Manaaki Whenua
Landcare Research

Socially acceptable compliance monitoring of predators

Prepared for: Hawke's Bay Regional Council

June 2018

Socially acceptable compliance monitoring of predators

Contract Report: LC3160

Al Glen, Grant Norbury, Bruce Warburton

Manaaki Whenua – Landcare Research

Reviewed by:	*Approved for release by:*
Andrew Gormley	Chris Jones
Quantitative Ecologist	Portfolio Leader – Managing Invasives
Manaaki Whenua – Landcare Research	Manaaki Whenua – Landcare Research

Disclaimer

Contents

Summary

Benefits for conservation and land management

Landscape-scale control of invasive predators can deliver benefits for native biodiversity, as well as for primary production. The effectiveness of landscape-scale management relies on the participation of each individual landholder; if some landholders are not suppressing predators on their properties, this could undermine the overall effectiveness of the programme. To determine whether predators are being effectively controlled at the individual property level, Hawke's Bay Regional Council need a robust method of estimating predator abundance at a localised scale. We describe a methodology to do this.

Project and Client

- The Cape to City programme aims to control feral cats and mustelids (hereafter 'predators') across 26,000 ha of predominantly private land in Hawke's Bay. A lack of control effort on some individual properties could reduce the overall effectiveness of the programme.
- Hawke's Bay Regional Council (HBRC) engaged Manaaki Whenua to design a socially acceptable predator monitoring method to check that property owners are fulfilling their obligation to control predator numbers.

Objectives

- This report discusses how camera traps can be used to monitor predators on individual properties for compliance purposes.
- To achieve social acceptability, we aimed to design a monitoring programme that is: (1) intuitively easy to understand, (2) legally defendable, and (3) equitable for landholders with small or large properties.
- In the absence of detailed information on the relationship between predator abundance and biodiversity outcomes, we aimed to set an interim threshold of predator abundance for compliance, which may be revised as more information is gathered.

Methods

- Information was collated from previous predator control, monitoring and population modelling exercises in Hawke's Bay. This included:
  - Numbers of camera traps
  - Spacing between cameras
  - Duration of camera deployment
  - Camera trap rate (CTR: an index of relative abundance) of predators before and after a successful control operation
  - The relationship between CTR and estimated population size of predators

- Model predictions of how the size of an individual property affects its importance for the overall effectiveness of landscape-scale predator control

Results

- Based on monitoring results from a predator control operation on Waitere Station, we found that a grid of 30 camera traps spaced 500 m apart and left in place for 21 days should provide an accurate and precise index of relative predator abundance.
- Before trapping on Waitere Station, CTR was > 2% for cats and > 6% for ferrets, with upper 95% confidence limits of 4% and 8%, respectively. After trapping reduced cat and ferret numbers on Waitere Station by an estimated 80–90%, CTR for each predator species was < 1%. The upper 95% confidence limits were also < 1%.
- There was a strong linear relationship between CTR and the estimated abundance of predators. This indicates that CTR is a reliable index of predator abundance.
- Camera trapping is unlikely to give robust information on predator abundance over areas < 500 ha.

Conclusions

- Based on the data available, CTR has a strong linear relationship with abundance of predators, and is therefore likely to be a reliable index for monitoring the success of predator control operations.
- Because numbers of predator detections are likely to be low, it will be necessary to pool data to estimate a combined CTR for cats, ferrets and stoats.

Recommendations

- Compliance monitoring using camera traps should take place on any property ≥ 500 ha if:
    - Annual broad-scale camera trapping detects high levels of predator activity on that property, and/or
    - Other information received by HBRC suggests traps are not being serviced adequately.
- A grid of 30 cameras should be set 500 m apart (± 100 m) for 21 days.
- An interim target for compliance should be that the combined CTR for cats, ferrets and stoats should be < 0.5%, with 95% confidence intervals < 1.5%.

1 Introduction

The Cape to City programme aims to control feral cats and mustelids (hereafter 'predators') across 26,000 ha of predominantly private land in Hawke's Bay. A lack of control effort on some individual properties could reduce the overall effectiveness of the programme (Glen et al. 2017). Manaaki Whenua has been examining socially-acceptable predator monitoring options to ensure that property owners are fulfilling their obligation to control predator numbers. Here we discuss how camera traps might be used to monitor predators on individual properties for compliance purposes.

2 Background

Camera traps are being used for annual monitoring of predators across the Cape to City area, and, for comparison, in an adjacent non-treatment area. This broad-scale annual monitoring is designed to measure the effects of predator control at the landscape scale, but does not provide information at the scale of each individual property. Therefore, if predator activity is higher in some parts of the landscape than others, it will not be possible to determine whether individual landholders are failing to suppress predator numbers. In order to ensure compliance of individual landholders, a more intensive, fine-scale monitoring approach is required.

3 Objectives

This report discusses how camera traps can be used to monitor predators on individual properties for compliance purposes.

To achieve social acceptability, we aimed to design a monitoring programme that is: (1) intuitively easy to understand, (2) legally defendable, and (3) equitable for landholders with small or large properties.

4 Methods

Information was collated from previous predator control, monitoring and population modelling exercises in Hawke's Bay, as well as discussions with HBRC staff. Many of our recommendations are based on the results of a predator control and monitoring operation on Waitere Station in 2014 (Nichols, Glen 2015). Using data from Waitere, we investigated: (1) numbers of camera traps required, (2) optimal spacing between camera traps, (3) optimal duration of camera deployment, and (4) relative abundance of predators before and after a successful control operation.

Forty camera traps were deployed to monitor predators over an area of 600 ha on Waitere Station. We first estimated the abundance of feral cats using all 40 cameras. To determine whether similar accuracy and precision could be obtained with fewer cameras, we then discarded the data from 20 cameras and repeated the estimation procedure using only the 20 cameras around the perimeter of the grid (Nichols and Glen 2015).

A spacing of 500 m between camera traps was originally chosen based on published estimates of home range size for predators in New Zealand (summarised by Glen and Byrom 2014). We estimated that this would allow for at least one camera per average cat home range, therefore providing good coverage of the study area. To test this assumption, we used detections of cats on Waitere Station to estimate the spatial detection parameter Sigma. We then applied a rule of thumb that the radius of a circular 95% home range can be approximated as 2.45 × Sigma (Jennrich and Turner 1969; Efford 2018).

We also subsampled data from Waitere Station to investigate how different levels of sampling effort (numbers of camera days) influenced the accuracy and precision of relative abundance estimates. We plotted relative abundance estimates of cats (± 95% confidence intervals) using a range of sample sizes from 40 to 880 camera trap days. Sample size was considered adequate when the graph showed that additional sampling effort made little difference to the size of the estimate, or the width of the error bars.

A simple metric of animal abundance based on camera trap data is the camera trap rate (CTR), which is the number of independent photographs of target animals per 100 camera trap days (Rovero and Marshall 2009). This is conceptually similar to metrics used in compliance monitoring for other pest species, e.g. the chew card index (Sweetapple and Nugent 2011) or residual trap catch index (Glen 2014) for possums.

We explored the relationship between CTR and estimated numbers of cats using data from three predator control operations on Waitere, Toronui and Ngatapa stations. In each of these operations known numbers of cats were removed, which allows absolute abundance to be estimated using the index-manipulation-index method (Caughley 1977).

Finally, we considered alternative compliance monitoring approaches for small *vs* large properties. Previous model predictions (Glen et al. 2017) suggest small properties are unimportant to the overall effectiveness of landscape-scale predator control. However, we also considered the question of fairness and equity between owners of small and large holdings, as well as the logistical feasibility of monitoring predators on small properties.

5 Results

The precision of CTR estimates improves with increasing sampling effort (Rovero and Marshall 2009). We used data from Waitere Station (before predator removal) to investigate how the precision of CTR estimates improved with increasing number of camera trap days (Fig. 1). Estimates based on ≤ 240 camera trap days had poor precision (indicated by wide confidence intervals). These estimates also appeared to be biased high. With a sampling effort between 280 and 520 camera trap days, precision was moderate. Estimated CTR was between 3.2 and 3.9%, and confidence intervals were ± 2%. Greater precision was achieved with ≥ 560 camera trap days. Estimated CTR was between 2.7 and 3%, with confidence intervals ± 1% (Fig. 1). We therefore recommend that compliance monitoring should involve a sampling effort ≥ 560 camera trap days.

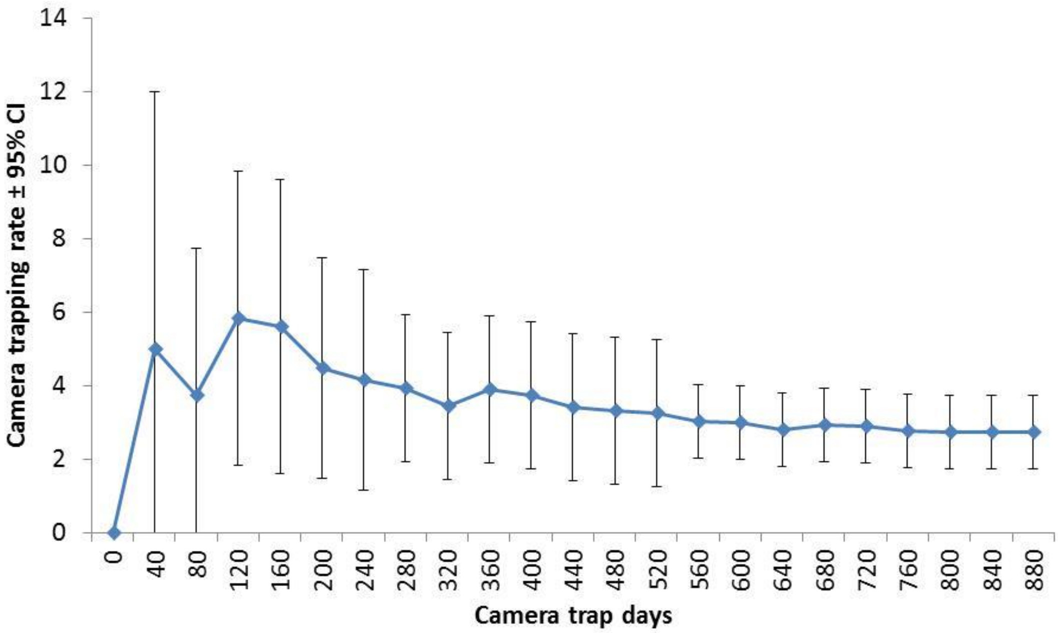

Figure 1. Estimates of camera trap rate (± 95% confidence intervals) with increasing numbers of camera trap days before predator removal on Waitere Station.

To be considered reliable, an index of relative abundance must have a strong, predictable relationship with actual abundance. Rovero and Marshall (2009) found a strong linear relationship (R^2 = 0.9) between CTR and population density of an African ungulate. (The closer R^2 is to 1, the stronger the relationship). Based on previous trials in Hawke's Bay, we estimated the relationship between CTR and estimated abundance of feral cats. Camera trap rate was estimated before and after intensive cat removal on Waitere, Toronui, and Ngatapa stations. Because known numbers of cats were removed in these operations, cat numbers could be estimated using the index-manipulation-index method (Caughley 1977). These abundance estimates were plotted against the CTR estimates obtained before and after each removal operation. There was a strong linear relationship (R^2 = 0.8) between CTR and estimated abundance of feral cats (Fig. 2), although the small number of points (n = 7) used to estimate this relationship means that there is some uncertainty in this result.

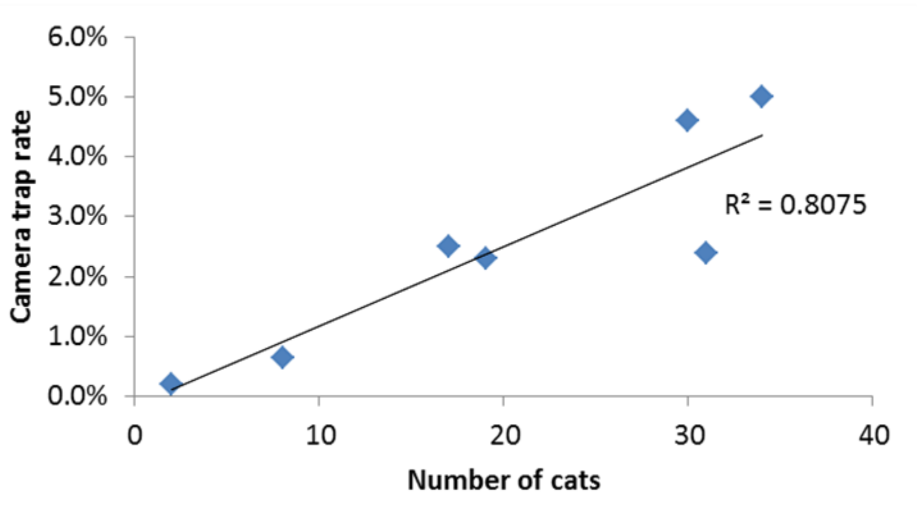

Figure 2. Estimated relationship between camera trap rate and estimated population size of feral cats on Waitere, Toronui and Ngatapa Stations, Hawke's Bay.

Based on annual camera trapping in Cape to City and the adjacent non-treatment area since 2015, mustelids are detected in low numbers compared with cats (Table 1). Small sample sizes such as these would yield imprecise estimates of CTR. We therefore recommend that data for cats and mustelids be pooled to estimate a combined CTR.

Table 1. Numbers of detections of cats and mustelids using camera traps in Cape to City and the adjacent non-treatment area

	2015	2016	2017	Total
Cats	180	70	110	360
Ferrets	29	1	14	44
Stoats	35	3	3	41
Weasels	0	0	0	0

A spacing of 500 m between cameras has been used successfully for camera trapping predators in Hawke's Bay. Our estimate of the spatial detection parameter Sigma for cats is consistent with this (Sigma = 182.5; Nichols, Glen 2015). Assuming a circular home range, this suggests an average home range radius of around 450 m, which means there would be more than one camera per average cat home range.

Based on cost estimates for the monitoring operation on Waitere Station, our recommended compliance monitoring approach should cost < $5,000 per property, including materials and labour. Cameras should be left in place for 21 days, giving a total of 620 camera trap days, which should be sufficient to achieve a high level of precision (Fig. 1).

Camera data should be pooled for all predator species and used to estimate CTR ± 95% confidence intervals. Consecutive photographs of the same species on the same camera < 30 minutes apart should be treated as a single encounter, unless the images clearly show different individuals (e.g. based on coat pattern).

Monitoring should take place at suitable times of year to produce accurate results that can be compared between different times and places. Seasonal events such as juvenile dispersal of predators should be avoided. Stoats and ferrets mostly disperse during late summer to early autumn (Glen, Byrom 2014). Little is known about the dispersal behaviour of feral cats in New Zealand; however, young males leave their maternal home range at 1–3 years of age (Fitzgerald, Karl 1986; Gillies, Fitzgerald 2005). Dispersal by two male cats in Hawke's Bay has been recorded; these limited data show that dispersal can occur in summer or winter (Langham, Porter 1991).

Owned cats are not being targeted for removal in Cape to City, and should not be counted when estimating the relative abundance of feral cats. We therefore recommend that landholders be issued with reflective collars for any cats they own. This should allow images of owned cats to be distinguished from those of feral animals (Fig. 3).

Figure 3. Camera trap image showing an owned cat wearing a collar in the Cape to City area.

Identifying a compliance threshold of CTR is difficult at this stage until the relationship between CTR and desirable management outcomes is understood. For now, the recommended compliance threshold is 0.5%, which means that the upper 95% confidence limit is less than 1.5%. This corresponds to ≤ 3 predator detections in 630 camera trap days (Table 2). This threshold was chosen based on CTR estimates from Waitere Station after a successful trapping operation that reduced cat and ferret numbers by around 80–90%. In that operation, the upper 95% CI for stoats, ferrets and cats ranged from 0.3 to 0.8% (Glen et al. 2018). A slightly higher CI has been recommended here based on the fact that data for all three predator species will be pooled, potentially leading to higher CTR estimates. The threshold could be refined as more knowledge is gained about the relationship between predator suppression and outcomes.

Table 2 Numbers of predator detections with corresponding camera trap rate (CTR) and 95% confidence intervals (CI), based on 30 camera traps deployed for 21 days

Number of predator detections	Camera trap rate (CTR)	95% CI
0	0%	0 – 0%
1	0.2%	0 – 0.9%
2	0.3%	0 – 1.1%
3	0.5%	0.1 – 1.4%
4	0.6%	0.2 – 1.6%
5	0.8%	0.3 – 1.8%

Previous modelling has shown that very small properties have a negligible effect on the overall effectiveness of predator control (Glen et al. 2017). In addition, estimating predator abundance at scales smaller than the home range of an individual predator is essentially meaningless. It is therefore recommended that properties < 500 ha be excluded from compliance monitoring with camera traps. However, the level of trapping effort should be monitored for all properties. This could be achieved using wireless trap monitors, electronic timers that record when a trap has been triggered, and/or temperature data-loggers that record when an animal has been captured.

For public relations, it is important that the compliance monitoring approach is seen by landholders as fair and equitable. It may therefore be valuable to discuss this proposed two-tiered approach with landholders in the Cape to City area.

6 Conclusions and recommendations

6.1 Where and when to monitor for compliance

Compliance monitoring should be triggered:

- where individual camera traps deployed during the annual broad-scale monitoring detect unusually high predator activity on one or more properties, or
- if HBRC receive information suggesting that particular landholders are not servicing the traps on their property as agreed.

Camera trapping offers a simple and robust means of estimating the relative abundance of predators on properties ≥ 500 m. For smaller properties, assessment of compliance should be based on whether traps are reset within a required time frame after being triggered.

6.2 How to monitor for compliance

For properties ≥ 500 ha, a grid of 30 camera traps deployed for 21 days should provide a fair, rigorous and legally defendable index of predator abundance. Camera trap rate should be estimated as the number of independent detections of predators per 100 camera trap days. Independent detections were defined by Rovero, Marshall (2009) as > 1 hr apart; however, camera trapping of predators in Hawke's Bay has shown that photographs > 30 minutes apart can be considered independent (Garvey 2016). Photographs taken less than 30 minutes apart are also classed as independent if they clearly show different individuals (e.g. based on coat pattern).

Initially, we recommend the compliance threshold be set at CTR < 0.5%, with the upper 95% CI being < 1.5%. This corresponds to a maximum of three predator detections (Table 2). This threshold may be adjusted up or down as more information is gathered on the level of predator suppression required for biodiversity and other benefits.

To avoid peak dispersal periods for mustelids, compliance monitoring should take place in winter. This also allows time to assess the results of annual monitoring, which takes place in spring, and decide if and where compliance monitoring is needed.

For properties < 500 ha, we recommend compliance monitoring should focus on whether landholders service their traps regularly. This could easily be achieved with wireless trap monitors, or timers that indicate the elapsed time between a trap being triggered and being reset. Landholders who do not reset a trap within an agreed time after it is triggered could be considered to be in breach of their obligations.

It is important for community goodwill that the compliance monitoring system is perceived by landholders as fair and equitable. HBRC should engage landholders with properties of various sizes to seek their views on the two-tiered monitoring system proposed here.

7 Acknowledgements

R Dickson, P Rakete-Stones and S Diphoorn provided data on numbers of cats removed during control operations. Thanks to D Stronge and A Gormley for helpful discussions and suggestions on a previous draft.

8 References

Caughley G 1977. Analysis of vertebrate populations. New York, John Wiley & Sons.

Efford M 2018. Package 'secr'. Available at: https://cran.r-project.org/web/packages/secr/secr.pdf Accessed: 20 April 2018

Fitzgerald BM, Karl BJ 1986. Home range of feral house cats (*Felis catus* L.) in forest of the Orongorongo Valley, Wellington, New Zealand. New Zealand Journal of Ecology 9: 71–82.

Garvey PM 2016. Interspecific competition and olfactory communication between New Zealand's invasive predators: Unravelling and exploiting stoat behaviour for conservation. Unpublished PhD thesis, University of Auckland, Auckland.

Gillies CA, Fitzgerald BM 2005. Feral cat, *Felis catus* Linnaeus, 1758. In: King CM ed. The handbook of New Zealand mammals. 2nd edn. Melbourne, Oxford University Press. Pp. 308–326.

Glen A 2014. Animal pests: residual trap catch index for possums. In: Greene T, McNutt K eds Biodiversity inventory and monitoring toolbox. Wellington, Department of Conservation.

Glen A, Norbury G, Warburton B, Pech R 2018. Predator monitoring for compliance in Cape to City: Discussion paper. Auckland, Manaaki Whenua – Landcare Research.

Glen AS, Byrom AE 2014. Implications of landholder buy-in for the success of regional-scale predator control: Part 1: Review of predator movements. Landcare Research Contract Report LC1956 for Hawke's Bay Regional Council.

Glen AS, Latham MC, Anderson D, Leckie C, Niemiec R, Pech RP, Byrom AE 2017. Landholder participation in regional-scale control of invasive predators: an adaptable landscape model. Biological Invasions 19: 329–338.

Jennrich RI, Turner FB 1969. Measurement of non-circular home range. Journal of Theoretical Biology 22: 227–237.

Langham NPE, Porter RER 1991. Feral cats (*Felis catus* L.) on New Zealand farmland. I. Home range. Wildlife Research 18: 741–760.

Nichols M, Glen A 2015. Camera trapping to monitor the results of predator removal on Waitere Station. Auckland, Landcare Research.

Rovero F, Marshall AR 2009. Camera trapping photographic rate as an index of density in forest ungulates. Journal of Applied Ecology 46: 1011–1017.

Sweetapple P, Nugent G 2011. Chew-track-cards: a multiple-species small mammal detection device. New Zealand Journal of Ecology 35: 153–162.