Optimising a kill-trap network for cost-effective predator control

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Introduction

Permanent networks of kill traps have the potential to provide long-term, cost-effective control of vertebrate pests. However, like any network that is established with multiple devices, there is a possibility that the initial number of devices is higher than required for long-term maintenance of a low density pest population. Some of the devices may have become redundant, and their removal might reduce the cost of checking and maintaining the network, without reducing its effectiveness.

Hawke's Bay Regional Council (HBRC) currently controls a suite of predators (viz. ferrets, stoats and feral cats) within their Poutiri Ao O Tane pest control programme. This programme covers approximately 15 000 ha and has an infrastructure (network) of 690 DOC 250 kill traps. The trapping programme has been running since November 2011, with traps checked, cleared, and rebaited monthly. The initial trap network was established by contractors who had two objectives: (1) maximise effectiveness, and (2) minimise costs. The first objective was achieved by spacing traps at 200–300m, which is currently accepted practice, and the second objective was achieved by locating traps along farm access roads and tracks to enable rapid travel between traps. All trap locations were verified by GPS and all captures recorded at each check.

The first phase of the programme was to reduce predator numbers, and traps were checked monthly during this phase. For the maintenance phase, which started recently, checking of traps is being reduced to once every three months for an initial period in order to determine if this checking frequency is adequate (i.e. how quickly traps fill up and are therefore redundant).

For the Poutiri Ao O Tane pest control programme, and for the planned roll-out of a similar programme (Cape-to-City), it is desirable to know if the same control effectiveness could be delivered with fewer traps, and therefore at lower cost. We used an individual-based spatial model to simulate trapping across the Poutiri Ao O Tane trap network in order to determine if similar numbers of predators could be captured with fewer trap sites, and/or with a combination of fewer trap sites but with multiple traps at each site.

Methods

Trap location data and predator capture data were provided by Wildlife and Environmental Trapping Advancements (WETA) for each month from November 2011 to May 2014. The Poutiri Ao O Tane trap network consisted of 690 traps across an area of approximately 15,000 ha (Figure 1).

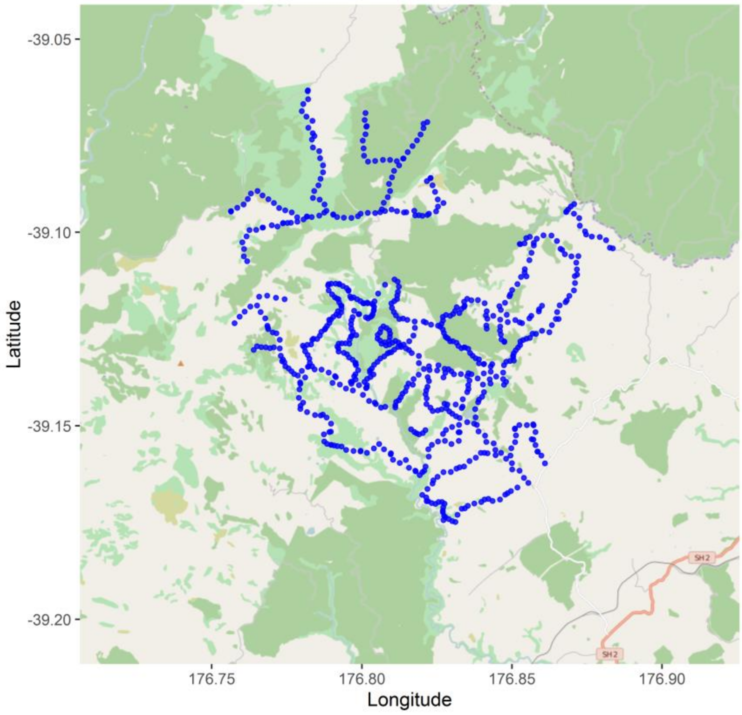
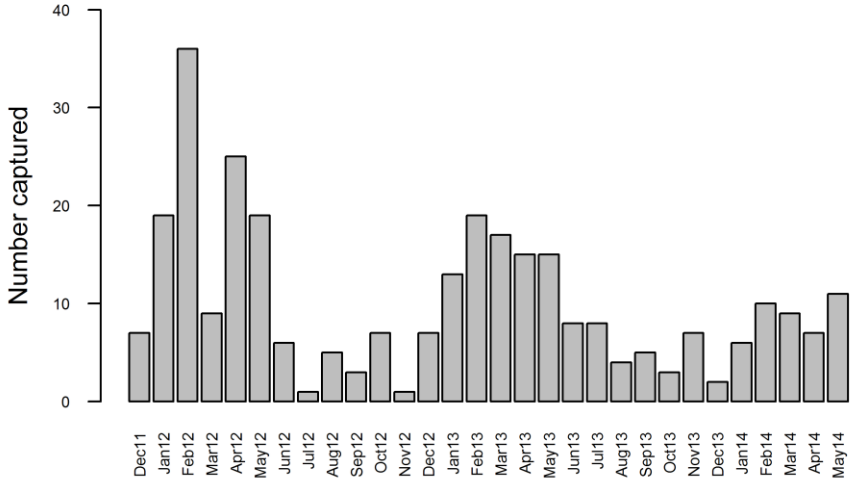


Figure 1: Location of the traps in the Poutiri Ao O Tane pest control programme.

Over the 30 months of trapping, the main targets (ferrets, stoats and feral cats) were captured (Figure 2a), along with captures of non-target species (possums, rabbits, ship and Norway rats, mice, hedgehogs, and weasels; Figure 2b). We used only the final 12 months of data, because by this stage the capture rate was assumed to better reflect the maintenance phase, rather than the initial knockdown phase, and this was supported by the lower number of captures of target predators in the third year compared to the first (Figure 2). Captures were binned in monthly groups to reflect the schedule of checking traps every month.



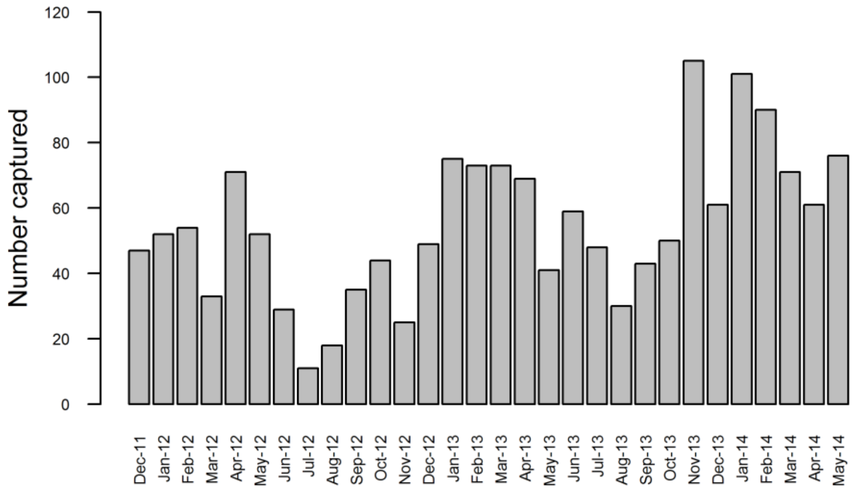


Figure 2: The total number of target predators (feral cats, ferrets and stoats) and non-target predators captured in each month from November 2011 to May 2014.

Trap site GPS data were used to locate each trap site in the simulated landscape, but the animals captured and their locations were only used to generate an estimate of the actual monthly population the animals were captured from (see below).

Simulation modelling

For each month, we used an individual-based model (Warburton & Gormley 2015) to simulate captures from the estimated underlying densities of the target and non-target species that would have resulted in the captures observed for both target (ferrets, stoats, and cats,) and non-target species (rats, hedgehogs, rabbits, and possums).

To obtain these estimates of the underlying monthly populations, we used a variant of Approximate Bayesian Computation (ABC). We initiated the simulation with 200 target and 1000 non-target animals distributed randomly across the landscape and then used the model to concurrently simulate captures of the target and non-target groups of predators over a period of 30 days. The total number of simulated captures of each predator group was compared with the actual captures for that month (i.e. those in Figure 2): the estimated background population size was adjusted downwards when the simulated captures exceeded the actual captures, and vice versa for when the simulated captures were lower than the actual captures. The simulation was then re-run with the new population size, and the process repeated for 50 iterations by which point the estimated population size was relatively stable. The population size of target and non-target groups from the last iteration was used as the background population size for simulating reductions in trapping effort.

We then simulated captures under five levels of trapping effort relative to the original trap layout: (1) all traps, (2) 75% of traps, (3) 50% of traps, (4) 33% of traps, and (5) 25% of traps. For each of these levels of trapping, we also simulated captures depending on whether the maximum trap capacity at each trap location was 1, 2, 3 or 4 animals (i.e. setting 1–4 traps at a location). These combinations of trap capacity and trapping effort resulted in 20 sets of simulations. Traps were removed systematically from the csv file of trap locations, ordered somewhat by latitude and longitude. This was preferable to randomly removing traps as that process when initially applied resulted in clusters of traps being removed. For each combination, the model was run 500 times for 30 nights for each of the 12 one-month periods, and number of animals captured for that data set from each predator group was recorded for each iteration. For each iteration, the results from each month were summed and the cumulative number of simulated captures was expressed as a percentage of the cumulative number of actual captures, for both target and non-target groups of predator species.

The individual-based model used to simulate captures (Warburton & Gormley 2015) assumes that each animal occupies a circular home range (the size defined by σ; scalar of home range size), and that the probability of an animal being caught in any empty trap on a given night (g0) declines with the distance between its home range centre and the trap (Ball et al. 2005). Values of σ of 400 m were used for the target species (stoats, ferrets and cats) and 40 m for most non-target species (rats, hedgehog and rabbits) and 65 m for possums. All species (both

target and non-target) were simulated with a g0 = 0.05 (the probability of catching an animal in a trap set for one night at the centre of its home range).

These values were chosen based on the ranges reported in published literature and reports (Table 1), but it is acknowledged that, especially for feral cats, more robust empirical values are required.

There were several assumptions made to enable the data to be modelled:

1. The three target species (ferrets, stoats, and feral cats) all had similar home range sizes and capture probabilities. This enabled the species to be grouped and modelled as a generic predator. That is, one value for σ and g0 was used across all three target species.

2. Animals were located across the simulated trapping area at random (i.e. there was no attempt to constrain their home range centres to habitat).

3. The overall percent kill achieved by any trapping event and the total population numbers were unknown (as it was for the real data), so effectiveness was determined by the animals caught in a simulation as a percentage of total animals actually caught in the field in any selected month.

4. Capture probabilities (g0) stayed constant over the period selected for the simulation (i.e. bait attractiveness remained constant).

5. Non-target species captured (rats, rabbits, hedgehogs and possums) were included in order to provide competition for traps.

6. All trap sites were equally attractive: we made no attempt to either remove traps that had not captured anything over the life of the programme or keep those that had captures. We did however examine the data to identify the likelihood of traps capturing a target predator based on whether it had had a previous capture.

We could not simulate the capture process across more than one month because we did not know the actual population sizes of target and non-target animals. That is, we could have used the cumulative catch over a three-month period, but this would have required us to assume they were all available for capture at the start of the first month, which was unlikely.

By summing simulated captures over the entire 12 month period and reporting this as a proportion of the 12 month cumulative actual captures removed the effect of months where only a small number of captures occurred (e.g. n = 3), which could mean that a slight difference in simulated captures (e.g. m = 5) would result in a large percentage difference.

Results

The proportional catch of target species declined with decreasing trapping intensity (i.e. from all traps to 25% of traps), but appeared largely unaffected by an increase in trap capacity (i.e. increasing the number of traps from one to four at each site; Figure 3). Reducing the percentage of traps to 75% and 50% of the original trap numbers reduced the mean proportional catch to an average of 95% and 89% of actual captures, respectively, but neither was significantly less than 100% (Figure 3). Further reduction in trapping effort (i.e. 33% and 25% of traps used) resulted in mean catches of 83% and 76% of actual captures, respectively, with both of these reductions being significantly less than 100% (Figure 3).

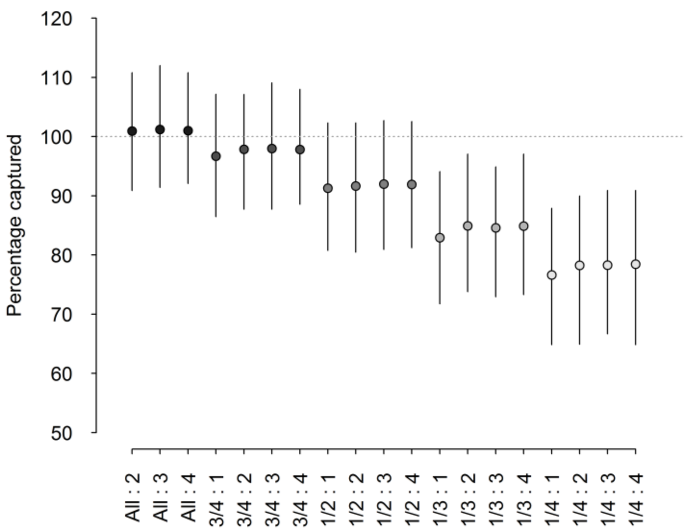


Figure 3: Target animals captured as a percentage of target animals captured under the current trapping configuration (i.e. all trap sites with 1 trap per site), averaged across 12 × one month trapping sessions for a range of trapping configurations. Vertical lines indicate the 5% and 95% percentile for each configuration, labelled as no. of original trap-sites: no. of traps at each site, e.g. ¾:2 = 75% of trap sites with 2 traps at each site. Note y-axis scale is from 50% to 120%.

For non-target species, the percentage of observed animals caught declined markedly with a reduction in trap numbers (i.e. when 75%, 50%, 33% and 25% of the original traps were

used, the percentages captured were 78%, 53%, 36% and 27% respectively; Figure 4). Similar to the target species, the percentage of the observed individuals caught was also relatively unaffected by trap capacity (i.e. number of traps at a site; Figure 4).

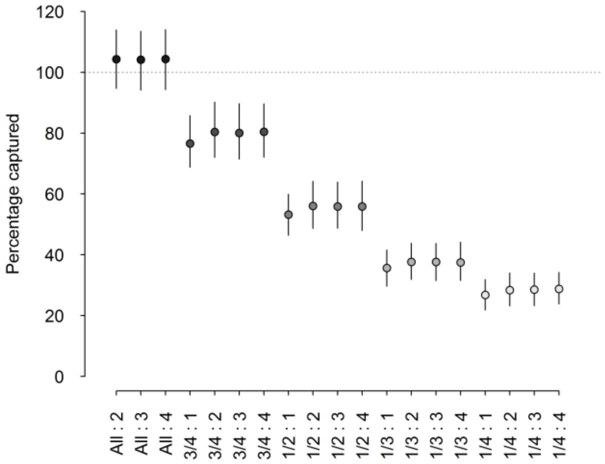


Figure 4: Non-target animals captured as a percentage of non-target animals captured under the current trapping configuration (i.e. all trap sites with 1 trap per site), averaged across 12 × one month trapping sessions for a range of trapping configurations. Vertical lines indicate the 5% and 95% percentile for each configuration, labelled as no. of original trap-sites: no. of traps at each site, e.g. ¾:2 = 75% of trap sites with 2 traps at each site

Of the 690 traps originally deployed, 71% had not captured any target species in the 30 months from December 2011 until May 2014. Nineteen percent caught one target animal, 6.5% caught two, up to a maximum of five target animals caught by just three traps over the entire period. Some preliminary analyses suggest that traps that caught a target animal in any given fixed length period were twice as likely to catch another target animal in a subsequent period of similar length. For example, on average only 10% of traps that had no captures in any six month period had captures in the next six month period, compared to 22% of traps that had a capture in the first six month also having a capture in the next six months. Similarly, of the 568 traps that had no captures in the first six months of the study, 82% (n = 466) had no captures for the remainder of the study.

Discussion

The simulation study showed that during a maintenance phase of trapping, (i.e. keeping populations at low levels), similar levels of trapping could occur even with substantial reductions in the trap network. The results indicate that even when 75% of traps are removed, close to 80% of the actual target animals caught could still be captured. However, if the proportion captured needed to be maintained above 90% of what was actually captured then 25% of traps could conservatively be removed (i.e. 95% captured) or up to 50% could be removed if a less conservative approach was chosen (i.e. 89% captured).

In general, the simulation predictions are likely to be conservative because there was no attempt to selectively remove traps based on their past performance. That is, 70% of traps had caught no target species in 30 months of trapping, in contrast to 3.5% of traps that captured at least three animals. If the low-capture traps were removed in preference to those traps that had captured several times, the overall effectiveness of the modified trap network might be greater than simulated.

The lack of an effect of increasing the trap capacity at each site was surprising, but is likely due to a combination of the relatively low density of both target and non-target species (i.e. no localised aggregations), and the length of time between trap checks (i.e. one month was not sufficient for traps to become saturated). We note, however, that in our simulations animals were located randomly across the landscape – if animals were clustered in areas around traps or in habitat patches, trap saturation would be more likely, and the effect of multiple capture traps would likely be more important.

This analysis of the Poutiri Ao O Tane trap data indicates there are potentially significant savings to be made, at least in the maintenance phase of a long-term predator control programme. The potential savings result primarily from each of the target predators (ferrets, stoats, and feral cats) having large home ranges ($\sigma = 400$ m), resulting in them potentially interacting with a greater number of traps in the original network, thereby enabling wider inter-trap spacings to be used than in the initially established trap network. In contrast, the smaller home-range of the non-target species meant that they had fewer traps to potentially

interact with. An increase in trap spacing therefore resulted in even fewer traps, leading to a greater reduction in the percentage of the original number of animals captured

It is not known whether the initial knockdown phase would have been as effective with a reduction in trap density. However, given the very low number of target species captured (and their generally low densities), it is likely that some reduction in trap density could be made without loss of network effectiveness.

Available data on g0 and sigma values are highly variable, and without carrying out sensitivity analyses it is unknown how changes in these values, especially for feral cats for which there are very few values, affects the model predictions.

Acknowledgements

We thank Wendy and Pouri Rakete-Stones for providing a very clean spreadsheet of trap location and capture data, Campbell Leckie and Rod Dickson for guidance and feedback. This study was partially funded by Hawke's Bay Regional Council and the Aotearoa Foundation.

References

Ball SJ, Ramsey D, Nugent G, Warburton B, Efford M 2005. A method for estimating wildlife detection probabilities in relation to home-range use: insights from a field study on the common brushtail possum (*Trichosurus vulpecula*). Wildlife Research 32: 217–227.

Clayton RI, Byrom AE, Anderson DP, Edge KA, Gleeson D, McMurtrie P, Veale A 2011. Density estimates and detection models inform stoat (*Mustela erminea*) eradication on Resolution Island, New Zealand. In: Veitch CR, Clout MN eds Island invasives: eradication and management. Gland, Switzerland, IUCN. Pp. 413–417.

Efford MG, Borchers DL, Byrom AE 2009. Density estimation by spatially explicit capture–recapture: likelihood-based methods. In: Thompson DL, Cooch EG, Conroy MJ eds Modeling demographic processes in marked populations. Environmental and Ecological Statistics 3. Springer.

Norbury G, Efford M 2004. Ferret density estimation. Unpublished Landcare Research Contract Report LC0304/110, prepared for the TBfree, Wellington.

Smith DHV, Wilson DJ, Moller H, Murphy EC, Pickerell G 2008. Stoat density, diet and survival compared between alpine grassland and beech forest habitats. New Zealand Journal of Ecology 32: 166–176.

Warburton B, Gormley AM 2015. Optimising the application of multiple capture traps for invasive species management using spatial simulation. PLoS ONE doi:10.1371 /journal.pone.0120373.