Manaaki Whenua
Landcare Research

Changes in rabbit abundance with predator control

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Changes in rabbit abundance with predator control

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Contents

Summary

Project and client

- Hawke's Bay Regional Council contracted Manaaki Whenua – Landcare Research to analyse rabbit abundance index data (from spotlight counts and camera traps) to assess whether rabbit numbers are affected by predator control.

Objectives

- To determine if predator control affects rabbit numbers in the Hawke's Bay region.

Methods

- Spotlight rabbit count data were available from two ecological restoration areas: Cape to City and Poutiri Ao ō Tāne. For the Cape to City area, three sites were subject to ongoing predator control, which was rolled out across the treatment area in 2016 and 2017, with two sites untreated. For the Poutiri Ao ō Tāne area, two sites were subject to ongoing predator control beginning in 2012 and three sites were not treated.
- Generalised linear mixed-effects models were fitted to spotlight count data from each area to assess whether the presence of predator control was a statistically significant predictor of relative rabbit abundance.
- Camera traps were deployed annually, beginning in 2015, in the Cape to City project, with 37 cameras in the predator treatment area and 31 in an adjacent non-treatment area. Predator control was rolled out across the treatment areas in 2016 and 2017. Mixed-effect models were also fitted to camera trap data from the Cape to City project using a 'Before After Control Impact' framework to assess whether the camera trap rate changed with predator control.

Results

- Fewer rabbits were counted under spotlight at the predator control sites at Cape to City, but no effect was detected in the camera-trap data. More rabbits were counted on the predator control sites at Poutiri Ao ō Tāne, but this effect was not statistically significant and only became apparent in the last 2 years of the monitoring period.

Discussion

- The effects of predator control on relative rabbit abundance in the Hawke's Bay region were contradictory and inconclusive. We suggest the failure to find a consistent effect is because the influence of predators on rabbit population is minor compared with other sources of population limitation or regulation. The lack of a definitive predator effect should be reassuring to landowners who were concerned that rabbit populations would irrupt in the absence of predators.

Recommendations

- If Hawke's Bay Regional Council wishes to quantify the effect of predator removal on rabbit populations, a robust experimental design with replication and pre-treatment monitoring is required.
- However, for the purpose of reassuring landowners that rabbit numbers are not irrupting, routine trend monitoring should suffice.

1 Introduction

Manaaki Whenua – Landcare Research was contracted by Hawke's Bay Regional Council (HBRC) to analyse spotlight rabbit count data to assess any changes in relative rabbit abundance following large-scale predator control programmes.

2 Background

Cape to City and Poutiri Ao ō Tāne are two large-scale ecological restoration projects in Hawke's Bay. A core component of these projects is the control of invasive predators: feral cats (*Felis catus*), stoats (*Mustela erminea*), ferrets (*M. furo*), brushtail possums (*Trichosurus vulpecula*) and, to a lesser extent, rats (*Rattus rattus* and *R. norvegicus*). However, there is ongoing concern among landholders that a reduction in cat and mustelid numbers will result in an increase in rabbit abundance (McKelvie-Sebileau 2020).

HBRC collects rabbit count data from spotlight routes for trend monitoring across the region, and some of the routes in the Cape to City and Poutiri Ao ō Tāne areas are subject to predator control. This provides a unique opportunity to investigate landholders' concerns about the effects of predator control on rabbit abundance. We also examined camera trap data collected by Manaaki Whenua – Landcare Research within the Cape to City area, which had the advantage of having 1 year of pre-treatment monitoring to account for any pre-existing differences between sites unrelated to predator control.

3 Objectives

To detect the effects of predator control on rabbit numbers in the Cape to City and Poutiri Ao ō Tāne ecological restoration areas.

4 Methods

Spotlight surveys of rabbit populations had been conducted by HBRC annually or biennially in winter following a standard protocol (NPCA 2020). These surveys entailed driving slowly along fixed routes and counting the number of rabbits detected within an approximately 50 m radius of the observer and spotlight. Spotlight counts were generally done on two nights with similar weather and within 5 days of each other. We used the mean number of rabbits counted over these two nights as the response variable in the analyses.

Annual spotlight counts were available for five sites in the Cape to City (C2C) area for 6 years from 2016 to 2021 (Figure 1). Three of these sites – Taraurapa Station, Okahu Station and Te Aratipi Station – were subject to ongoing predator control (using kill traps), which was rolled out across the treatment area in 2016 and 2017. Two of the C2C sites, Haupouri Station and Clifton Station, were untreated (no predator control). The Poutiri Ao ō Tāne (PAoT) project area encompassed five sites that were monitored for rabbits with spotlight counts, which were carried out annually up until 2015 then every 2 years thereafter. The analysis for the PAoT area covered the period 2012–2021. Predator control at two sites, Opouahi and Rangiora Trust, began in 2012. Monitoring at Opouahi began in 2002 but did not start until 2012 at the Rangiora Trust site. The three remaining sites, Woodstock Station, Tarawera Station, and Riverlands, were not subject to predator control (Figure 1).

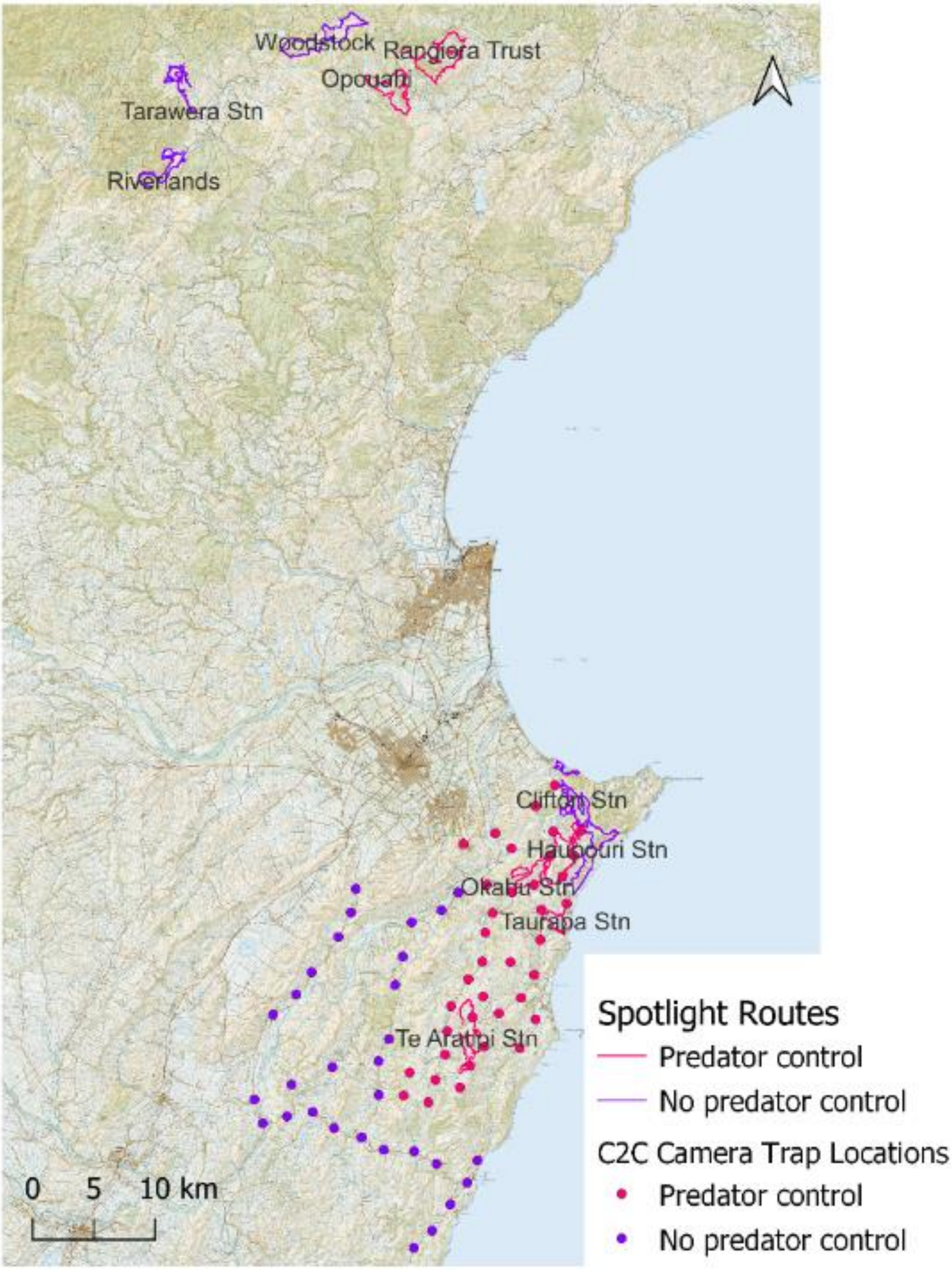

Figure 1. Map of study area showing Poutiri Ao ō Tāne spotlight routes in the north and Cape to City spotlight routes and camera trap locations to the south. Sites subject to predator control are indicated with pink symbols, untreated sites with purple symbols.

For both C2C and PAoT, the mean nightly number of rabbits counted per site was modelled using Poisson mixed-effects regression, with an offset for the route length (km) to account for variable effort between routes. Predator control was included as a fixed-effect predictor, and site and survey were included as random effects predictors (year was nested within site; i.e. an observation-level random effect). An effect of predator control on rabbit numbers was indicated if the 'predator treatment' predictor was statistically significant (Wald test, p-value <0.05). Analyses were done in R (R Core Team 2019) using the lme4 package (Bates et al. 2015).

Rabbit control (and its potential effects on predator populations) was not included as a factor in the analyses because there was only one instance of widespread coordinated rabbit control at one of the study sites during the analysis period (burrow fumigation and shooting at Opouahi Station in 2012; Ruscoe et al. 2016). Rabbit haemorrhagic disease (RHD) can also affect rabbit numbers, and serological data identifying the presence of antibodies to rabbit haemorrhagic disease virus (RHDV) were available for rabbit samples shot in the Hawke's Bay Region over the 2004–2019 period. However, because these data were not available for 4 of the 6 years of the C2C, and 2 of the 7 years of the PAoT monitoring periods, they could not be included in the analyses.

Camera trap images of rabbits were available for the C2C area from a camera-trapping network designed to monitor predators (Glen & Peace 2021). Camera data were collected annually from 2015 to 2020, which included one year (2015) before the predator treatment within C2C began. Motion-triggered cameras were deployed across the study area in November/December each year for 21 days. There were 37 cameras placed in the treatment area (i.e. within C2C) and 31 cameras in an adjacent non-treatment area (outside C2C). Rabbits and hares could not be reliably distinguished from the images, so they were grouped together as lagomorph detections.

The camera trap data (number of lagomorph detections per 21 days) were over-dispersed, consisting mostly of zero detections with occasional very high (>40) detections. We therefore assumed a negative binomial error distribution for the analysis. The annual number of lagomorph detections per camera was regressed against the following fixed effect predictors: predator removal treatment (yes/no) and period (pre/post treatment), plus the interaction between them.

This model specification is called a 'Before After Control Impact' (BACI) design, and the treatment is judged to have an impact if the interaction effect is statistically significant, because it indicates the response to treatment occurred after the treatment was applied and was not due to pre-existing differences between the sites. The regression also included an offset for the number of nights the cameras were deployed, and a random effect for camera ID to account for the repeated surveys at the same location.

5 Results

Rabbit counts increased at both treatment sites at PAoT, but only in the last 2 years of monitoring, while rabbit counts at all three treated sites at C2C remained at very low levels (Figure 2).

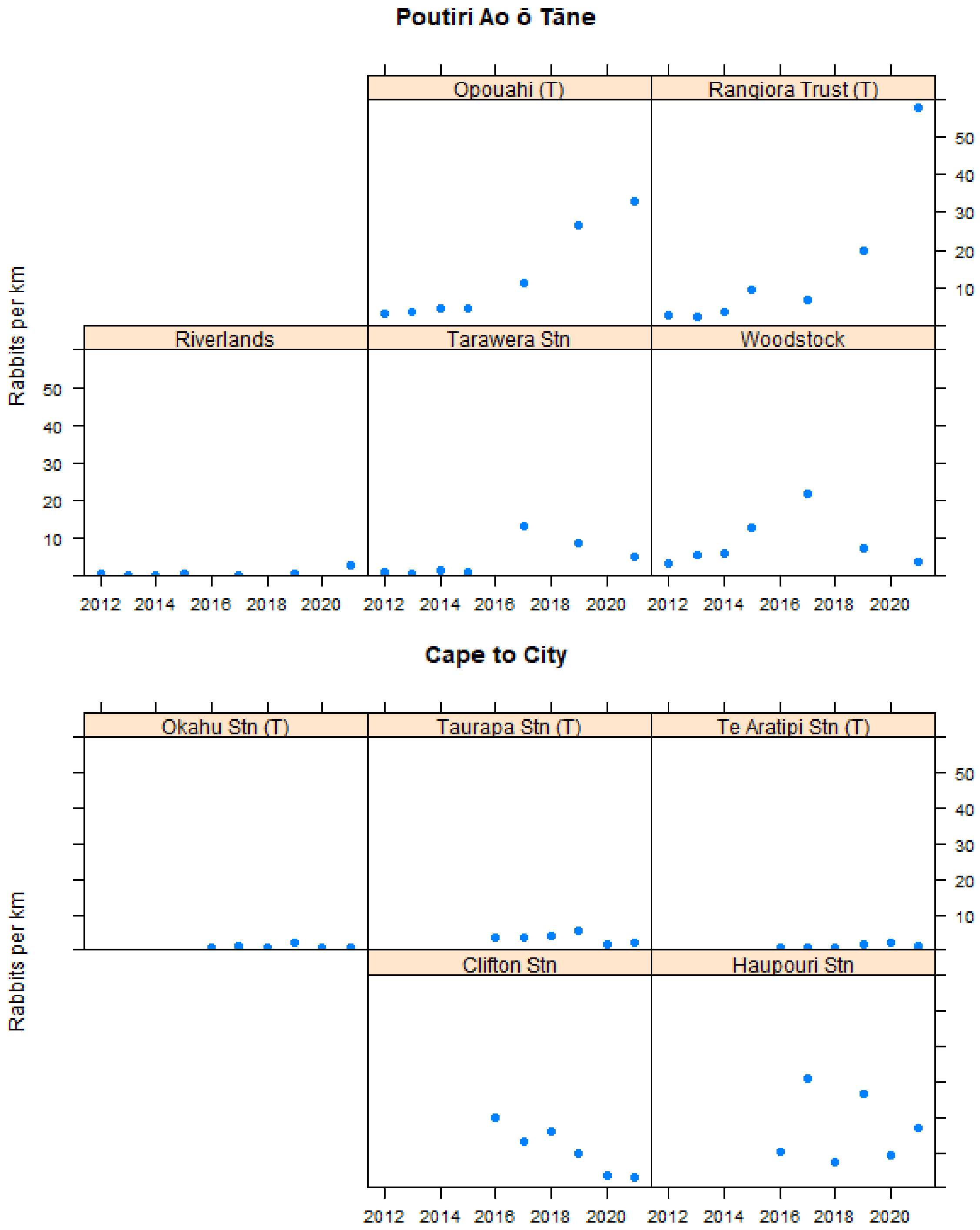

Figure 2. Time series of rabbit spotlight counts per kilometre for each site within the two Hawke's Bay ecological restoration areas. Sites subject to predator control are indicated with (T).

There was no statistically significant difference in rabbit numbers between the predator control treatments at the PAoT sites (p = 0.081) despite noticeable increases in rabbit numbers at the two treatment sites (Opouahi Station and Rangiora Trust Station) in 2019 and 2020 (Figure 3). Counts were more variable between years than between sites (SD_{year} = 1.00 vs. SD_{site} = 0.69) and the combined (site and year) variation was greater than that attributed to predator control (β_{tmt} = 1.26).

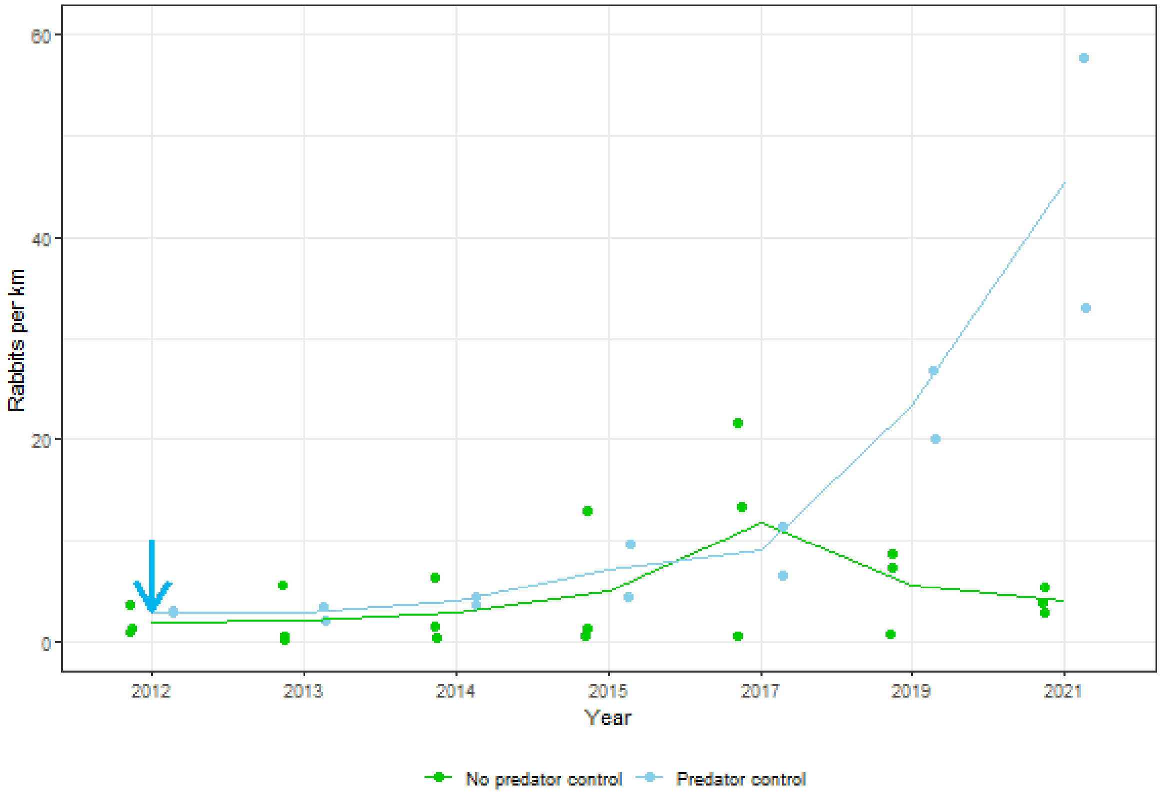

Figure 3. Changes in rabbit abundance from 2012 to 2021 for the Poutiri Ao ō Tāne ecological restoration area under different predator control treatments. Dots represent data from individual sites (jittered horizontally to distinguish sites); lines show estimates from the fitted model; blue arrow shows when predator control began.

At the C2C sites there was a statistically significant (p < 0.0001) reduction in rabbit numbers with predator control, with rabbit counts at predator control sites approximately 13% of those at non-treatment sites (Figure 4). Counts were 1.5 times more variable between years than between sites (SD_{year} = 0.56 vs. SD_{site} = 0.38), but the effect of predator control (β_{tmt} = -2.01) was more than double that of year and site effects combined.

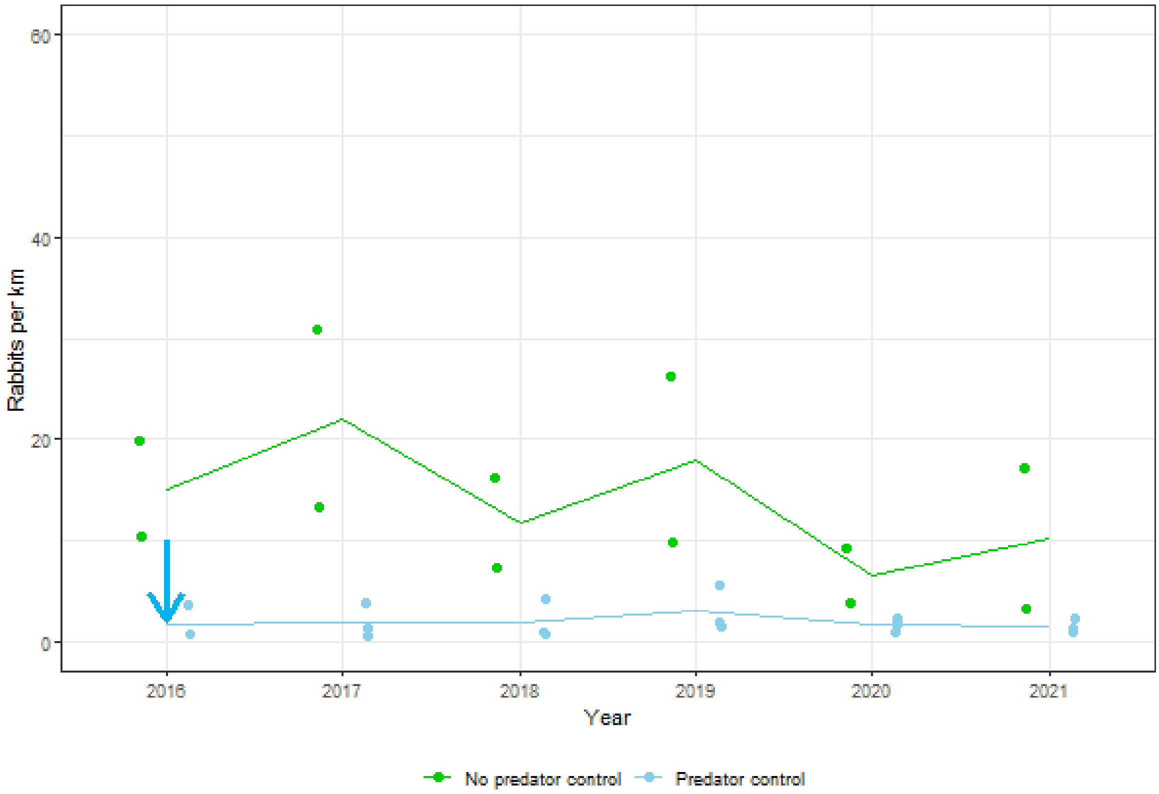

Figure 4. Changes in rabbit abundance from 2016 to 2021 for the Cape to City ecological restoration area under different predator control treatments. Dots represent data from individual sites (jittered horizontally to distinguish sites); lines show estimates from the fitted model; the blue arrow indicates when predator control began.

There was no statistically significant interaction effect between predator treatment and treatment period (p = 0.902) on lagomorph camera trap rates in the C2C area, indicating no effect of predator control on lagomorph activity (Figure 5).

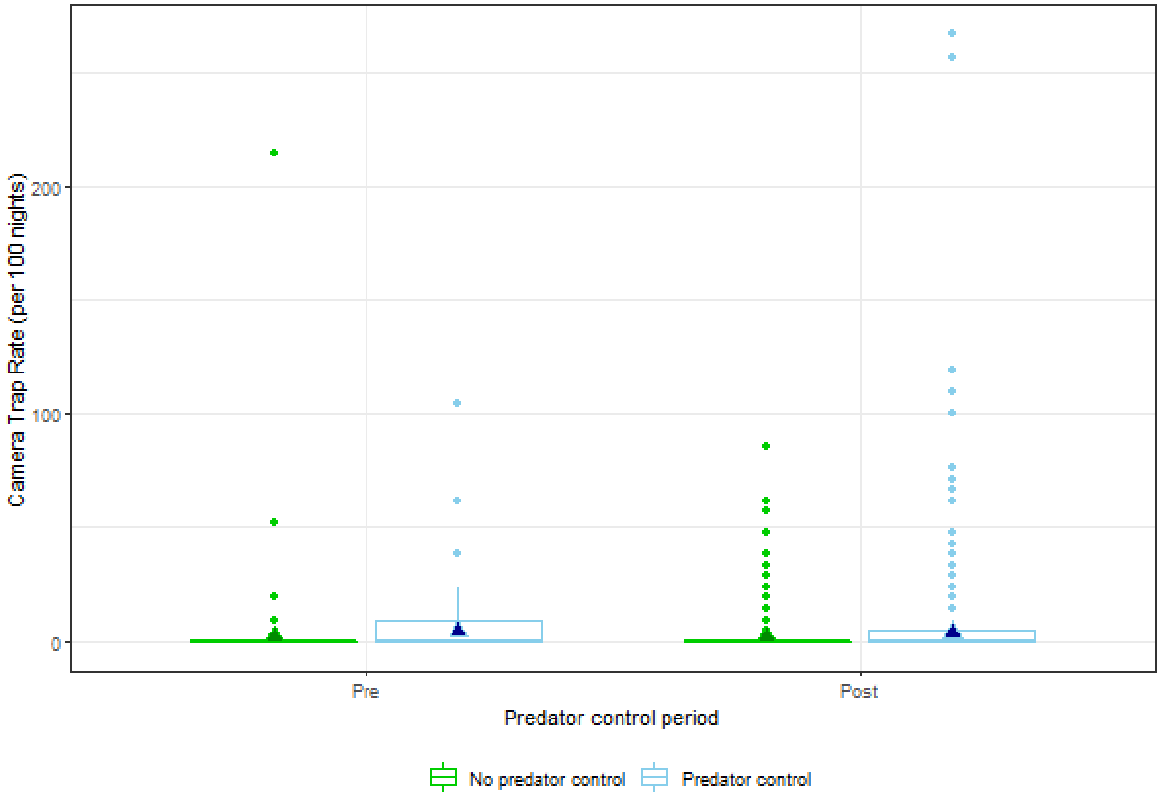

Figure 5. Box plots for annual lagomorph camera trap rate, 2015–2021, for the Cape to City ecological restoration area under different predator control treatments and pre- and post-treatment. The outline boxes encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers. The filled triangles show estimates from the fitted model.

6 Discussion

The effects of predator control on relative rabbit abundance in the Hawke's Bay region were contradictory and inconclusive. In one project area, C2C, there was a significant negative effect of predator control on rabbit abundance, based on spotlight counts, but no effect on abundance based on camera trap rates. Conversely, in PAoT, there was a positive, but not statistically significant, effect of predator control on rabbit abundance based on spotlight counts.

The lack of a treatment effect in the model fitted to the PAoT data is probably because differences between treatments only became apparent in the last 2 years of the analysis period (2019 and 2021, see Figure 3), whereas, in theory, predator control was in effect for the whole of the analysis period. We would expect rabbit populations to respond rapidly to an absence of predators because of their high rate of increase and general year-round breeding.

The realised abundance of predators at each site over the rabbit survey period is unknown, which limits inferences about cause and effect. Overall feral cat and mustelid numbers were reduced following the introduction of the C2C and PAoT predator control programmes, although outcomes varied in time and space and with the control method used (Glen et al. 2018; de Burgh et al. 2021; Glen & Peace 2021).

A possible explanation for the lower rabbit numbers at the predator control sites within the C2C area is that release from predation resulted in a rabbit population irruption, over-exploitation of their food resources, followed by a population crash. However, there is no evidence of this in the time series of rabbit numbers at the treatment sites: they remain low throughout the monitoring period (Figure 1). Alternatively, a predator species not targeted by the control programme, such as the Australasian harrier, may have been released from interspecific competition and become a limiting or regulatory factor for rabbit populations. However, the simplest and most likely explanation for lower rabbit numbers at the predator control sites is that rabbit abundance at these sites was determined by pre-existing site conditions rather than any influence of predator removal. This highlights the importance of having more replication (i.e. more than the two to three in C2C) and pre-treatment monitoring to be able to quantify other sources of variation between sites and over time, and to detect a difference due to the treatment.

If the effect of predation on rabbit populations is small compared with other regulatory or limiting mechanisms, it may be difficult to detect even with the best study design. Indeed, other New Zealand and overseas studies have shown that predators have a minor role in rabbit population regulation compared with the effects of climate, food, disease, and habitat (Norbury & Jones 2015). The rabbit populations at the sites monitored for this study showed a range of trajectories (Figure 1), from low and stable (Riverlands, Okahu Station), oscillating between highs and lows (Haupouri Station), exponential-like growth (Rangiora Trust), and possibly cyclic (Woodstock Station). Furthermore, there did not appear to be synchrony in population fluctuations between sites, and models with random effects for year nested within site were a better fit compared to those that had a uniform effect of year across sites. For these best-fit models, the estimated 'random' variation between years within a site was 1.5 times greater than the variation between sites. This suggests that local dynamics were predominating, rather than climatic effects, for example, which we would expect to be manifested region-wide.

One potential site-specific limiting factor not accounted for in this analysis is rabbit population control. There was one known instance of large-scale, coordinated rabbit control during the study period (at Opouahi Station in 2012), but there were undoubtedly many instances of individuals or small groups doing night shooting at individual sites. In general, shooting is considered to be an effective method of rabbit control only when rabbit numbers are already low (Williams et al. 1995), but we have no way of knowing what the effect of night shooting was on rabbit populations in our study areas.

Due to missing serology data (6 of 13 area-year data were not available) we could not retrospectively estimate what impact, if any, RHD was having on rabbit numbers. Like predation, RHD impacts on rabbit abundance are likely to be highly variable over time and space. Disease and predation can also interact. Reddiex et al. (2002) found the reduction in rabbit numbers due to the first wave of RHD was much greater at North Canterbury sites, where predators had not been removed, compared to where they had; however, there was no effect of predator removal on RHD impacts at the high-rabbit-density Central Otago sites (Reddiex 2004).

A new strain of RHDV, the K5 strain, was released in the Hawke's Bay region in autumn 2018. Spotlight routes were not surveyed at the PAoT sites in 2018, but two of the non-treatment sites where K5 releases took place (Woodstock and Tarawera) showed a downward trend in the following year. Yet at a predator control site (Rangiora Trust) adjacent to a K5 release, numbers continued to rise dramatically. In contrast, a non-treatment site in the C2C where K5 was released (Clifton Station) showed an increase in spotlight counts from 2017 to 2018, but no change in rabbit numbers was apparent at a predator treatment site adjacent to a K5 release location (Taurapa Station). In Central Otago and the Mackenzie Basin, the introduction of RHDV-K5 caused only minor epidemics with little rabbit population suppression, and the strain has subsequently died out (J Duckworth, unpub. data); it is likely a similar outcome occurred in Hawke's Bay.

In summary, rabbit numbers in Hawke's Bay were highly variable across sites and years and it was difficult to detect a clear effect of the predator control programme over and above all the other sources of variation, which were largely unmeasured. The lack of a definitive predator effect should be reassuring to landowners who were concerned that rabbit populations would irrupt in the absence of predators.

7 Recommendations

A robust experimental design with increased replication and pre-treatment monitoring is needed to measure the effect of predator removal on rabbit populations. However, this may not be warranted if the council simply wants to reassure landowners that predator control is not leading to rabbit irruptions: trend monitoring, if conducted annually, should suffice.

8 Acknowledgements

I thank Natalie de Burgh of HBRC for providing the data and answering queries, and Grant Norbury and Cecilia Arienti of MWLR for providing useful comments and ideas.

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