MONITORING AND CONTROL
OF MUSTELIDS ON CONSERVATION LANDS
PART 1: PLANNING AND ASSESSING AN OPERATION

by

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PREFACE

DoC's system of planning and auditing proposed operations against pests

Any kind of animal control work is very expensive, and therefore must be well planned. DoC is setting up a system designed to test all proposed control operations, concerned with any pest species including mustelids, to make sure that all funds committed to control work are well spent.

DoC's system involves four levels of documents, to be produced over the next few years.

First, there is to be a national policy on control of pests, applicable to any pest species, which outlines the general principles of pest control. This document is addressed mainly to national policy advisers.

Second, there is to be a set of national strategy documents, one for each pest or group of pests. Each considers the questions of whether, when and where control of that pest is justified, and in what conditions. Proposed field operations must be approved under the criteria laid down in this document, or they will not be funded. These documents are addressed mainly to Conservancy advisers and scientists.

Third, there are to be operational plans which list the performance and conservation goals to be met by each control operation. These documents are intended to guide field personel working on control or monitoring programmes.

Finally, there is to be a set of field guides, one for each pest or group of pests, which give instructions on how to undertake a control operation that has been approved under the above procedures. These guides are addressed mainly to local field managers and field operators.

Not all the documents are yet available in printed form; until they are, the system will operate informally.

Research on pest control strategy and technique is continuing all the time, and all the policy and strategy documents and guides will be periodically revised as necessary. Most of the comments made here about control work also apply to monitoring operations.

This guide is among the first to be produced, and is to some extent experimental. It does not consider the important question of whether control of mustelids is necessary in any given conditions. It is addressed to DoC field managers and operators who have already gained approval to undertake a mustelid control or monitoring programme. For further information, consult The Manager, Animal Control Policy, DoC Head Office, Wellington, who is in charge of preparing the national strategy.

The structure of this guide

A successful control or monitoring programme requires both planning (deciding what method to use) and technique (using the chosen method with greatest efficiency). These two jobs involve two rather different skills, and may be done by different people; often, of course, they are done by the same person.

Either way, planning must be done first, and usually in an office. Most of the work is in the reading and thinking required to fit the written information supplied in the policy

documents to the local field conditions. By contrast, implementing the chosen technique is done only later, virtually all of it in the workshop or field, in the practical implementation of the plan that has been decided upon.

To plan a mustelid control or monitoring operation, it is necessary to:
- Be familiar both with DoC's general policy on pests, and also with the national strategy for mustelids
- Have a clear understanding of the local problem, and especially with the species to be protected
- Set clear and achievable objectives, and
- Choose appropriate field techniques that will serve the objectives and assess whether they have been met.

To operate the chosen plan, it is necessary to:
- Develop experience in the efficient use and maintenance of the field techniques to be used
- Keep systematic records on what has been done, and be prepared to report on it, and
- Note and think about any potentially significant observations made during the course of routine field work.

In this guide I have presented these two subjects separately; the section on planning and assessment in this book for office use, and the section on practical technique in *Department of Conservation Technical Series No.* 4 (King *et al.* 1994) to be used in the field.

I will address the reader directly, as if in conversation; I hope thereby to make both guides easy to read, and to encourage you to respond (either to me directly or to DoC) if you have any suggestions that might improve future editions of them.

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MONITORING AND CONTROL OF
MUSTELIDS ON CONSERVATION LANDS
PART 1: PLANNING AND ASSESSING AN OPERATION

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ABSTRACT

This is the first part of a two-part guide for Department of Conservation (DoC) staff concerned about protecting native species against predation by mustelids. Control operations against mustelids can, in certain circumstances, be fully justified and cost-effective, but must be carefully planned and monitored in order to qualify for DoC funding.   This, the first part, summarises the information required at the planning stage of the work; the second part describes the currently available field techniques.   The two parts are published separately, but are designed to be read together.

Detecting the presence or absence of mustelids (especially on islands), and monitoring their numbers, may be done by footprint tracking or trapping, but no method is entirely reliable because some individuals always avoid any kind of artificial device.   Removing of individual mustelids can in practice be done only by Fenn trapping, since no other kill-traps or poisons are at present registered by DoC as approved for use against mustelids.

When planning a trapping operation it is important to identify the values at risk; implement a means of monitoring success in terms of benefit to those values; identify the aim (eradication, sustained control, or damage prevention); and choose the appropriate methods. Details are given here to assist making those decisions, and practical instructions on implementing them are given in part 2.

1.   INTRODUCTION

1.1   What are mustelids and why did they come to New Zealand?
Mustelids are members of the animal family Mustelidae, all carnivores native to the northern hemisphere.

Three species of small mustelids (the stoat, the weasel and the ferret) were brought to New Zealand last century, because they kill rabbits, but are too small to attack sheep and lambs. They did indeed eat many rabbits, but made no impression on the numbers of rabbits remaining.

The mustelids also spread from farmland into forest, and added birds, lizards and insects to their diet. All members of the native fauna had already suffered much from the attentions of rats, cats, dogs, human hunters and fire. But at that time many native animals that have since disappeared still survived, especially in the last few untouched wilderness areas of the south and west of the South Island. About thirteen species of birds suddenly declined or vanished when the mustelids arrived (listed by King 1984),

and others continue to decline more slowly up to the present day, for various reasons including predation by mustelids. The clearest evidence of their effect comes from recent work on the yellowhead (Elliott & O'Donnell 1988; O'Donnell *et al.* 1992). Hence the need for this guide.

1.2 Public attitudes to mustelids and their implications for DoC

The deliberate introduction of mustelids is commonly regarded as the worst mistake ever made by European colonists in New Zealand. This attitude has consequences which both help and hinder DoC staff working on mustelid control.

Because mustelids are often blamed for much of the historic and contemporary damage to native bird populations, it seems unlikely that DoC field staff will encounter any public protest against control campaigns. This is a greater advantage than we may realise; in the northern hemisphere, such protests now frequently hinder even legitimate control work against wild animals (e.g., on badgers in UK to assist the control of bovine TB, and on mongooses in Hawaii to protect native birds).

On the other hand, generalised public hostility towards mustelids leads people to blame them for damage to bird populations that was done in places or at times that mustelids were absent, or was the work of other less obviously predatory mammals such as rodents, or was the unavoidable result of the many other environmental changes set off by the human settlement of New Zealand. Such people often criticise DoC staff for not doing enough to control mustelids, even in situations where control operations would be entirely ineffective. For some answers to such comments, see King (1984, 1985a).

2. A BRIEF BIOLOGY OF MUSTELIDS

In general, all small mustelids share the same strong family resemblance: all have a long, sinuous body, short legs, sharp-pointed "weaselly" face, small rounded ears, bright beady eyes and apparently inexhaustible energy. The main differences between them are summarised in Part 2 (King *et al.* 1994); for more details, see King (1990).

2.1 Stoats

The stoat is the most widespread of the three, and the most common in forest. Stoats are active in the daytime as well as at night, and are fearless and obviously carnivorous. They are most abundant in summer, when reserves are most often visited by people interested in wildlife and likely to notice them. They are certainly capable of doing great damage to populations of native birds, especially in beech forests after a seedfall, when stoats become temporarily very numerous.

Stoats have high natural productivity and mortality. When food is abundant, they produce 8-10+ young in September or October. Juvenile female stoats are extremely precocious, and mate before leaving the nest; the adult females mate whilst suckling. By November almost all females of all ages are carrying next year's litter (in a state of suspended animation), that is, virtually all female stoats are pregnant all the time. The young can disperse over long distances from January onwards.

First-year stoats form the great majority (averaging 60%+) of the population in most years and in most habitats. In beech forest the proportion of stoats under a year old can be up to 90+% after a good seedfall, and their average mortality rate is higher than usual-fewer than three in ten survive long enough to see their first breeding season. The average age of wild stoats is about a year, reaching, rarely, a maximum of 8-10 years.

2.2 Ferrets

The ferret is different from the weasel and stoat because, unlike them, the ferret is not a truly wild species. Ferrets have been domesticated (from the wild polecat, not present in New Zealand) and bred in captivity since before Roman times. Artificial selection has produced a great variety of coat colours in ferrets, from cream through shades of brown to black, and these can still be seen in feral (living wild) ferrets in New Zealand-though most have returned to the original colours of the ancestral polecat type as shown in Part 2 (King *et al. 1994,* fig. 1). Domesticated species are also usually more docile and tolerant of handling than wild ones, and this trait too is still common in feral ferrets in New Zealand.

Ferrets have smaller litters than stoats, but may live for longer. They are usually more common than stoats in open country.

2.3 Weasels

The weasel is the smallest of the three and, in New Zealand, the rarest. It is seldom a significant threat to wildlife.

2.4 Why mustelids are hard to control

Some of the biological characters of mustelids make them very resistant to control. For example:

1. All New Zealand mustelids live alone for most of the year, on individual home ranges varying in size according to the amount of food available. Males have large ranges (usually at least 10 ha, and up to 100 ha or more) that may include the ranges of one or more females, but there is no permanent den or pair bond. This means that it takes a lot of trapping effort to catch a few mustelids, except during the brief post-seedfall irruptions of stoats.

2. The natural population density of mustelids is ultimately controlled by food supplies, which influence the number and the survival of the young born each season. This means that traps may register many more kills at some times and places (Figs 2, 3), yet without having any more effect on the population than less productive traps at other times and places. Worse, the additional mortality caused by trapping seldom has more than a local and temporary effect on density.

For more details on the life cycle and population dynamics of stoats, much of which was worked out in New Zealand, see King (1989).

3. DETECTING THE PRESENCE OF MUSTELIDS

Mustelids are small animals, generally scarce, and the efficient scent marks by which they communicate with each other are seldom perceptible to the human observer. There are only three ways to detect whether they are present in an area or not:
- A chance sighting
- A systematic search for natural field signs (tracks, scats and dens), or
- Artificial recording devices.

All these methods work only in the positive-that is, absence of evidence is not evidence of absence. Some give no estimate of numbers at all; some can be used to calculate an index.

Detecting the **presence** of mustelids, usually on islands, is a very different matter from monitoring the **abundance** of mustelids, usually on the mainland, described in Sections 4 and 5 below.

Ideally, methods for monitoring presence or absence of mustelids should reliably detect even a single individual. Unfortunately, there is great variation between individual mustelids, in, for example, their willingness to cross an open space where they might be seen, or to approach a new object such as a tracking tunnel or trap (see Section 6.8). A single individual, especially a mature and wary adult, can defy detection for months. No one monitoring method is sufficient to outwit such an animal; on an island such as Maud, where early detection of immigrants is essential, every possible combination of methods is used, plus trapping on the nearby mainland (Crouchley 1992).

3.1 Natural field signs
In forest, natural signs such as footprints and scats (droppings) are scarce and hard to find, and feeding remains are not reliably identifiable. Monitoring by natural tracking can be very successful on snow or smooth sand, but such opportunities are limited. For descriptions of footprints, scats, dens and signs of kills of mustelids, see Part 2 (King *et al*. 1994).

3.2 Artificial recording devices
If there is no reliable natural means of recording footprints, e.g., on sand or snow, artificial tracking tunnels can be used. Depending upon the skill of the operator and the co-operation of the animals, this method can give good results in remote locations where survey parties have only a very short time available. Tunnels can be set out quickly on one visit and left for several weeks. They are particularly useful where there are only small numbers of animals present. Tunnels can also be fixed to trees containing nests; at Kaikoura, Moors (1978) identified the predators that destroyed four robin nests from their tracks (two mustelids, a rat and a mouse). For further details on tracking tunnels, see Section 4 below.

An alternative device records the presence of small mammals from their hairs. A strategically placed tunnel or tube guides small mammals to brush past a strip of sticky paper or Velcro. Loose hairs collect on the strip, and can then be identified under the microscope.

Continuous video monitoring gives far more information than tracking tunnels or hair tubes, but is much more expensive to set up.

4.   MONITORING ABUNDANCE OF MUSTELIDS BY TRACKING

The design and technique of a monitoring programme depend on the reasons for conducting it (DoC 1989). Moreover, monitoring the abundance of active and wide-ranging animals like mustelids has to be done on a large scale. The most obvious technique, trapping, is inappropriate if it is important to monitor an undisturbed population. One alternative is artificial tracking tunnels, which were first used to monitor seasonal and annual changes in mustelids at Kaikoura by Moors (1978). They are still used at Mapara and Kaharoa to check on the recovery of rat populations after poisoning (Anon. 1991).

The tracking tunnels use a refinement of the paper and ink technique which, instead of relying on the purely mechanical deposition of ink on paper, makes use of a chemical reaction. It is based on a two-component dye system, of which one part is in the "ink" and the other is sprayed onto the paper. An animal transferring even a very little ink onto the paper from its feet produces indelible, sharply defined blue-black prints which develop in a few seconds and thereafter are permanent and unaffected by damp, heat or sunlight. The ink resists evaporation for up to 10-30 days, depending on the position of the tunnel and the climate of the study area. The papers can be collected and/or replaced rapidly in the field, and analysed later.

These features greatly simplify the logistics of operating surveys on islands, and moreover footprint tunnels have other advantages over traps for monitoring work. More tunnels can be set out per field worker than traps, they need less attention, and they are probably visited by a greater proportion of the target population than are traps, since they are not made ineffective after the first visitor.

Unfortunately, the footprints of the three species of mustelids overlap in size, so are difficult to distinguish; and there is no way to calibrate the tracking rate with the real . density. For rats, indices from tunnels and traps usually agree reasonably closely; but the number of positive records for mustelids in either device is always lower than for rats, and sometimes apparently contradictory. These problems are being addressed in current research programmes.

For instructions on how to prepare and set out the tunnels, see Part 2 (King *et al.* 1994).

5. MONITORING ABUNDANCE OF MUSTELIDS BY KILL-TRAPPING

Removal trapping affects the population being studied in ways that we are only now beginning to understand, although it also has the huge advantage that it produces carcases for study. The best alternatives (livetrapping and/or radio-tracking) affect the population less but are very labour-intensive and unlikely to be used in ordinary management. Regular or periodic kill-trapping, which can be integrated with other work, is therefore still the most usual method of making routine density estimates of mustelids.

5.1 Animal ethics

The gin trap, a typical steel-jawed leg-hold type, is still legal in New Zealand, although it has been banned in Britain since 1958, mainly for humanitarian reasons. A similar ban in New Zealand would not affect official operations against mustelids, which have used the Fenn humane steel trap since 1972.

The Fenn, designed specifically for mustelids and rats, is the only trap type approved by DoC's Animal Ethics Committee for use in mustelid trapping on public lands.

The Fenn trap is well made and reliable, especially if oiled occasionally. It comes in two sizes. The smaller one, No. 4, is for rats, small stoats and weasels. For animals with well-protected or muscular necks (large stoats, hedgehogs, ferrets), the No. 6 size is better. Animals which are too large to be caught except by the leg (possums, cats, dogs) should be excluded from access to the trap. Smaller animals (mice, small birds) are usually too light to set off the treadle, unless it is set very fine.

The manufacturer's claim, that the Fenn kills stoats and weasels more humanely than the gin trap, has been confirmed in New Zealand. Of 1599 stoats examined during the 1970s, significantly fewer of those caught in Fenn traps had gross external injuries (broken legs or teeth, crushed or severed feet); fewer were still alive when the traps were checked; fewer had partially or wholly evacuated their guts, and fewer had fleas (i.e., they had been dead and cold for longer), compared with those caught in gins (King 1981). Stoats held alive by only a foot have often been known to chew through their own leg to escape: 21 of 29 stoats that had done this were caught in gins, and others collected in areas were gins were set regularly for possums had well-healed injuries (missing front legs, toes or tails, or deformation in leg bones caused by breaks mending out of line) showing that they had escaped from a previous trap. Therefore DoC is correct to assume that Fenn traps, correctly set, kill stoats more humanely than do gins.

Future revisions of the Animals Protection Act 1960 might well follow the British example and prohibit all traps that do not pass certain stringent tests. "Soft-catch" leg-hold traps (i.e., gin traps with padded jaws), and "Conibear" traps are considered to be more humane for possums than the standard gin trap, but are less efficient for mustelids and rats than the Fenn.

Fenn traps can be obtained only from the manufacturer, Mr A. H. Fenn, at the FHT Works, Hoopers Lane, Astwood Bank, Redditch, Worcester, England. DoC's Threatened Species Unit in Wellington maintains a database on who has stocks of Fenn traps within DoC, and can also order them for DoC operations for about $13 each.

For a full description of the Fenn, and advice on setting and maintaining it, see Part 2 (King *et al.* 1994).

5.2 Setting the objectives of the monitoring programme

Suppose the objective is to find out more about the diet of a local mustelid population, or the effects of a control campaign. Closely spaced traps (say, 100 m apart) operated intensively over a short period will collect a very high proportion of the animals living in, or passing through, a given area at one time-the "standing crop". But mustelids commonly show large variations in diet or population structure from one year to the next, so a single year's sample, even if large, may not mean much.

Suppose the objective is to document the long term variations in a local population, perhaps in order to predict periods of danger to wildlife. For this purpose, traps 300-400 m apart and set periodically take a smaller proportion of the mustelids living in a given area over several years (traps should be closer for weasels: see Section 8.2.2). Provided the sample is representative, this technique can track changes in total numbers, diet and productivity between years. The work is also less expensive in time and manpower, so can be continued for longer.

However, Fenn traps set at 400 m can catch up to half the total number of stoats present along the whole line, during a period of low average stoat densities (King 1980). This level of sampling of low-density species such as mustelids could itself alter the structure and/or dynamics of the population; the problem can be avoided by using live traps (Section 10).

At spacings greater than 400 m, the number of mustelids caught per km of trapline will be low, because only a small proportion of the population will be sampled, mostly males (Fig. 1, Tables 1, 2). Overspaced Fenn traps have less effect on the target population, but also give a false picture of it (see Section 8.2.2).
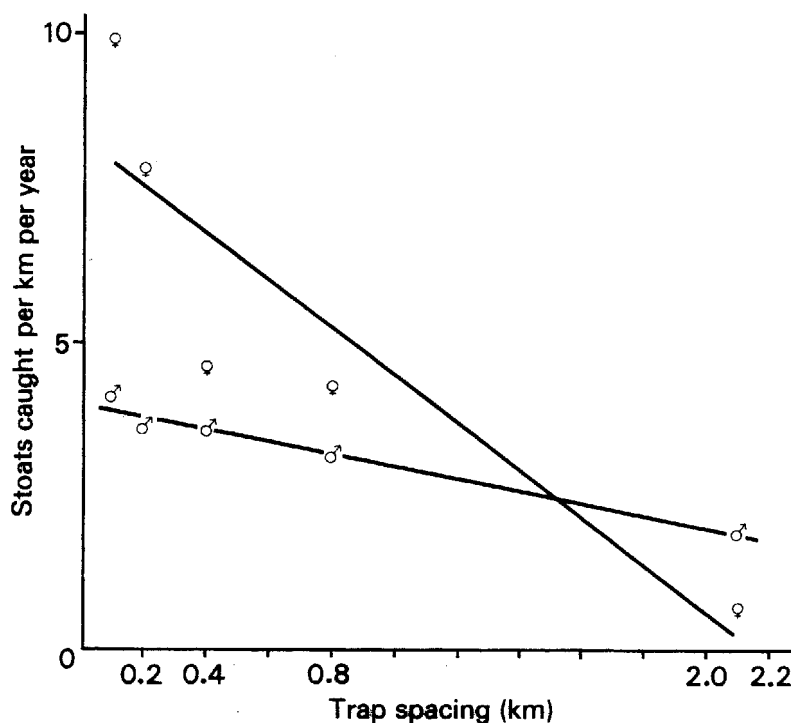

Figure 1 On a routine trapline, underspaced (<200 m apart) **or overspaced** (>800 m apart) **traps do not capture stoats of both sexes at the same rate.** (Reproduced from King 1980)

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5.3 Arrangement of traps for sampling

For a survey of mustelids, a long, more or less straight roadside trapline allows you to sample a large area and to do daily checks from a vehicle in the minimum possible time. For example, in Fiordland during the 1970s we ran 48 traps at 400 m on 18 km in the Eglinton and 40 traps on 15 km in the Hollyford. The traps were inspected daily, and the total inspection round was 100 km per day. This effort gave us the largest samples that could be collected with the available manpower and funds.

The disturbed vegetation along the roadside is not typical of the undisturbed habitat well away from the road. But mustelids have very large home ranges, and travel through many different types of habitat, both in the roadside zone and also far away from it.

Table 1   The effect of trap spacing on capture rate In Fenn traps (data for Mapara, from Murphy & Bradfield (1992); for Kaharoa, from H. Speed). Fiordland, Pureora and Kaharoa traps baited with fish-based catfood; Mapara traps unbaited after November 1989.

Location	Eglinton and Hollyford Valleys, Fiordland				
Habitat	Beech forest (non-seeding years)				
Years	1972–1976, all seasons				
Mustelids caught	Stoats only				
Trap spacing* (m)	100	200	400	800	av.2100
Period (months)	17	17	17	17	20
Number of traps	22	22	22	22	19
Length of line (km)	1.8	4.0	8.0	16.0	42.0
Total captures	14	25	36	65	123
C/100 TN	0.47	0.59	0.87	1.45	1.13

Location	Mapara		Pureora		Kaharoa
Habitat	Cutover podocarp		Virgin + cutover + exotic[†]		Podocarp
Years	1989/90	1990/91	1983 only	1983–87	1990/91
Mustelids caught	Stoats, ferrets, weasels		Stoats, ferrets, weasels		Stoats
Trap spacing (m)	150–300		300	300	148
Period (months)	6	6	12	60	5
Season	<----Oct–Apr---->		<----All year---->		Oct–Mar
Number of traps	103	142	122	122	71
Length of line (km)	24.0	24.0	36.9	36.9	10.5
Total captures	47	62	31	84	2
C/100TN (stoats only)	0.12	0.15	0.44	0.16–0.37[†]	<0.05

*   The distribution of captures at the 5 spacings in Fiordland Is significantly different from random.

t   Distribution of mustelids collected in each habitat: 18% of the 84 came from virgin and 32% from cutover podocarp; 50% from exotic plantations.

5.4 Baseline measures of density

It is extremely time-consuming to estimate the actual density of a population (numbers per unit area), but trapping results from standardised lines of Fenns can be used to calculate the next best thing, a density index. The index is calculated as the number of captures per 100 trapnights, and these figures reflect the real density closely enough for most purposes. For method of calculation, see Part 2 (King et al. 1994).

The key assumptions behind the index are that, if the capture technique is appropriate, dependable and consistent, and the trapping routine remains carefully standardised in every session, then variations from one session to another in the number of mustelids

Table 2 How trap spacing affects the sex ratio of the catch (data for Mapara from Murphy & Bradfield 1992).

Location	Eglinton and Hollyford Valleys, Fiordland					Mapara	
Habitat	Beech forest (non-seeding years)					Cutover podocarp	
Years	1972–1976					1989/90	1990/91
Mustelids caught	Stoats only					Stoats, ferrets, weasels	
Trap spacing (m)	100	200	400	800	av.2100	150–300	
Season	<--------------- All year --------------->					<--- Oct–Apr --->	
Number of traps	22	22	22	22	19	103	142
Length of line (km)	1.8	4.0	8.0	16.0	42.0	24.0	24.0
Total captures	14	25	36	65	123	47	62
Sex ratio (% males)	29	32	44	42	76	57	56

Table 3 Baseline density indices for mustelids.

		Stoat	Weasel	Ferret
In northern hemisphere	(approx. no./100 ha)			
		3–10	10–20	–*
New Zealand mainland	(captures/100 trapnights)			
In beech forests				
	normal years	0–2	Absent	Absent
	seed years	2–9	Absent	Absent
In podocarp forests		0–1	<0.1	<0.1
In grassland		0–3	<0.1	0–2
Number of offshore islands occupied or visited in recent times				
		About 28	None	None

* New Zealand is the only country that has a large population of feral ferrets, so there are no data from the northern hemisphere.

caught reflect real variations in the number present. If this is true, then there are real differences between habitats, years and seasons in the baseline density of mustelids in New Zealand (Table 3).

These figures cannot be used to predict the possible catch to be expected from a new trapline in similar habitat unless the baiting and inspection regimes, seasons trapped, etc. are the same. For example, over five years at Pureora we caught an average of 18 mustelids a year, of which few came from broadleaved forest. But the first six months of trapping at Mapara in 1989 produced 47 mustelids, and the second, 62 (Table 1). When these figures are converted to the standard density index, C/100TN, the capture rates for stoats in broadleaved forest were similar in both places (Mapara 0.12, 0.15 in two seasons; Pureora 0.16 in virgin, 0.19 on cutover forest over 5 years). But no real comparison is possible because the Mapara traps were not baited and not operated in winter.

5.5 Predictable variations in numbers of mustelids

In a population of mustelids routinely trapped every year, capture rate is always low in winter and spring, suddenly increases in summer (more in some years than in others), and then declines slowly over the late summer and autumn to the winter low again. Regular samples show this pattern both in beech forests and in open grassland, both in stoats (Fig. 2) and in ferrets (Fig. 3). Therefore, if you want to make comparisons between traplines or areas, you must make sure you compare only figures relating to the same season, (i.e., summer with summer, not summer with winter or summer with all year: see above on comparing Mapara and Pureora).
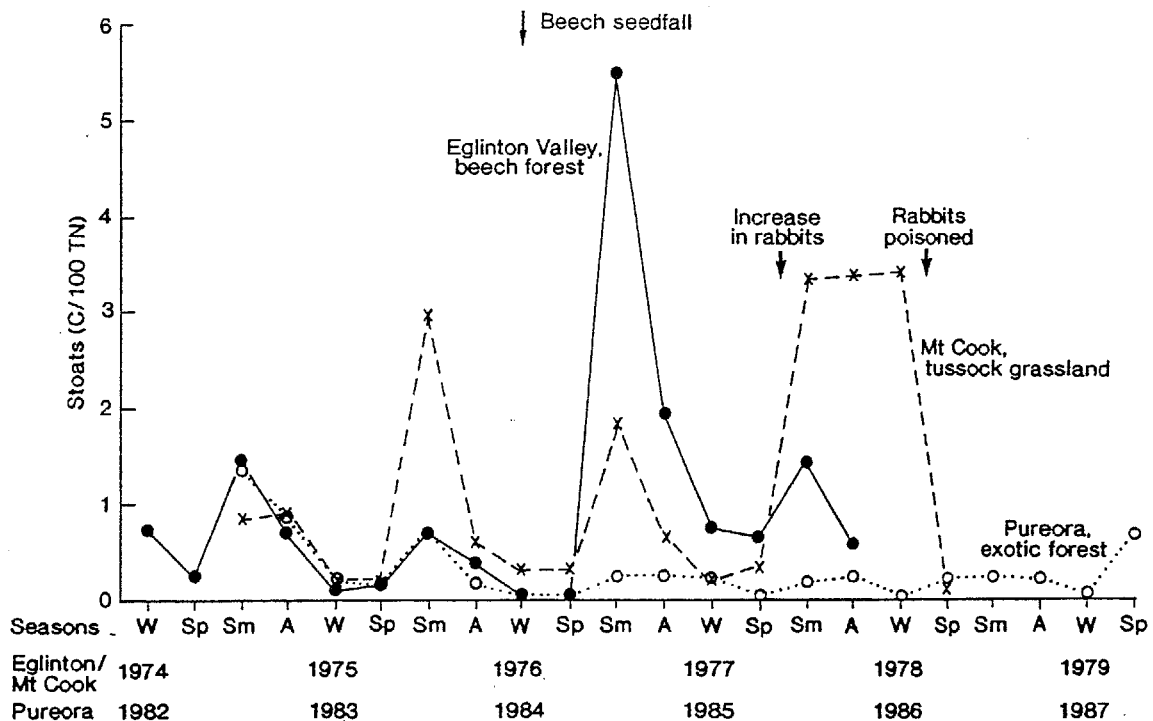

Figure 2 In most habitats there Is a regular increase in capture rate of stoats In summer, which Is higher In years when there Is plenty of food.

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The numbers of mustelids generally follow the numbers of their main prey. The normal summer increases in captures of mustelids, caused by the dispersal of the current year's young, are higher if an especially favoured prey was abundant during the spring (August to November). The usual autumn decline in captures can be postponed into the winter if prey remain abundant; if all prey disappear, the mustelids follow.

For example, when rabbits are numerous in grassland over winter, mustelids survive better than usual, and may produce large litters in the following breeding season. A single, well-timed poisoning operation against the rabbits only can remove both, since alternative prey are scarce there (Fig. 2).

The post-seedfall peaks in numbers of mice are short-lived, and die down rapidly in autumn, well before the following breeding season. The stoats must eventually follow, more rapidly if Fenn trapping continues into winter (see Fig. 9). If Fenn trapping stops at the end of the peak summer, there may still be more stoats than usual in the following summer. Most of these will be non-breeding one-year-olds born during the previous seed-year, whose litters were eliminated at an early stage by the higher than average mortality that falls on young born in the "crash" year following a seed fall (King 1989).
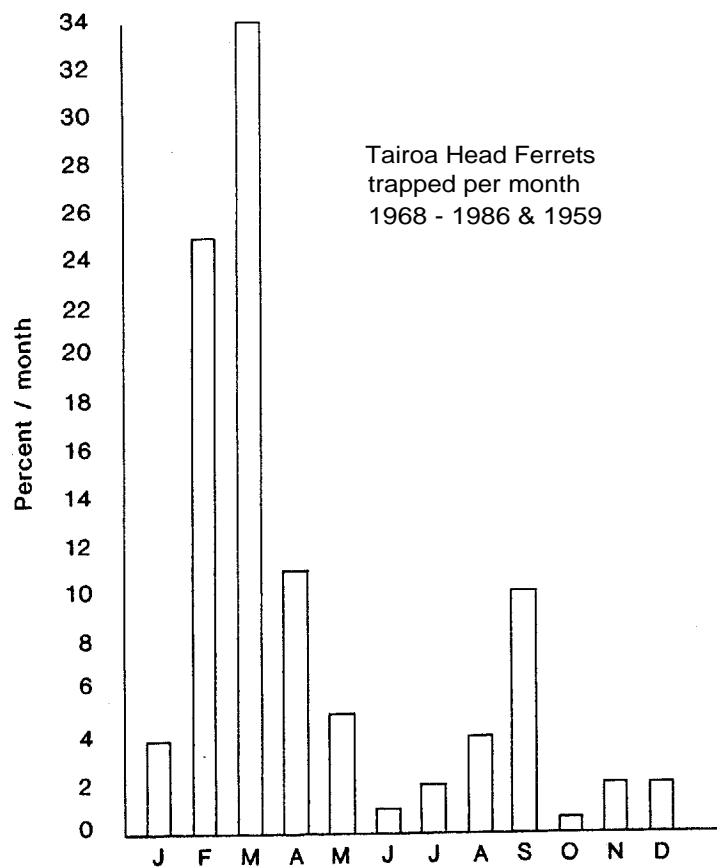

Figure 3   Seasonal variation In monthly capture rate off errets at Talaroa Head, 1968-1986 + 1959; total n = 170 (CA Robertson).

Tairoa Head Ferrets trapped per month 1968 - 1986 & 1959

6. PLANNING A CONTROL OPERATION AGAINST MUSTELIDS

6.1 Setting the objectives

The form of a trapping operation will always depend on balancing the ideal management objectives against practical constraints. When formulating control objectives, it is very important to identify the:

- Species or communities to be protected
- Predator that is doing the damage
- Ecology of both the threatened species and the predator
- Season of risk to the threatened species
- Chances that predator control will be beneficial
- Possible side effects
- Scale of operation required
- Resources available

The interaction of factors determines when, where and how extensive the operation needs to be. For example;

> "Mohua [yellowheads] are a hole nesting species in which only the female incubates the eggs and broods the young. She is especially vulnerable during this period. During most breeding seasons stoats are not common and there is little predation of breeding birds. However, high stoat densities occur in beech forests in the summer following heavy seeding of beech trees (on average every 4-6 years). It is believed that the increased amount of seed produced supports a larger than normal population of mice. The increased mouse population in turn provides an abundant food source for the stoats, whose population also rapidly increases [King 1983]. Higher stoat numbers result from increased litter sizes and survival of young stoats. In these seed years population declines of mohua of up to 75% have been recorded and about 50% of incubating female mohua are preyed upon"
>
> Elliott & O'Donnell (1988)

In this example the appropriate management objective was to trap only in years with higher than normal stoat densities, and at the time when females, eggs and fledglings are vulnerable in the nest (from October to March).

More details on how to decide whether and when a mustelid trapping operation is required in other circumstances will be available in the National Strategy document. The rest of this guide assumes that the decision to begin control work has been approved.

6.2 The difference between predator control and damage prevention

Included in the general term "predator control" are two rather different ideas:

1. **Eradication**, which means removing the animals faster than they can replace themselves over a long enough period to exterminate them; and

2. **Population control**, which means deciding what density of animals is tolerable, and then repeatedly removing them at the rate they can replace themselves from that density.

No mustelids can be permanently eradicated from anywhere in New Zealand, not even the offshore islands. About 28 islands have stoats, all within 1-2 km from shore; none have weasels or ferrets. Since stoats can reach these islands unaided at any time, and cannot be eradicated from the mainland with current technology, they cannot at present be permanently excluded from any island within their reach-even though some are of

very high wildlife value (e.g., Resolution). If zero density is achievable, an irregular but indefinite harvest of immigrants must be expected, as on Maud (Crouchley 1992).

On the mainland, many individual mustelids can be killed in Fenn traps, but this does not necessarily amount to effective population control, because the individuals removed are so rapidly replaced, and because some will never enter traps.

However, a special kind of population control is worth applying to stoats in beech forests. Their normal density in non-seed years is tolerable, but the massive production of young after a seedfall causes a temporary peak in density which far exceeds the tolerable level. Trapping only during this peak removes mostly young stoats that would soon disappear anyway (Fig. 9) and has no effect on their longterm density; but it is worth doing because it can minimise the impact of the irruption on birds. Hence I call this sort of work damage prevention. It is a cost-effective compromise, if we know when the protected species is particularly vulnerable to predation. The yellowhead example quoted above shows that well-planned damage prevention programmes can be efficient and effective. They should be a high priority in seed years, and be extended into the following year to assist post-irruption recovery (O'Donnell 1992).

6.3 Trap number and spacing
The number of traps used will depend upon the aim of the operation, the size of the area to be covered, the amount of money available for associated materials i.e. traps, baits and wood for tunnels, and the number of people available to check traps.

In general, the larger the number of traps the greater the area that can be covered, or the greater the intensity of trapping in a given area. If access to a trapped area is good, one person can easily check up to 100 tunnels (200 traps) in an eight hour day.

Various things affect the capture rate, of which some depend on the animals (e.g., the number of mustelids available to be caught, and the reactions of individuals to traps), and some depend on the trapper (e.g., the layout of the traps). Trap spacing is the most important of the factors under human control; it affects the total catch, the proportion of the population caught, the proportion of females in the catch, and the cost of the operation.

Traps set very close together (100 m apart or less) probably catch most of the stoats present on a small area, including many females. The same number of traps set further apart (over 400 m) collect a smaller proportion of a much larger population (because wider-spaced traps traverse a much larger area), of which most are males.

For control or damage prevention, traps should be set closely, say down to 100-200m; the closer the traps, the greater the chance of a mustelid encountering one. If there are no other traps operating nearby, a close-set line or grid will also collect individuals passing through from further afield. Virtually all mustelids entering the area will be exposed to the chance of being caught, but the area covered will probably be small, because it takes such a lot of effort to operate a close-spaced line.

For control work, straight lines of traps are much less likely to be effective than a grid, or at least a looped arrangement of lines. The ideal is to have each trap within about 100-200 m of another one in every direction, over the whole area to be protected. Whether this is possible depends on the terrain.

For example, in the Eglinton Valley the 10 pairs of mohua studied occupied a 50 ha area of wide, relatively flat forest; the traps were laid out in a grid at 100m spacing (Fig. 4). This intensity of trapping proved to be effective in eliminating predation of mohua in the trapped area (O'Donnell *et al.* 1992). If specific nest sites are to be protected, an additional ring of traps can be laid around the sites. The problem is that such a programme is very labour-intensive; further trials are needed to reconcile the opposite requirements of maximum benefit for minimum effort.

If the terrain is too rugged for a grid, some compromise must be worked out (e.g., see Section 6.7). Either way, planning an effective operation requires knowledge of the area and careful preparation long before the trapper goes out into the field.

Trap spacing and layout are being investigated further in current DoC research; future editions of this guide will update this section.

6.4 Timing of trapping for population reduction
Around important small reserves or aviaries, e.g., at Mt Bruce or Taiaroa Head (Fig. 3), trapping for local population reduction should continue all the year round if it can be integrated with other work, especially if the area to be protected is vulnerable all year and there is no effective barrier against immigration from untrapped areas outside.

All-year trapping is usually not possible in larger reserves, and is not necessary if the protected species is not vulnerable all year. An acceptable minimum is to trap at least from September (when the earliest young mustelids are born) to April (the end of the main period of dispersal of young).

Every female stoat, and most female weasels and ferrets, caught between August and early November will be at some stage between active pregnancy and round-the-clock providing for growing nestlings, and her removal could well could mean a whole litter of young wiped out. It is very difficult to catch females at that time of year, but worth attempting since those that both survived over winter and also escape capture have a good chance of living through the coming breeding season.

By contrast, the males dominate the catch in winter and spring. Unfortunately their removal need not make any difference to the numbers of young born the next season, since all mustelids are promiscuous. In stoats, the females are already carrying next year's young, so the removal of all males over winter has no effect on the productivity of the next season.

6.5 Timing of trapping for damage prevention
Trapping to prevent damage to a vulnerable native species at a time of particular risk, (e.g., in a yellowhead nesting area in a beech forest), should run from just before the young mustelids disperse to just after the danger to the protected species is past. The proportion of males and females in the catch does not matter, since both are capable of causing damage and the operation is not attempting to affect the mustelid population.

Trapping after late summer is less likely to be necessary for preventing damage to birds, even though it may still give a high catch per unit of effort. Mustelids do kill some birds in autumn and winter, but fewer than at other times of year (Fig. 5). Apparently they turn their attention to rodents and rabbits in autumn, which are more abundant then compared with the rest of the year.
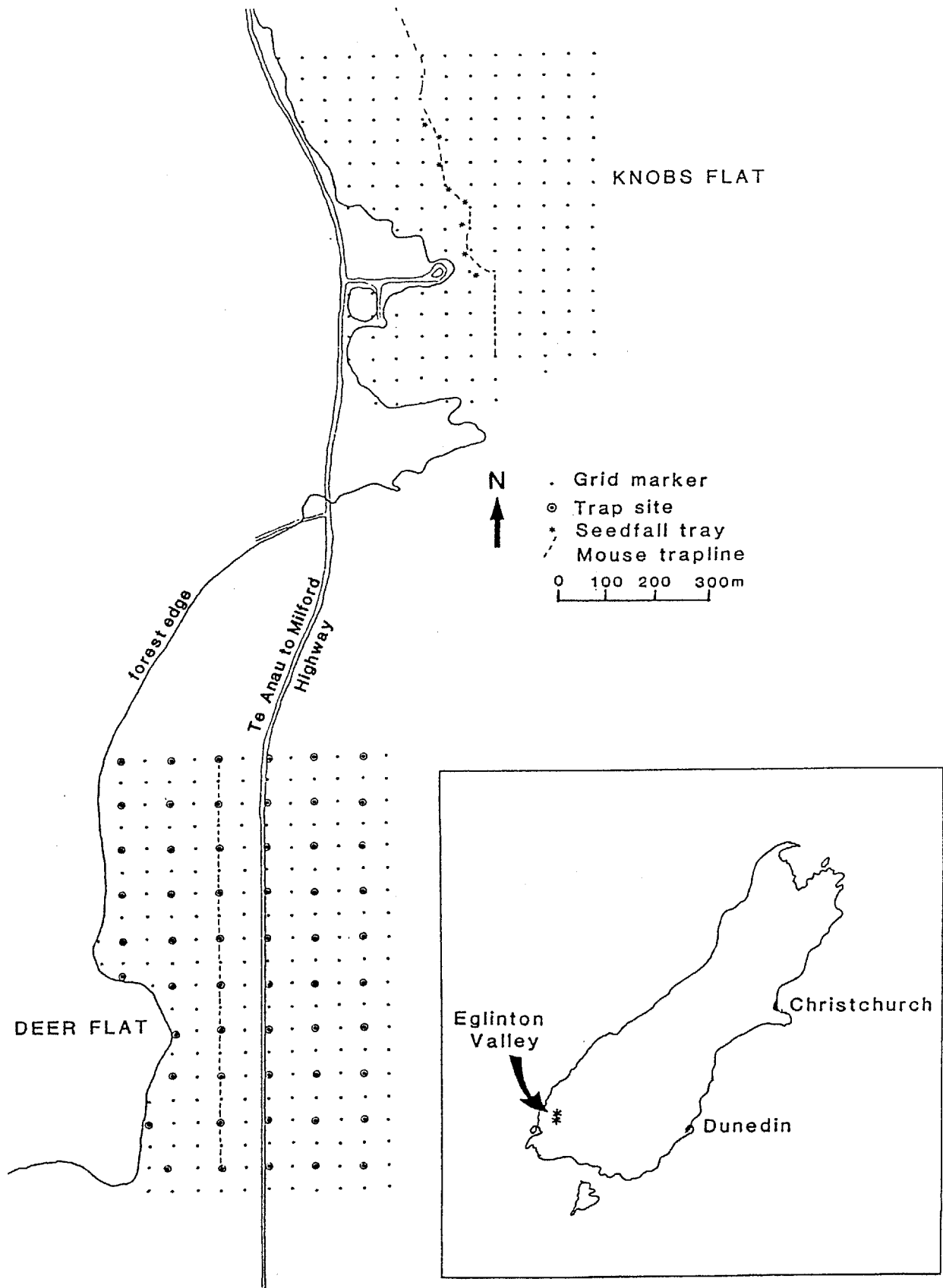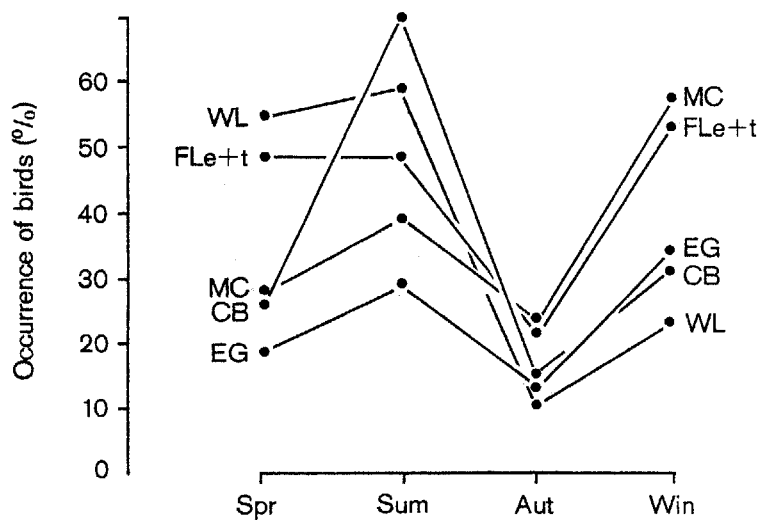
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Figure 4 A typical grid-pattern trap layout, as used in an Eglinton Valley yellowhead nesting area. Dots=grid markers 50 m apart; circles=trap tunnels; dotted line=inspection route; double line= road.

(Reproduced from fig. 1 of O'Donnell *et al.* 1992)

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Figure 5 Extensive gut analyses (sample sizes tabulated) in five different habitats in all seasons showed that stoats eat significantly fewer birds in autumn. CB = Craigieburn Forest Park; FL+t = Fiordland, Eglinton Valley, and Te Anau area; EG = Mt Egmont; WL = Westland; MC = Mount Cook. (Reproduced from King & Moody 1982)

n:	Spr	Sum	Aut	Win
CB	35	63	40	13
FLe+t	51	59	26	72
EG	16	7	15	35
WL	11	22	41	13
MC	18	66	53	7

6.6 Inspection routines

If the area to be covered is small, or if there is plenty of manpower available, the traps may be left set all the time, so long as they can be inspected daily.

If manpower is limited and the area to be covered is large, the most economic method of trapping is to set the traps for 7-14 days at a time, inspect them daily, and then either shift them to a new area or spring them closed for a rest period. The capture rate tends to be higher during the first few days of trapping, so a "pulsed" routine catches the most animals for the least effort (see Section 8.2.1 below, "Extinction curves").

If manpower does not permit daily inspections, but the need to keep the area clear of mustelids is considered to be great, the temptation is to leave the traps set permanently and inspect them whenever possible, even if only once a week. This is both illegal and inefficient (see Part 2, King *et al.* 1994, section 2.7).

6.7 The sink effect

If the trapped area is small and the population in the surrounding area is high (e.g., if traps were protecting only, say, 50 ha out of 5000 ha of beech forest after a seedfall, as in Fig. 4), it will inevitably become a "sink" in which no residents live and which collects transients from miles around. However the sink effect can be reduced by extending a single line of traps at say 300 m spacing outside the intensively protected area, e.g., along a road for 10-20 km in both directions from the key area. Whilst these traps will not control the population of the wider area, they may help to reduce the number of

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mustelids that approach the intensively protected area (S.M. Phillipson and J. Steven, unpubl.).

6.8 Trap avoidance

Some mustelids always escape capture, either because they do not encounter a trap, or because they will not enter it. For example, in the summer of 1979/80, when stoats were at very high density, we set live traps at 400 m spacing in the Eglinton and Hollyford Valleys. Of one group of 21 stoats marked on or before 15 January, and known to be present in the same area on or after 25 January, 9 were not recaptured on any of the 7 days on which traps were set between 15 and 25 January. In other words, a full third of the stoats known to be present were not caught in a whole week's trapping (King & McMillan 1982).

In December 1990, a young male was radio-tracked back to its family group, but even though the den site was ringed with live traps, the mother and the other young were never caught (Murphy & Dowding 1991).

6.9 Immigration

Young stoats are able to travel over great distances from their birthplaces within their first few months of independence. Three males that were first livetrapped, marked and released after the 1979 seedfall in the Eglinton turned up a few weeks later over 20 km away in the Hollyford (King & MacMillan 1982). In 1990 a young female travelled at least 65 km from the Eglinton to Burwood Bush, near Te Anau, in less than one month (Murphy & Dowding 1991).

We do not know if such travels are undertaken in low-density years, but we can say that, when stoats are numerous and most in need of control, replacements for those removed can easily come from at least 65 km away. Some wandering stoats are probably always available to occupy patches of suitable habitat, e.g., an isolated haybarn full of mice, or a protected area in the MacKenzie from which ferrets have been removed (Pierce 1987).

6.10   The human element

Regular daily inspections of a network of closely-spaced Fenn traps demand many hours of mainly unproductive and excruciatingly boring tramping around mainly empty traps; this in turn limits the extent of operations over inaccessible country, and creates well-worn tracks. One way to overcome these human problems is to use a team of trappers that operate a trapline in relays. But since not all are equally skilled or enthusiastic, this introduces an additional problem, an increase in variation in the results.

The alternative strategy, especially useful where the traps are numerous, well-sited and do not require regular rebaiting, is to exchange the traditional method of direct inspection by eye for some means of electronic inspection from a distance, at least on some days. This can enormously increase the number of traps that can be operated by one person, and reduce habitat damage and the distribution of human scent.

Even so, visual inspection of the set and the trap mechanism is still necessary from time to time, and traps using a perishable bait (other than eggs) have to be rebaited every few days. There is apparently no means of entirely avoiding the limitations imposed on large-scale Fenn trapping by the human element.

7. ASSESSING THE BENEFITS FOR THE PROTECTED SPECIES

The main purpose of any kind of control work is to benefit some protected species, usually a population of native birds. Obviously, even if you are reasonably sure that you have greatly reduced the number of mustelids or the amount of damage they are doing, you still cannot claim a successful campaign unless the birds are better off. Conversely, if the birds increase after a control programme, you cannot honestly attribute this to your action unless you can eliminate other explanations. Controlled trials are required to decide the point, such as those conducted in the Eglinton Valley by O'Donnell et al. (1992). They showed that the risk of predation on yellowheads during post-seedfall stoat plagues can be significantly reduced by well-timed trapping, and that other risks (e.g., nest parasitism by cuckoos) are minor by comparison.

The benefits of predator control are minimised if the birds also suffer from other problems. For example, the decline in population density of the takahe during the late 1960s was due to competition with deer as well as to predation by stoats; and protection of young black stilts from predation since the early 1980s has increased their survival (Murray 1992), but has not so far got many of them into the breeding population. On the other hand, when so few breeding adult takahe or black stilts survive, any loss is damaging. To be effective, predator control must be part of a total management programme addressing all preventable losses together. If birds protected from predation have a real chance of surviving most other hazards, the expense of removing predators is fully justified; if birds protected from predation continue to die for other reasons, it is not.

The question of whether trapping increases the numbers of common bush birds is still unresolved, mainly because the numbers of birds vary for many reasons besides the effects of predation. For example, on Adele Island (87 ha), 800 m off the coast in Tasman Bay, stoats were removed for three years from August 1980. Bird counts on the island showed that bellbirds were more numerous there than on the mainland in 1981 and 1982; but yellow-breasted tits, grey warblers, blackbirds, song thrushes and hedge sparrows were all less numerous in those years (Wilson 1988).

Equally variable results were found by Kim Morrison in the Eglinton and Hollyford Valleys in the late 1970s (Efford & Morrison 1991). Morrison did regular five-minute bird counts for a year in two areas in each valley, one in which stoats were being trapped and another in a comparable area away from the trap line. He continued over the next year, after the trapping had been stopped, to compare the trapped areas during and after regular removal of stoats. The results showed no large and consistent benefit across all bird species. Some, including bellbirds, yellowheads, and blackbirds, were both relatively more abundant in the trapped areas and also less abundant after trapping ceased. But it is difficult to attribute these differences to the trapping because (a) there is room for doubt about the extent to which the study areas were both independant and strictly comparable; (b) there is always substantial variation between times, places and years in bird counts (Fig. 6), that has more to do with food or habitat than with predation; and (c) there is no way of calculating how far local stoat densities had been reduced by trapping.

The counts of other species, including grey warblers, tits, riflemen, fantails, kaka, and kereru detected no such differences. Again, that does not mean that those birds did not benefit in some undetectable way: on the other hand, some species are less vulnerable
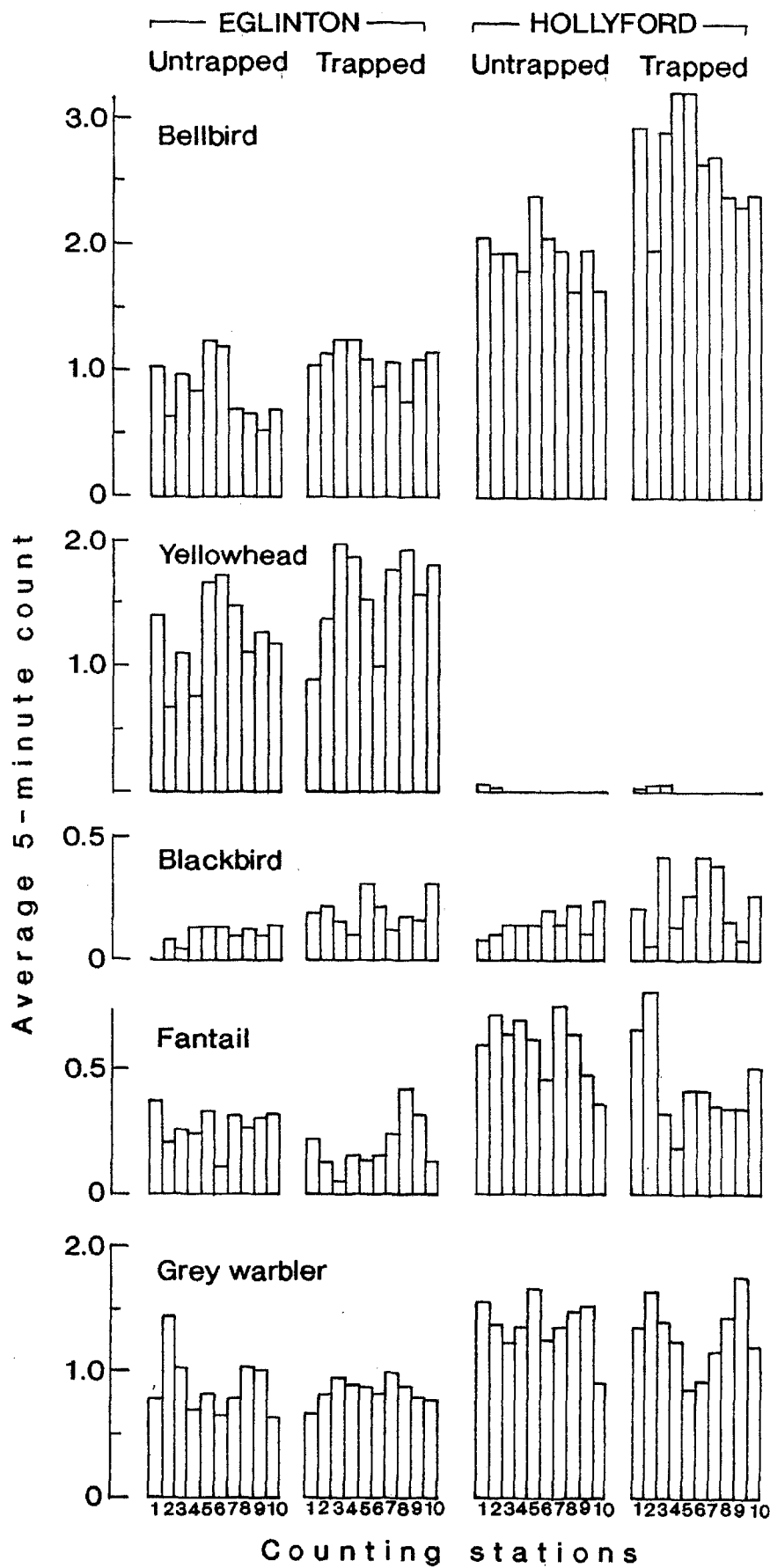
Figure 6 The normal variation in bird counts between seasons, areas and counting stations, both in trapped and untrapped areas, makes it difficult to decide whether the apparent benefit in some species, and lack of it in others, is attributable to removal of stoats or to other differences between areas, e.g., habitat (M.G. Efford).

to predation, and less likely to benefit from predator removal, than others (King 1984, 1985a).

It may well be that the level of trapping used in that study did not remove enough mustelids to make any difference to the birds. The trapping programme was set up for sampling, not for control; but on the other hand, it was prolonged and regular, and apparently did make a difference to at least one of the stoats' prey. In both valleys, the post-seedfall irruptions in mice lasted much longer when the stoats were removed at first capture (Fig. 7) than when they were released alive. Preliminary calculations suggested that the potential predation pressure on common birds during an uncontrolled post-seedfall irruption of stoats could also be substantial, because each of the unusually large number of stoats hunting in a post-seedfall summer ate about the same number of birds per head as in a normal summer (King 1983). The point will be settled only by further trials.
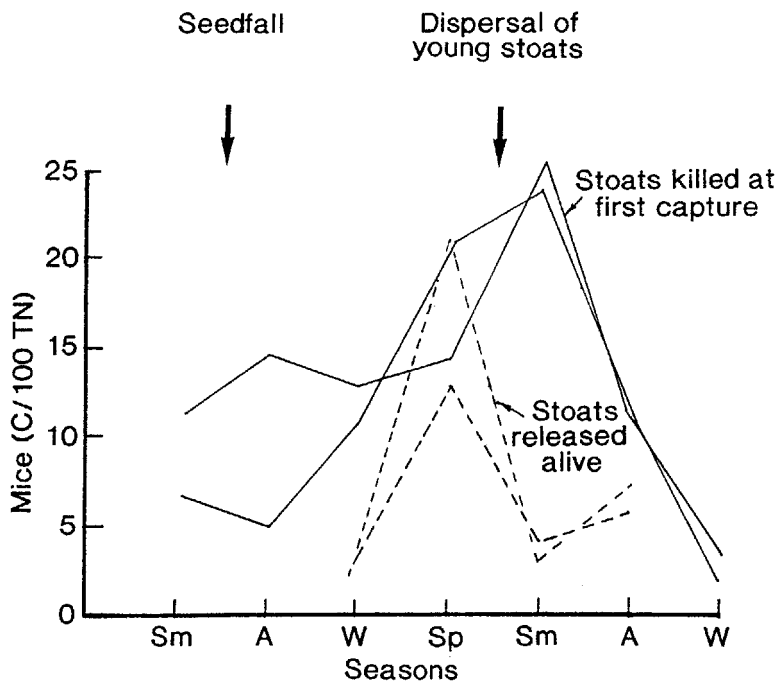
Figure 7 In 1976/77 (solid line), when Fenn-trapped stoats were removed at first capture, the post-seedfall irruption in mice remained higher for longer, in both valleys, than in 1979/80 (dashed line) when stoats were released alive. (Reproduced from King 1985b)

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8. ASSESSING THE IMPACT OF TRAPPING ON THE MUSTELIDS

8.1 Asking the right question

The simplest and commonest yardstick for measuring the success of a control programme is the number of animals killed. The unstated assumption behind it is that every kill is worth the effort made. But, as any tramper besieged by sandflies knows, it may be easy to kill individual pests and yet still impossible to reduce whole populations of them, even locally or temporarily.

You will probably want to know whether your campaign has removed 10% or 90% of the target population. This is a simple question to which there is no simple answer. Besides, it is not in fact the right question: what you really want to know is what degree of protection your trapping is conferring on the protected birds, regardless of what proportion of the mustelids have been removed. The goal of the operation is not to kill mustelids, but to protect birds. If this distinction is forgotten, the programme becomes an end in itself. Unless you have already decided that the only acceptable number of mustelids is zero, or unless you know what number has to be removed to benefit the birds, you cannot judge your progress from the tally, however impressive the pile of dead animals.

Direct control and harvesting use the same technology; the efficiency of control depends on how severely the animals are harvested (Caughley 1977). The Fenn trap is a simple and effective method of harvesting individual mustelids, and DoC field staff certainly operate it well; but most Fenn trapping operations are exercises in harvesting, not in control. It is impossible to tell the difference, without monitoring.

Managers sometimes object that money should not be diverted from trapping operations to monitoring, because that reduces the number of kills that can be achieved for a given expenditure. This is true only in a campaign for which continuation has already been approved whether it is effective or not (e.g., for research, or as a routine preventative measure around an aviary), or until eradication is achieved, however long it takes. If the only aim of the operation is sustained control, money will be wasted if no attempt is made to determine whether the operation was worth attempting, or whether it should be repeated next year. To calculate that you have to know, among other things, the density and breeding rate of the population, the proportion killed, and the longevity and natural mortality pattern of the adults. These things can be determined only by monitoring. (For monitoring techniques see Sections 4 and 5, above.)

8.2 Indicators of success in trapping

Here is a list of pointers which may indicate whether or not the trapping has been effective, and some that you should avoid because they cannot tell you one way or the other.

8.2.1 Extinction curves

If the capture rate per day remains about the same over the long term (e.g., year after year at the same season) the target population is probably not being affected, because the losses are either inconsequential or are being rapidly made good. But consistency in capture rate is unlikely in mustelids, since their numbers vary naturally during the year and from one year to the next (see Section 5.5). If this variation is not allowed for, trapping data can be badly misinterpreted.

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In easily accessible lowland habitats, such as English farmland, gamekeepers traditionally set traps in late winter and spring. An intensive effort can produce a lot of mustelids at first, and then fewer each month for as long as the trapping continues. A plot of the monthly kill rate against time produces an "extinction curve", and if it reaches zero it implies that the local population has been eliminated, as illustrated for stoats in Fig. 8. However, it takes only a few months after the gamekeepers have turned to other work for stoats to recolonise the cleared ground, so the process has to be repeated every year-there is no "carry-on" effect.
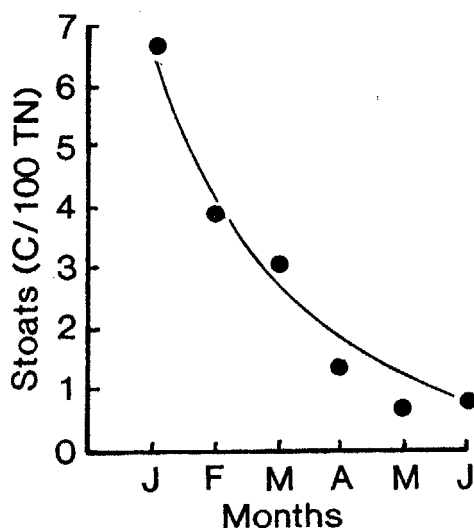
Figure 8 **A seasonal extinction curve (late winter to early summer) showing near-total but temporary removal of stoats from an English game estate.** (Reproduced from Tapper et al. 1982).

Plotting extinction curves is a favourite and easy method of tracking "trapping success"; but it can be deceptive. A curve like that in Fig. 8 means that the population is being reduced artificially only if it is applied at a time when the population is not declining (or not by that much) naturally. Otherwise, it might mean only that the trapping record is documenting what would have happened anyway.

For example, a decline in capture rate of stoats from mid summer to the following winter is not proof of the effectiveness of a control programme. There are always more stoats about in summer than at any other time of year, especially after a beech seedfall, and most will disappear naturally whether traps are set or not. The most that trapping can do is to bring forward the inevitable autumn losses (Fig. 9).

After the 1976 and 1979 seedfalls in the Eglinton and Hollyford Valleys, the autumn drop in numbers of stoats was steep, with or without control. But the density index dropped rather earlier in 1976/77, when stoats were removed monthly throughout the peak, than in 1979/80, when no kill-trapping was done until April. Whether or not stoats were removed during the seedfall year, they were scarcer the following summer in both valleys. But the rate of the decline of the post-seedfall population need not be the same every year, especially if Fenn trapping stops over winter; so, for example, many stoats of the 1990/91 seedfall cohort in the Eglinton survived into the 1991/92 summer.

The same sequence of events is likely in any habitat within about 50 km of extensive beech forest. For example, in the summer of 1979/80 on the Riverslea Wetland Area,
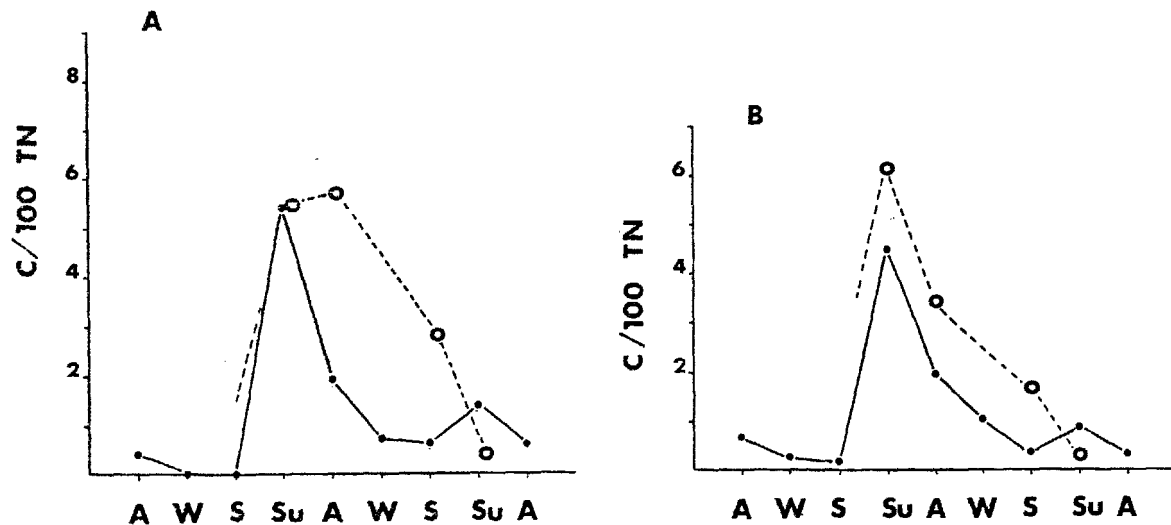
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Figure 9 Fenn trapping of stoats during a post-seedfall Irruption (solid line) brings forward the decline In numbers that would follow anyway (shown by live-trapping, dashed line), but is an important short-term management strategy to protect endangered birds at risk in beech forests during post-seedfall summers. A = Eglinton Valley; B = Hollyford Valley. (Reproduced from King & McMillan 1982)

near Manapouri, the honorary ranger noticed increased sign of predation around waterfowl nests, and poor survival of ducklings. He borrowed three Fenn traps, and in the three months from 1 February 1980 he caught 9 ferrets, 6 stoats, 12 hedgehogs and 1 cat. Over the following winter months he caught a further 1 stoat, 1 cat, 5 hedgehogs and 7 rats. When he noted increased breeding populations and larger broods among the waterfowl next spring, he understandably attributed them to the success of his control efforts. But 1979 was a beechmast year in Fiordland, and the unusually high predation in the summer of 1979/80 would probably not have been repeated in the following season even if the ranger had done nothing.

If the traps are set for only half of each month over a long period, as they were on our experimental trap lines in Fiordland, the results come out like a series of mini-extinction curves, separated by a series of mini-recolonisations. The capture rate declined from an average of 1.07 captures per 100 trapnights (C/100TN) on day 2 to 0.42 C/100TN by day 14, an apparent reduction, through each 14-day trapping session, averaging 60% of the number originally present (Fig. 10). This same trend appeared in separate calculations for most months of the year, and in both sexes and age-groups. But immigrants replaced the trapped stoats almost all the year round, so we always caught more stoats at the beginning of each new trapping session than would have been expected from the decline in captures during the previous month.

Stoats living in exotic forest do not show such wild fluctuations in numbers. In a five-year study at Pureora, we found all three mustelids present, and all were scarce compared with Fiordland and Mount Cook (Fig. 2). After the presumed resident animals were removed at the beginning of the trapping programme, few mustelids were caught in the subsequent three and a half years (C.M. King, J.G. Innes, M. Flux, M.O. Kimberley, J.R. Leathwick and D.S. Williams: Distribution and abundance of small mammals in relation to habitat in Pureora Forest Park, in prep.).
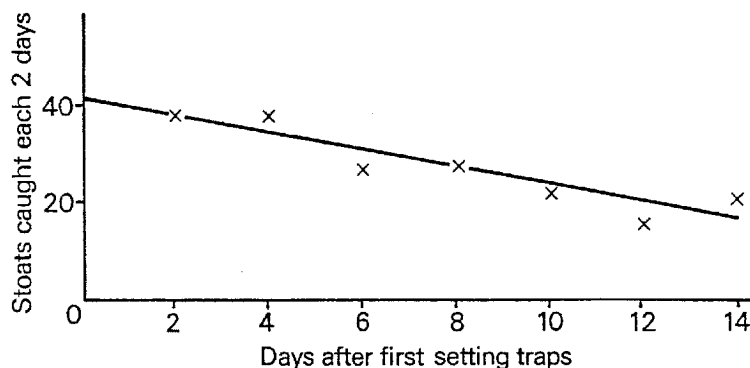
Figure 10 **Most stoats are caught on the first days after setting the traps. Pooled data from 17 months of field experiments In Fiordland.** (Reproduced from King 1980)

A long-term decline over several years that cannot be explained from variations in food supplies might be attributable to control, but only if there is other evidence that the trapping affected the population dynamics of the mustelids. In Fiordland there was too much natural variation in density to determine whether or how trapping might have been affecting numbers.

Another way to estimate trapping success is to compare the density indices and population dynamics of two populations, one sampled by live trapping and the other by Fenn trapping. If there is a real and consistent difference in the Fenn-trapped area, the case for claiming an effect is strengthened-especially if the two areas are swapped after a few years and the difference re-establishes itself in reverse. Such an experiment could be incorporated into a "research-by-management" programme.

8.2.2 **Catch comprises under 50% males** A trapline intended to monitor a mustelid population will be ineffective if it catches many more males than females, because it will not be giving a true sample; likewise if it was supposed to control the population, because it will be letting too many breeding females escape. However, a trapline whose only aim is damage prevention will be effective if it does prevent damage, regardless of the sexes of the mustelids caught.

There are several reasons why a trapline might be catching too few females:

1. **Trap spacing** On experimental traplines in Fiordland, the number of stoats of both sexes caught declined as the traps got further apart. But this decline was steeper in females than in males (Fig. 1), which means that relatively more females than males were caught at the closest spacings. The ratio did not approach 50:50 until the trap spacing was 400 m. Traplines in other areas, using similar spacings, also collected stoats of approximately equal sex ratio: e.g., Craigieburn Forest Park, 54% males; Mount Cook National Park, 48%; Mount Bruce, 44%. Therefore, if the catch comprises 50% males or less, you can be reasonably sure that the whole local population is exposed to the traps.

The "sink effect" (see Section 6.7) explains an apparent exception to this rule: during an irruption of stoats in beech forest, traps set at very close spacings in a small area surrounded by a large untrapped area may still record an excess of males (Dilks et al. 1992), because males generally travel about more.

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However, a trap spacing which is about right to collect roughly equal numbers of male and female stoats will probably produce mainly male weasels and mainly female ferrets. This is because the chances of an individual mustelid being caught at, say, 400 m are reduced if it is much smaller or much larger than the average stoat, for two reasons. Very small mustelids (e.g., female weasels), are often either too light to set off the trap, or have a home range small enough to fit between adjacent traps set at 400 m. Very large mustelids (e.g., male ferrets), may be too big to enter the tunnels, or have a home range large enough to extend far outside the trapped area.

2.   **Season**   It is only the **average** sex ratio of a full year's harvest of stoats collected from traps set at 400 m that might be about even; during the year it may range from an excess of males in winter and spring to about evens, or even an excess of females, in summer and autumn (see Section 5.5). This is because in winter and spring the adult males roam about more often and more widely than the adult females do, whereas in summer and autumn most of the population comprises the dispersing young of the previous year, which are of more or less even sex ratio.

8.2.3   **Disappearance of sign**   Sometimes, natural tracking on sand or snow can give an independent confirmation of trapping results. For example, when the first Fenn line was set up in Takahe Valley in May 1972, stoats were relatively abundant and their tracks were seen frequently in the snow. In an intensive effort to eliminate stoats from the takahe area, 33 stoats were killed in the 14 months to July 1973; but the distribution of fresh tracks and sign remained unchanged, and the population was clearly little affected (Lavers & Mills 1978).

The trapping has continued on and off ever since, although the captures are few and no detailed records are kept. But the numerous dens found by Lavers on the tussock floor in 1972/73 were not used again, and fewer fresh tracks and scats are now found on trails. The shortage of casual observations of tracks confirms that stoats have been less abundant in Takahe Valley since the mid 1970s.

Near the Tekapo River in 1986, Pierce (1987) used snowtracking to check how many resident ferrets were being accounted for by livetrapping. He found that most ferrets entered live traps eventually, and some quite regularly.

Where natural tracking is not possible, artificial tracking tunnels can be used to check the progress of a control operation (see Section 4).

8.3 Value of negative results
Some people say that an intense effort that produced few kills was wasted. This is wrong, since reliably negative results from a well-organised trapping programme supply important information in their own right.

For example, at Kaharoa State Forest in 1990/91, a trapline 10 km long with 71 traps at about 150 m spacing was set up in late October and run continually for 5 months until the end of March. The traps were set in tunnels in the usual way, baited and inspected 2-4 times a week. The total catch was two stoats, no other mustelids and very few rats (Table 1). Because this trapline was well set up and its results properly recorded, and because we can compare it with other traplines set up in the same way, its operator (Hazel Speed) can be reasonably sure that the traps were catching few mustelids because few were present at that time, not because they were there but avoiding the

traps. This information may lead to the important conclusion that control of mustelids at that place and time might be less urgent than some other management option.

Of course, such a conclusion would not always be valid, even in the same place at other times. Indeed, in the next field season (December 1991-July 1992) the same trapline, operated in the same way in every respect except that the bait was changed to fresh eggs, caught 13 stoats, 6 weasels, and 1 ferret; even more stoats were caught in the 1992/93 season. We need to collect more records of carefully documented trapping operations conducted in specified conditions, so we can more confidently interpret variations in their results, positive or negative.

9. HABITAT MANIPULATION

Successful predator control does not necessarily mean inventing new and more effective ways of killing animals, for reasons explained by Caughley (1977):

> "Most populations extinguished by man were eliminated by accident, often in spite of vigorous efforts to avert the extinction. In contrast, most premeditated attempts to destroy a population have been unsuccessful. The paradox is less puzzling when it is realised that unplanned exterminations are usually caused by a change in the animal's habitat, whereas the planned attempts are usually aimed at the animals themselves. The message is clear: populations are more vulnerable to a manipulation of their habitat than they are to a direct manipulation of their numbers ... a population attacked frontally by shooting, [trapping] or poisoning does not have to contend with a deteriorating habitat. Quite the reverse. The reduction in density occasioned by the control measures leaves the quality of the resources intact, whilst increasing the quantity available to each surviving animal. The control campaign automatically boosts rp [the potential rate of increase of the surviving population]. This is precisely the aim of a harvesting programme ... [so] ... whenever possible, attempts at lowering density should be aimed towards manipulating the habitat".

What are the prospects of applying this principle to mustelids? The most effective way to manipulate a habitat to the detriment of any predator is to remove its food. If it cannot turn to an alternative food that is not already the preserve of another predator, it is bound to decrease in numbers. On two occasions, this effect has greatly reduced the numbers of mustelids over enormous areas, although neither was the result of a deliberate policy aimed primarily at the mustelids themselves.

In Britain, the first epidemic of myxomatosis in the mid 1950s, which reduced the rabbit population by over 99%, virtually cleared stoats (but not weasels) from the countryside (King 1989). In most New Zealand farmlands, stoats and ferrets became less common between the late 1940s and the mid 1980s. That was the heyday of the Pest Destruction Boards, which maintained substantial control of rabbits by aerial poisoning and night shooting, aided by changes in farming practice.

In New Zealand, stoats and ferrets depend for the bulk of their diet on the introduced mammals-possums, rabbits, hares, rats, mice and carrion. Any really substantial reduction in these important sources of food, especially if permanent and in a place with few alternative prey, could have a suitably bad effect on a local mustelid population (for an example, see Fig. 2). Unfortunately, there are hidden snags.

Mustelids, especially stoats, are very adaptable, and will not necessarily decrease in numbers if they can survive on other prey. In the MacKenzie Country in the mid 1980s, removal of rabbits was followed at first by increased predation on birds, in one area because the ferrets hung on until the nesting season, and in another because the departed ferrets were replaced by stoats (Pierce 1987). Forest habitats offer a variety of prey, and removal of rats will not necessarily affect the numbers of stoats. On the contrary, at Mapara after rats were poisoned in 1990/91, stoats remained at the same density as in 1989/90, but ate many more birds than then (Murphy & Bradfield 1992).

Large scale shooting, trapping or poisoning of potential prey mammals have undesirable side-effects. Besides being expensive, they usually increase the distribution of carrion;

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if sustained, this can benefit the overwinter survival (though probably not the breeding) of mustelids. Carrion and offal used to supply substantial food for mustelids in Westland and Egmont when possums were intensively hunted for fur, and also in the early days of intensive hunting for deer.

An alternative form of habitat manipulation might aim to reduce the frequency of encounters between mustelids and native birds. Waders that choose to nest on islands or in fenced exclosures in braided riverbeds can be protected from ferrets, which are deterred by a fence or a river; but stoats can climb almost any rough surface, enter by holes only 3 or 4 cm in diameter, and swim for over 1 km in either fresh water or salt. In Otago, barriers of long grass and flax are being planted around known breeding sites of hoiho-although it is not yet known whether predators are deterred by them. They might not be, since small predators are often well adapted to hunting in thick cover (Moller *et al.* 1992).

10.   LIVETRAPPING

Livetraps are of no use in large-scale control work, as they are heavy and cumbersome to move about, and have to be inspected daily without fail. On the other hand, live traps are useful in smaller-scale control work, for example round an aviary, where daily inspections can be made in the course of other work. If it is important to ensure the release without harm of any other animals or birds caught incidentally, livetrapping may be the only acceptable method.

Livetrapping also has three other useful applications. First, although radio-tracking has now replaced livetrapping as a method of studying mustelids in the wild (Murphy and Dowding 1991), the work of attaching and maintaining the radios still depends on live trapping. Second, monitoring the abundance of mustelids by live trapping avoids the disruption to the population caused by kill-trapping. If a local area is to be sampled regularly, index lines of live traps at critical times of year will give a more accurate picture of the standing population than Fenn trapping.

Third, the worst pests on the offshore islands are undoubtedly rats. Fitzgerald (1978) suggested that one way to exterminate rats from an island would be to release a number of marked, live male stoats on it, removing them after they had done their work. This method has been used successfully to remove water voles from islands in Holland and Denmark (see King 1989).

For any such work, an efficient livetrap is needed, such as the Edgar trap. Full instructions on how to make and operate the trap, and how to handle and tag live mustelids under anaesthetic, are given in Part 2 (King *et al.* 1994).

11. POISONS

No poisons have been developed specifically for mustelids, and DoC has none registered for use against them (Kurt Jansen, DoC Head Office, pers. com.). Mustelids could in theory be affected by secondary poisoning after 1080 drops against possums or rats, but this apparently seldom happens in practice.

Poisoning is an alternative means of harvesting mustelids by the direct removal of ¡ndividuals-what Caughley calls "frontal attack"-and it suffers from some of the same disadvantages as trapping. The main problems are in (a) ensuring that the poison is available to and only to the target species, and in (b) the instability and high recovery potential of the target populations.

Poisoning on any substantial scale requires prior research on effectiveness (proportion of the target population that escapes) and risks (other species killed, accumulation of toxins in the environment, side-effects of successful removal of predators) just as for trapping. In places where a vulnerable species is already present, and where a suitable poison would be most useful, distribution with present technology would have to be as careful (i.e., as labour-intensive) as trapping-but with the right bait, it could be a lot quicker. Landcare New Zealand Ltd (Weeds and Pests Division) is at present attempting to develop a pellet bait for carnivores that can be stored long term and delivered by air.

12. ACKNOWLEDGEMENTS

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