Best-Practice Trapping of Ferret Populations

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Summary

Project and Client

The Animal Health Board commissioned Landcare Research to analyse a database (owned by Environment Southland and Southern Pest Management) on ferret control operations in Southland and Otago to determine trap-set characteristics that maximise ferret captures. The analysis was carried out from September 2000 to March 2001.

Objectives

- Determine from an existing database on ferret control operations, the optimum characteristics of traps that maximise ferret captures.
- Identify ways of improving the utility of the database by reducing the effects of confounded variables, and by streamlining data entry.

Methods

- Data were collected by Environment Southland and Southern Pest Management in 1999 and 2000. We analysed 3,677 ferret captures taken over 320,818 corrected trap nights (representing a trap rate of 1.1%).
- Generalised linear models were fitted and compared using likelihood-ratio tests to test for relationships between ferret capture rates and the trap-set characteristics, bait type, trap type, habitat, temperature, McLean score (high or low), and rainfall (high or low).
- Too many types of trap-set characteristics were listed to enable sensible interpretation of the analysis. This was overcome by pooling category types.
- Models included only up to second-order interactions (e.g., does the effect of bait depend on trap type?). Estimating higher order effects was not worthwhile due to the sparseness of the data, and many combinations of trap-set characteristics were absent (e.g., Fenn traps were not used with possum bait).

Results

- Timms tunnel traps often caught the most ferrets, particularly in bush, bush edge, and culverts (2.0 - 2.3% trap-catch rate), and on nights with dew or frost (2.1% and 2.5%, respectively).
- Victor traps also caught relatively high numbers of ferrets, but only on bushedge-fenceline boundaries. Victor traps with wire covers (Victor cages) also caught relatively high ferret numbers, but only around offal pits, and especially during frosts. Fenn tunnel traps also had high catch rates, mainly along fencelines, culverts, and waterways, and during warm or cold conditions. However, Fenn traps are not recommended because they are unacceptably inhumane.
- Timms traps (without tunnels) performed more consistently than other traps types in all conditions, though maximum ferret captures were not apparent in any particular habitat.
- Rabbit was the most consistent bait and was especially effective on bushedge-fenceline boundaries and in Fenn tunnels. Possum bait performed even better along waterways and in Timms tunnels and Victor cages. Possum bait may be equally effective in other habitats and traps, but this requires further investigation.
- Rabbit appeared to be the most effective bait where rabbit abundance was relatively high, as did possum bait where rabbit abundance was relatively low.

- Rainfall and temperature had either no relationship, or an inconsistent relationship, with catch rates of ferrets.
- The quality of data was sometimes undermined by pest contractors using inconsistent definitions of trap-set characteristics, despite their being provided with strict definitions.

Discussion

- Although Timms traps appear to be the best option, there are often difficulties obtaining permission from landholders to use them near houses because these traps also kill cats. Victor traps or Victor cages are recommended in this case.
- Timms traps (and perhaps Victor cages) might catch more ferrets because they catch fewer non-target species, thereby making more trap nights available to catch ferrets.
- The potentially high attractiveness of possum meat is reinforced by the fact that possum meat is used as bait mostly in areas where rabbits are less obtainable, and therefore where ferrets are less abundant.
- There was some evidence that linear features (e.g., fencelines, bushedges, waterways) were attractive to ferrets.
- Because all trap sites have GPS coordinates, a spatial analysis of the database could be undertaken to see if ferret capture rates are spatially clustered. If captures are clustered, and trap-set characteristics are not, this would suggest that ferret density may partly confound the results.
- This analysis of correlative data can only be a guide to best practice. The relative ability of rabbit and possum meat to attract ferrets, and the relative efficacy of Timms traps, Victor traps, and Victor cages, are best determined from field experiments.

Recommendations

- Because the data were not collected in a random fashion, there is the potential for variables to be confounded with ferret density. We therefore emphasise that care be taken when using the guidelines from this study.
- Where possible, Timms traps (with or without tunnels) should be used, and baited with either rabbit or (pending further investigation) possum meat. Victor traps or Victor cages should be used where Timms traps cannot.
- Greatest ferret captures will be obtained by placing traps in areas with highest rabbit abundance. However, because there are generally more ferrets where there are more rabbits, this may not necessarily maximise *reductions* in ferret populations.
- The guidelines that have emerged from the database are useful, but we suggest that future expenditure on data collection is better utilised by contributing to field experiments to test some of the hypotheses raised.
- Such experiments should test whether possum bait has the ability to catch more ferrets than rabbit bait, and whether Victor traps or Victor cages catch more ferrets than Timms traps.
- If the same sort of data collection is continued, we suggest that fewer types of trap-set characteristics be recorded, that steps be taken to ensure contractors adhere to strict definitions, and that data are captured electronically by recording trap-set characteristics in the GPS way-points for each trap location. Most importantly, we recommend that in order to minimise the confounding effects of ferret density, data are collected in a random fashion by ensuring that variable types are randomised across the landscape.

1. Introduction

The Animal Health Board commissioned Landcare Research to analyse a database (owned by Environment Southland and Southern Pest Management) on ferret control operations in Southland and Otago to determine trap-set characteristics that maximise ferret captures. The analysis was carried out from September 2000 to March 2001.

2. Background

Reducing the threat that ferrets pose to the spread and transmission of bovine Tb requires cost-effective tools for reducing their abundance. Trapping is currently the primary tool for controlling ferret populations. There are many ways that traps can be presented to ferrets, and indeed, each pest control contractor has their own view on what makes the perfect set. There has been no formal study of the conditions that maximise ferret trap-catch rates, although Clapperton (2001) recently reviewed habitat preferences by ferrets. In the absence of experimental evidence that tests the conditions that maximise trap-catch rates, the success or failure of commercial contractors are all we have to go on.

3. Objectives

- Determine from an existing database on ferret control operations, the optimum characteristics of traps that maximise ferret captures.
- Identify ways of improving the utility of the database by reducing the effects of confounded variables, and by streamlining data entry.

4. Methods

Ferret capture data were collected in Southland and Otago by commercial contractors employed by Environment Southland and Southern Pest Management in 1999 and 2000, and entered into a relational database (Microsoft ACCESS). The database matches ferret captures with trap type, habitat, bait, time of year (February to May), GPS coordinates, weather, and local abundance of rabbits. We analysed 3,677 ferret captures taken over 320,818 corrected trap nights. This represents a trap-catch rate of 1.1%.

Data were analysed by fitting generalised linear models for count data (Poisson models) in the statistics computer program, S-PLUS. Nested models were compared using likelihood-ratio tests in order to test for relationships between ferret trap-catch and the independent variables. Models included only up to second-order interactions (e.g., does the effect of bait depend on trap type?). Estimating higher order effects was not worthwhile due to the sparseness of the data, and many combinations of factors were absent (e.g., Fenn traps were not used with possum bait).

The data were not collected in a purely random fashion. Traps were set in clusters along trap lines (mostly at intervals of 50–100 m), trap lines were not assigned randomly to different areas, and they were subjected to repeated measures during one-off periods of mostly 10 consecutive nights. Ideally these effects would be explicitly accounted for in the statistical modelling. We could only do this to a limited degree. The clustering of trapping effort is likely to lead to over-dispersed data (variance greater than mean). We allowed for this over-dispersion by using the approximate *F*-tests detailed in McCullagh & Nelder (1989), rather than the usual chi-squared tests.

Because of the sparseness of the data, it was necessary to simplify the analysis by pooling variable categories (see Appendix). Pooling was also required where pest contractors used inconsistent definitions of category types.

The dependent variable was counts of ferret captures, and the independent variables were bait type, trap type, habitat, temperature (cold, dew, frost, mild, warm), rabbit abundance (low McLean score = 1,2 (none or very infrequent rabbit sign or sightings); high McLean score = 3,4,5,6 (some or very abundant rabbit sign or sightings)), and rainfall (low = <10 mm per night; high = >10 mm per night). The varying numbers of traps used for each combination of the independent variables were accounted for by including log(corrected number of trap nights) as an offset term. This effectively makes the response variable log(captures/trap night), the natural logarithm of trap catch. The number of trap nights was corrected for traps set-off and non-target captures.

5. Results

5.1 Test of rainfall

Using the classification of "low" and "high" rainfall, there was no evidence that rainfall was a useful predictor of ferret catch ($F_{30,1740}$=0.93, P=0.574: combined test of main effect and all second-order interactions with rainfall).

5.2 Other factors

All other independent variables were significant predictors of ferret catch, with each variable interacting in some way with at least one other (Table 1).

Table 1 Statistically significant second-order interactions

Interaction	*F* value	*P* value
trap*habitat	$F_{68,1233}$=1.68	0.001
trap*temperature	$F_{25,1233}$=1.83	0.006
bait*habitat	$F_{72,1233}$=1.43	0.012
bait*trap	$F_{33,1233}$=1.50	0.034
McLean score*bait	$F_{4,1233}$=2.59	0.038

Trap*habitat

This interaction can be interpreted using the mean catches in Table 2. It is clear that some traps have higher catches than others, and that the performance of some trap types depends on the habitat in which they are set. It is important to consider the standard errors in this table: many combinations of factors had few trap nights, and this is reflected in high standard errors. The estimated catch rates for these are imprecise, and so are less reliable than more frequently observed combinations. Such values are given less weight in the discussion that follows.

Good catches were made using Timms tunnels, especially in bush, bush edge and culverts. Timms traps without tunnels were more consistent, though maximum ferret captures were not apparent in any particular habitat — the best being waterways. Victor traps had high mean catches along bushedge-fenceline boundaries, as did Victor cages in offal pits. Captures in Fenn tunnels were more erratic but they had relatively good catches along fencelines, culverts, and waterways. Other trap types either performed poorly, or high catches were accompanied by high standard errors making the estimates unreliable (e.g., Fenn tunnels in buildings and pad runs).

Table 2 Mean catch rate and standard errors (in brackets) for trap*habitat interactions. High catch rates (≥1.8%) with low standard errors (≤1.0%) are highlighted. Approximate 95% confidence intervals for catch rates = ± 2 standard errors. NA = insufficient data available.

Habitat	Trap							
	Timms	Timms tunnel	Victor	Victor tunnel	Victor cage	Fenn tunnel	Gin	Misc.
Mean catch/trap night (%)								
Fenceline	0.9 (0.1)	1.0 (0.2)	0.9 (0.1)	1.5 (0.2)	1.1 (0.1)	1.9 (0.5)	1.2 (0.5)	0.9 (0.8)
Building	1.1 (0.2)	1.2 (0.3)	0.7 (0.4)	0.6 (0.4)	0.7 (0.2)	3.3 (1.5)	<0.05 (0.1)	<0.05 (0.1)
Bush	1.5 (0.2)	2.3 (0.5)	0.8 (0.2)	1.3 (0.2)	1.2 (0.2)	1.5 (0.9)	0.5 (0.3)	<0.05 (0.3)
Bushedge	1.2 (0.2)	2.0 (0.4)	0.8 (0.3)	0.6 (0.2)	0.8 (0.1)	1.4 (0.7)	3.1 (3.0)	<0.05 (0.6)
Bushedge / Fenceline	1.1 (0.3)	0.9 (0.6)	1.9 (0.8)	0 (0)	1.7 (0.2)	0 (0)	NA	NA
Culvert	1.3 (0.2)	2.0 (0.5)	0.7 (0.4)	1.4 (0.5)	1.5 (0.3)	2.7 (1.0)	1.0 (0.5)	NA
Misc.	1.2 (0.7)	2.1 (3.0)	0.5 (0.7)	<0.05 (0.5)	0.5 (0.4)	<0.05 (0.3)	NA	NA
Offal	0.9 (0.3)	1.4 (0.6)	0.9 (0.6)	1.6 (0.8)	2.0 (0.5)	1.5 (1.5)	<0.05 (0.1)	NA
Open	1.3 (0.1)	1.2 (0.4)	0.8 (0.2)	0.3 (0.3)	1.0 (0.3)	0.8 (1.2)	0.2 (0.2)	<0.05 (0.4)
Pad run	1.2 (0.3)	0.8 (0.4)	0.7 (0.5)	0.5 (0.3)	0.8 (0.8)	3.7 (2.3)	<0.05 (0.2)	NA
Tracks	1.2 (0.1)	0.9 (0.2)	0.8 (0.3)	1.1 (0.2)	1.0 (0.1)	1.0 (0.5)	0.7 (1.0)	<0.05 (0.1)
Waterways	1.6 (0.1)	1.5 (0.2)	1.2 (0.3)	1.0 (0.2)	1.4 (0.1)	1.8 (0.5)	1.5 (0.5)	<0.05 (0.1)

Trap*temperature

The success of most traps depended on the temperature (Table 3). Catches in Timms tunnels doubled on nights with frost or dew, Victor tunnels appeared more effective in warm conditions, Victor cages in frosts, Fenn tunnels in either cold or warm conditions, and gin traps in mild conditions. Again, Timms traps were comparatively consistent. Imprecise estimates for other trap*temperature interactions makes it more difficult to say with confidence under which conditions they catch most ferrets.

Table 3 Mean catch rate and standard errors (in brackets) for trap*temperature interactions. High catch rates (≥1.8%) with low standard errors (≤1.0%) are highlighted. Approximate 95% confidence intervals for catch rates = ± 2 standard errors. NA = insufficient data available.

Temperature	Trap							
	Timms	Timms tunnel	Victor	Victor tunnel	Victor cage	Fenn tunnel	Gin	Misc.
Mean catch/trap night (%)								
Cold	1.2 (0.1)	1.3 (0.1)	1.0 (0.1)	1.0 (0.1)	1.2 (0.1)	2.2 (0.5)	0.5 (0.2)	0 (0)
Dew	1.1 (0.6)	2.1 (0.9)	<0.05 (0.4)	NA	0.9 (1.3)	4.3 (1.7)	NA	NA
Frost	1.5 (0.2)	2.5 (0.4)	1.0 (0.4)	0.7 (0.3)	1.9 (0.4)	0.9 (0.4)	<0.05 (1.7)	<0.05 (0.2)
Mild	1.1 (0.1)	1.0 (0.1)	0.9 (0.1)	1.0 (0.1)	1.0 (0.1)	1.5 (0.4)	1.8 (0.5)	2.6 (2.6)
Warm	1.1 (0.1)	1.2 (0.3)	0.4 (0.1)	1.8 (0.2)	1.1 (0.2)	2.0 (0.7)	1.3 (0.8)	<0.05 (0.1)

Bait*habitat

Rabbit was the most consistent of the baits and was especially effective on bushedge/fenceline boundaries. Higher mean catch rates in habitats where other baits were used were generally imprecisely estimated (Table 4). The most notable of these other baits was possum, which had high mean catches in most habitats, but all (except waterways) had high standard errors due to its infrequent use. It is clearly desirable to collect more data for this bait to determine if these results are just due to chance, or if in fact possum has the potential to catch substantially more ferrets than the standard rabbit bait.

Table 4 Mean catch rate and standard errors (in brackets) for bait*habitat interactions. High catch rates (≥1.8%) with low standard errors (≤1.0%) are highlighted. Approximate 95% confidence intervals for catch rates = ± 2 standard errors. NA = insufficient data available.

Habitat	Bait									
	Rabbit	Bird	Cat food	Fish	Horse	Offal	Possum	Red meat	Misc.	No bait
Mean catch/trap night (%)										
Fenceline	1.3 (0.1)	0.8 (0.2)	0.6 (0.2)	0.6 (0.1)	4.3 (5.8)	0.4 (0.1)	1.2 (0.4)	1.3 (0.3)	0.5 (0.4)	NA
Building	1.0 (0.2)	1.4 (0.7)	0.7 (0.9)	0.6 (0.3)	<0.05 (0.5)	0.5 (0.3)	4.3 (1.8)	0.9 (0.9)	NA	<0.05 (0.3)
Bush	1.6 (0.1)	1.2 (0.5)	0.7 (0.7)	0.8 (0.2)	NA	0.4 (0.1)	2.7 (1.3)	1.0 (0.6)	0 (0)	NA
Bushedge	1.1 (0.1)	1.7 (0.7)	0.7 (0.4)	1.2 (0.4)	NA	0.6 (0.1)	<0.05 (0.2)	0 (0)	NA	NA
Bushedge / Fenceline	1.8 (0.2)	0.7 (0.5)	<0.05 (0.1)	0.1 (0.2)	NA	0.4 (0.3)	<0.05 (0.1)	0.7 (0.6)	NA	NA
Culvert	1.7 (0.2)	1.4 (0.6)	1.1 (0.7)	1.6 (0.6)	NA	0.7 (0.2)	4.6 (2.8)	1.1 (0.5)	<0.05 (0.2)	NA
Misc.	1.1 (0.5)	0 (0)	NA	<0.05 (0.1)	NA	0 (0)	3.8 (5.2)	NA	NA	NA
Offal	1.3 (0.3)	1.0 (0.8)	1.9 (1.2)	1.2 (0.7)	NA	0.7 (0.4)	4.8 (2.1)	0.8 (0.7)	NA	NA
Open	1.5 (0.1)	0.7 (0.6)	0.4 (0.4)	0.8 (0.2)	NA	0.3 (0.1)	2.8 (2.2)	0.4 (0.3)	<0.05 (0.1)	<0.05 (0.4)
Pad run	1.1 (0.2)	1.0 (0.8)	0.6 (0.5)	0.5 (0.2)	<0.05 (0.2)	1.6 (1.0)	<0.05 (0.2)	3.6 (2.2)	NA	NA
Tracks	1.3 (0.1)	0.9 (0.3)	1.3 (0.1)	0.9 (0.2)	3.1 (3.0)	0.4 (0.1)	1.4 (1.1)	1.6 (0.7)	<0.05 (0.1)	NA
Waterways	1.6 (0.1)	1.3 (0.3)	0.5 (0.3)	1.2 (0.2)	NA	1.1 (0.2)	3.0 (0.8)	0.9 (0.3)	0.5 (0.7)	NA

Bait*trap

Again, the mean catch rates indicate that possum meat may be the best bait, especially in Timms tunnels and Victor cages (Table 5). As mentioned above, data are insufficient to draw firm conclusions about this bait. Rabbit was the most consistent of the baits and was especially effective in Fenn tunnels.

Table 5 Mean catch rate and standard errors (in brackets) for bait*trap interactions. High catch rates (≥1.8%) with low standard errors (≤1.0%) are highlighted. Approximate 95% confidence intervals for catch rates = ± 2 standard errors. NA = insufficient data available.

Trap	Bait									
	Rabbit	Bird	Cat food	Fish	Horse	Offal	Possum	Red meat	Misc.	No bait
Mean catch/trap night (%)										
Timms	1.4 (0.1)	1.5 (0.3)	NA	0.8 (0.1)	2.7 (2.1)	0.6 (0.1)	1.7 (0.5)	1.3 (0.3)	0.7 (1.0)	NA
Timms tunnel	1.5 (0.1)	1.2 (0.8)	NA	0.8 (0.1)	NA	1.2 (0.8)	3.5 (1.0)	1.0 (1.4)	NA	NA
Victor	1.1 (0.1)	1.4 (0.5)	<0.05 (0.3)	0.6 (0.3)	NA	0.2 (0.1)	1.7 (1.6)	0.5 (0.3)	0.3 (0.4)	NA
Victor tunnel	1.5 (0.1)	0.4 (0.2)	0.4 (0.1)	0.8 (0.8)	NA	0.3 (0.2)	1.6 (2.1)	0.9 (0.7)	<0.05 (0.3)	NA
Victor cage	1.3 (0.1)	1.2 (0.2)	0.7 (0.2)	0.9 (0.2)	NA	0.6 (0.1)	2.9 (0.7)	0.9 (0.5)	0.4 (0.4)	NA
Fenn tunnel	1.8 (0.3)	<0.05 (0.4)	NA	2.6 (1.6)	NA	3.1 (3.0)	NA	1.0 (0.3)	NA	NA
Gin	1.4 (0.6)	NA	NA	0.6 (0.3)	NA	0.7 (0.9)	NA	NA	NA	NA
Misc.	0.6 (0.5)	NA	NA	<0.05 (0.3)	NA	<0.05 (0.1)	NA		NA	<0.05 (0.3)

McLean score*bait

Trapping was only infrequently undertaken where McLean scores were high, and then almost always with rabbit bait (Table 6). Thus it is difficult to make statements about the relative performance of other bait types in areas of low or high McLean scores. But for rabbit bait, mean catch rates were almost three times as high where rabbit abundance was high. Catch rates were similarly high using possum bait where rabbit abundance was low. Comparisons with high rabbit abundance were unavailable.

Table 6 Mean catch rate and standard errors (in brackets) for McLean score*bait interactions. High catch rates (≥1.8%) with low standard errors (≤1.0%) are highlighted. Approximate 95% confidence intervals for catch rates = ± 2 standard errors. NA = insufficient data available.

Bait	McLean Score	
	Low	High
Mean catch/trap night (%)		
Rabbit	1.3 (0)	3.0 (0.2)
Bird	1.1 (0.1)	6.1 (4.4)
Cat food	0.6 (0.1)	<0.05 (0.1)
Fish	0.8 (0.1)	1.4 (0.4)
Horse	2.7 (2.0)	NA
Offal	0.5 (0)	3.6 (1.4)
Possum	2.5 (0.4)	NA
Red meat	1.0 (0.1)	NA
Misc.	0.4 (0.3)	NA
No bait	<0.05 (0.4)	NA

6. Discussion

Recent trials with stoats have indicated that Fenn traps are unacceptably inhumane (Bruce Warburton, Landcare Research, pers. comm.). This also appears to be the case for other species caught in gin traps. In terms of animal welfare, these traps may not be an acceptable option for ferret control. We therefore recommend that the use of these traps be discontinued.

Although Timms traps appear to be the best option from this analysis, there are often difficulties obtaining permission from landholders to use them near houses because these traps also kill cats. The data suggest that the next best options are Victor traps or Victor cages. Until the efficacy of these traps are further investigated, it is unclear whether they will achieve the same capture rate as Timms traps.

One possible reason Timms traps (and perhaps Victor cages) have high catch rates is because they catch relatively few non-target species, thereby making more trap nights available to catch ferrets (less interference = greater catch opportunity). However, this seems unlikely because the competition for traps is so low (only 1.1% of traps were occupied by ferrets). This could be tested by looking at the relative number of non-target species caught in each trap type.

A more likely explanation for higher catch rates in Timms traps is that ferrets were more abundant where Timms traps were used. Most of the Timms traps were used in dryland Otago where rabbits, and therefore ferrets (see Norbury & McGlinchy 1996), were abundant. However, the analysis did not point to this potential bias because no interaction was found between trap type and McLean score. Nevertheless, our general finding was that greatest ferret captures were obtained from areas with highest rabbit abundance. Therefore, greatest ferret captures may not necessarily reflect greatest *reductions* in ferret populations. We looked to see if there were higher rates of decline in trap catch in areas where rabbits were abundant, but there were insufficient long-term data.

Because all trap sites have GPS coordinates, further work with the database could include a spatial analysis to see whether ferret capture rates were spatially clustered. If captures were clustered, and trap-set characteristics were not, this would suggest that ferret density may partly confound the results.

The suggestion that possum meat may be highly attractive to ferrets is reinforced by the fact that possum meat was used as bait mostly in areas where rabbits were less obtainable, and therefore where ferrets were less abundant. The attractiveness of possum meat versus rabbit meat should be examined further.

Climate appeared to have little consistent effect on catch rates of ferrets. No effect of rainfall was detected, and there were inconsistent relationships with temperature. There were also inconsistent relationships with habitat features. However, in addition to high catch rates in culverts and offal pits, there it appeared that linear features (fencelines, bushedges, bushedge/fenceline boundaries, waterways) were also attractive to ferrets. This has been reported in Clapperton's (2001) review of habitat use by ferrets.

The aim of collecting the data was to provide guidelines on best practice and to develop hypotheses that could be explored further. The relative ability of Timms traps, Victor traps, and Victor cage traps, baited with rabbit or possum meat, to catch ferrets should be experimentally

tested in a field study. Landcare Research, Southern Pest Management, and Environment Southland have agreed, in principle, to co-operate in this venture by providing research sites and manipulating management accordingly. We propose to conduct these trials in an area of high rabbit abundance (e.g., 9,000-ha Shag Valley in Otago) and low rabbit abundance (e.g., 18,000-ha Pebbly Hills in Southland). We would conduct simple experiments during existing commercial operations whereby contractors would be required to set random combinations of the above trap and bait types. Because trap and bait types will not be independent (i.e., attraction to one type will mean repulsion from another), this trial will not provide unbiased estimates of the extent to which a given trap and bait type attracts ferrets, but it will provide information about which type is preferred over another. We believe the significantly lower costs and pragmatic advantages of this simple design outweigh the disadvantages of less powerful data. If we were to go ahead with this trial, we also see an opportunity to answer a more important question of what level of ferret population decline is achieved by trapping. This would require contractors to mark and release ferrets for 10 days prior to the trap-bait trial. These mark-recapture data would be modelled in program MARK to provide robust estimates of population size. The number of ferrets captured and removed during the trap-bait trial would indicate the population decline achieved by trapping. Although there would be considerable cost savings using existing commercial operations, we will need to seek external funding.

In the meantime we suggest data collection be continued, but with five modifications:

1. Record fewer trap-set characteristics, but include at least trap type, bait type, and rabbit abundance because they were important variables in this study.
2. Record fewer definitions for a given trap-set characteristic. This will help to simplify future analyses and enable more coherent interpretation of results.
3. Ensure contractors adhere to strict definitions.
4. Streamline data entry by capturing data electronically in the field.
5. Most importantly, we recommend that data are collected in a random fashion by ensuring that variable types are randomised across the landscape.

Every pest contractor records the position of traps using GPS units. A simple way of capturing trap, bait, and rabbit abundance data electronically is to record them as single-character codes in the way-points for each trap location. This would allow data to be downloaded directly into spreadsheets without the cost and errors of inputting data from raw field sheets.

7. Recommendations

- Because the data were not collected in a random fashion, there is the potential for variables to be confounded with ferret density. We therefore emphasise that care be taken when using the guidelines from this study.
- Where possible, Timms traps (with or without tunnels) should be used, and baited with either rabbit or (pending further investigation) possum meat. Victor traps or Victor cages should be used where Timms traps cannot.
- Greatest ferret captures will be obtained by placing traps in areas with highest rabbit abundance. However, because there are generally more ferrets where there are more rabbits, this may not necessarily maximise *reductions* in ferret populations.

- The guidelines that have emerged from the database are useful, but we suggest that future expenditure on data collection is better utilised by contributing to field experiments to test some of the hypotheses raised.
- Such experiments should test whether possum bait has the ability to catch more ferrets than rabbit bait, and whether Victor traps or Victor cages catch more ferrets than Timms traps.
- If the same sort of data collection is continued, we suggest that fewer types of trap-set characteristics be recorded, that steps be taken to ensure contractors adhere to strict definitions, and that data are captured electronically by recording trap-set characteristics in the GPS way-points for each trap location. Most importantly, we recommend that in order to minimise the confounding effects of ferret density, data are collected in a random fashion by ensuring that variable types are randomised across the landscape.

8. Acknowledgements

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9. References

Clapperton, B.K. 2001: Advances in New Zealand Mammalogy 1990-2000: Feral ferret. *Journal of the Royal Society of New Zealand 31*: 185-203.

McCullagh, P.; Nelder, J. A. 1989: Generalized linear models. Second Edition. London, Chapman and Hall.

Norbury, G.; McGlinchy, A. 1996: The impact of rabbit control on predator sightings in the semi-arid high country of the South Island, New Zealand. *Wildlife Research 23:* 93–97.

10. Appendices

10.1 Trap codes

Original trap code used in database	New trap code used for analysis
BC Bridger	Victor cage
Black Fenn	Fenn tunnel
Bridger Cage	Victor cage
Bridger Tunnel	Victor tunnel
Cup	Misc.
Fenn	Fenn tunnel
Fenn Tunnel	Fenn tunnel
Gin Trap	Gin
Holden Cage	Victor cage
Lanes Ace	Misc.
None	Misc.
Shot	Misc.
Timms	Timms
Timms Tunnel	Timms tunnel
Timms with tunnel	Timms tunnel
V Tunnel	Victor tunnel
VC Victor with Cage	Victor cage
Victor	Victor
Victor Cage	Victor cage
Victor Tunnel	Victor tunnel
Wilton Trap	Misc.
Yellow Fenn	Fenn tunnel

10.2 Habitat codes

Original habitat code used in database	Description of original habitat code	New habitat code used for analysis
B	Buildings	Building
B/BE	Buildings Bush Edge	Building
B/F	Fenceline/buildings	Building
B/GB	Buildings / gorse broom	Building
B/OF	Buildings/open farmland	Building
B/PD	Pond/building	Waterways
B/S	Building/stream	Waterways
B/T	Buildings/Treelanes	Building
B/TP	Building/tussock pasture	Building
B/VT	Building/vehicle track	Building
B/W	Buildings/willows	Building
bd	Bridge	Tracks
BE	Bush Edge	Bushedge
BE/C	Bush Edge/Carcase	Offal
be/cd	Bush edge/culvert/drain	Culvert
BE/F	Bushedge/fenceline	Bushedge/Fenceline
BE/G	Gates/bushedge	Bushedge
BE/GB	Gorsebroom/bushedge	Bushedge
BE/OF	Bushedge/open farmland	Bushedge
BE/OP	Bushedge/Offal Pit	Offal
BE/PD	Bush Edge/Ponds/Dams	Waterways
BE/PF	Bush Edge Pine Forest	Bushedge
BE/R	Bush Edge/Animal Run	Pad run
BE/RB	Bushedge/Riverbed	Waterways
BE/S	Bush edge/Streams/Creeks	Waterways
BE/ST	Stocktracks/bushedge	Bushedge
BE/T	Bush Edge Treelane	Bushedge
BE/TP	Bush Edge/Tussock/Pasture	Bushedge
BE/VT	Bushedge/vehicletrack	Bushedge
BE/W	Bush Edge/Willow	Bushedge
C	Carcass	Offal
CD	Culvert/Drain	Culvert
CD/BE	Culverts Drains Bush	Culvert
CD/F	Culverts/drains/fencelines	Culvert
CD/G	Cuvert/drains/gates	Culvert
CD/GB	Culverts Drains Gorse Broom	Culvert
CD/OF	Culverts/Drains/Open Farmland	Culvert

Original habitat code used in database	Description of original habitat code	New habitat code used for analysis
CD/OP	Culvert/drains/offal pit	Offal
CD/PF	Culverts Drains Pine Forestry	Culvert
CD/S	Culvert/drains/streamscreeks	Culvert
CD/ST	Stocktracks/culverts/drains	Culvert
CD/T	Culvert/drains/treelanes	Culvert
CD/TP	Tussock/pasture/culverts	Culvert
CD/VT	Culvert drains/vehicle track	Culvert
CD/W	Culverts drains/willow	Culvert
CO	Coast	Misc.
EF	Eucalyptus forest	Bush
EF/F	Eucalptus forest/fenceline	Bushedge/Fenceline
EF/VT	Eucalyptusforest/vehicletrack	Bush
F	Fenceline	Fenceline
F/BE	Fenceline/bushedge	Bushedge/Fenceline
F/FB	Fenceline/floodbank	Fenceline
F/G	Fenceline/gates	Fenceline
F/GB	Fenceline/gorse/broom	Bushedge/Fenceline
F/H	Fenceline/hedge	Fenceline
F/OF	Fenceline/open farmland	Fenceline
F/P/W	Fenceline/pond/willows	Waterways
F/PD	Fencelines/ponds	Waterways
F/PF	Fenceline/pineforest	Bushedge/Fenceline
F/R	Animalrun/fenceline	Pad run
F/RB	Fenceline/riverbed	Waterways
F/S	Fenceline/streams	Waterways
F/S/T	Tussock/fenceline/streams	Waterways
F/S/W	Fenceline/stream/willows	Waterways
F/SB	Fence/Scrub/broom/gorse	Bushedge/Fenceline
F/ST	Fenceline/stocktracks	Fenceline
F/T	Fenceline/treelanes	Bushedge/Fenceline
F/TP	Tussock/pasture/fenceline	Fenceline
F/VT	Fenceline/vehicletrack	Tracks
F/W	Fencelines/willow	Bushedge/Fenceline
F/W/R	Fenceline/willow/riverbed	Waterways
FB	Floodbank	Misc.
FB/B	Flood bank/bush edge	Bushedge
fb/be	Floodbank Bush Edge	Bushedge
FB/PD	Floodbank/pond/dams	Waterways
FB/T	Floodbank/treelanes	Misc.

Original habitat code used in database	Description of original habitat code	New habitat code used for analysis
FB/W	Floodbank/willow	Bush
G	Gate	Fenceline
G/B	Gates/buildings	Building
G/GB	Gates/gorse/broom	Bushedge/Fenceline
G/OF	Gates/open farmland	Fenceline
G/PD	Gate/pond	Waterways
G/PF	Gates/pineforest	Bushedge/Fenceline
G/RB	Gates/riverbed	Waterways
G/S	Gates/streams	Waterways
G/SB	Gate/Scrub/Broom/Gorse	Tracks
G/ST	Gate/Stock Track	Tracks
G/T	Gates/treelanes	Tracks
G/TP	Tussock/pasture/gates	Open
G/VT	Gates/vehicletracks	Tracks
GB	Gorse/broom	Bush
GB/B	Gorse/Broom/Buildings	Building
GB/F	Gorse/broom/fenceline	Bushedge/Fenceline
GB/OF	Gorse brrom / open farmland	Bush
GB/PD	Gorsebroom/pond	Waterways
GB/PF	Gorsebroom/pineforestry	Bush
GB/RB	Gorse broom/riverbed	Waterways
GB/S	Gorse broom / streams creeks	Waterways
GB/ST	Stocktracks/gorse/broom	Tracks
GB/VT	Vehicletrack/gorse/broom	Tracks
GB/W	Gorse broom/willow	Bush
Gully	Gully	Misc.
H	Hedge	Fenceline
HB	Haybarn	Building
LE	Lake Edge	Waterways
LE/ST	Lake edge/Stock track	Waterways
LE/VT	Lake edge/Vehicle Track	Waterways
M/ST	Stocktracks/manuka	Tracks
O/W/S	Offal Pit/willows/stream	Offal
OF	Open Farmland	Open
OF/OP	Open farmland/offal pit	Offal
OF/PD	Open farmland / pond	Waterways
OF/PF	Open farmland/pine forestry	Bush
OF/S	Open farmland/streams/creeks	Waterways
of/st	Open farmalnd/ stocktrack	Tracks

Original habitat code used in database	Description of original habitat code	New habitat code used for analysis
OF/T	Open farmland/treelanes	Open
OF/VT	Open farmland/vehicletrack	Tracks
OF/W	Open farmland/willow	Bush
OP	Offal Pit	Offal
op/of	Open paddock offal pit	Offal
OP/S	Offal Pit/Streams/Creeks	Offal
OP/W	Offal Pit/Willows	Offal
P	Pond	Waterways
PD	Pond/Dam	Waterways
PD/BE	Pond/Dam/Bush Edge	Waterways
PD/PF	Ponds Dams Pine Forestry	Waterways
PD/R	Ponds Dams Animal Run	Waterways
PD/RB	Pond/riverbed	Waterways
PD/ST	Ponds/Dams/Stock Track	Waterways
PD/T	Ponds/Dams/Trees	Waterways
PD/TP	Pond/tussock pasture	Waterways
PD/VT	Ponds/Dams/Vehicle Tracks	Waterways
PD/W	Pond/willow	Waterways
PF	Pine/Forestry	Bush
pf/b	Pine forestry/building	Building
PF/C	Pine Forestry Carcass	Offal
PF/F	Pines/Forestry/Fenceline	Bushedge/Fenceline
PF/G	Pines/Forestry/Gates	Bushedge/Fenceline
PF/OP	Pines/Forestry/Offal Pit	Bush
PF/R	Pineforest / animalrun	Pad run
PF/S	Pine forest/streams	Waterways
PF/VT	Pineforestry/vehicle tracks	Bush
PF/W	Pineforestry/willow	Bush
Py	Pylon	Building
Q	Quarry	Misc.
R	Animal Run/pad run	Pad run
R/S	Aniaml Run/Pad/Streams/Creeks	Pad run
R/TP	Tussock/pasture/animal run	Pad run
r/w	Animal Run/Pad Willows	Pad run
RB	Riverbed	Waterways
RB/FB	Riverbed Floodbank	Waterways
RB/ST	Stocktracks/riverbed	Waterways
RB/T	Riverbed / treelanes	Waterways
RB/VT	Riverbed/vehicletrack	Waterways

Original habitat code used in database	Description of original habitat code	New habitat code used for analysis
RB/W	Riverbed/willow	Waterways
Road	Road	Tracks
RT	Rubbish Tip	Offal
S	Streams/Creeks	Waterways
S/B	Stream/buildings?	Waterways
s/c	Stream/carcass	Offal
S/CD	Streams/Creeks/Culvert/Drains	Waterways
S/F	Streams/fenceline	Waterways
S/PD	Streams Creeks/Ponds Dams	Waterways
S/R	Streams/animal run	Waterways
S/ST	Streams/stock trap	Waterways
S/TP	Tussock/pasture/strems/creeks	Waterways
S/VT	Vehicletrack/streamcreeks	Waterways
S/W	Streams/willow	Waterways
S/W/O	Streams/willows/open farmland	Waterways
SB	Scrub/broom/gorse	Bush
SB/F	Scrub/bush/gorse/fences	Bushedge/Fenceline
SB/VT	Scrub/broom/gorse/vehicle trac	Tracks
SC	Scrub	Bush
Silo	Silo	Building
SP	Silage Pit	Offal
ST	Stock Track	Tracks
ST/CD	Stock track/Culvert/Drain	Culvert
ST/G	Stock track/gate	Tracks
st/rb	Stocktrack/Riverbed	Waterways
ST/S	Stock Track/Streams and Creeks	Waterways
ST/SB	Stock track/Scrub/broom/gorse	Tracks
ST/T	Stocktrack/treelanes	Tracks
ST/TP	Stock track/Tussock/Pasture	Tracks
ST/VT	Stock tracks / vehicle tracks	Tracks
SW	Swamp	Waterways
T	Tree lane	Fenceline
T/F/O	Trees/fenceline/open farmland	Open
T/OP	Trees/Offal Pit	Offal
T/R	Trees/Animal Run	Pad run
T/S	Trees/stream	Waterways
T/VT	Treelanes/vehicletracks	Tracks
Tank	Tank	Building
TBA	Lots of different kinds	Misc.

Original habitat code used in database	Description of original habitat code	New habitat code used for analysis
Tor	Rocky Tor	Misc.
TP	Tussock Pasture	Open
TP/PF	Tussock pasture/pineforestry	Bush
TP/R	Tussock/Pasture/Animal Run/Pad	Pad run
TP/S	Tussock/Pasture/Streams/Creeks	Waterways
TP/T	Tussock pasture / treelanes	Open
TP/VT	Tussock pasture/veh track	Tracks
Tree	Tree	Bush
VT	Vehicle Track	Tracks
VT/EF	Vehicle Track/Eucalptus Forest	Tracks
VT/F	Vehicle Track/Fenceline	Tracks
VT/G	Vehicletrack/gates	Tracks
VT/R	Vehicle Track Run	Tracks
VT/S	Vehicle track/stream	Waterways
VT/SG	Vehicle Track/Stream/gate	Waterways
VT/W	Vehicle track/willows	Tracks
W	Willows	Bush
W/S	Willows/Streams/Creeks	Waterways
Y	Yards	Building

10.3 Bait codes

Original bait code used in database	Description of original bait code	New bait code used for analysis
A	Apple	Misc.
B	Beef	Red meat
Bird	Bird	Bird
Bl	Blood	Misc.
C	Chicken	Bird
CF	Cat Food	Cat food
D	Duck	Bird
F	Fish	Fish
FL	Flour	Misc.
G	Goose	Bird
H	Hare	Rabbit
HO	Horse	Horse
K	Kidney	Offal
L	Liver	Offal
M	Mutton	Red meat
Nil	No Bait Used	No bait
O	Ox Heart	Offal
P	Possum	Possum
Pi	Pig	Red meat
Q	Quail	Bird
R	Rabbit	Rabbit
R/F	Rabbit/fish	Rabbit
R/V	Rabbit/Venison	Rabbit
SH	Sheep Heart	Offal
T	Tuna	Fish
V	Venison	Red meat

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