Other differences between the two study sites may have influenced the difference in catch rates. For example, the area trapped at Mimiwhangata is smaller, has a greater trap density, has a longer trapping history, and uses different trap covers than Whananaki. The differences in bait preference between the two sites may need to be explored further, and extrapolation of these results to other sites at this stage would be inappropriate.

Comparison of hen eggs, freeze-dried laboratory mice and freeze-dried feral rats as lures for trapping stoats

Rhys Burns and Pete Shaw (DOC, Opotiki) undertook a study to compare white hen eggs, freeze-dried laboratory mice and freeze-dried feral rats as lures for a trap-based stoat control programme in the northern Te Urewera National Park. The trial was conducted over the period of September 2001 to May 2002. A total of 845 tunnels, each containing two Mark VI Fenn traps, were arranged at 150 m intervals along ridges, spurs and streams over the 4500 ha study area. Each tunnel contained one of the three different lures (the order of the lures was randomly allocated for each trap line). Generally the traps were checked fortnightly and lures replaced six-weekly (although the periodic replacement of freeze-dried mice lures was highly variable due to supply shortages at different times during the season).

Over the duration of the study, a total of 205 stoats were caught with 45% caught in traps lured with hen eggs, 32% in freeze-dried rat lured traps and 23% in traps with freeze-dried mice as a lure. In summary, eggs as a lure consistently caught more stoats than the two other lures tested. Age structure and sex analyses have yet to be undertaken to determine whether there is any correlation between these parameters and lure. The most significant by-catch was rats, where the freeze-dried mouse lure caught 52% of the total rat by-catch (total = 562).

Outcome monitoring of resident kiwi resulted in one of the four kiwi chicks, monitored from hatching, surviving to over 1000 g.

Control of stoat dens with magnesium phosphide (Magtoxin) after locating with trained dogs—a pilot study

Scott Theobald and Natasha Coad of DOC, Northland investigated the effectiveness of 'Magtoxin' as a method of killing stoats in natal dens at Trounson Kauri Park. The pellets of Magtoxin (Magnesium phosphide) produce a poisonous gas that has been shown to be effective against burrowing pests. Trounson Kauri Park experiences an influx of young stoats (many of which appear to be reared locally) during the summer. A mustelid control programme has been undertaken in the Park for the last five years to protect the young kiwi chicks that are particularly vulnerable to stoat predation. While this project of poisoning dens would not negate the need for mustelid control during the summer, it has the potential to significantly reduce the numbers of young stoats entering the area.

The contents of one den: a female stoat, her kits, and a half-eaten kiwi chick. The nest was lined with kiwi feathers.
Photo: Natasha Coad, DOC

This study successfully demonstrated that stoat natal dens could be located by trained dogs. In the spring of 2001, 15 stoat dens were located in and around Trounson Kauri Park by specially trained dogs. The pellets of Magtoxin (Magnesium phosphide) produce a poisonous gas that has been shown to be effective against burrowing pests. However, this technique met with mixed success because of the location of the dens and the inability to seal the dens completely.

This pilot study has lead to a new two-year investigation—see section 2.2.3.

2.2.2 Ongoing 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.

Tentative results have indicated that cracked eggs show a low-level response, which is consistent with the experience from some field trials where rabbit and hare bait are more effective than eggs. Rabbit, rat, mouse and sparrow have all shown promising results in terms of their attractiveness to stoats. Whole animals have been offered so that all sources of possible odour are present. Further trials have indicated that flesh and gut were more attractive than skin. Tests using dried pet food indicated that this material held no attraction for stoats.

A series of lure attractiveness trials which included whole prey odours, two novel odours (fish head oil and canned quail eggs) and a range of prey-based odours have been tested and assessed on captive stoats. The promising odour materials are currently being tested in various edible bait and long-life lure formulations. Trials to date have confirmed the attractiveness of rodent, rabbit and sparrow. Rabbit and mouse are being used as the active ingredient for further bait trials 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. The lack of attractiveness of highly processed forms of prey or any single chemical prey odours confirmed the findings of previous studies. Spirulina is of interest both for its green colour (indicating a poisonous bait) as well as its attractiveness. With respect to fish oil, the small pen for the trials proved unsuitable for testing this product as its strong smell tainted the whole pen. This odour needs to be re-tested in the field. Colostrum was not attractive. Male anal sac secretion may have potential. Both freeze-drying and salting may be suitable means of preservation but the trials to date have indicated that their attractiveness is reduced as a result. Promising results were found in the tests for attractiveness and palatability of chewable or edible baits based on recipes used for other mammals (e.g. wax/tallow, and gelatine/bran/wax).

In the final year of this project new chewable and edible formulations will be tested, and the most successful baits will be 'aged' and their palatability re-tested. It is intended that the most attractive lures will be field-tested on stoats at Lake Waikaremoana.

This project will be completed in June 2003.

Prey odours as lures for stoats

Andrea Byrom and co-workers Eric Spurr and Cheryl O'Connor (Landcare Research) are developing a prey odour lure encapsulated into a long-life, slow-release matrix.

To date four potential lure matrices, containing ground-up freeze-dried lab rats, have been developed. These are:

- A PVC matrix developed in the USA and created at Landcare Research
- A casein-based matrix, Albert®, developed by KiwiTech Ltd
- A gel matrix created by KiwiCare Corporation
- A pelletised meat-and-bone-meal developed by KiwiCare Corporation

The four lure matrices have been tested on 24 captive stoats in pens at the Landcare animal facility at Lincoln (including 8 females). Video footage of 15 of the 24 stoats has also been analysed in terms of the behavioural responses of the stoats to each of the four lures.

Open-air trials have been carried out to determine the longevity of all four lures. This is important in ascertaining which lure would be the most suitable as a long-life bait in the field.

From the preliminary results obtained the Albert matrix looks promising in terms of attractiveness to stoats; the PVC lure has greater longevity in the field and also looks very promising. These two lures will now undergo further investigation in terms of getting the right combination of 'longevity' and 'attractiveness'.

Liquid odour compounds, extracted from around the headspace of live ship rats, have been analysed by AgResearch and a report provided to Landcare Research on the main chemical odour compounds present. Additional funding has been obtained to incorporate this 'liquid' odour (identified by AgResearch and available 'off the shelf') in the two most promising lure matrices and to test it on captive stoats at the Landcare Research animal facility. This will mean that the two most promising lure matrices will be tested with both freeze-dried ship rat as well as 'liquid' ship rat odour compounds.

This project will be completed by June 2003.

Toxic micro tabs and a bait for stoats

Jeremy Kerr (Feral R & D Ltd) has developed two micro sized toxic tablet formulations (tabs). Plans are underway to trial them with lethal doses of 1080 and Zinc Phoshide, for the control of stoats. It is envisaged that the 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. A lure based on rabbit to attract stoats to the bait, is also being developed.

This project will be completed by February 2003.

Development of a new toxin for stoat control

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. In conjunction with the Victorian Department of Natural Resources and Environment (Australia) and DOC, a promising toxic compound which mammalian predator species may be highly susceptible to (designated 'Mustelid New Toxin' MNT for confidentiality) is being developed for use in baits for mustelid control. Initial results indicated a lethal dose of MNT to be less than 25 mg/kg in stoats and suggest that toxicosis is relatively humane and rapid. Penny Fisher and Cheryl O'Connor (Landcare Research) have built on these encouraging results and conducted dose-range-finding trials in stoats to derive a working lethal dose value for this species, which was 9.3 mg/kg. The project also reviewed the likely susceptibility of non-target species to MNT in baits prior to its further development as a new tool for stoat control. MNT may not be as predator-specific as hoped for and more non-target testing needs to be undertaken, especially on birds. This project addressed the first stage in the development of a new toxin for stoat control and has built a baseline of information about the efficacy and humaneness of MNT in stoats.

The project will now be completed in September 2002.

2.2.3 New research funded for 2002/03 (Year 4)

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

Kay Clapperton with co-workers Lloyd Robbins and Dick Porter will produce a multi-sensory stoat bait/lure system to attract bait-shy or trap-shy animals. Preliminary trials have indicated that the visual characteristics of baits are important determinates of bait attractiveness. The sensory cues to be tested would be those primary stimuli used by stoats in prey detection, i.e. vision, sound, and movement. These stimuli will be added to stoat lure/bait formulations to improve their attractiveness and/or palatability and acceptance. Bait consumption and video recordings will be used to assess the effectiveness of each lure or combination of lures. In terms of the olfactory material used in the bait this will be limited to a small range (probably rabbit or mouse) with a range of visual cues such as shape and colour along with sound and movement. Promising combinations will be replicated with enough stoats to allow statistical confidence in the results.

This project will be completed by June 2004.

Development of a long-life toxic bait control for stoats

Ray Henderson (Pest Tech. Ltd) and co-workers Chris Frampton and James Ross (Lincoln University) will build on previous work completed in 2001, on the development of a long-life toxic bait for stoats. To date, a prototype stoat bait has been developed which was eaten in moderate amounts by captive stoats. The 'hardness' of the bait was thought to be a factor that limited the amounts eaten by stoats. To enhance bait consumption this project will optimise the texture of bait, assess the effects of amino acids on bait palatability, attempt to further improve palatability by enrobing baits with animal extracts, and finally assess the shelf and field life of the baits over a 6 month period. The efficacy of baits containing a toxicant will then be tested on captive stoats. Initially the effectiveness of cholecalciferol (either in a resin or encapsulated form) will be assessed on a group of captive stoats. If this is not lethal to most animals (i.e. >90%), then encapsulated zinc phosphide will be assessed on a further group of stoats.

This project will be completed by June 2003.

Pen trials of small-volume toxic baits for stoats

Kim King (HortResearch, Ruakura) along with Murray Potter and Paul Barrett (Massey University) will investigate the reactions of captive stoats to lethal doses of 1080 presented in small (1–3 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 than it would be in a 1–3 g bait. The bait used will be one which is known to be acceptable in a non-toxic form.

It is intended that this study will be completed in June 2003, but the contract is still pending.

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

Scott Theobald, supported by Natasha Coad and Craig Gillies, will continue to build on the pilot study initiated last year to look at targeting natal stoat dens for control after locating with trained predator dogs and investigating den control techniques.

Phase Two of this project will determine the effectiveness of using trained dogs to locate stoat natal dens during the spring and summer of two stoat breeding seasons. Appropriate control methods will be applied to each den in an attempt to eliminate the juveniles before they become independent (Magtoxin, trapping or another method of control). The effectiveness of targeting stoat natal dens as a technique to supplement existing control operations will be assessed by analysing data from previous years mustelid control and kiwi chick survival rates.

As an aside, Scott Theobald and his specially trained predator dogs featured on the 'Park Rangers' series on TV One earlier this year.

This project will be completed by June 2004.

Scott Theobold and Tui, the stoat-sniffing dog.
Photo: Natasha Coad, DOC

2.3 ECOLOGY

2.3.1 Research completed during 2001/02 (Year 3)

The movement and diet of stoats in an alpine-beech forest habitat

Des Smith (MSc student) and Ian Jamieson (University of Otago) have completed their study of stoat movement, diet, and relative abundance in an alpine/beech forest habitat during a stoat outbreak.

Almost all of the ecological research on stoats in New Zealand has been confined to forest habitat, with little or no study of alpine regions. This study used live trapping, radio-tracking and tracking tunnels to examine the movement, diet and abundance of stoats above the tree line in tussock grassland and in the adjacent beech forest valleys in the Murchison Mountains, Fiordland during two consecutive summers of high stoat numbers. It sought to determine whether trapping in the adjacent, more accessible valley floors would impact on the alpine stoat population.

This study found that stoats, when within their home range, do not appear to move between the two habitat types of beech forest and alpine habitat. Therefore, trapping in the easily accessible beech forest is unlikely to protect takahe nesting above the tree line. Trapping in both habitats is probably necessary to protect takahe and other threatened alpine species from stoat predation.

Analysis of the diet from stoats in other areas of the Murchison Mountains, found that mammals (mostly mice) were the main prey item in beech forest. Interestingly, ground weta were a predominant food item in both habitats. This study found that as mice numbers declined, stoat switched to eating ground weta and not birds, as has been found in other studies.

Stoat abundance in alpine habitat exceeded that in beech forest in three different valleys in the Murchison Mountains during the summer of 1999/2000, following a record snow tussock mast (flowering). However, during the summer of 2000/01, which followed a weak snow tussock mast, stoats all but disappeared from the alpine habitat, suggesting that there was a numerical response to the earlier snow tussock mast. However, concurrent stoat monitoring work carried out by DOC in the nearby Eglinton Valley, showed a different pattern of stoat abundance over the same two years, when compared to the abundance of stoat inhabiting the snow tussock and beech forest in the Murchison Mountains. Therefore, conservation managers should not use any one site or habitat as a benchmark for estimating stoat abundance or cyclic dynamics over a whole area, or across ecotones.

This study has formed the basis of a thesis (refer to bibliography at the back of this report for details).

Quantifying stoat and rodent population parameters in podocarp/broadleaf forests for predictive modelling

Wendy Ruscoe and Andrea Byrom from Landcare Research initiated a project in September 2000 to investigate the interactions between ship rats and stoats and the dispersal and survival patterns of juvenile stoats in podocarp-broadleaf forest habitat.

Mike Elliott setting a stoat live-trap.
Photo: John Dowding

Mechanisms regulating the density of stoats in podocarp-broadleaf forests and their propensity to prey on key native bird species, are not well understood. Dietary studies implicate rats as an important resource for stoats, however the data linking changes in rat availability with stoat density are confounded by secondary poisoning of stoats during possum control operations. In addition, mechanisms driving variation in rat density in the absence of control are poorly understood, but may plausibly include food availability, predation, and the effects of social factors such as dispersal and territoriality. The density-dependent relationship between juvenile stoats and population density and the effect dispersal has on population regulation is unknown.

Live trapping was used to measure the density of ship rats and tracking tunnels were used to measure the abundance of mammals (stoats and rodents) within Tongariro Forest. The study found very few animals to be present on any of the grids prior to the control operation—although the tracking tunnels were not baited with meat. The number of trapped animals declined to zero after the poison operation and only one tracking tunnel recorded footprints following the control operation. As a result of the low densities of rats and stoats, no conclusions could be drawn with respect to their interactions within a central North Island podocarp-broadleaf forest.

Six juvenile stoats were radio-collared in the Tongariro Forest in the 2000/01 field season. Four survived for more than a few weeks and three survived until the autumn (March 2001). None of the radio-collared juveniles moved more than one kilometre from the point at which they were trapped. For the 2001/02 field season the study area was moved to Erua Forest because of the low numbers present in Tongariro Forest. However, no juveniles were radio-collared at Erua Forest despite the fact that one adult female was radio-collared there. These results suggest that at low stoat densities, juvenile survival is high and that little long-distance dispersal occurs. However, this would need to be verified by larger sample sizes.

Due to the low numbers of rats and stoats tracked at Tongariro, the small sample sizes of juvenile stoats radio-collared, and the lack of adult females captured in either field season, a decision was made to discontinue this research. The project on stoat dispersal has been transferred to South Island beech forest (refer to research summary under 2.3.3 New research funded for 2002/03).

2.3.2 Ongoing research

Ecology of stoats in a South Island braided river valley

John Dowding (DM Consultants) and co-worker Mike Elliott are studying the ecology of stoats in the Tasman River valley, Mackenzie Basin. South Island braided rivers, such as this, provide important breeding habitat for a number of threatened endemic ground-nesting birds such as black stilt, wrybill, and black-fronted tern.

Live-capture and radio-tracking of stoats in and around the Tasman River is being undertaken to gain information on stoat home range size, activity patterns and habitat preferences. Radio-tracking is being done during a 3-month period in spring–early summer (when the shorebirds are breeding) and again in autumn–early winter (when the shorebirds are absent). Some problems have been experienced with transmitter life in the bouldery environment of the riverbed; however, good data have been collected, as animals could often be re-trapped and fitted with new collars when necessary.

Results for the 2001/02 radio-tracking sessions have indicated that stoat density in the Tasman Valley was considerably lower than in the corresponding periods in 2000/01. In addition, survival during the autumn 2002 session was low, with half the study animals dying during the 3-month session. However the reason for this is unknown as rabbits and birds (the bulk of the diet) were not scarcer in the second year and the weather was not noticeably more severe. Productivity and survival of stoats in surrounding areas may have been lower in 2000/01, resulting in lower rates of migration of juveniles into the valley in 2001.

As in the previous year, home ranges were similar in size between the spring and autumn sessions. Range sizes appear to be within the limits found in other studies in different habitat types in New Zealand. Stoats were found to be generally evenly spread throughout the area with no obvious 'hot spots' and no large areas where they were absent.

As in 2000/01, rabbit numbers were low (RHD was introduced to the study area 3 years earlier) and rodents also appeared to be scarce for much of the year. Scat and den contents have been collected and preliminary analysis indicates that stoats exploit a wide range of prey in this system. Lagomorphs (rabbits and hares) and birds form the bulk of the diet, with other items including invertebrates, mice, hedgehogs and fish. It appears that moderate–high densities of stoats can persist in spite of the lowered rabbit densities.

Remains of eggs, chicks, or adults of pied oystercatcher, banded dotterel, spur-winged plover, wrybill, and black-fronted tern have all been found in dens, indicating that stoats in this area are having a substantial impact on breeding shorebirds.

Stoats sharing dens consecutively (i.e. not at the same time) have been recorded in both sessions, indicating that interactions between stoats may be much more common than previously thought. While males and females are known to interact during the breeding season, this study has also found examples of males using a common den site consecutively in spring, and males and females using them consecutively in autumn (i.e. outside the breeding season). These findings have implications for the transfer of potential biocontrol agents.

In the first year of this study consecutive den sharing by stoats and ferrets was also detected. To investigate this further, ten additional ferrets were radio-collared in the second year of this study. A few further examples of consecutive den sharing between the species were recorded, but many of the ferrets had ranges that did not overlap with stoat ranges. One male ferret had a range over 12 km in length.

Fieldwork for this project ended in June 2002; detailed analysis of diet samples and home range data will be completed in December 2002.

Effect of reducing possum densities on ship rat and stoat abundance

Peter Sweetapple and Graham Nugent (Landcare Research) are looking at the effects of possum control on ship rat and stoat abundance. Periodic aerial control of possums on five to seven year cycles (either for Tb control or conservation management) is the most common management regime on land administered by DOC. 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 and presumably stoats can recover from any direct effects of poisoning within a year. However, there is some evidence that decreased possum numbers allow rats and perhaps stoats to reach much higher densities than before the 1080 control. For example, at Pureora the density of rats after 1080 control was three times higher than pre-control densities. This increase may be due to a reduction in competition from possums for fruit and seeds.

Questions which need to be answered are:

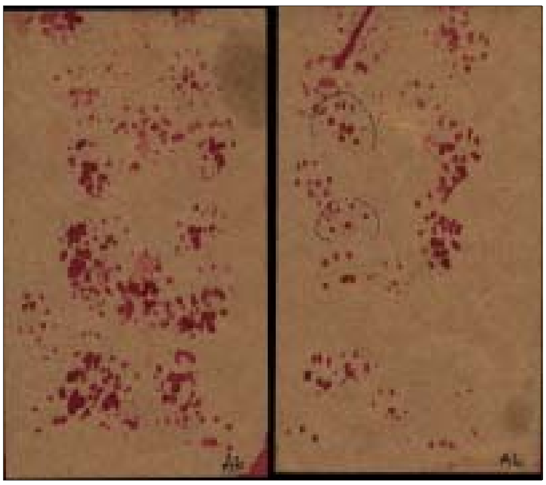
- Do rats and stoats increase as a consequence of reduced possum density?
- If so, how long does the effect last?
- What are the causes of changes in rodent and stoat numbers?
- What are the benefits and losses of fewer possums but more rats and stoats?

This study will address the first two key questions.

Two study sites have been 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. Possum control reduced possum abundance to a residual trap-catch of 8.5% which was higher than the anticipated <5% residual trap catch. However, it was noted that the residual trap catch varied from 0–17% over the 10 individual transects which may prove useful for testing the possum-rat competition hypothesis. Rat abundance has increased four-fold at the Okahu possum control site since June 2001 while it declined by more than 50% at the Whirinaki non-treatment site, although abundance was low at both sites throughout the year. Stoat abundance fluctuated during this period.

Tracking papers showing rat footprints.
Photo: Craig Mumme, DOC Ruapehu



The second study area (Mokau) was established in February 2002 and animal abundance before possum control was similar in both the possum control and non-treatment sites. Aerial control (1080) of possums at Mokau is planned for winter of 2002.

Work at the Okahu site will be completed by June 2004 while work at the Mokau site will be completed in June 2005 (this final year at the Mokau site will be funded by Landcare Research).

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

Craig Gillies and Peter Dilks (DOC Science & Research Unit) have been investigating whether a small change in the current protocol for using tracking tunnels to monitor rodents is all that is required to allow the same tunnels to be used to track mustelids. Ink footprint tracking tunnels are now commonly used at many mainland conservation sites to monitor the effects of pest control operations on rodent abundance. The abundance indices obtained can be directly related to rodent impacts on several native bird species. Since the technique does not impact the pest population it can be used for direct comparisons between managed and unmanaged sites.

Fraser Maddigan transporting stoat live-traps.
Photo: Peter Dilks

The same tunnels used to track rats (with peanut butter as bait) can also be used to track stoats (using meat bait) without any residual effects on rat tracking rates. However, because there are huge differences in the ranging patterns of stoats and rodents the currently accepted tunnel layout for rodents does not provide much in the way of statistically reliable information on stoat abundance beyond simple presence or absence. At sites where managers wish to monitor both rodents and mustelids it would be logistically much simpler if the same tunnels could be used to track both pests. A small change in the current design protocol for using tracking tunnels to monitor rodents may be all that is required to allow the same tunnels to be used to track mustelids.

Tracking tunnel indices for mustelids using the trial layout were compared against live trapping indices of mustelids at several sites around New Zealand. Mustelid tracking rates were recorded in the North branch of the Hurunui, at Craigieburn, in the Hollyford and at Waimanoa immediately following (or in some cases prior to) ten-day live trapping sessions. The results from the field surveys conducted during 1999–2001 revealed that high mustelid tracking rates in the tunnel surveys corresponded with large numbers of stoats caught in the live traps. Conversely, lower tracking rates corresponded with very few mustelids caught in the live traps. The seven field surveys conducted during 2001/02 indicated that 'mid-range' mustelid tracking rates in the tunnel surveys corresponded with 'mid range' (for our data) numbers of mustelids caught in the live traps. Based on results to date, tracking tunnels can be used to monitor both rodents and mustelids. For stoats (and possibly other mustelids) the index should be considered as a very basic management indicator and at best as a coarse index of mustelid abundance. The fieldwork has now been completed and the data is now being fully analysed. The conclusions above should be considered as interim and with due caution.

Data analysis and write up will be completed by June 2003.

Modelling the immigration rate of an island stoat population

Graeme Elliott and Murray Willans (DOC) have initiated 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.

Predator-free islands are important in the conservation of some of our most endangered species and while many of the islands in this study are too small for this purpose, the information obtained will enable the likely re-invasion rates of larger islands by stoats to be estimated. While it is impossible to permanently eradicate stoats from these islands, if re-invasion rates are low and stoat control efficient, such islands (although within swimming distance for stoats) may be safe enough to support key endangered species.

DOC boat m.v. *Renown* in Fiordland. *Photo: from the DOC collection*

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.

Twenty-eight islands in Doubtful, Breaksea, and Dusky Sound and Lakes Te Anau and Manapouri were 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.

From the most recent trap servicing, rats were found on Elizabeth Island (Doubtful Sound) for the first time in this study and a stoat was captured on Shelter Island (Doubtful Sound) for the first time. No stoats have been detected on Anchor Island (since the stoat eradication operation—see section 2.1.2) although one stoat was trapped on an island at the North East end of Anchor Island and this is significant as it probably swum there from Resolution Island.

To date this study has confirmed anecdotal 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 is being undertaken by Nigel Barlow (AgResearch) and implements one of the recommendations from the review of modelling carried out in 1999/2000. Initially, this project was based on kill-trapping data and was due to finish in 2002, however it has been extended for a further two years to include the live-trapping data from studies currently being undertaken in the Tasman Valley (John Dowding), and from live-trapping work being undertaken by DOC at three forest sites (Hurunui, Craigieburn, and Pureora).

Establishing the extent and nature of density-dependence is vital to any model-based assessment of the relative effectiveness of different controls. The extended modelling project will use the data gathered from live-trapping investigations to improve the stoat population models currently developed which were based on kill-trapping data. The project will also recalculate the assessments of the likely impacts of controls. A spatial version of the model will be developed using data on dispersal obtained from the Tasman project to address the critical question of control effectiveness as a function of area controlled.

Results to date using kill-trap data have indicated 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 immunocontraception, 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 work could eventually be extended to apply to the evaluation of all controls (traditional and novel).

The project has been extended (to include new data based on current work) and will now be completed in 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 species of pest mammals (rodents, mustelids and possums) at the five kiwi sanctuaries and two non-management areas adjacent to kiwi sanctuaries. The focus of kiwi sanctuary management is the control of cats and mustelids through intensive trapping, coupled with public education/ advocacy on other threats to kiwi such as straying dogs. The success of this approach will be measured by the increase in survival rate of kiwi chicks following pest control.

Though predation of kiwi chicks and adults poses an immediate threat to kiwi, the medium to long-term viability of kiwi populations is likely to depend upon the healthy functioning of the biological communities in which they occur. The impact, both direct and indirect, of pest species such as possum, pigs, hedgehog and even rats may increase once the primary threats are controlled. Thus success in controlling one pest mammal population may lead to an irruption in another.

This project will monitor the abundance of pest mammals as well as monitoring the nesting success of birds such as tomtit and fantail (which are primarily threatened by predation, and possibly competition with, rats and possums). 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 is intensively managed?

To date, rodent and mustelid monitoring lines have been established at all 7 sites, and 2–3 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. It is expected that it will take several years of data collection before patterns of change in mammal populations can be attributed to any of the potential controlling factors. Data on general bird abundance was also collected at each site, though the identification of passerine nesting attempts to determine breeding success and causes of failure was less successful.

The project currently relies on routine possum monitoring carried out by Conservancies, however trials of hair-based presence/absence possum index will be initiated shortly and this will then be compared directly with established techniques.

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 Peter Dilks, Elaine Murphy and Fraser Maddigan (DOC) will establish and maintain a network of permanent standardised tracking tunnel lines at a range of sites throughout New Zealand to determine the relationship between stoat and rodent indices of abundance over time and at different stoat and rodent abundance. These tracking tunnel indices will also be calibrated against standardized snap trapping and live trapping indices of rodent abundance at a selection of sites throughout New Zealand.

The results of this work will have a direct benefit for conservation areas that are actively managed. Currently, the nature of the relationship of stoat and rodent (particularly rat) abundance is poorly understood and based largely on untested predator-prey models. In areas where stoats are the only predator controlled, as in some kiwi protection areas, the response of this decrease in stoats may be an increase in rodents (particularly rats) and if this is the case then the overall conservation benefit of the predator control work may be reduced. Conversely, sustained reduction in rodent abundance over time may lead to a localised reduction in stoat abundance in some areas.

Craig Gillies checking a stoat.
Photo: Natasha Coad

This study will determine the effect of stoats on rodent abundance and vice versa (the effects of rats on stoat abundance). If the effects are small then the ecosystem impacts are also likely to be small. However, if there is a large effect, i.e. a large increase in rodents (particularly rats) following the control of stoats then this will be detected using standardised tracking tunnel surveys. Conversely, the use of tracking tunnels should also indicate if areas of high rodent abundance also have higher abundances of stoats (and vice versa).

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

2.3.3 New research funded for 2002/03 (Year 4)

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

Andrea Byrom (Landcare Research) will conduct a two year project looking at the dispersal and survival patterns of adolescent stoats at Criagieburn beech forest in the South Island. This project was started in Tongariro Forest in September 2000, but due to small sample sizes of stoats captured, was transferred to South Island beech forest.

Andrea Byrom placing a stoat live-trap at Craigieburn. *Photo: Caroline Thomson, Landcare Research*

While stoats are known to move over long distances in search of prey, anecdotal evidence suggests that juvenile stoats move even longer distances during dispersal and that there is high juvenile mortality in areas of high stoat density. Therefore, a better understanding of the survival and dispersal of juvenile stoats is very important in terms of management of areas to protect indigenous species. Intensive mustelid control may serve to reduce the population to low density, thereby making it an attractive area for re-invasion by juvenile stoats during dispersal. Detailed information about juvenile dispersal can assist management of an area by optimising the timing and intensity of control after the initial removal of resident stoats, the size of control areas and the buffer areas needed to provide ongoing protection of indigenous wildlife.

Mountain beech in Craigieburn forest masted (flowered) in early 2002. It is expected that rodents and stoats will respond to this seed-fall in spring and summer of 2002/03. Therefore, stoats should be present in high densities in 2002/03 and in lower densities in summer of 2003/04, allowing the comparison of dispersal and survival of juvenile stoats in a mast year (high stoat density) and a non-mast year (lower density of stoats).

The timing and distance of natal dispersal will be measured by radio-tracking young stoats caught near their natal dens. The results from the radio tracking data will provide information on the survival of juvenile stoats, the timing and distance of dispersal from their natal dens and will determine the relationship between natal dispersal of juvenile stoats and stoat population abundance.

This project will be completed by June 2004.

Dispersal of juvenile stoats in the Mackenzie Basin

John Dowding (DM Consultants) and co-worker Mike Elliott will be studying dispersal of juvenile stoats in the Mackenzie Basin. Very little is known about the distances young stoats disperse and the timing of dispersal, partly because studying dispersal in stoats is difficult. If kits are caught while dependent or in dens (i.e. the young are of precisely known origin), they are too small to carry radio-collars. If they are caught when independent, and large enough for collars, they may already have dispersed.

Trapping and collaring of females will be undertaken in winter and they will then be monitored through pregnancy to locate the natal dens. While still dependent, kits will be ear-tagged. When they are larger, as many of these kits as possible will be trapped, fitted with collars, and radio-tracked to obtain data on

Tasman River, Mackenzie Basin. *Photo: John Dowding*

distance and timing of dispersal. Some data on juvenile survival during the early phase of independence should be gathered at this stage.

The tracking tunnel lines set up in the study area for the investigation on the 'Ecology of stoats in a South Island braided river valley' (see section 2.3.2) will continue to be run to index rodent, mustelid, and hedgehog densities. Spotlight counts for rabbits will also be continued. Together, these should show up any gross annual differences in prey availability in the study area that might influence stoat dispersal. The tracking tunnels will also provide another index of stoat abundance (in addition to the live-trapping index).

Improved knowledge of stoat dispersal has obvious implications for the size of control and buffer zones around sensitive areas and for the timing of stoat control. Knowledge of dispersal would also assist in estimating the rate at which stoats might spread in newly colonised areas (e.g. on islands). Information on juvenile survival will assist in modelling stoat population dynamics.

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

Des Smith (Otago University) will build on his recent research which has shown that stoats can be resident in alpine grasslands during the summer months and that stoats in the valley floor and alpine habitats appear to be insular in their relationship to each other (Des Smith, unpublished MSc thesis). Stoat populations are resource dependent, and in particular respond numerically to increased densities of mice and invertebrates that result from heavy beech mast (seed-fall) events. Alpine grasslands (*Chionochloa* spp.) also show a strong annual variation in flowering, with seed production being exceptionally high in some years relative to others (in general snow tussock flowering years correspond with beech masts). Some insects also show a strong numerical response to snow tussock masting, 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
- Use trapping grids to impose perturbations on resident stoat populations with the aim of providing information for designing more effective strategies for stoat control in alpine grassland and beech forest habitat

The Borland Valley (south-eastern Fiordland), near Takahe Valley has been identified as 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. This research will form the basis of a PhD.

The Borland Valley is also the site of an associated study 'Inter-annual variations in pest densities in alpine grassland and strategies for limiting pest effects' being undertaken by Landcare Research.

This project will be completed by September 2005 and will be funded by the Science & Research Unit after June 2004, when the stoat programme ends.

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 response to the production of seed in periodic masts (responding to high temperatures in the previous summer) exhibited by alpine tussock grasses (*Chionochloa* spp.). As in forests where rodents increase in numbers in response to masting, mammalian pests may also respond numerically to these seeding events 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 how abundance of these mammals in the alpine zone and in adjacent beech forest related to temporal variation in fruiting of beech trees over the same period
- Determine whether there are periods of potential heightened threat to native species in the alpine zone as a result of the above

This study is co-funded by Science & Research Unit, DOC, Wellington, and STAG.

This project will be completed by June 2004.

2.4 BIOLOGY

2.4.1 Research completed during 2001/02 (Year 3)

Review of potential 'Achilles' heel' characteristics of the stoat

Clive Marks (sub-contracted by the Pest Animal Control Cooperative Research Centre, Australia), has undertaken a review to find possible Achilles' heel characteristics of the stoat. This type of review attempts to identify anomalies in the pest that could lead to the development of highly targeted methods of control.

Predation by the stoat (*Mustella erminea*) is a major threat to indigenous New Zealand wildlife. The stoat is phylogenetically divergent from New Zealand's endemic animal groups. Significant phylogenetic divergence between groups of fauna may produce equally divergent behavioural, physiological, and biochemical characteristics compared to indigenous or endemic species.

Identification and exploitation of such anomalies represents a unique opportunity to produce species-specific control techniques and strategies for the control of exotic pest species. Existing studies suggest that the stoat red blood cells (RBC) may be susceptible to methaemoglobin (MetHb) forming compounds that birds are highly tolerant of. In addition, it appears that some carnivores maintain unusual monovalent ion (Na^+ and K^+) concentrations in their RBC's and lack Na^+ membrane pumps. These species maintain an unusual transport system that could be selectively activated by certain chemicals. Opportunities may exist to predispose the stoat RBC to oxidative stress and increase the target-specificity of certain MetHb forming compounds. Additional strategies to do this may include means to inhibit hexokinase and glucose-6-phospate deydrogenase in the RBC.

The small body weight of the stoat implies that actual LD_{100} doses of some toxicants may be well below that which may cause harm in non-target species. Even if the stoat is less sensitive to some toxicants than other species, its low weight may be the most important factor in considering the relative target-specificity of a toxicant. Its weight, body shape and high metabolic rate contribute to its potential susceptibility to agents that can cause lethal hypothermia. Brown adipose tissue thermogenesis is a mechanism exclusive to mammals and essential for thermoregulation in cold adapted species. Compounds that cause rapid hypothermia are likely to be most potent in cold adapted small mammals and ineffective in birds. A mechanism to selectively increase metabolic rate in some carnivores, which may predispose them to 1080 toxicosis, is also considered.

The breeding cycle of the stoat is highly seasonal and the species maintains an unusually long period of embryonic diapause. Dopamine (DA) agonists have the potential to terminate pregnancy, whilst potent DA antagonist may be appropriate for disrupting diapause. A two month window of opportunity where birds are not reproductively active could be exploited to bait deliver DA antagonists. A range of delivery systems for toxicants and anti-fertility agents that use the short gastro-intestinal passage time of the stoat and differential bite force and particle size ingestion should be further examined.

Summary of recommendations

- Agents that are known to cause selective haemolytic anaemia and/or the formation of MetHb in carnivores should be investigated as bait-delivered toxicants. Sub-lethal dose response trails in stoats and non-target species could be undertaken to assess relative selectivity.
- The unique monovalent ion balance and Ca^{++}–Na^+ transport in the RBC of carnivores are potential targets for subjecting the RBC to stress whilst under an oxidative assault. Both mechanisms should be further examined with the objective of determining likely compounds that could be used to selectively disrupt or activate their function.
- Resiniferatoxin shows potential as a highly mammal specific means of inducing lethal hypothermia in stoats by inhibiting BAT thermogenesis. Larger mammals (e.g. domestic cat and dog) may be far less susceptible to effective doses used for stoat control given their larger size. Some anaesthetics that compromise the defence of body temperature may also be appropriate to further assess. A range of potential agents could be quickly assessed in trials using widely available species of similar size, such as the mink, that are held under controlled conditions.

- Elevation of basal metabolism may enhance the susceptibility of an animal to poisoning from fluoroacetic acid (1080). Species-specific elevation of basal metabolism has been demonstrated in another carnivore. While the mechanism has not been fully elucidated, it is appropriate to assess the potential for similar compounds to affect basal metabolism in the stoat.
- Bait delivered dopamine agonists may cause abortions and litter mortality post partum if consumed during pregnancy. However, dopamine agonists have a narrow window of usefulness and must be delivered to stoat populations when they are reproductively susceptible. Baiting will correspond to a time when many PBC bird species are reproductively active.
- A two month window of opportunity where baiting with dopamine antagonists can be undertaken corresponding to little reproductive activity in bird species. Preference should be given to this method of fertility control as it is likely to be highly target specific and less dependent upon critical timing of bait delivery. Preliminary trails should be conducted in closely related domestic species that uses embryonic diapause, such as mink, that has a known and consistent reproductive success in captivity. Trials should assess the relative potency, palatability and oral activity of various dopamine antagonists. Subsequent trials of promising agents should be conducted in wild New Zealand stoats either in captive trials or as trials that assess reproductive success after bait delivery, using control/treatment bait marker and recapture procedures.
- The development of selective toxicant and bait delivery techniques could be based upon differentials between bite forces, gastrointestinal agitation forces, passage time and particle size ingestion. However, some fundamental research on the comparative physiology of digestion in stoats and non-target species is required before practical technologies can be envisaged.

2.4.2 Ongoing 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 from 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
- To alter photoperiod (light-dark cycle) to examine control of oestrus, seasonal breeding and the prolonged 10-month period of embryonic diapause
- To develop techniques to assess and manipulate the reproductive state of stoats during oestrus and pregnancy
- To 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 stoat kit at approximately six weeks old. One of the first ever captive-born in New Zealand. *Photo: Grant Morris, Landcare Research*

A captive stoat breeding facility has been established at the Landcare Research Animal Facility. Six female stoats

The first ever captive-born stoat kits in New Zealand. *Photo: Grant Morris, Landcare Research*

were paired with males in breeding pens during October to December 2000 and one litter of two kits was produced from one of the six female stoats in the captive breeding trial. Mammary gland development in one of the other females indicated that a litter may have been carried near to term or born, however no evidence of kits was found. Breeding stoats in captivity is a first for the Southern Hemisphere.

During the 2001/02 breeding season, at least 10 of the 12 females in the trial came into oestrus and are believed to have been mated. This included the female kit that was born in captivity in October 2001. This kit was determined to be sexually mature and in oestrus at 6 weeks of age and allowed to mate. Kits from these matings are due to be born in October 2002.

Results to date indicate that there is no obvious effect of captivity on blastocyst survival (study continued through to 24 weeks after capture). Because blastocysts were still present after 24 weeks post capture, 4 females were held to determine whether blastocysts would successfully implant and result in the birth of live young. However, no kits were born and when two of the animals were euthanased, no implantation sites or blastocysts were detected. There were no differences in ovarian tissue and reproductive tract weights after different periods in captivity.

There is no published reference ranges for the blood haematologic parameters for stoats. Samples from 23 individuals indicated that there are no differences between blood parameters of freshly captured male and female stoats. However, the values did change during acclimatisation. In freshly captured stoats, white bloods cells were dominated by neutrophils and lymphocyte populations were depleted. This is indicative of stress. By week 12, the proportion of neutrophils and lymphocytes were more like those reported for other mustelids indicating that they had adjusted to captivity.

Enhanced day length trials have now begun with 12 stoats (6 male and 6 female stoats), along with matching numbers of control animals on normal day length. Results to date have not indicated any obvious change in behaviour or reproductive organ development. Maximal effects of photoperiod treatment are expected to be detected between July and September.

This project has been extended to investigate additional aspects of stoat reproduction including techniques to monitor female oestrus and male testicular activity, the monitoring of successful mating behaviours, trialling techniques such as ultrasound, CAT scan and faecal steroid analysis for determining pregnancy status, determining the fate of blastocysts in wild-caught stoats brought into captivity and investigating the implantation of melatonin to reduce the length of embryonic diapause.

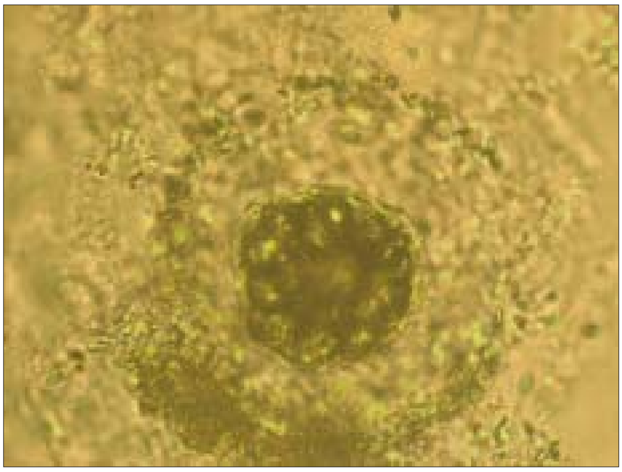
This project will now be completed by September 2003.

Stoat artificial reproductive technology

Andy Glazier and Frank Molinia (Landcare Research) are developing 'assisted reproductive technologies' (ART) for the stoat so that aspects of their reproduction may be controlled and manipulated in captivity to generate gametes, embryos/blastocysts and, ultimately, live young on demand. This information will significantly broaden our knowledge of the key features of stoat reproduction, and thereby assist in captive breeding and the future identification, development, and testing of unique reproduction-based targets for biocontrol.

The development of stoat ART is being undertaken in three broad parts. It will:

- Maximise the use of materials opportunistically available from wild-trapped stoats, to establish methods for collection and handling of sperm, eggs, embryos/blastocysts and reproductive tracts.
- Develop *in vivo* models of key reproductive events. A model for egg maturation will be established by developing oestrus synchronisation and/or ovulation induction of females. Primed females could then be used to generate embryos /blastocysts following either natural mating or artificial insemination. In this way, models of sperm maturation, gamete interaction, fertilisation and embryogenesis, occurring within the female stoat can be developed.
- Develop *in vitro* models of these processes. Given that stoats carry blastocysts for up to 10 months, thus presenting a logical target for biocontrol, development of *in vitro* methods for culturing embryos/blastocysts will be undertaken.



An *in vitro* fertilised (IVF) generated stoat 8-cell embryo produced by mixing sperm and superovulated eggs. *Photo: Andy Glazier*

To date, uterine horns have been flushed with tissue culture media to recover fully expanded, diapausing blastocysts. Maintenance of blastocyst viability is a vital step in understanding the relationship between diapause, implantation and (hormonal) regulation of these events. Attempts have been made to establish stoat uterine cells in culture as a means of supporting blastocyst viability and to allow the study of blastocyst function. Initial cultures indicated that cells were seeded at too low a density to form confluent monolayers. The protocol has now changed to seed cells in larger clumps and partial success was achieved, with cells forming isolated patches of growth across the growth matrix surface. It may be necessary to culture uterine cells as explants (section of uterus excised from a whole organ) or as whole organs.

Development of an induced ovulation protocol has commenced. Eggs were recovered from female stoats stimulated with hormones that promote growth of ovarian follicles. Viable sperm have been recovered by back-flushing the epididymides of males after testicle removal. However it was noted that collection of sperm outside the breeding season was not possible. Eggs recovered were cultured in the presence of sperm flushed from a donor male and three of the seven eggs formed embryos up to the 8-cell stage.

An application to the Landcare Animal Ethics Committee (AEC) for permission to perform experimental manipulation of stoat reproduction, towards development of *in vivo* and *in vitro* models of key reproductive events, has been approved.

Initial success of this project has been very encouraging and perhaps novel to the stoat. This project has been extended for a further two years to allow for the further development of stoat artificial reproductive technology in terms of:

- Facilitating the maintenance of stoat blastocyst viability and hatching
- Continuing the investigation into the development of exogenous hormone treatment protocols to synchronise oestrus and/or induce ovulation
- The development of a technique for the cryopreservation of sperm and the development of methods to generate embryos/blastocysts from ovulation induced stoats by artificial insemination or *in vitro* fertilisation

This project has now been suspended, pending a replacement for Andy Glazier who has recently left Landcare Research.

Monitoring hormones of stoat reproduction

Andy Glazier and co-worker Frank Molinia (Landcare Research) are providing information on the major hormones associated with reproduction in stoats (testosterone in male stoats and oestradiol, progesterone and prolactin in female stoats) and validate these against serum samples. Little is currently known about these hormones in stoats and the development of assays to monitor the hormones throughout the natural reproductive cycle 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, any artificial manipulations of the breeding cycle can be validated. Knowledge of the reproductive hormones is essential if biocontrol through interruption or manipulation of the breeding cycle is to be contemplated in the future.

A continuous set of faecal samples from four males have now been collected, dried and processed to extract testosterone. Once the assays have been conducted and other information gained such as male scrotal volumes, testicular size and sperm counts then it is likely that the onset of sperm production may be able to be detected and the observation that male stoat reproductive capacity is highly regulated by season will be confirmed.

This project has now been suspended, pending a replacement for Andy Glazier who has recently left Landcare Research.

2.5 BIOTECH/BIOCONTROL

2.5.1 Ongoing research

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

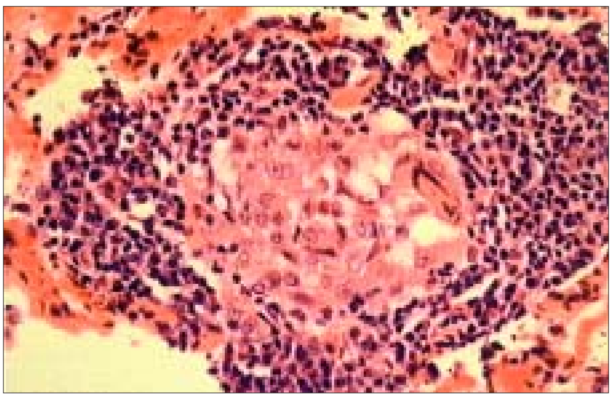
Robbie McDonald (University of Waikato, now at The Game Conservancy Trust, United Kingdom) with co-workers Richard Birtles and Michael Day (University of Bristol) looked at the carriage rates and species diversity of *Bartonella* in stoats and alternative hosts in Britain and New Zealand. *Bartonella* is a relatively benign arthropod-borne bacterium known to infect 73% of stoats living in Great Britain and is therefore worth investigating as a vector for biocontrol. This study used a histopathological survey of disease in major organ systems along with culture and PCR techniques to determine carriage rates of *Bartonella.*

Tissue and blood samples were collected between October 2000 and June 2001 from five broad locations in New Zealand and also opportunistically through a live capture programme undertaken by Landcare Research. Samples were transported to Bristol, UK for analysis. For a range of tissues collected from 94 animals, including 60 stoats, a haemotoxylin and eosin (H&E) stained section was prepared and examined by light microscopy for pathological change. Cultivation of bartonellae and PCR-based analysis was attempted for 168 blood samples, including 94 from stoats.

This study found that 38 of 60 stoats sampled (63%) exhibited signs of pneumonia and/or pulmonary granulomas or other forms of pulmonary inflammatory disease. Eighteen of the 60 stoats sampled (30%) showed signs of liver disease and 8 of the 60 (13%) showed signs of inflammation of the gut. A few cases of heart disease and inflammation of the spleen, brain, and pancreas were also identified. One stoat showed signs of a serious systemic granulomatous disease affecting all the major organ systems examined.

None of the samples of any species tested by either culture or PCR techniques were positive for *Bartonella*. Two samples gave PCR results suggestive of infection by *Yersinia* sp., possibly *Y. enterocolitica* or *Y. pestis*. A further sample collected from the same location as the two positives also repeatedly showed positive signals, but insufficient PCR product was available for sequence analysis.

Pneumonia, characterised by pronounced inflammation of the lung was unusually common among New Zealand stoats. *Photo: Michael Day*



These results are both encouraging and unexpected. By comparison to British samples, New Zealand stoats experience unusually high rates of lung disease and this is probably the most significant finding of the study. In a previous study of disease among British stoats that was also sponsored by DOC, (McDonald et al. 2001; see section 3.), only 5 of the 44 (11%) showed signs of pulmonary granulomatous inflammation and the most common form of disease was nematode parasitism of the gut (14%) and lungs (11%), which were both relatively infrequent among New Zealand stoats. The apparent absence of *Bartonella* among New Zealand stoats is surprising given the high incidence among British animals mentioned above.

Identification of the cause of pulmonary disease would be a useful and valuable addition to knowledge of the naturally occurring infectious agents amongst New Zealand stoats, both in terms of direct biological control of stoats and as candidate vectors for immunocontraception. Identification of the parasites occurring among British stoats may provide some candidate organisms for introduction to New Zealand for biological control. Based on these findings and related work, recommendations for future work on disease as a control technique for stoat populations are currently being formulated.

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

Tao Zheng with co-workers Bryce Buddle and Lindsay Matthews (AgResearch) has initiated a three-year investigation of the 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 the vaccine strains of this virus have caused mortality in ferrets.

However, results to date have indicated that there were no adverse clinical effects from inoculating ferrets with the four commercially available canine distemper virus (CDV) vaccines even though the dosage was ten times more than that used on dogs. This is contrary to previous reports on the effect on the vaccine on ferrets indicating that the vaccines currently available may be different from those earlier commercial vaccines. As a result of these findings current commercial CDV vaccines are no longer being pursued as an option for stoat control.

This project is now 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. Passaging the two strains in specific pathogen-free hen eggs is now progressing. Testing virulence in ferrets of the different passage levels of viral preparations will take place later this year. Once appropriate viral levels have been ascertained using ferrets, then these will be tested on stoats. This project does not involve the genetic manipulation of the agent.

The project will be completed by November 2003.

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

Chris Hardy (Pest Animal Control Cooperative Research Centre, Australia) and Janine Duckworth and Frank Molinia (Landcare Research) will investigate 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 immuno-contraceptives when delivered by recombinant species-specific viruses. Direct immunisation of these antigens can also be undertaken to assess their potential at 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 will be inserted into delivery systems for use in the field.

To date, recombinant porcine zona pellucida protein has been synthesized in a mammalian gene expression system and prepared for use. This study will form the basis of a PhD doctorate.

This study will be completed in June 2004.

2.5.2 New research funded for 2002/03 (Year 4)

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 stoat. 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.

It is intended that this study will be completed in June 2004 but the contract is still pending.

White stoat, Craigieburn Forest.
Photo: Caroline Thomson, Landcare Research

2.6 MISCELLANEOUS

2.6.1 Research completed during 2001/02 (Year 3)

Potential techniques for marking stoats to determine optimum spacing of tracking tunnels, bait stations and traps

Chris Jones, Henrik Moller (Ecological Consultants Ltd) and Billy Hamilton (Ecological Networks Ltd) undertook a review of mustelid marking and monitoring techniques, with the aim of determining a method of counting the number of visits by individual stoats to control stations. A reliable marking technique would help in determining the optimum spacing of bait stations, traps or tracking tunnels and thus increase efficiencies in the field.

The following methods were reviewed and assessed:

DNA sequencing

DNA sequencing of hair, skin and faeces would allow the identification of individual stoats. However, there was considerable expense ($30 per sample) and time delays in terms of perfecting and proving such systems.

Electronic methods

Electronic methods using either short-range detection (via radio transmitters) or Passive Integrated Transponder (PIT) tags would be the best tools for determining the optimum spacing of stations. However, while PIT tags are inexpensive, the capital investment needed for antennae to detect the tags and associated data-loggers would be high. A PIT reader ($500 each) would be needed at each tracking tunnel or bait station being monitored in the study. Data-loggers for the PITs or radio-tracking would cost over $2500 each. The wide spacing between control stations would mean that few stations could be monitored from the same data-logger. Thus the scale of stoat movements makes the use of electronic tools impractical.

Chemical markers

Chemical and dye markers appeared the most promising 'group markers' as they are cheap and can easily be added to baits. Tetracycline and Rhodamine B have been used for other small mammals.

Footprints

Identification of individuals from footprints has not yet been tested in stoats. Toe-clipping has been used successfully in rodents but it failed to distinguish individual ferrets in one study. Improving the clarity of prints by elongating tracking tunnels and using sooty substrates rather than ink was outlined as a possible solution. However, there are ethical objections with this method, as well as practical difficulties.

Marking the footpads with an individual tag was considered and trialed in the field using small pads of Braille stippling. However the tag did not remain attached to the foot pad of the stoat, despite being glued with cyanoacrylate adhesive (superglue).

Not withstanding the above, the development of individual recognition from prints was ultimately considered to be the ideal option because it:

- Provides a cheap signal of a visit to a specific location (e.g. tunnel or bait station)
- Involves equipment which is simple, easily operated and robust
- Would lead to an increase in understanding about the interaction of individual stoats to tracking tunnels

However, because a reliable method of marking individual stoats was not found, no further work in this area will be undertaken.

Current stoat control practice at 16 sites nationally: Identifying long-term cost-effective approaches for killing stoats

Kerry Brown assessed current control practices at 16 key sites nationally (data collected as of July 1999). Improvements in stoat control being initiated by people in the field between 1999 and the present were also identified.

Findings were:

- Stoat control is undertaken in a wide range of habitats.
- Fenn traps were the main tool used for stoat control with a mixture of Mark 6 and Mark 4 being used either exclusively or in a combination.
- Aerial 1080 was used as a control in one site (secondary poisoning), while another used poison eggs.
- A range of tunnels, the most common being wood (in a blind or run through design) were used to cover the traps. Tunnels were modified when necessary to exclude the different non-target species present at each site.
- Hen eggs were the most common bait, although meat baits were also used in isolation or to complement the egg bait. A range of other baits were trialed (e.g. freeze-dried rats and mice and salted rabbit).
- The frequency of checking traps varied from twice a week to twice a year in the case of the eradication of stoats from Te Kakahu. Most traps were checked weekly or fortnightly over summer and monthly or bimonthly in winter.
- Stoat trapping caught non-target predators (e.g. cats, possums and hedgehogs) at all sites but the species and abundance varied between sites.
- Trap catch was the main result monitoring tool.
- Costs in terms of person effort per annum for trapping, result monitoring and outcome monitoring and management were quantified at most sites but estimated costs of establishing control and monitoring were mostly not obtained.
- Performance measures tended to be based on chick survival, five minute bird counts or adult female survival and nest productivity of specific species.

An ear-tagged stoat.
Photo: Peter Dilks

Improvements being made in the field include:

- Stoats have been eradicated from islands and kiwi, mohua and kaka protected in some years by trapping.
- Locating stoat dens using trained predator dogs is a new tool that could be used to locate and remove trap-shy stoats. Dogs were used to confirm the absence of stoats following island eradications.
- Trap cover designs to exclude kiwi, weka and kea.

- Wooden tunnels were shown to be more effective than wire tunnels at one site.
- Trapping along valley floors alone has proven effective and far less labour intensive than grid trapping but this approach does not work in all situations.
- Innovations are constantly being tested to improve the cost-effectiveness of stoat control programmes.

This project has provided baseline information at one point in time (1999). It is intended that a similar exercise will be undertaken after June 2004 to determine the effect of long-term cost-effective stoat control approaches which have been initiated since the start of the stoat control research programme.

Risk assessment of stoat control methods

John Parkes (Landcare Research) and Elaine Murphy (DOC) reviewed current and potential stoat control methods to identify where the main constraints and risks on their optimal use lie, and suggested ways to overcome these where possible. The following conclusions and recommendations are ordered according to their assessment of the likely benefits and risks of failure of each major control method for stoats.

Bait development

Managers' lack of choice of an effective bait is the main constraint on a variety of current and potential control methods for stoats. Success in this area is the most likely to deliver improved stoat control in the medium term.

There is a need for a variety of bait types for different delivery routes (aerial, ground-laid, bait stations) and to contain different active ingredients (toxins, sterilants, living or dead biocontrols). The approach recommended to develop new baits is to specify a range for each character of a bait (size, robustness, bait-life, palatability) that it must meet for its particular purpose (aerial, ground, bait-station, which active ingredient). These baits can then be tested and manipulated within their desired range, to maximise bait acceptance in the field.

The optimal strategy to use baits in the field is unknown and uncertain. The best density, frequency of replacement, and seasonal use of baits can only be investigated at large-scales. An adaptive management experiment is the best way to do this.

Toxins

Currently there are no toxins registered for stoat control, although a number of toxins have been trialed using experimental use permits. In the short-term, registering an effective toxin already used for other pest species is a priority. Development of a mustelid-specific toxin is also recommended, however the time frame for this will be longer and there is a risk that no such toxin will be found.

Trapping

In the short-term, trapping is likely to continue to be the main method employed. New traps need to be developed that are humane and efficient, and the best ways of setting them with tunnels and lures needs to be investigated by pen and field experiments.

More generally, there are likely to be significant gains in stoat control effectiveness in the strategic usage of traps. A formal adaptive management experiment to take advantage of differences between managers' views of what is best practice in the use of traps would provide the most efficient way to improve their use.

Fertility control

Disruption of stoats' reproduction to limit their numbers has a range of potential benefits, from modest if the agents all have to be delivered in a bait to very high if they act as a self-replicating biocontrol. None the current options has been taken past the 'proof of concept' phase for any wild animal pest, but preliminary research on stoats has been justified because it can build on the work already done in Australia and New Zealand on mice and possums.

Nevertheless, the work remains risky and a cautious approach is recommended with some clear stop rules should either the mouse or possum programmes fail (e.g. from public disapproval of GMOs) or the stoat research is constrained (e.g. lack of commitment to continue to invest in the research).

Classical biological control

Biological control using a pathogen or parasite has the potential of achieving widespread stoat control but unfortunately no species-specific candidate has been identified. Completion of trials on the vaccine strain of canine distemper is recommended but no further targeted work in this area unless a mustelid-specific pathogen is identified.

One key issue that both fertility control and classical biological control need to address is the lack of data on contract rates of stoats.

Minor control methods

None of the other methods are likely to deliver acceptable widespread control of stoats, but several boutique methods (use of dogs and fencing) might prove useful adjuncts to the stoat control armoury.

2.6.2 Ongoing research

Social acceptability of control options for stoats

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

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. The findings from this research will enable DOC to assess the level of public knowledge of stoats and their impact on New Zealand's environment and their knowledge of current stoat control strategies. This information will assist the department and other researchers in their decisions on, and marketing of, stoat control strategies.

The first phase of the research involved the organising and conducting of seven focus groups, covering the public, iwi and various special interest groups. The groups were selected so to capture a range of views about stoats, their impacts and the acceptability of current and potential future control methods. The focus group participants included urban men, urban women, rural residents, East Coast Maori, animal welfare interests, environmental interests and people with scientific and technical interests. Informal interviews were also held with Northland Maori and field pest controllers. Analysis of the data from the discussions has been completed and a draft report has been prepared and peer reviewed. Preliminary results indicate that many of the participants had little experience or knowledge of stoats and their impacts. Once the impact of stoats was explained, most of the participants were keen to eradicate them, and to increase efforts to protect kiwi. However, during discussion of the possible new control technologies and their associated issues, they tended to retreat from such a view. Many participants expressed unease about the use of genetic engineering for stoat control and, particularly about the prospect of unforeseen effects.

The results of this qualitative phase of the research were used to design the second (quantitative) phase of the work, a national telephone survey of the New Zealand public. A regionally representative random sample of 1000 members of the public was drawn from households with telephone numbers listed in telephone books covering the whole of New Zealand, and the survey interviews were conducted during March, April and the first week in May 2002. Interviewers indicated that people were happy to participate and were particularly keen to comment on the issue of protecting native birds and the various means for controlling stoats. The average interview time was 15 minutes. The data from the interviews is being entered for computer analysis, and will be analysed during the last quarter of 2002.

A full report on the survey will be prepared by June 2003.

Testing the efficiency of options for best practice stoat control during a stoat irruption in southern beech forest ecosystems

Attaching a transmitter to Kamilla Kaka Bowles.
Photo: Peter Dilks

Peter Dilks (DOC) assessed the effectiveness of stoat control on mohua and kaka in the Eglinton Valley, Fiordland where continual low intensity stoat control has been undertaken for the past four and a half years. Within this period the Eglinton Valley has experienced two beech masts and two stoat population irruptions. Predator control during this period consisted of a trapping line of Fenn traps which ran the length of the valley and these were checked monthly.

Throughout this period the kaka only bred during the two beech flowerings and 13 radio-tagged adult female kaka and 12 nestlings were monitored. 80% of the monitored nests successfully produced fledglings. All 12 radio-tagged kaka nestlings survived to one year old. Two studies carried out in similar beech forests at Nelson Lakes found that with no stoat control only 10% of the nests produced fledglings but when a more intensive stoat control regime was implemented (more intensive than that undertaken at the Eglinton Valley) 80% of the nests produced fledglings.

A total of 27 pairs of banded mohua were intensively monitored during the summer of 1999/2000 and 66% of the nests fledged successfully, however 37% of the females were lost mostly due to rat predation. No stoat predation was recorded during the summer of 1999/2000 even though during a stoat irruption in 1990/91, 60% of the nests were lost and 60% of the females were killed mostly by stoats. Due to the very high rat numbers which was the result of two consecutive beech masts in 1999/2000 and 2000/01 mohua have almost disappeared from the valley.

This study found that low intensity Fenn trapping in the Eglinton Valley appeared to provide protection from stoat predation for breeding kaka and mohua. However, further work is required to determine if the high rat populations were due to continual stoat control or as a result of three mild winters and two consecutive beech mast years.

This project is ongoing, low input monitoring that has been part funded by STAG.

Use of colour to increase trap and tracking success rates of stoats

Billy Hamilton (Ecological Networks Ltd) and Henrik Moller (Ecosystems Consultants Ltd) are studying the effects of different coloured control stations on stoat trappability and tracking rates. Previously there have been anecdotal reports of increased capture rate and bait take when yellow trap surrounds or yellow bait stations are used in control operations involving small mammalian predators. There is also scientific evidence that many animal sensory systems are triggered or 'biased' in favour of certain colours, such as red.

During February, March, and April 2001 tracking tunnels of four different colours, i.e. black, green, red and yellow, were set out in two different mixed forest sites. These tunnels were run for over 700 tracking nights per colour per site. Initial indications suggest that the darker-coloured control stations, such as black and green, are more successful in tracking stoats than the brighter colours of red and yellow. Conversely, the brighter-coloured tracking tunnels tend to be disturbed more regularly by possums than the black- or green-coloured tunnels. Records of the use of different colours by other mammalian species such as hedgehogs, rats, mice, and weasels have also been recorded, but not analysed as yet.

This study was repeated between November and August using kill-traps encased with covers in the four colours (black, green, red and yellow). While full analyses have not been completed yet, out of a total of 14 stoats, only one was caught in the darker coloured traps. Of the remaining 13 stoats, 1 was caught in a red trap and the rest in the yellow coloured traps. Of the non-target species, 2 ferrets were caught in red coloured traps, while hedgehogs (n = 15) did not appear to have any preferred trap colour. Again, non-target species colour bias both in kills and disturbance were recorded but not fully analysed as yet.

A report on this work will be completed by December 2002.

2.6.3 New research funded for 2002/03 (Year 4)

Genetic tagging for estimating stoat population parameters in the field

Dianne Gleeson and Andrea Byrom (Landcare Research) will look at using recently developed genetic (DNA) markers (micro-satellites) which when

Stoat entering PVC tube with adhesive gel on a rubber band stretched across the aperture, designed for hair collection. *Photo: Andrea Byrom, Landcare Research*

combined with traditional statistical methods and novel tissue capture techniques will provide new opportunities for measuring population census and behavioural parameters in the field. Initially this project aimed at determining the probability of identifying individual stoats in the field. To achieve this, both wild populations and captive stoats will be used. The results from this study will provide both an overview of the genetic variability and population structure of stoats in New Zealand and a mark-recapture method using non-invasive genetic sampling which will have implications for monitoring current and future control strategies.

This project will be completed by June 2004.

STAG visit to Landcare Research. (From left to right: Mick Clout, Leonie Fechney, Cheryl O'Connor, Elaine Wright, Fiona McKay, Elaine Murphy, Craig Gillies, Jenny Christie, Ian Flux, Darren Peters. Graham Hickling in front.) *Photo: Andrea Rhodes*

3. Bibliography of published research from stoat research programme

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Thesis

Smith, D.H.V. 2002. The movement, diet and relative abundance of stoats *Mustela erminea* in the Murchison Mountains (Special Takahe Area) Fiordland. MSc thesis, University of Otago, Dunedin.

Appendix 1

NEW STOAT RESEARCH PROJECTS INITIATED IN YEAR 4 (2002/03)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Comparison of three stoat trapping set designs	Rhys Burns	DOC
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 control for stoats	Ray Henderson (Chris Frampton and James Ross)	Pest Tech. Ltd
Control of stoat dens after location by trained predator dogs at Trounson Kauri Park	Scott Theobald (Nastasha Coad and Craig Gillies)	DOC
Dispersal of juvenile stoats in the Mackenzie Basin	John Dowding (Mike Elliott)	DM Consultants
Dispersal and survival of juvenile stoats in a South Island beech forest.	Andrea Byrom	Landcare Research
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
Genetic tagging for estimating stoat population parameters in the field	Dianne Gleeson and Andrea Byrom	Landcare Research
Proof of concept studies to determine feasibility of cont rolling stoats using a species-specific technique	Brian Hopkins	Landcare Research—contract still pending
Pen trials of small-volume toxic baits for stoats	Kim King (Murray Potter and Paul Barrett)	HortResearch (Massey Univers-ity)—contract still pending

Appendix 2

ONGOING STOAT RESEARCH PROJECTS INITIATED IN YEAR 2 (2000/01) AND YEAR 3 (2001/02)

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Multiple kill trap testing	Ian Domigan	Lincoln Ventures (Lincoln University)
A new kill-trap for stoat control	Ian Domigan	Lincoln Ventures (Lincoln University)
Trials to test a prototype kill-trap for stoat control.	Malcolm Thomas	Pest Control Research Ltd
Self-resetting mustelid eradicator (Feral-X-it)	Frank Greenall	Private
Production of an alternative kill trap for stoats	Phil Waddington	Private
Toxic micro tabs and a bait for stoats	Jeremy Kerr	Feral R&D Ltd
Testing attractiveness, palatability, longevity of stoat lure and bait formulations	Kay Clapperton (Lloyd Robbins, Tony Woolhouse and Dick Porter)	Private
Prey odours as lures for stoats	Andrea Byrom (Eric Spurr and Cheryl O'Connor)	Landcare Research
Development of a new toxin for stoat control	Penny Fisher and Cheryl O'Connor	Landcare Research
The relationship between stoat and rodent relative abundance in North and South Island forests	Craig Gillies (Peter Dilks, Elaine Murphy and Fraser Maddigan)	DOC
Ecology of stoats in a South Island braided river valley	John Dowding (Mike Elliott)	DM Consultants
Effect of reducing possum densities on ship rats and stoat abundance	Peter Sweetapple (Graham Nugent)	Landcare Research
Evaluating the use of tracking tunnels to monitor mustelids as well as rodents	Craig Gillies (Peter Dilks)	DOC
Modelling the immigration rate of island stoat populations	Graeme Elliot and Murray Willans	DOC
Modelling the dynamics and control of stoats	Nigel Barlow	AgResearch
Kiwi sanctuaries: Ecological consequences of mustelid control to benefit kiwi	Ian Flux	DOC
Stoat reproductive biology	Cheryl O'Connor and Janine Duckworth	Landcare Research

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION
Stoat artificial reproductive technology	Andy Glazier (Frank Molinia)	Landcare Research
Monitoring hormones of stoat reproduction	Andy Glazier (Frank Molinia)	Landcare Research
Biological control of stoats using a vaccine strain of	Tao Zheng (Bryce Buddle and canine distemper virus	AgResearch Lindsay Matthews)
Identification of zona pellucida antigens of the the stoat and assessment of their potential for immunocontraception	Chris Hardy (Janine Duckworth and Frank Molinia)	PAC CRC, Australia and Landcare Research, NZ
Evaluating a low intensity stoat control regime on large inshore islands	Graeme Elliott and Murray Willans	DOC
Use of colour to increase trap and tracking tunnel success rates of stoats	Billy Hamilton and Henrik Moller	Ecosystems Consultants Ltd/ Ecological Networks Ltd
Testing best practice stoat control	Peter Dilks	DOC
Pilot project for the collation and exploration of data from DOC stoat trapping operations across NZ	Jenny Christie (Ian Westbrooke and Elaine Murphy)	DOC
Incidence and diversity of *Bartonella* in stoats and other wildlife	Robbie McDonald (Richard Birtles and Michael Day)	University of Bristol
Social acceptability of the various control options for stoats	Gerard Fitzgerald (Roger Wilkinson)	Fitzgerald Applied Sociology

Appendix 3

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR 3 (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 4

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR 2 (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 5

SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR 1 (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, UK
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, UK
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