Predator monitoring for compliance in Cape to City: Discussion paper

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Introduction

The Cape to City programme involves controlling feral cats and mustelids (hereafter ‘predators’) across 26,000 ha of predominantly private land in Hawke’s Bay. The programme aims to restore native biodiversity at the landscape scale, to increase numbers of game birds, and to reduce the prevalence of toxoplasmosis in livestock by controlling its primary host (cats).

The results of predator control are being monitored at a wide scale using camera traps. These will be deployed annually at 38 locations in the Cape to City area, and 31 locations in the adjacent non-treatment area (Fig. 1). This will assess the effectiveness of predator control across the area as a whole, and estimate predator numbers in the area surrounding each camera, but will not provide information on every individual property.

(a) (b)

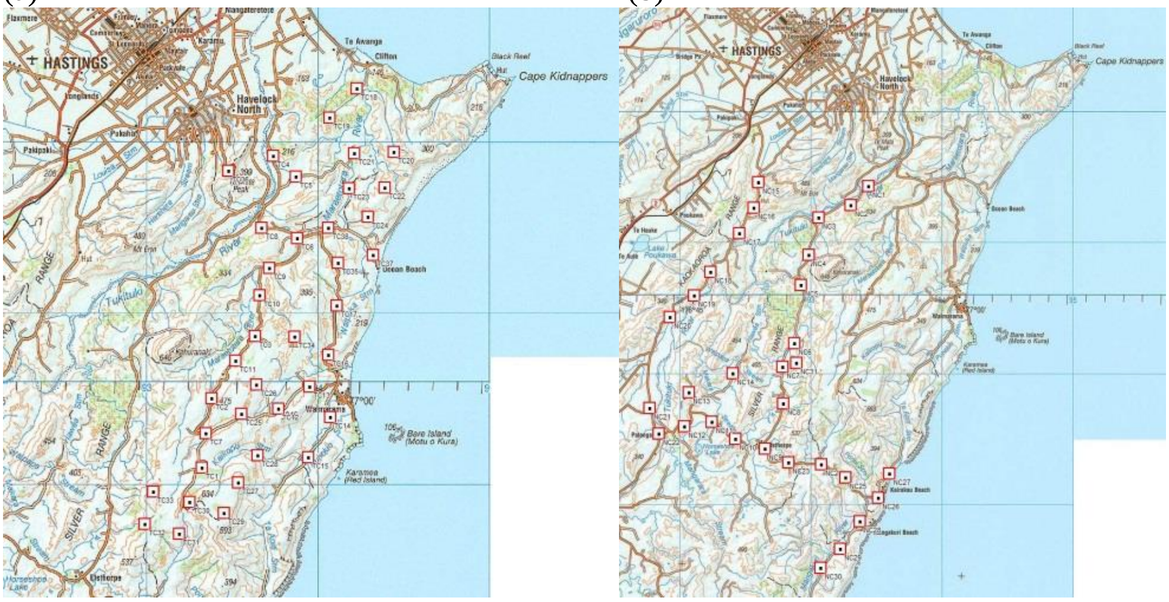

Fig. 1. Locations of camera traps for annual monitoring of predators in the Cape to City area (a) and adjacent non-treatment area (b).

There are 163 properties in the Cape to City area, and participation in predator control is initially voluntary. However, if 75% of landholders agree to participate, the agreement becomes binding for all landholders in the area. A lack of control effort on some individual properties could allow predators to reinvade surrounding areas, reducing the overall effectiveness of the programme (Glen et al. 2016). It is therefore important to monitor individual properties to ensure they are meeting their obligation to control predators. Here we discuss how camera traps might be used to monitor predators on individual farms for compliance purposes. The following questions are considered:

- What to measure
- How to measure it

- When to measure it
- What threshold to set for compliance / non-compliance

What to measure
Camera traps can be used to estimate relative abundance (e.g. Rovero & Marshall 2009), population density (e.g. Royle et al. 2009; Rich et al. 2014), or occupancy (e.g. Bengsen et al. 2014). Perhaps the simplest metric available is the camera trapping rate, which is the number of encounters recorded for a given level of sampling effort. A strong linear relationship (R^2 = 0.9) was found between camera trapping rate and population density of an African ungulate (Rovero & Marshall 2009). This measure is conceptually similar to metrics currently used for compliance monitoring for other pest species, e.g. the chew card index for possums (Sweetapple & Nugent 2011).

Various approaches have been developed to estimate animal density from camera trap data. However, most methods rely on individual animals being uniquely identified (e.g. Royle et al. 2009). Recently, models have been developed that do not require individual identification (e.g. Rowcliffe et al. 2008; Ramsey et al. 2015). However, these are computationally complex and data intensive, making them impractical for operational monitoring (Nichols & Glen 2015).

Occupancy models (MacKenzie et al. 2002) do not require individuals to be identified, and are well suited to analysing camera trap data. However, these models do not estimate abundance directly. Instead, they estimate the proportion of the landscape that is occupied by the target species, and the probability of encountering the target species (MacKenzie et al. 2002). If a control operation is successful, both of these measures should be reduced. Occupancy models can also estimate rates of local extinction and colonisation. If predator control is effective, local extinction rate should match or exceed colonisation rate (Bengsen 2014; Bengsen et al. 2014). Royle and Nichols (2003) developed an extension of occupancy modelling that estimates abundance based on variation in detection probability. This model has been applied to invasive predators in Australia (Bengsen 2014).

Trapping effort could also be monitored in addition to, or as an alternative to, estimating predator abundance. For example, a minimum frequency of servicing / resetting traps could be applied. This could be monitored using a wireless trap monitoring system (Jones et al. 2015).

How to measure
The number of camera traps required, as well as the methods of deploying them and analysing the resulting data, will depend on whether we wish to measure relative abundance, population density or occupancy.

Camera trap rate
Camera trap rate (CTR) is calculated as the number of independent photographs per 100 camera trap days (Rovero & Marshall 2009). Independent photos were defined by Rovero and 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). The precision of estimates improves with increasing sampling effort (Rovero & Marshall 2009).

We used data from Waitere Station to estimate CTR of cats before and after predator control. Before predator control, CTR was 2.7 ± 1%. Trapping reduced the CTR to 0.2 ± 0.3%.

We also used the pre-control data from Waitere Station to investigate how the precision of CTR estimates improved with increasing number of camera trap days (Figure 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 (Figure 1).

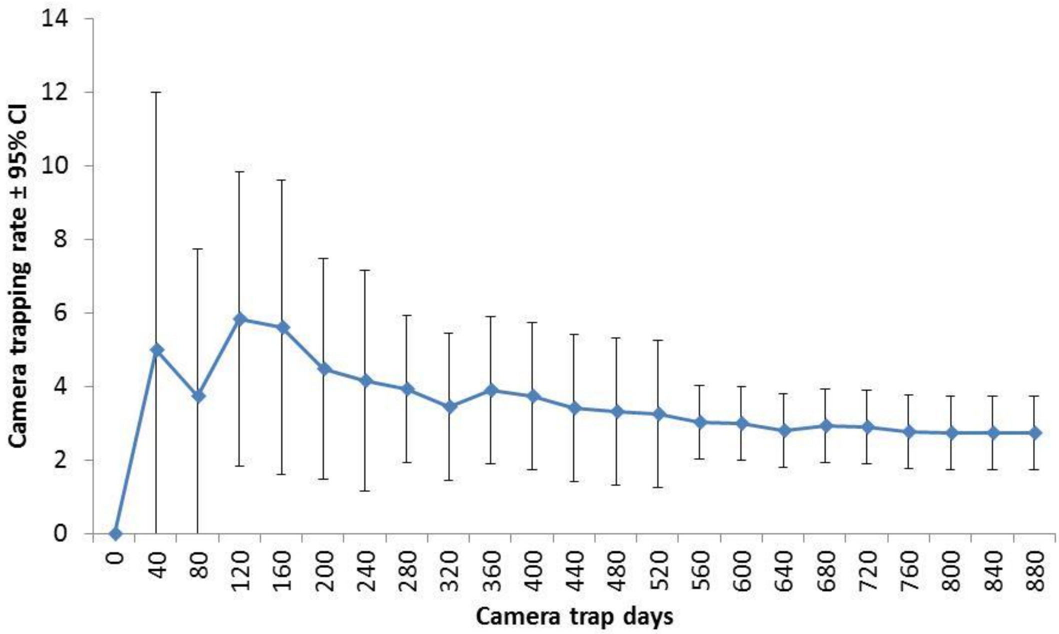

Figure 1. Estimates of camera trapping rate (with 95% confidence intervals) with increasing numbers of camera trap days on Waitere Station.

Population density

Using a model developed by Ramsey et al. (2015), previous work in Hawke's Bay has shown that population density of predators can be estimated from camera trap data without the need for individual identification (Nichols & Glen 2015). However, this approach requires large amounts of data, and delivers estimates with wide confidence intervals. This makes the method unsuitable for compliance monitoring.

Occupancy

Occupancy modelling uses repeated samples from discrete locations to estimate the probability that the target species is present at each location. Sampling locations must be far enough apart so that the same animal will not be detected at more than one location during a sampling period. For predator monitoring in Cape to City, individual camera traps are therefore placed at least 2 km apart. The probability of encountering a predator is estimated separately for each camera location, then averaged across the entire study area (Bengsen 2014; Bengsen et al. 2014). The estimates of detection probability for each camera can also be used to estimate the number of predators within a 2-km radius around each camera. This can provide some information about localised abundance of predators, but not at the scale of each individual property. The need for wide spacing of cameras means that this approach cannot be used to monitor every property at once.

Where and when to monitor for compliance

It would not be practical to monitor predators annually on every property in the Cape to City area. However, some level of monitoring at the individual property level is necessary to ensure that landholders are fulfilling their obligation to control predators. Monitoring on individual properties could be triggered when one or more cameras used in wide-scale monitoring indicate a high probability of encountering predators. Nearby properties could then be sampled more intensively with a larger number of camera traps.

For intensive monitoring, cameras could be placed approximately 500 m apart as this spacing has been used successfully for camera trapping predators in Hawke's Bay (Nichols & Glen 2015). Numbers of cameras could be assigned to each property based on its size. For example, properties of 100 ha might have a grid of nine cameras, while larger properties might have one additional camera for every 10 ha, perhaps up to a maximum of 20 cameras on a single property. Camera trap rate could then be calculated for each individual property.

Previous modelling has shown that very small properties have a negligible effect on the overall effectiveness of predator control (Glen et al. 2016). In addition, estimating predator abundance at very small scales (much smaller than the home range of an individual predator) is essentially meaningless; predators may pass through these areas but they require much larger areas in order to survive. It is therefore recommended that properties <100 ha in size be excluded from compliance monitoring.

Monitoring will have to 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 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).

Compliance threshold

A threshold camera trapping rate could be set based on camera data obtained before and after predator control on Waitere Station. That operation reduced cat and ferret numbers by around 90%, and can therefore be regarded as an example of successful predator control. Precision of the estimate would have to be taken into account. Thresholds could be refined as more knowledge is gained about the relationship between predator suppression and outcomes.

Camera trapping rates before and after predator control on Waitere Station are summarised in Table 1. For all three predator species the upper limit of the 95% CI was reduced to <1% after predator control. This might serve as a useful starting point for a compliance threshold.

Table 1. Camera trap rate (CTR) of stoats, ferrets and cats on Waitere Station before and after predator control.

Species	Camera trap rate ± 95% CI	
	Before	After
Stoat	0	0.1 ± 0.2 %
Ferret	6.4 ± 1.6%	0.4 ± 0.4 %
Cat	2.7 ± 1%	0.2 ± 0.3%

Risks and issues for discussion

There is a risk that numbers of predators detected may be too small to generate reliable estimates of CTR. For example, on Waitere Station there was only one recorded encounter with a stoat. Sample sizes could be improved by pooling data for all three predator species. This would deliver more precise estimates of CTR, which might be more suitable as a compliance threshold.

A decision will have to be made on how many camera trap days are used to estimate CTR. The results from Waitere Station (Figure 1) suggest that at least 280 camera trap nights are required for acceptable precision. This could be achieved by deploying 10 cameras for 28 days or 20 cameras for 14 days, depending on the size of the property being monitored.

Another issue is monitoring on properties <100 ha where it is not possible to set 10 or more cameras at 500-m spacing. These properties could be deemed exempt from compliance monitoring, or a different monitoring approach could be used. For example, one or two cameras per property might be able to monitor trends in the number of detections of predators over a longer period (e.g. a breeding season). It should be possible to evaluate the potential of a metric like this using existing data from Poutiri, or later on using C2C data.

Monitoring the level of trapping effort should be considered for all properties, and may be particularly important for smaller properties, where small area precludes estimation of predator abundance.

Another potential problem is that owned cats could inflate the camera trapping rate. Owners could be issued with cat collars (perhaps with reflective material) so that their pet cats can be identified on camera and discounted when calculating CTR. One collared cat was detected in the recent C2C monitoring (Figure 2).

Figure 2. A collared cat photographed by a camera trap during post-knockdown monitoring in the Cape to City Area.

Summarised potential approach

- Estimate the daily probability of encountering predators at each of the 38 cameras used for annual monitoring in the Cape to City area
- If probability of encounter exceeds the accepted threshold, compliance monitoring is triggered on all properties ≥ 100 ha within a 2-km radius of that camera
- Properties of 100 ha would have nine cameras placed in a grid at 500-m spacing. For every additional 10 ha, another camera is added, up to a maximum of 20 cameras
- Cameras should be deployed for a minimum of 280 camera trap days, e.g. 10 cameras for 28 days; 20 cameras for 14 days
- Camera trap rate is estimated for each property, pooling data for cats, stoats and ferrets
- A compliance threshold would be based initially on results from Waitere Station; this may be refined as additional knowledge is gained on the relationship between camera trap rate and biodiversity outcomes
- Trapping effort should be monitored on all properties – regardless of their size – using the wireless trap monitoring system

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