EXAMINING THE CAPTURE EFFECTIVENESS OF VARIOUS TRAP SETS FOR THE CONTROL OF FERRETS

PROJECT R-80664

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1. Executive Summary

- **Project Title and Client**

An investigation examining the capture effectiveness of various trap-sets for the control of ferrets was conducted by Dr Justine Ragg, an independent research scientist, Dunedin for the Animal Health Board, Wellington.

- **Objectives**

Determine whether setting traps in burrows increases the trap catch of ferrets in autumn and spring.
Assess whether adding a visual lure to a trap set increases the trap catch of ferrets.
Assess the relative capture efficiency of traps baited with fresh rabbit and salted rabbit.
Evaluate whether placing supplementary food outside the burrow increases the trap catch of burrow sets.
Identify a method of trapping most ferrets in autumn and spring.

- **Methods**

Two field trials were undertaken in Central Otago during the summer and autumn of 2006. The first trial at Ardgour Station and The Point, in late March examined the catch rate of four trap sets – ground set Holden live capture traps, ground set Set-n-Forget kill-traps under covers, Set-n-Forgets down rabbit burrows and leg-hold traps (Victors or Dukes) set down burrows. All traps were baited with salted rabbit meat. A further treatment involved the use of a visual lure (made from a white ice-cream container lid with a luminescent strip) and no visual lure.

The second trial, at Bendigo Station and the Queensbury area in late April examined the catch rate of ground set Holden live capture traps, ground set leg-hold traps set under covers, leg-hold traps set down rabbit burrows, and leg-hold traps set down rabbit burrows with a portion of rabbit carcase left outside the burrow entrance. Salted and fresh rabbit were used as bait treatments.

Traps in both trials were spaced approximately 250 m apart and trap-sets were randomised in traplines. Traplines were set in areas that had suitable ferret habitat, particularly where rabbits were abundant. All sites were approximately 2000 ha and traps were serviced for ten days.

- **Results**

Stage One trial

The combined data for all trap types demonstrated that traps without a visual lure caught similar numbers of ferrets (n=130) as traps with a visual lure (n=100) (χ^2=1.91, d.f.=1, p=0.17). For the burrow set traps, the addition of a visual lure had no effect. Therefore, results for traps with and without visual lures were pooled for comparison of trap types.

Although approximately 25% of traps set were Holden live capture traps, these traps caught 51% of all ferrets. The burrow-set leg-holds caught 20% of all ferrets, followed by the Set-n-Forget ground sets (15%) and burrow-set Set-n-Forgets (14%). There were differences in the capture efficiency of traps (χ^2=81.3, d.f.=3, p<0.001). In paired comparisons with Holden live-capture traps, all the traps tested caught fewer ferrets. Ground set traps (Holdens and Set-

n-Forgets) caught significantly more ferrets (χ^2=21.43, d.f. =1, p<0.001) than the burrow sets (leg-holds and Set-n-Forgets). The Set-n-Forget kill trap did not always kill ferrets consistently and humanely.

Stage Two trial
There was no differences in the capture efficiency of traps baited with salted rabbit (53 ferrets caught) and fresh rabbit (68 ferrets caught) (χ2 =2.02, d.f. =1, p=0.17), so results for traps with these two types of bait were pooled. No significant differences were found for the four trap types (χ2 =6.33, d.f. =3, p=0.097). When data were pooled for burrow sets and ground sets, it was found that the ground set traps had significantly higher capture rates (χ2 =4.155, d.f. =1, p=0.042). Examining the above-ground and below-ground comparison with the leg-hold traps, it was found that significantly more ferrets were caught in the ground sets (50 ferrets) compared with burrow sets (31 ferrets) (χ2 =4.82, d.f.=1, p=0.028).

The study did not proceed to the third stage that was planned for winter/spring. The ground-set Holdens and leg-holds had the best capture rates and previous experience by researchers and managers has already established that these sets will not overcome the low trapability response seen in winter and spring.

- **Discussion and Conclusions**

The present study found that traps set down rabbit burrows were not as effective as ground set traps in high rabbit abundance country. In areas of moderate to high rabbit abundance, traps should continue to be set on the ground. This result contrasts that of Phil Commins, in the low rabbit abundance country of the Bay of Plenty. Whilst the possibility exists that burrow sets do perform better in low rabbit abundance country, it was not possible to resolve this definitively due to the non-randomness of trap sites in the Commins trial.

The Holden trap, which is popular with contractors, performed well in these trials. Size 1 leg-hold traps also performed well in these trials but generally they are not the most desirable trap for ferret control (having animal welfare issues, added risk of non-target capture and increased logistical requirements).

Ecological and behavioural factors that affect the rate at which ferrets encounter traps are the most likely explanations for the lower capture rate in burrows in Central Otago.

Salted rabbit meat performed as well as fresh rabbit as an attractant for ferrets. It smells and resembles fresh rabbit with the advantages of a longer life span. It is simple and inexpensive to prepare and I recommend its use to contractors.

Luminescent strips as a visual lure did not enhance trap catch rates for ferrets.

Investment into research and development of a compact, effective and humane kill-trap for ferrets is required.

Little progress with be made in establishing best practice for ferret control or improving the overall standard of ferret control until investment is made into further scientifically sound research on the evaluation of traps and baits.

2. Introduction

An investigation examining the capture effectiveness of various trap-sets for the control of ferrets was conducted by Dr Justine Ragg, an independent research scientist, Dunedin for the Animal Health Board, Wellington.

3. Background

One of the long-term aims of the Animal Health Board is to identify a cost-effective and practical means of killing a minimum of 80% of female ferrets in the southern half of the South Island during the period June to December. Although research projects have tried to address the underlying biological factors involved in the low performance of control operations (Byrom *et al.* 2002, Ragg 2002), and others have tested various control regimes (Byrom *et al.* 2003, Ragg *et al.* 2003), to date this objective has remained elusive.

Although mathematical modelling has provided contradictory results with regard to the optimal time to control ferrets (Roberts *et al.* 1999, Barlow and Norbury 2001), controlling ferrets in the winter/spring time has many perceived advantages. During this time, ferrets are at a natural population low, therefore those animals that are able to be removed from the population are those that will contribute to breeding. Presently with summer and autumn control, the rates of juvenile emergence have been unaltered from year to year. Another important factor, especially in light of the ferret's possible role in spreading disease geographically, is that dispersal from control areas (usually occurring in February and March) is unlikely to be a complicating factor during winter and spring as ferrets will be adhering to an established home range (Byrom 2002, Ragg 2002).

From late autumn until early summer, female ferrets show a pronounced decline in trap catch and bait-take from bait stations (Ragg 1997, Moller *et al.* 2002, Spurr *et al.* 2000, Morley 2002, Ragg 2002). The two most likely hypotheses explaining low trap catch and bait take of female ferrets during the late autumn to spring period are an inherent avoidance of control stations or a change in activity and/or movement patterns resulting in lowered encounter rates with control stations (Ragg 2002). It has been demonstrated that female will avoid traps in spring that they have encountered (Ragg 2002). Byrom *et al*. (2002) suggested that ferrets exhibit a neophobic response to control stations during the period of low trapability. A control method that is presented in a more natural way may successfully overcome this avoidance response. The present project examined whether placing leg-hold traps in rabbit burrows increased trap catch rates in summer - and planned to test this trap set in the period of low trapability if summer trial results were promising.

The ultimate aim of this project was to identify a trap set that could be used in the winter/spring period to counter-act the low observed ferret capture rate.

Lochinver Operational area, Bay of Plenty.
The main rationale behind the testing of burrow set traps was the favourable outcome achieved by Phil Commins under contract to Environment Bay of Plenty (EBOP) to provide ferret control. Lochinver Station and surrounding area (approximately 30,000 ha) in East

Taupo, has been the subject of ongoing ferret control since 2001 because of a history of Tb problems. This area consists of flat to gentle hill country at an altitude of 700m. Topography is generally flat to undulating with easy hill country. The area is predominantly pasture with remnant native forest and scrub in gullies associated with hill country and pine shelterbelts throughout the flats. The operational area adjoins and includes a 500-metre buffer into Pahautea Forest, Wharetoto and the undeveloped frost-flat country of Lochinver Station. Land use includes dry stock, dairying, commercial forestry, conservation and recreational. Rabbit densities are relatively low but patchy.

Data were collected by Phil Commins from 2003-5, on the capture rates of two trap sets – baited ground-set Holden live capture traps and un-baited Lanes Ace traps set in rabbit burrows. Ferret control was conducted between the months of January and May. Lanes Ace traps were placed in all rabbit burrows that could be found as long as they were not within 100m of another trap. Rabbit burrows that were judged to be 'active' were targeted (rabbit sign or recent activity observed at the burrow, no cobwebs present). The EBOP contract specified that areas with active rabbit burrows were to be intensively trapped with all other possible ferret habitat receiving good coverage (trap-site spacing should not be greater than 500 m within ferret habitat). Traps were serviced for ten days. McLean scale scores to assess rabbit abundance were conducted at each trap site by contractors (see Appendix 1).

More ferrets were caught in Holden traps where there was less rabbit sign (<3) than where rabbits were more abundant (χ^2 = 7.24, d.f. = 1, p=0.007). The Lanes Ace traps down burrows caught more ferrets than Holden traps where rabbit sign scored 3 or more (χ^2 =97.62, d.f. =1, p<0.001).

Table I. Capture of ferrets in ground-set Holdens and Lanes Ace traps set in burrows during the Lochinver ferret control operation, Bay of Plenty. This dataset combines data from three years of ferret control conducted between January and May of each year.

	Low rabbit abundance (McLean scale 1 & 2)	Moderate rabbit abundance (McLean scale 3 or more)	Totals
Ground-set Holdens	193 ferrets/60,745 trap-nights 0.0032 trap-catch	54 ferrets/25,631 trap-nights 0.0021trap-catch	247 ferrets/86,376 trap-nights 0.0029 trap-catch
Lanes Ace set in burrows	-	71 ferrets/6782 trap-nights 0.0105 trap-catch	71 ferrets/6782 trap-nights 0.0105 trap-catch

Supplementary food

Rabbits were occasionally caught in the burrow set traps in the Lochinver ferret control operations and were killed by contractors. One of the observations made by Phil Commins was that burrow set traps that had a dead rabbit left outside the burrow were more likely to subsequently catch a ferret. It is hypothesized that ferrets were caught by the trap in the burrow as they try to drag the carcase underground. Utilizing this instinctive behaviour may be one way to get round the control device wariness that is observed in ferrets during the winter/spring - the ferret is captured because it is distracted by the food and does not detect the trap or is preoccupied enough not to successfully avoid it.

Visual lures and baits
Anecdotal reports from contractors that capture rates were better with leg-hold traps that used a solid trap cover rather than a wire-mesh cover (which made the trap set harder to see) lead to the suspicion that during periods of high trapability, ferrets are attracted to objects. This is the basis for the visual lure concept, especially in light of recent success with visual lures for possums (Thomas and Maddigan 2004). With ground set traps, the actual trap may be acting as a visual lure for ferrets. The addition of a visual lure could enhance the trap encounter rate for burrow set traps though.

A good long-life bait for ferrets has been hard to achieve. In the contracting environment, where traps are checked daily and bait can be maintained easily, fresh baits have been preferred as attractants. In fact, the Southern Pest Management contract for contractors specifies that commercially produced long-life baits should only be used in emergency situations - with fresh rabbit or fish as the preferred baits. Long-life bait becomes more relevant when using kill-traps that are checked infrequently. The Department of Conservation has reported success with using salted rabbit meat for stoats (Pierce *et al.* 2007).

4. Research Objectives

1. Determine whether setting traps in burrows increases the trap catch of ferrets in autumn and spring.

2. Assess whether adding a visual lure to a trap set increases the trap catch of ferrets.

3. Assess the relative capture efficiency of traps baited with fresh rabbit and salted rabbit.

4. Evaluate whether placing supplementary food outside the burrow increases the trap catch of burrow sets.

5. Identify a method of trapping most ferrets in winter/spring.

6. Provide an estimate of cost-effectiveness of the various trapping regimes.

Objectives 5 and 6 were not completed as the study did not proceed to the third trial (which was scheduled for the spring/winter period).

5. Methodology

Stage One
The field work was undertaken in late March 2006. The original proposal aimed to use one site of 4000 ha for the Stage One trial. Difficulties were experienced in finding a suitable site as many areas with high ferret abundance in Central Otago were scheduled to receive ferret control as part of Southern Pest Management's 2006 vector control programme. Two sites, each of approximately 2000 ha were used - Ardgour Station (25.3ºE, 83.8ºN) and The Point

(30.5ºE, 90.4ºN), both near Tarras. These properties are approximately 7km apart and had high numbers of rabbits. Both properties had open plateau country dissected regularly by gullies. On the plateau country, pasture was developed and there was very little vegetation cover. The vegetation cover in the gullies consisted mostly of mategouri and rose-hip. Rabbits had degraded both properties extensively in places. In the gullies and sunny faces, rabbit holes were extremely numerous with extensive warren systems in many places. In general, rabbit holes could be described as 'complicated' – consisting of many branches and exits/entrances.

Given the topography of both sites, traps were not able to be randomized on a 300m x 300m grid as initially planned. Ferret capture rates were expected to be much higher in the gullies where there was suitable cover and where rabbits were abundant. Traps were spaced approximately 250 m apart using a GPS. Traplines were placed along gullies, terraces, water-courses, tracks, patches and edges of cover (all features that are considered to maximise ferret encounters). Trap sets were randomized along the traplines to reduce trap-site bias as much as possible. Except for the randomisation of trap sets, trap spacing and placement were as similar as possible to a standard Southern Pest Management ferret control operation. The overall density of traps was approximately 100 per 1000 ha, with 230 traps set at The Point and 240 traps set at Ardgour Station. The field trials were conducted over 10 nights at each site.

The trial consisted of four different trap sets:
Holden live capture traps (Trappers Cyanide Ltd, Amberley),
Set-n-Forget kill-traps under covers on the ground (Pest Tech Ltd, Leeston),
Set-n-Forgets kill traps set in rabbit burrows,
Leg-hold traps (Size 1 Victors and Dukes) set in rabbit burrows.

The Holden live capture trap. Bait is placed at the far end of the trap as an attractant and animals are caught when the treadle pivots and locks into place.

The Set-n-Forget kill trap (a cover is required for ground sets). Similar in design to a rodent snap trap. Trap is sprung through interference with the bait hook , releasing a steel jaw that strikes the animal in the head/neck region.

The Holden trap was included in the trial as it has a proven track record as an effective ferret trap. The capture efficiency of the other trap sets could then be compared against the Holden. All traps were baited with salted rabbit meat. A further treatment involved the use of a visual lure (made from a white ice-cream container lid with a luminescent strip) and no visual lure. The visual lure was threaded onto a wire and stuck into the ground outside the burrow or beside the entrance of the trap.

Salted rabbit was made by coating the chopped rabbit pieces liberally with table salt. The rabbit is then left overnight in a watertight container, whereby a bloody brine forms around the rabbit pieces. Before use, the rabbit should be washed to remove salt remains that can make the bait crusty and dry. Salted rabbit can be stored in an airtight container, preferably in the brine solution or chilled (freezing does not occur as the salt lowers the freezing point).

During the trial, field assistants observed that many burrow-set leg-hold traps showed signs of interference (often the bait was missing). In the later stages of this trial, rocks were put down the burrows to block them on the far side of the trap to prevent the ferret running over the trap and taking the bait once clear of the trap. The bait was also pegged down so that the ferret would have to stop to eat the bait.

Stage Two

Two sites were used for the Stage Two trials; Bendigo Station (18.6º, 80.2º), beside Ardgour Station and the Queensbury area (19.7ºE, 89.5ºN) near Luggate (on the opposite side of Lake Dunstan to Bendigo Station). Bendigo Station had moderate to high rabbit abundance. Ferret control had been conducted by the gamekeeper employed by Bendigo Station so much of the trial was conducted over the Department of Conservation scenic reserve within Bendigo Station - which had not been trapped. Some of the trapped area also included the adjacent Northburn Station (south-west of Bendigo Station). The study area was reasonably steep and manuka cover was prevalent in many of the gullies (which were mostly inaccessible). Access was mostly restricted to the farm tracks, so trap-lines were not always in the most optimal ferret habitat. The Queenbury area comprised mostly of open flat river terraces. Cover consisted mainly of rosehip with manuka patchy and was mostly restricted to along the Clutha River. Rabbits were patchy, and rabbit abundance at this site was the lowest of the four sites used. The field trials were undertaken in late April/early May 2006.

As the performance of the above-ground and below-ground trap sets had not been resolved by the first trial, two above-ground traps sets and two below-ground trap sets were used;
Baited Holden live capture traps set above ground,
Baited leg-hold traps set under covers above ground,
Baited leg-hold traps set down rabbit burrows (burrows blocked with wire mesh and bait secured),
Leg-hold traps set down rabbit burrows with a portion of rabbit carcase left outside the burrow entrance, secured to the pin with a piece of string to prevent removal. Attempts were made to hide the rabbit from harriers by covering it with vegetation.

Leg-hold traps consisted of a mixture of size 1 Victors, Dukes and Bridgers. The leg-holds set under covers on the ground were included in this trial to provide an above-ground and below-ground comparison of the same trap. Again, the Holden traps were included as a type of control trap. The fourth trap set (rabbit portion outside burrow containing a leg-hold trap) was included to test the concept of supplementary food enhancing the capture rate. Trap sets were randomized in traplines, following the same methodology as in the first trial. There were 238 traps set at Queensbury for nine nights and 230 traps set at Bendigo Station for 10 nights. Instead of re-testing the visual lure concept (which had not enhanced trap catch), a bait treatment factor – salted rabbit and fresh rabbit, was included

Stage Three.
This study initially proposed to have a third trial in winter/spring 2007, to test the 'best' trap set to address the AHB objective to try to a minimum of 80% of female ferrets in the southern half of the South Island during the period June to December (Objective 5). The study did not proceed to the third field trial which was scheduled for the winter/spring period. The ground-set Holdens and leg-holds had the best capture rates and it has already been established through previous research (Ragg 1997, Moller *et al.* 2002, Morley 2002, Ragg 2002) and the experience of various regional vector control managers that normal ground-set traps will not overcome the low trapability response seen in winter and spring. Objective 6 (which aimed to test a kill-trapping regime), was also not tested as a kill-trap that was humane, had proven capture effectiveness and able to be used down rabbit burrows was not available.

6. Results

Stage One trial
Adding a visual lure to traps made no difference to the proportion of Holdens, burrow-set leg-hold traps, burrow-set Set-n-Forget, or ground-set Set-n-Forgets that caught ferrets (p values ≥ 0.19). The combined data for all trap types demonstrated that traps without a visual lure caught similar numbers of ferrets (n=130) as traps with a visual lure (n=100) (χ^2=1.91, d.f. =1, p=0.17). For the burrow set traps, the addition of a visual lure had no effect (38 ferrets caught in lured traps and 40 ferrets caught in un-lured traps). Therefore, results for traps with and without visual lures were pooled for comparison of trap types.

Table II. Catch rate of ferrets using eight different trap sets at The Point and Ardgour Station, Central Otago. Catch rate is expressed as the number of ferrets caught/total number of trapnights (for each trap-set).

Trap Set Visual lure	Holden Ground Lure	Holden Ground No lure	Leg-hold Burrow Lure	Leg-hold Burrow No lure	SnF Burrow Lure	SnF Burrow No Lure	SnF Ground Lure	SnF Ground No lure	Totals
The Point									
# ferrets	27	44	14	10	6	7	5	9	122
# trapnights	213	315	221	272	221	213	230	272	1955
Catch rate	0.127	0.140	0.063	0.037	0.027	0.033	0.022	0.033	0.062
Ardgour									
# ferrets	22	24	11	12	7	11	8	13	108
# trapnights	255	255	255	255	255	255	255	255	2040
Catch rate	0.086	0.094	0.043	0.047	0.027	0.043	0.031	0.051	0.053
Combined									
Catch rate	0.105	0.119	0.053	0.042	0.027	0.039	0.027	0.042	0.058

Although approximately 25% of traps set were Holden live capture traps, these traps caught 51% (120/232) of all ferrets. The burrow-set leg-holds caught 20% of all ferrets, followed by the Set-n-Forget ground sets (15%) and burrow-set Set-n-Forgets (14%). There were differences in the capture efficiency of traps (χ^2=81.3, d.f. =3, p<0.001). In paired statistical comparisons with Holden live-capture traps, all the traps tested caught fewer ferrets. Ground set traps (Holdens and Set-n-Forgets) caught significantly more ferrets (χ^2=21.43, d.f. =1, p<0.001) than the burrow sets (leg-holds and Set-n-Forgets). There was no difference between the capture rate of ground-set Set-n-Forget and burrow-set Set-n-Forgets.

Table III. Summary of catch rates for Trial One, Central Otago. Catch rate is expressed as the number of ferrets caught/total number of trapnights (for each trap-set).

Trap Set	Holden Ground	Leg-hold Burrow	Set-n-Forget Burrow	Set-n-Forget Ground
Total ferrets caught	117	47	31	35
Catch rate	0.113	0.047	0.033	0.035

The Set-n-Forget kill trap did not kill animals consistently. Ferrets were found alive in traps, caught in a variety of positions (over the head, body, and limbs). In some cases, ferrets were found dead in traps that had been dragged some distance from the trap site indicating that they had not been killed immediately. Some traps disappeared from trap sites altogether and could not be relocated - even though the immediate areas were often easy to search (open country with little ground cover). Ferrets, harriers and cats were likely to be involved in the removal of traps from trap-sites. One harrier was caught some distance from the trap-site with a trap on its leg.

Stage Two trial

There was no differences in the capture efficiency of traps baited with salted rabbit (53 ferrets caught) and fresh rabbit (68 ferrets caught) ($\chi 2$ =2.02, d.f. =1, p=0.17), so results for traps with these two types of bait were pooled. No significant differences were found for the four trap types ($\chi 2$ =6.33, d.f. =3, p=0.097).

Table IV. Catch rate of ferrets using eight different trap sets at Bendigo Station and the Queenbury area, Central Otago. Catch rate is expressed as the number of ferrets caught/total number of trapnights (for each trap-set).

Trap Set Bait	Holden Ground Fresh	Holden Ground Salted	Leg-hold Burrow Fresh	Leg-hold Burrow Salted	Leg-hold Ground Fresh	Leg-hold Ground Salted	Leg-hold Burrow Portion	Totals
Queensbury								
# ferrets	11	6	5	6	5	5	11	49
# trap-nights	289	247	221	289	272	247	459	2023
Catch rate	0.038	0.024	0.023	0.021	0.018	0.020	0.024	0.024
Bendigo								
# ferrets	14	9	10	10	23	17	19	102
# trap-nights	295	295	276	276	266	266	523	2185
Catch rate	0.049	0.031	0.036	0.036	0.086	0.064	0.036	0.047
Combined								
Catch rate	0.044	0.028	0.030	0.028	0.052	0.043	0.031	0.036

When data was pooled for burrow sets and ground sets, it was found that the ground set traps had significantly higher capture rates ($\chi 2$ =4.155, d.f. =1, p=0.042). Examining the above-ground and below-ground comparison with the leg-hold traps, it was found that significantly more ferrets were caught in the ground sets (50 ferrets) compared with burrow sets (31 ferrets) ($\chi 2$ =4.82, d.f.=1, p=0.028).

Table V. Summary of catch rates for Trial Two, Central Otago. Catch rate is expressed as the number of ferrets caught/total number of trapnights (for each trap-set).

Trap Set	Holden Ground	Leg-hold Ground	Leg-hold Burrow	Leg-hold/ Burrow/portion
Total ferrets caught	40	50	31	30
Catch rate	0.035	0.048	0.029	0.031

7. Discussion

The two Central Otago trials revealed that ground set traps had higher ferret capture rates than burrow sets. The present project achieved a significant result, even though the trials were reasonably small scale, indicating that the effect of trap position is strong. In the present study, trap site bias was reduced as much as possible by randomising trap sets within traplines, and traplines were placed in areas to maximise ferret encounter rates.

I believe the most compelling explanation for the result of the present study relates to the differential rate at which ferrets encountered the ground and burrow set traps. In the rabbit prone country of Central Otago (and especially at the sites which were used), rabbit holes are extremely numerous and complicated. In these conditions, the chances of a ferret encountering a burrow with a trap in it would be comparable to searching for a 'needle in a haystack'. Also, a ground set trap is more likely to attract the interest of a ferret compared to a trap that is placed in the more natural setting of a rabbit burrow, especially when there is nothing else about the burrow trap-set that would set it apart (or enhance its encounter rate) from the hundreds upon hundreds of other (un-trapped) burrows.

In normal conditions, ground set traps can be placed in optimal positions to increase their probability of being encountered by a ferret, but there are some restrictions to where burrow sets can be placed. Not all burrows are suitable for placing traps in them (too wide and shallow, or too narrow, or the burrow floor is too uneven or rocky or pegs are unable to be driven in to secure traps etc). It is possible that traps that rely on pressure on a trigger plate do not perform well down burrows in Central Otago because of the sandy floor of the burrow which interferes with the functioning of the trigger plate. One of the big differences between a leg-hold in a burrow and a leg-hold on the ground is the use of a cover. Although, the visual lure tested in the present study did not enhance trap catch, it is possible that trap covers are effective visual lures. It is also possible that trap covers are particularly effective at directing the ferret over the trigger plate (more so than the conditions down burrows).

The Commin's trial.

The result of the present study is in contrast to that of Phil Commins, who found burrow set traps had a higher capture rate in low rabbit abundance country. Commins was under contract to EBOP to provide ferret control. The Commins trial was not set up with the robustness in design of a scientific trial because he was constrained by the requirement that he had to deliver optimal ferret control to EBOP. One of the main issues concerns the non-random selection of trap sites. Lanes Ace traps were placed in all active rabbit burrows that could be found by contractors as long as they were not within 100m of another trap (whereas in the Central Otago trials only a very small proportion of available rabbit burrows would have had

a trap). Trap placement is regarded as fundamentally important to the success of ferret control. Ferrets are selective in how they use their home ranges; microhabitats with ground cover are preferred (Ragg and Moller 2000) along with those that support higher numbers of rabbits (Alterio 1994, Pascoe 1995, Pierce 1987). Ferrets are known to target rabbit stops when hunting (Robson 1993). In the Commins trial, trap placement would have been much better for the traps down burrows compared to the ground set traps. There were many times more Holden traps used than Lanes Ace traps (only 7% of traps were Lanes Ace). A good coverage of traps throughout the Lochinver control area had to be achieved. The reality of this requirement is that contractors have to set traps regularly and often where ferret habitat is not present. Holden traps were many times more likely to be placed in less than optimal positions and used as 'fillers' compared with the Lanes Ace traps. Given these issues, it was not possible to resolve whether the use of the burrow sets improved the level of ferret control above that which would have been achieved by a normal ground setting regime.

In low rabbit abundance country, rabbit holes are more likely to be limited to fragmented areas within farmland that have suitable soil types, topography, vegetation and degree of development. In this country, rabbit holes typically are simple with a single entrance/exit. This is in direct contrast to Central Otago, where rabbits can be breeding over extensive areas, especially the sunny faces. The prey and habitat differences between Central Otago and the Bay of Plenty would undoubtedly have implications for the way ferrets forage throughout their home ranges and consequently these factors are likely to influence the probability that they would encounter burrow set traps.

Performance of Lanes Ace traps versus the leg-hold traps

One possible reason for the conflicting results between the present study and Commins is that there are significant differences in the performance of Lanes Ace versus leg-hold traps. I did not want to replicate Commins design of Lanes Ace traps set in burrows on animal welfare grounds. Even when Lanes Ace capture ferrets on the lower part of a limb, they can cause unacceptable leg injuries. The most serious problem is that as they are too large a trap for ferrets and can capture the animal high up on the body, over a shoulder or thigh, or even over the body (Phil Commins pers. comm.). In 2002, the National Animal Welfare Advisory Committee (NAWAC) recommended prohibition, so there is no future for this trap[1] and very little point in research involving this trap. Some operators used Lanes Ace traps in the early days of ferret control. In 2002, only three out of 46 ferret-control contractors surveyed for a ferret control manual (Ragg and Clapperton 2004) used Lanes Ace. Those that have used Lanes Ace believe they perform well in terms of capture effectiveness for ferrets (Phil Commins pers. comm., Clem Small pers. comm.). This was probably due to the large square trigger plate which is particularly sensitive and the overall springing mechanism which is reliable.

Although the possibility exists that the capture rate of Lanes Ace traps is superior to the Size 1 leg-holds, in general the performance of Size 1 leg-hold traps for ferret control has been good. They were initially used extensively for ferret control (before the availability of live capture traps), and were regarded as a good trap for ferrets by contractors (Ragg and Clapperton 2004). In the Stage two trials, ground set leg-holds had the highest capture rate of the four trap-sets.

1 Regulations prohibiting the Lanes Ace from general use could be in place as early as 31 December 2007 (MAF 2007).

In summary, it is not possible to determine whether Lanes Ace traps would have performed better than the leg-hold traps, but it is unlikely their use would have increased the capture rate enough to have influenced the outcome of the present study. This conclusion is supported by the significantly better performance of leg-holds on the ground versus leg-holds down burrows (Trial Two), the best test of the effect of trap position.

Bait and olfactory lures

A result that could have good management implications is that salted rabbit has been proven to be as good as fresh rabbit as an attractant for ferrets. It smells and resembles fresh rabbit with the advantages of a longer life span. It is simple to prepare, store and easy to handle. Salted bait does not become fly-blown – which is the main problem with fresh rabbit meat. Ferrets do not usually eat the salted bait – so bait can be used again. Unless conditions are dry, salted rabbit should perform well for the duration of a ten day trapping operation. A 20kg sack of salt costs around $25.00 so there is relatively little extra cost involved in salting rabbit. In fact, salting rabbit probably reduces time and expense for contractors as there is a reduced need to change baits regularly. One of the disadvantages of salted rabbit is the corrosive nature of the salt. This may make it unsuitable for use in some traps with non-stainless steel components. Long-life baits that retain the prey odour and do not use salt as the main preservative are likely to be effective general purpose products.

The olfactory senses of ferrets are well developed and acute. Scent plays an important role in social organisation. Ferrets have anal glands and will scent mark throughout their home ranges. Scent is important for social communication of sex and status and becomes even more vital during the mating season (Clapperton and Byrom 2005). Scent is likely to play an important role in attracting ferrets into control devices. Traps may still catch if left un-baited but catch rates are higher if some attractant is used (Clapperton *et al.* 1989). Traps that have caught ferrets before are considered to be better performing than new traps. Apart from the Holdens used at Ardgour Station, all other traps used in the Stage One trial had not been used previously for ferreting. In the contracting environment, traps that are used regularly accumulate the smell of ferrets and other non-targets, so differential performance based on the presence or absence of odour would cease to be a possible factor.

Lures using natural prey odours are likely to perform best for ferrets, as has been found for stoats (Clapperton *et al.* 2006). In the present study, the success of salted rabbit was probably because the olfactory properties of the rabbit meat were relatively unaltered by the preservative. Byrom *et al.* (2003) found that trap catch was no better in traps baited with dead rabbits than in those baited with live rabbits, which suggests that smell not movement was the main attractant. The addition of scent trails between traps increased trapping efficacy slightly (but not significantly) (Norbury *et al.* 2004).

There are a variety of triggering strategies for traps (treadles which require no contact with bait, bait hooks which require ferret interference, pressure plates which use bait to attract ferrets into position). It is likely that there will be differential performance between baits across the range of traps which relates to how effectively they are at getting the ferret to spring the trap. This may have been a factor in this study, for example salted rabbit may have been very effective in Holdens which require no interference with bait but less effective in the Set-n-Forgets which require the ferrets to pull on the bait to trigger the trap.

When ferrets are foraging in country with high densities of rabbit burrows, they will usually sniff at the entrance of burrows for signs of recent rabbit scent rather than entering each one to

check for rabbit occupation (Justine Ragg personal observation). The burrow sets in the present study were baited, whereas in Commins trial they were not. Presumably baiting the burrow sets would have increased the likelihood that ferrets would enter the burrow.

Visual lures
The addition of a luminescent strip as a visual lure to traps did not have any influence on the ferret capture rates in this study. The best test for the visual lure effect is the comparison between lure and non-lured burrow sets, where no differences were detected. It appears that ferrets are not attracted by luminescent strips, unlike possums (Thomas and Maddigan 2004). It is possible that further investigation could reveal that there are visual lures that will enhance trap sets for ferrets, although the vision is not the most developed of their senses, sight is reasonably poor during the day but better at night (Clapperton and Byrom 2005). Other sensory lures, particularly olfactory, may prove to be more effective.

At least with the ground set traps, the actual trap is possibly enough of a visual lure. The ground-set traps may have been encountered at a higher rate than the burrow sets because of their greater visibility. During the period of high trapability, ferrets can be curious and attracted to new objects.

Supplementary food.
The supplementary food concept did not increase trap catch rates in the present project. We used rabbit portions instead of whole rabbits and this may have been a factor. Of all the trap sets, this set attracted the most non-target interference, particularly cats and harriers. It is reasonably easy to identify the scavenging of harriers because of the way they pick flesh from a carcase. Cats were also caught in the burrow sets and seen at trap sites. There is little that can be done to prevent such non-target interference and it would probably always be a factor in areas with high predator abundance. The catch rate of this set was similar to that of the leg-holds down burrows. Given the additional time and resources involved in re-baiting and servicing this trap-set, there is little reason to recommend using this trap-set for ferret control.

Overcoming the winter/spring low trapability.
Ferrets hunt underground mostly (Gibb *et al.* 1978) and their diet is influenced strongly by the availability of rabbits, particularly young rabbits (Smith 1994). The length and timing of the rabbit breeding season could be a factor that influences whether ferrets are actively searching for rabbit burrows. Consequently seasonality may be a factor that affects the rates of encounter with a burrow set trap.

Because the study did not proceed to test the effectiveness of burrow sets in winter/spring, the possibility still exists that burrow sets may have a higher trap catch rate in winter/spring than the traditional ground set traps. In considering this scenario, burrow sets would have to perform exponentially better than ground sets in winter/spring in order to be an effective form of ferret control. It is very likely that they won't. Some of the most likely reasons for a lower catch rate of burrow sets in these summer/autumn trials included (i) the leg-hold traps do not perform well in burrows, (ii) that the encounter rate of traps in burrows is lower (compared with ground set traps) or (iii) combination of both. These factors are unlikely to change favourably in the winter/spring period, in fact encounter rates for any control device is likely to be worse in winter/spring. It is possible that ferrets may respond better to a trap in a burrow during the winter/spring period (compared with a ground set trap) as the burrow set trap is presented in a more natural way. But the response of ferrets to this trap-set in

winter/spring is unlikely to counter-act the lower encounter rate of this trap-set sufficiently to make winter/spring trapping worthwhile.

It remains a possibility, however, that in low rabbit abundance country, burrow sets may be effective in winter and spring.

Animal welfare considerations.
The Set-n-Forget trap did not always kill ferrets or kill them humanely. This may be due to the strike position of the frontally located trigger which did not consistently strike ferrets on the head. The varied size and shape of the salted rabbit may have meant that the ferrets were in varying positions when the trap was triggered, causing some to be caught improperly. The manufacturer has since made alternations to the strike bar in an attempt to remedy the problem. So far, with the exception of the Hammer trap (NZTrap), which is no longer commercially available and the DOC 250 (Curtis Metal Products Ltd), all kill traps tested for ferrets have failed the NAWAC requirements for kill trap performance (Warburton *et al.* 2002, Warburton and Poutu 2003) or have not been tested (including the Set-n-Forget)[2].

Ferrets can be particularly hard to kill, a substantial blow to the head is required to break the skull and cause fatal injury. The oesophagus and wind-pipe are reasonably well protected in ferrets (as they are surrounded by the musculature of the neck) and this can pose problems for traps that rely on constriction of the neck/throat region. This field trial illustrates the need for new traps to be trialled in field conditions to evaluate performance and to highlight issues. New traps should not only be assessed for animal welfare of the target animal but also for commonly caught non-target species. Cats will sometimes investigate and then trigger traps using their forelegs (Poutu and Warburton 2006). Limb capture of cats in kill-traps set for ferrets are a particular concern, especially if they are not checked daily. The technique of setting traps in burrows may pose increased risk to non-targets as the burrow does not always protect the trap from investigation. In the present study, it was observed that harriers were able to spot and then access some of the burrow set traps, particularly those in banks or sloped ground. The use of a cover for ground set traps reduced the problem of non-target capture, although not totally. Trap covers can be dislodged. Integrity of the trap set is very important for kill traps that remain set for long periods - they must withstand investigation from stock, other non-target animals, and sometimes extreme weather conditions.

The lack of an effective and humane kill–trap for ferrets has restricted ferret control to regimes that require daily checking. This daily checking requirement usually limits ferret control to ten days annually and this level of control is inadequate to maintain ferret populations below their normal densities. It is likely that significant gains in ferret control will occur once kill-traps could be used with confidence about capture effectiveness, humaneness and risks to non-targets.

Leg-hold trapping
Leg-hold traps are not the most desirable trap available for ferret control. The main management issues concern the quality of autopsy, animal welfare and limitations on where leg-holds can be used safely (problematic around suburban/semi-rural areas, farm houses etc). Most contractors have voluntarily moved away from leg-holds to the live capture traps because of their ease of use, reliability, convenience, and reduced risk of non-target capture.

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2 The Holden Multi-kill (Trappers Cyanide Ltd), PossumMaster (PossumMaster Industries Ltd) and the Sentinel (Pest Management Services) are presently undergoing NAWAC testing (Bruce Warburton pers. comm.)

Logistically, the burrow sets did not rate well; trap sets consist of many components, were time consuming to set and service and additional tools had to be carried. Leg-hold traps are subject to greater variation in the quality of the set compared with Holdens or other similar live capture traps. In order for leg-holds to perform well the traps need to be set finely and then to be maintained properly (sprung periodically). Operator experience and diligence are much bigger factors with leg-hold trapping compared with a trap like the Holden, for which trap functionality does not change over time (as long as bait quality is maintained).

Improving the quality of ferret control.
Until more proper experimentally designed trials of traps and baits are undertaken, it is going to be very difficult to improve the quality of ferret control. Trap type, trap position, bait, presence/absence of odour, use of trap covers, etc are all possible variables that could affect the attractiveness of a trap set. The lack of understanding of the target animal is illustrated by the fact that we can only speculate what effect the vast changes in habitat and prey abundances have on parameters such as the encounter rate and response to control devices. Vector managers use data and field audits of ferret control contractors to evaluate performance instead of targets based on reduction of ferret density. In many instances, contractors are given freedom to use traps and bait of their choice and there is still considerable variation in practice, which must surely translate to variation in trapping success. Considering the expenditure on ferret control by the Animal Health Board is approximately 1.8 - 2 million annually (Penny Fairbrother pers. comm.), this is a rather unsatisfactory situation. Conversely, the Animal Health Board has invested considerably in the development and implementation of the NPCA Protocol for Designers in order to achieve low residual possum densities, with contractors being paid on achievement of RTC targets.

8. Conclusions and Recommendations

The present project found that traps set down rabbit burrows were not as effective as ground set traps in high rabbit abundance country. In areas of moderate to high rabbit abundance, traps should continue to be set on the ground.

The Holden trap, which is popular with contractors, performed well in these trials. Managers can be confident that it is a good reliable trap for ferrets.

Size 1 leg-hold traps also performed well in these trials but generally they are not the most desirable trap for ferret control. There would have to be a very compelling reason to recommend the use of leg-hold traps over other traps and the present study has not identified any.

Ecological and behavioural factors that affect the rate at which ferrets encounter traps are the most likely explanations for the low capture rate in burrows in the present study.

It is not possible to resolve whether burrow set traps are more effective than ground set traps in low rabbit abundance country or during the winter/spring period.

Salted rabbit meat performs well as a long-life bait for ferrets. It is inexpensive and easy to prepare. It is suitable for use by contractors to reduce the frequency of bait changes.

Luminescent strips as a visual lure did not enhance trap catch rates for ferrets.

Investment into research and development of a compact, effective and humane kill-trap for ferrets is required. Kill traps for ferrets should be tested in field conditions to identify issues and evaluate performance. Animal welfare considerations should include commonly caught non-targets. Until a suitable kill trap for ferrets is identified, little advance will be made into developing alternative cost-effective regimes (to the standard 10 day trapping operation).

Little progress with be made in establishing best practice for ferret control or improving the overall standard of ferret control until investment is made into further scientifically sound research on the evaluation of traps and baits.

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11. Appendix 1

McLean Scale used to score rabbit abundance in the Lochinver ferret control area, Taupo.

1. No sign seen. No rabbits seen
2. Very infrequent sign seen. Unlikely to see rabbits
3. Sign infrequent with heaps more than 10m apart. Odd rabbits seen
4. Sign frequent with heaps more than 5 m apart but less than 10 m. Groups of rabbits seen
5. Sign very frequent with heaps less than 5 m apart in pockets. Rabbits spreading.