Manaaki Whenua
Landcare Research

Predator and biodiversity response monitoring in Cape to City: annual report 2020

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Predator and biodiversity response monitoring in Cape to City: annual report 2020

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Contents

Summary

Project and Client

- The Cape to City programme aims to control invasive predators (feral cats, stoats, and ferrets) across 26,000 hectares of farmland, peri-urban areas, and native bush in Hawke's Bay. Rats are also controlled in some targeted areas. The objective is to restore the landscape such that 'native species thrive where we live, work and play'.
- Monitoring is necessary to determine whether predator control is having an effect on predator populations, and on populations of native species.
- Manaaki Whenua – Landcare Research have been contracted by Hawke's Bay Regional Council (HBRC) to monitor the relative abundance and distribution of predators, as well as native lizards and invertebrates, in the Cape to City area and an adjacent non-treatment area.

Objectives

- This report summarises the predator and biodiversity monitoring conducted in Cape to City since monitoring began in 2015.

Methods

- Predator control is being carried out by HBRC and local landholders. Stoats and ferrets are being removed using a network of 1467 kill traps, which was rolled out in 2016 and 2017.
- Feral cats were subject to a pulsed control operation in 2016 and 2017 using a rolling front of cage and leghold traps across the treatment area. Some localised pulses of control have been conducted since, but there has been no attempt at sustained, widespread control of feral cats.
- Since 2015, predators have been monitored in November each year using 37 motion-triggered cameras (camera traps) in the treatment area, and 31 cameras in the non-treatment area.
- Relative abundance of native lizards and invertebrates are monitored in the treatment and non-treatment area using tracking tunnels, wētā houses, tree wraps, frass funnels, and artificial cover objects. Tracking tunnels also detect rats and mice.

Results

- Before the main pulse of cat trapping was completed in mid-2017, relative abundance of feral cats was similar in the treatment and non-treatment areas.
- In late 2017, and again in 2018, cats were significantly less abundant in the treatment than in the non-treatment area. In 2019 relative abundance of feral cats was similar in both areas.
- Before predator control began, relative abundance of stoats was significantly higher in the treatment area. From 2016 to 2019, relative abundance of stoats was similar in both areas, and no stoats have been detected in either area since 2017.

- Relative abundance of ferrets has fluctuated in both areas. However, no ferrets have been detected in the treatment area since completion of the trap roll-out.
- Tracking tunnels suggest that skinks, geckos and wētā are generally more abundant in the treatment area, although differences are statistically significant only in some sampling periods.
- Wētā houses suggest that wētā were already more abundant in the treatment area before predator control began. Since summer 2017/18 there has been an upward trend in wētā numbers in the treatment area, but not in the non-treatment area.
- No lizards have been recorded under the tree wraps in either the treatment or non-treatment area.
- Frass funnels indicate that arboreal stick insects and tree wētā are more abundant in the treatment area.
- The mean number of skinks found in ACOs ranged from zero to 0.01 in the treatment area, while no skinks were recorded in ACOs in the non-treatment area. Mean numbers of geckos ranged from zero to 0.04 in the treatment area, and zero to 0.01 in the non-treatment area.

Conclusions

- Our results suggest that predator control has reduced the relative abundance of feral cats, stoats, and ferrets.
- Although the initial knock-down of feral cat numbers was apparently effective, their relative abundance has now recovered to pre-control levels.
- No stoats or ferrets have been detected in the treatment area for the last 2 years. This could be a result of predator control and/or natural variation.
- Native lizards and invertebrates appear to be more abundant in the treatment than the non-treatment area, although pre-existing differences were apparent.
- Together, tracking tunnels and wētā houses suggest that relative abundances of wētā, skinks, and geckos have increased in the treatment area relative to the non-treatment since predator control began.
- Due to a lack of replication, we cannot firmly conclude that the observed differences were the result of predator control, as opposed to natural variation between areas.

Recommendations

- Our predator monitoring suggests that additional cat control is required if sustained reductions in feral cat populations are to be achieved.
- Although no stoats or ferrets have been detected in the treatment area since 2017, continued monitoring is required to determine whether their abundance is significantly lower than in the non-treatment area.
- Monitoring of lizards and invertebrates should also be continued using tracking tunnels, wētā houses, tree wraps, and frass funnels.

1 Introduction

Part of the Predator Free Hawke's Bay initiative, the Cape to City programme aims to control invasive predators (Feral cats *Felis catus*, stoats *Mustela erminea*, and ferrets *M. furo*) across 26,000 hectares of farmland, peri-urban areas and native bush in Hawke's Bay. Rats (*Rattus rattus* and *R. norvegicus*) are also being controlled in selected areas. The objective is to restore the landscape such that 'native species thrive where we live, work and play' (HBRC 2020).

Achieving this objective requires monitoring to demonstrate 1) reduced abundance and distribution of predators, and 2) increased abundance, distribution, and diversity of native species.

Manaaki Whenua – Landcare Research have been contracted by Hawke's Bay Regional Council (HBRC) to monitor the relative abundance and distribution of predators, as well as native lizards and invertebrates, in the Cape to City area and an adjacent non-treatment area.

2 Objectives

This report summarises the predator and biodiversity monitoring conducted in Cape to City since monitoring began in 2015. For each year I compare the relative abundance of:

- feral cats, stoats, ferrets, and rodents in the Cape to City treatment area and adjacent non-treatment area
- native lizards and invertebrates in the Cape to City treatment area and adjacent non-treatment area

3 Methods

3.1 Predator control

Predator control is being carried out by HBRC and local landholders. Stoats and ferrets are being removed using a network of kill traps, which was rolled out across the treatment area in 2016 and 2017. The network comprises 1467 kill traps (podiTRAP, Metalform, Dannevirke, NZ) spaced at one trap per 10 ha in Areas A and C, and one trap per 20 ha in Area B (Fig. 1). Rats (*Rattus* spp.) are also controlled using poison bait in some selected areas.

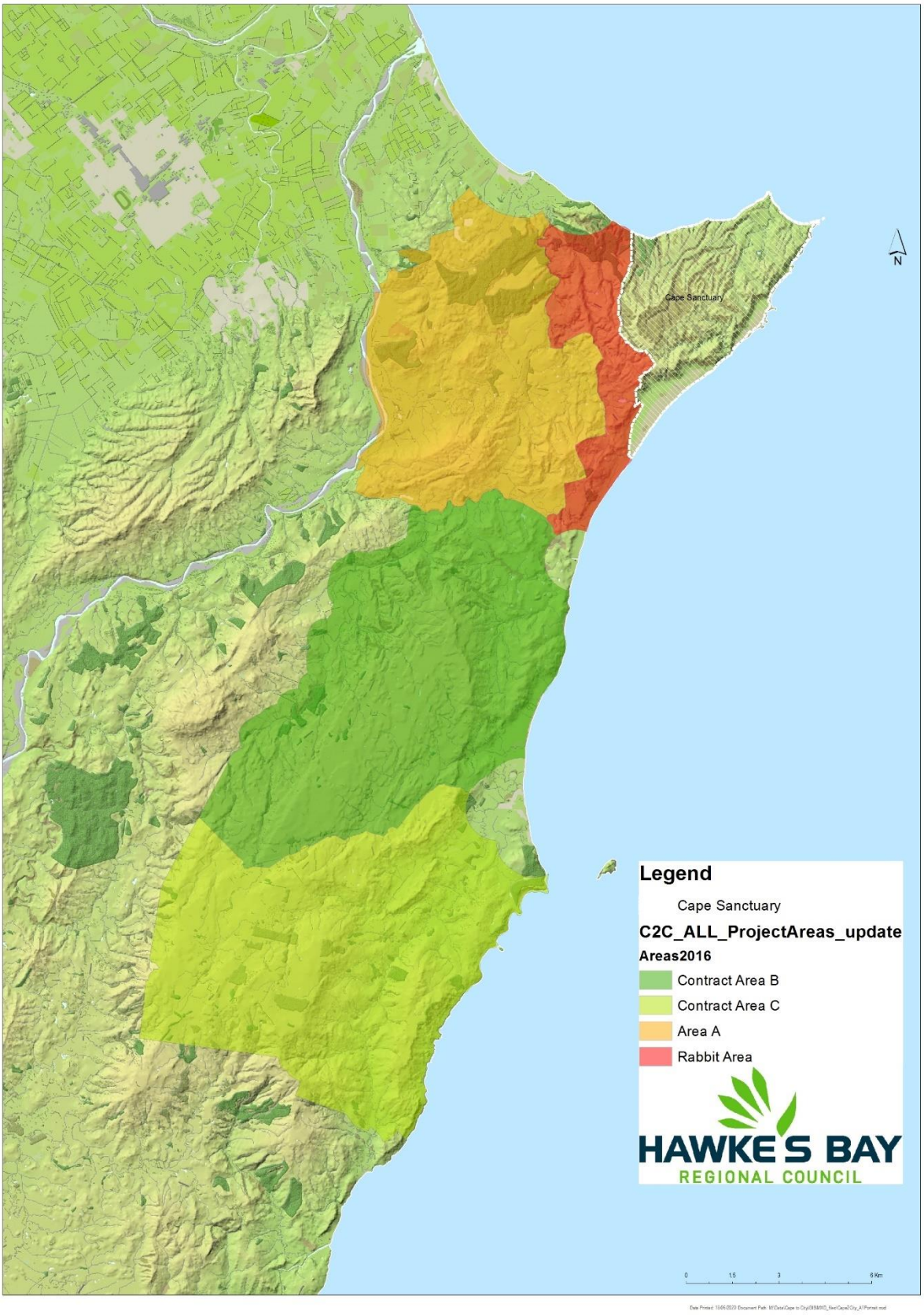


Figure 1 Map of the Cape to City treatment area showing predator control operational Areas A (pale orange), B (dark green) and C (pale green). No predator control has been conducted in the area labelled 'Rabbit Area' (dark orange). Adjacent to the west and south of Areas A, B and C is the non-treatment area. Map courtesy of HBRC.

Feral cats were subject to a pulsed control operation in 2016 and 2017 using a rolling front of cage and leghold traps across the treatment area. Cage traps were deployed in about 1230 locations, and leghold traps in 130 locations, resulting in the capture of 250 cats (HBRC, unpublished data). Some localised pulses of cage trapping were conducted in 2018 and 2019, resulting in removal of a further 48 cats, but there has been no attempt at sustained, widespread control of feral cats.

3.2 Predator monitoring

Since 2015, predators have been monitored in November each year using 37 motion-triggered cameras (camera traps) in the treatment area and 31 cameras in the non-treatment area (Fig. 1). Camera traps (Browning Strike Force BTC-5, Prometheus Group, Birmingham, Alabama) are placed ≥2 km apart, achieving broad coverage of the study area, and are left in place for 21 days. Cameras are set to take three images in quick succession when triggered, with no delay between successive triggers. To reduce the probability of detecting owned cats, which are not being targeted for control, cameras are placed at least 100 m away from the nearest dwelling.

(a)

(b)

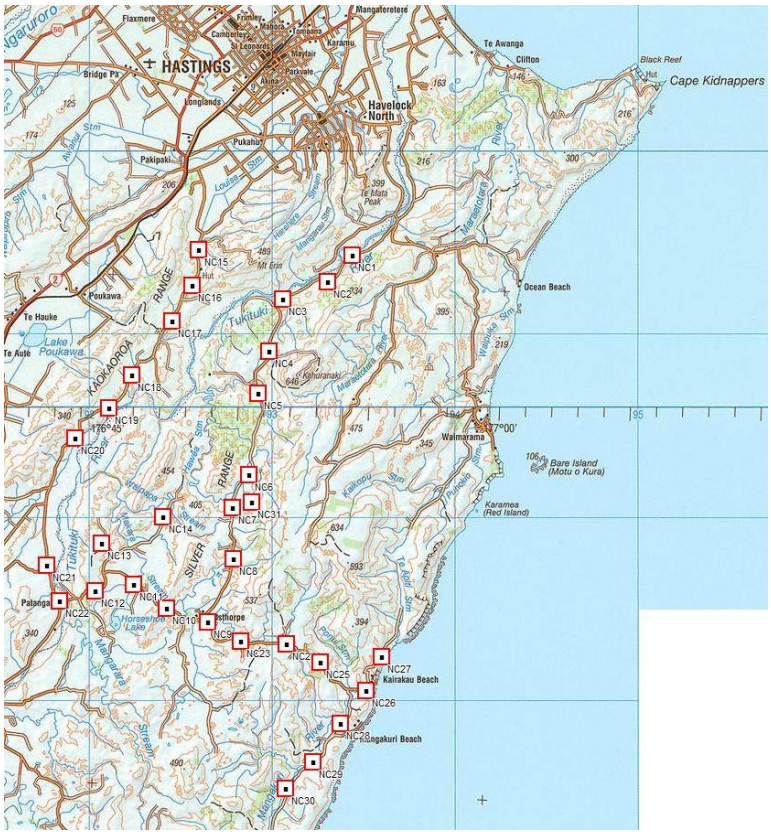


Figure 2 Locations of camera traps used to monitor predators in the Cape to City treatment area (a) and adjacent non-treatment area (b).

The relative abundance of feral cats, stoats, and ferrets is estimated by calculating the camera trap rate (CTR), which is the number of detections of a species per 100 camera trap days (Rovero & Marshall 2009). Detections of the same species by the same camera are considered to be separate encounters if they are separated by >30 minutes (Garvey et al. 2017), or if separate individuals can be identified based on appearance (e.g. coat colour). Any images of cats wearing a collar are discounted as these are assumed to be owned cats.

To judge whether there are statistically significant differences in CTR between the treatment and non-treatment area, I use visual inspection of the 95% confidence intervals (CIs), which are an indication of precision. Where the lower 95% CI for one estimate overlaps less than halfway with the upper 95% CI of another estimate (or vice versa), this is analogous to a statistically significant difference with p <0.05 (i.e., <5% probability that this result was obtained by chance). Non-overlapping 95% CIs are analogous to a significant difference with p <0.01 (Cumming 2009).

3.3 Tracking tunnels

To monitor relative abundance of wētā and lizards, as well as rats and mice, tracking tunnels are set 20 m apart in lines of five, with ≥100 m between adjacent lines. The tunnels are left in place year-round. There are 75 lines of tracking tunnels in the treatment area (nine of which are in Mohi Bush, where rats are also controlled), and 50 lines in the non-treatment area. Until 2020, tracking tunnels were run twice each year in Summer and Spring. From 2020 onwards, tracking tunnels will be run once each year in Spring.

Tracking ink (Black Track, Pest Management Services, Wellington) is applied to the floor in the middle of each tunnel, and sheets of tracking paper are fastened to the tunnel floor at each end with drawing pins. Each tunnel is baited with a small blob of peanut butter in the middle of the tracking ink. Tracking papers are retrieved after three days and labelled with line number, tunnel number and date. Footprints on the tracking papers are identified using field guides (Gillies & Williams 2002; Agnew 2009; NPCA 2014). Tracking rates (the percentage of tracking tunnels in which footprints were recorded) are then calculated for wētā, skinks and geckos. Once again, differences between treatment and non-treatment are judged by overlap in 95% CIs.

3.4 Wētā houses

To monitor invertebrates in forested areas, wētā houses have been set 20 m apart in lines of five, with ≥100 m between adjacent lines. There are 13 lines of wētā houses in the treatment area (nine of which are in Mohi Bush), and 18 lines in the non-treatment area.

Four of the five wētā houses on each line have two holes ('galleries') in which invertebrates can shelter. The third (i.e. middle) wētā house on each line is larger, has six galleries, and can accommodate larger numbers of invertebrates (see Glen et al. 2019). All wētā houses are attached to tree trunks at approximately chest height, left in place year-round, and checked in Spring and Summer each year.

For each monitoring season, I estimate the mean number of wētā, spiders, and other invertebrates per wētā house. Potential differences between treatment and non-treatment are investigated using two-tailed t-tests with adjustment for unequal variance.

3.5 Tree wraps

Tree wraps (sheets of foam-rubber attached to tree trunks) can be effective for monitoring arboreal lizards, which shelter between the tree wrap and the trunk (Bell 2009). In forested areas, tree wraps have been installed 20 m apart in lines of five, with ≥100 m between adjacent lines. There are 13 lines of tree wraps in the treatment area (nine of which are in Mohi Bush), and 18 lines in the non-treatment area. These are left in place year-round, and checked in Spring and Summer.

3.6 Frass funnels

Frass funnels provide an effective method to estimate relative abundance of large arboreal invertebrates such as tree wētā and stick insects (Sweetapple & Barron 2016). Conical nets of fine wire mesh are mounted on wooden stakes under the tree canopy. The wide end of the net faces upwards, while the narrow end is tied closed so that the droppings (frass) produced by arboreal invertebrates fall into the net and are captured (Sweetapple & Barron 2016).

Frass produced by tree wētā and stick insects are readily distinguished based on shape and size, and the weight of frass collected in the funnels provides an index of relative abundance of these taxa (Sweetapple & Barron 2016). There are 20 frass funnels in the treatment area, 16 of which are in Mohi Bush, which has also been subject to rat control since mid-2016. There

are 30 frass funnels in the non-treatment area. Twice each year (Spring and Summer) the contents of the funnels are collected and brought to the laboratory for sorting and identification of frass. Relative abundance of tree wētā and stick insects is estimated based on the mean weight of frass per funnel.

3.7 Artificial cover objects

Artificial cover objects (ACOs) consist of three corrugated roof tiles stacked on top of each other, with twigs or pebbles to create a space of 5–10 mm between the layers. Lizards and invertebrates use these spaces for shelter and/or thermoregulation. At the start of each monitoring session (Spring and Summer each year), ACOs are set 20 m apart in lines of five, with ≥100 m between adjacent lines. There are 49 lines of ACOs in the treatment area and 30 lines in the non-treatment area.

Vegetation under ACOs is first trimmed to a height of 5 cm. The ACOs are secured to the ground with a steel peg, or weighed down with rocks or logs, and left in place for three weeks. The observer then dismantles the ACOs, identifying and counting any lizards and invertebrates sheltering in them. For each monitoring season, I estimate the mean number of skinks, geckos, and invertebrates per ACO, and investigate potential differences using two-tailed t-tests with adjustment for unequal variance.

4 Results

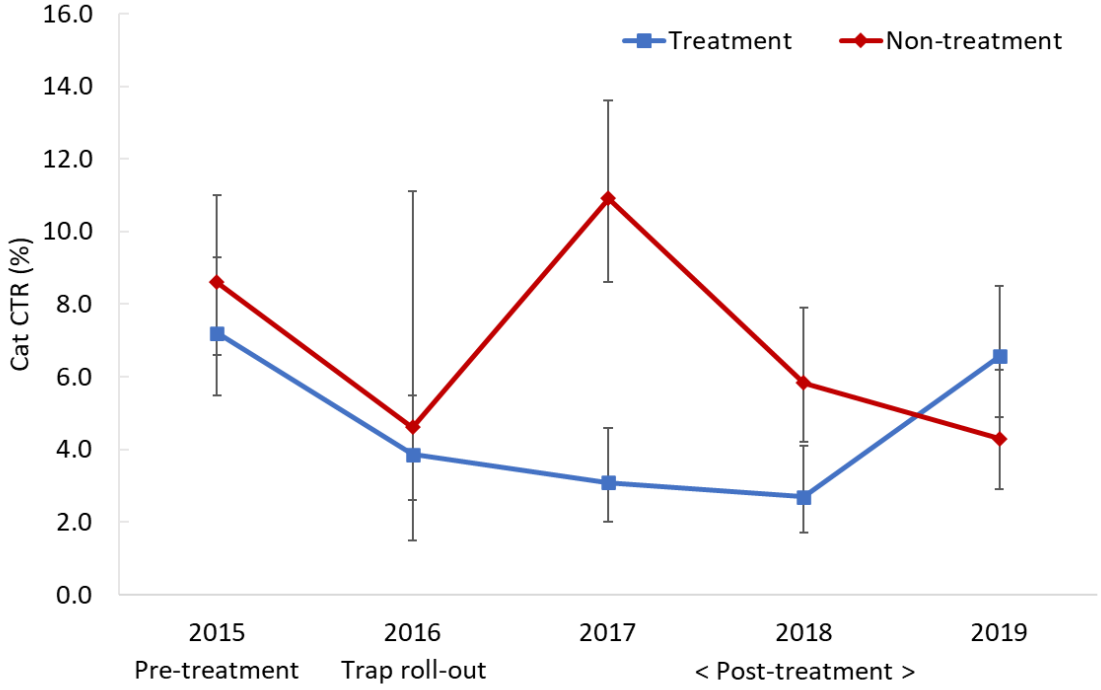
4.1 Predator monitoring

Before the first pulse of cat trapping in 2017, CTR of feral cats was similar in the treatment and non-treatment areas (Fig. 3a). In 2017 and 2018, cats were significantly less abundant in the treatment than in the non-treatment area. However, in 2019 relative abundance was again similar in both areas. Only one cat detected on camera had a collar.

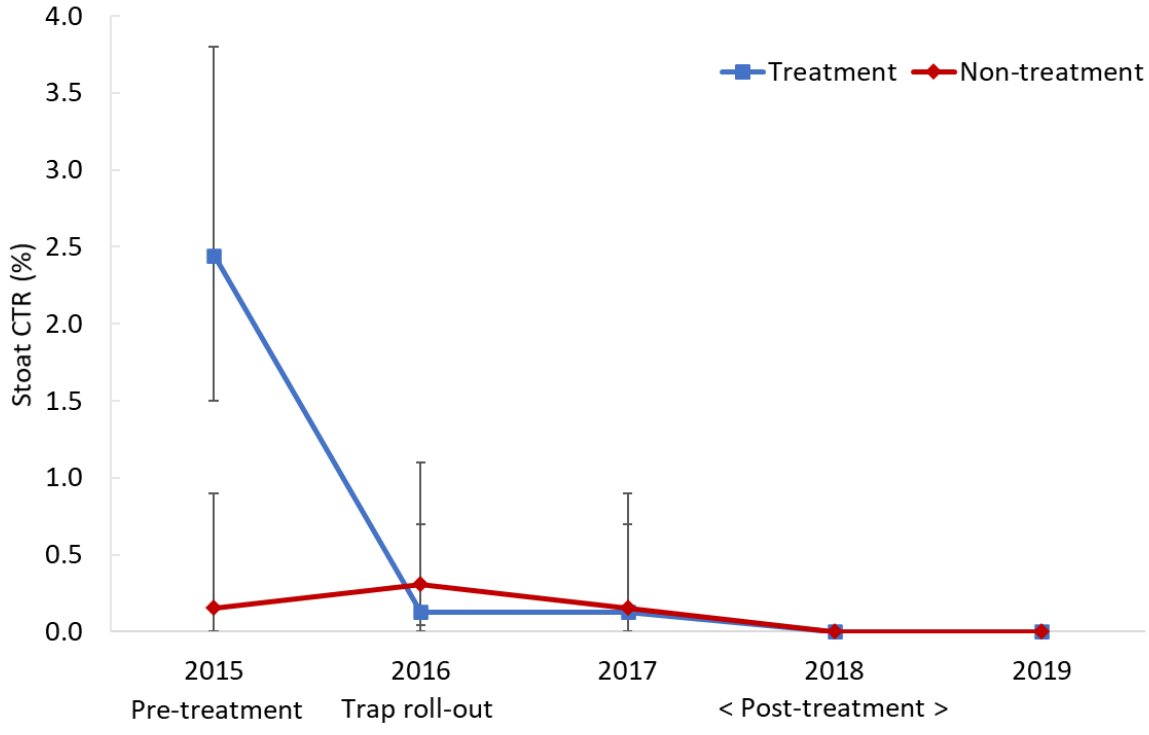
In 2015, before predator control, relative abundance of stoats was significantly higher in the treatment area (Fig. 3b). From 2016 to 2019, CTR of stoats was similar in both areas, and no stoats have been detected in either area since the trap roll-out was completed in 2017.

Relative abundance of ferrets has fluctuated in both the treatment and non-treatment area (Fig. 3c). No ferrets have been detected in the treatment area since completion of the trap roll-out. In 2019, CTR of ferrets was significantly lower in the treatment than in the non-treatment area.

(a)


Treatment
Non-treatment
Cat CTR (%)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2015
Pre-treatment
2016
Trap roll-out
2017
2018
2019
< Post-treatment >

(b)


Treatment
Non-treatment
Stoat CTR (%)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2015
Pre-treatment
2016
Trap roll-out
2017
2018
2019
< Post-treatment >

(c)

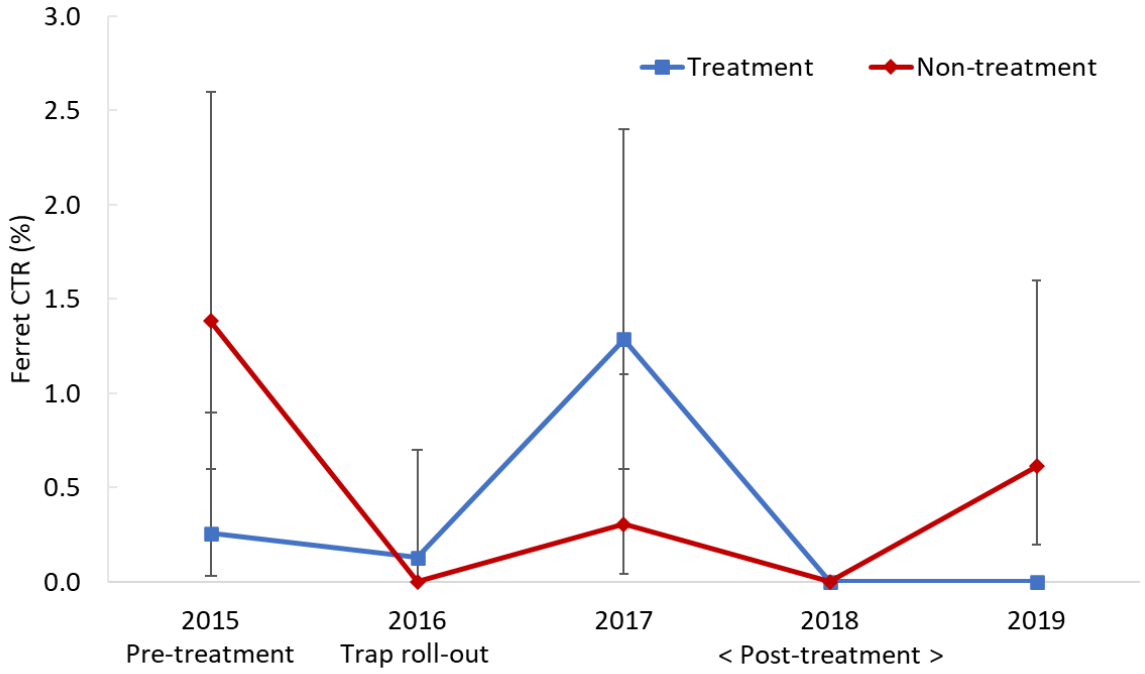


Figure 3 Camera trap rate (CTR) ± 95% CI of (a) feral cats, (b) stoats, and (c) ferrets in the Cape to City treatment area (red) and adjacent non-treatment area (blue).

4.2 Tracking tunnels

Tracking rates of rats were initially similar in the treatment and non-treatment areas. However, tracking rates were much higher in Mohi Bush – a forest remnant within the treatment area – before rat control was applied there (Fig. 4a). Since rat control was applied in Mohi Bush, rat numbers have been significantly lower than pre-control levels in every sampling period. Tracking rates of rats in the wider treatment area have also been consistently lower than in the non-treatment area (Fig. 4a).

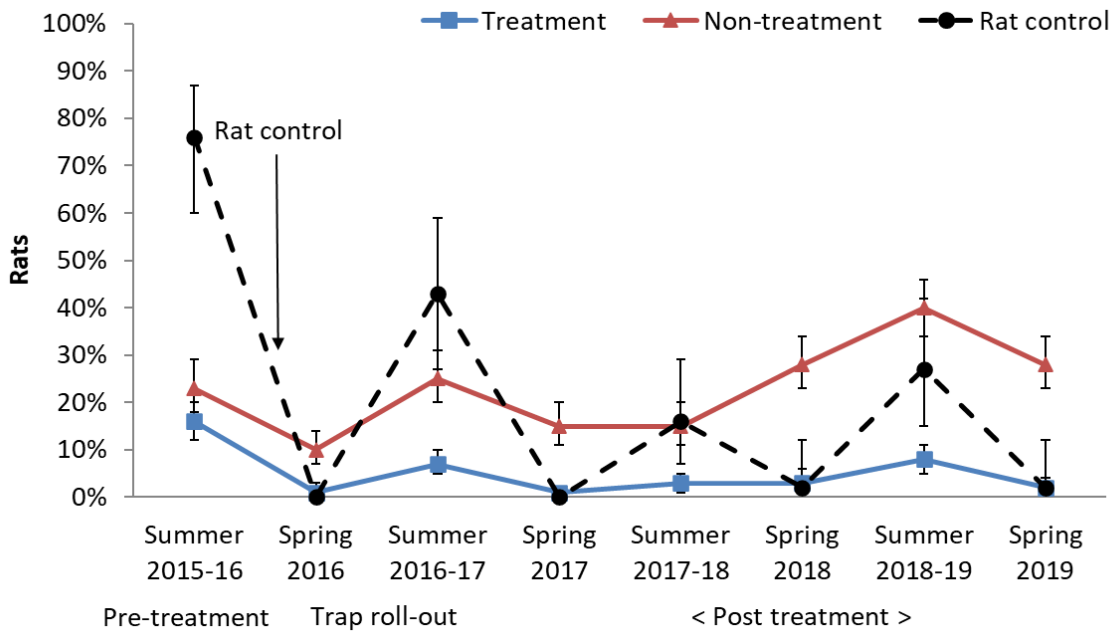
Tracking rates of mice have been similar in the treatment and non-treatment areas in every monitoring session. However, in the rat control area, tracking rates of mice increased significantly after rat control, before returning to pre-control levels (Fig. 4b).

Tracking rates of wētā have fluctuated between zero and 3.5% in the treatment area, but have been consistently low (0–0.8%) in the non-treatment area (Fig. 4c). A lack of overlap in the 95% confidence intervals suggests significant differences between the treatment and non-treatment area in some seasons, but not in others. Tracking rates of wētā in Mohi Bush have ranged from zero to 9%. However, extensive overlap in 95% CIs indicates that these estimates are not significantly different to those from the wider non-treatment area (Fig. 4c).

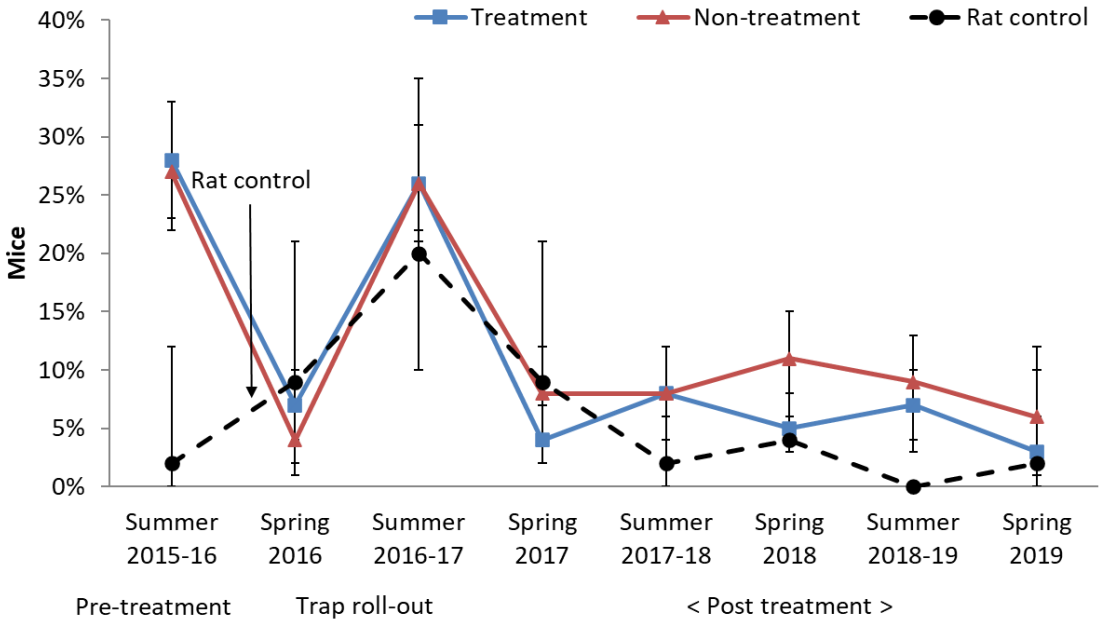
Tracking rates of skinks have ranged from zero to 2.4% in the treatment area (Fig. 4d). Skink tracks have been detected in the non-treatment area on only one occasion, in Summer 2018-19. The difference between treatment and non-treatment appears significant in some seasons but not in others. No skink tracks have been recorded in Mohi Bush.

Tracking rates of geckos in the treatment area range from 0.3% to 4.5%, while those in the non-treatment area range from zero to 1.2% (Fig. 4e). However, extensive overlap in 95% CIs indicates that differences in most seasons are not statistically significant. No gecko tracks have been recorded in Mohi Bush.

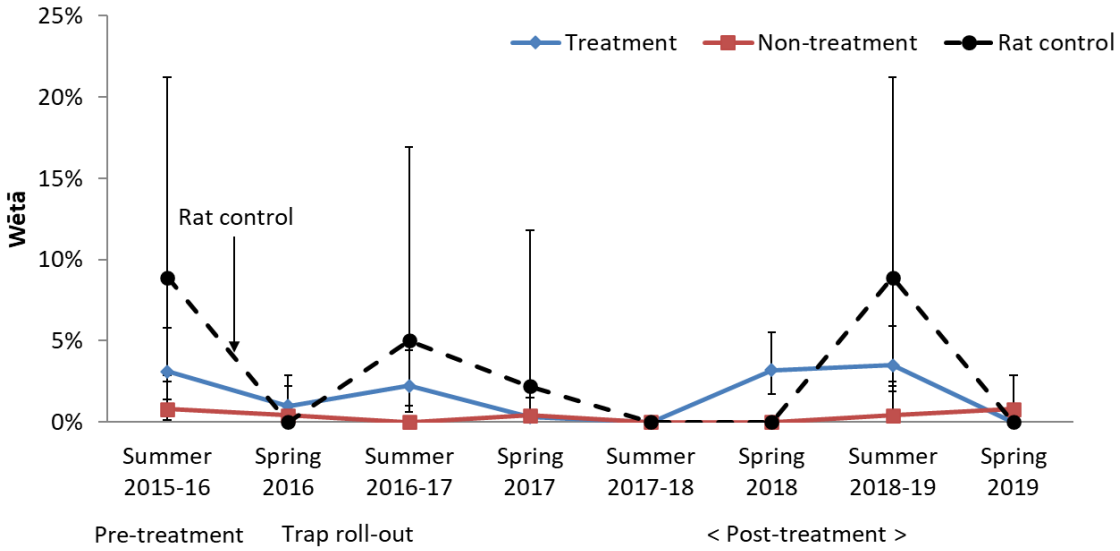
(a)



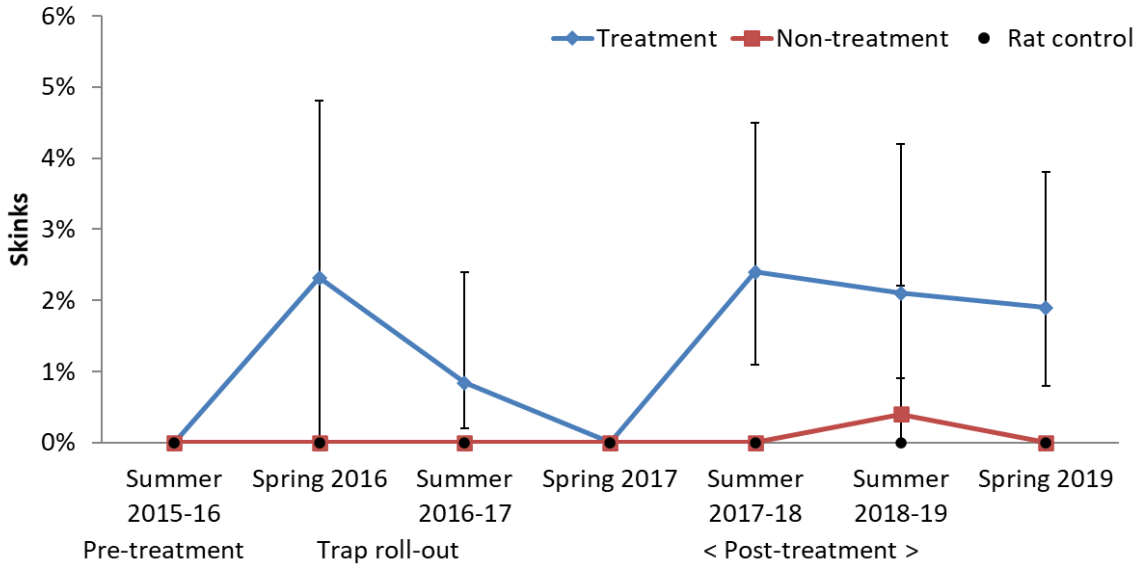
(b)



(c)


25%
20%
15%
10%
5%
0%
Wētā
Rat control
Treatment
Non-treatment
Rat control
Summer 2015-16
Spring 2016
Summer 2016-17
Spring 2017
Summer 2017-18
Spring 2018
Summer 2018-19
Spring 2019
Pre-treatment
Trap roll-out
< Post-treatment >

(d)


6%
5%
4%
3%
2%
1%
0%
Skinks
Treatment
Non-treatment
Rat control
Summer 2015-16
Spring 2016
Summer 2016-17
Spring 2017
Summer 2017-18
Summer 2018-19
Spring 2019
Pre-treatment
Trap roll-out
< Post-treatment >

(e)

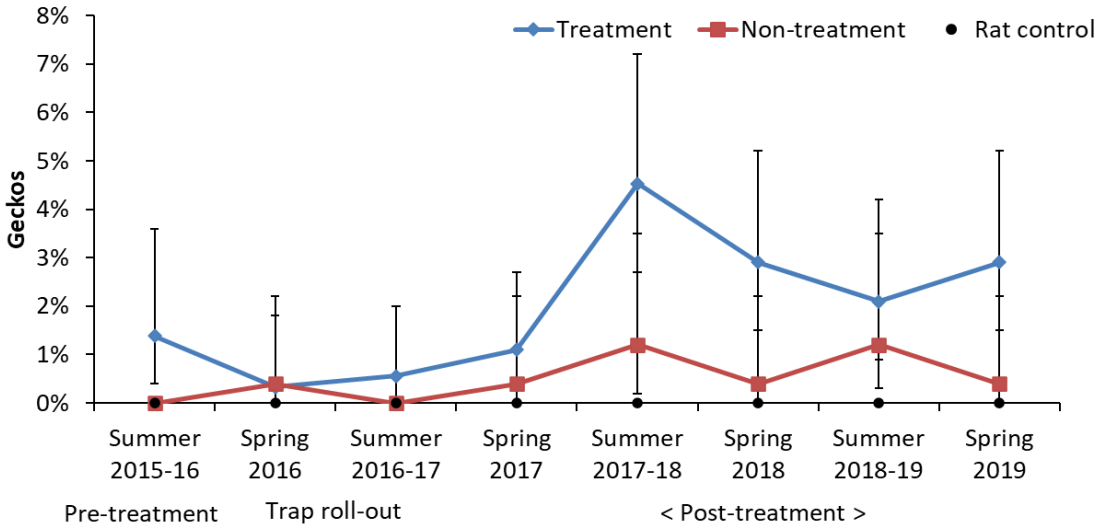


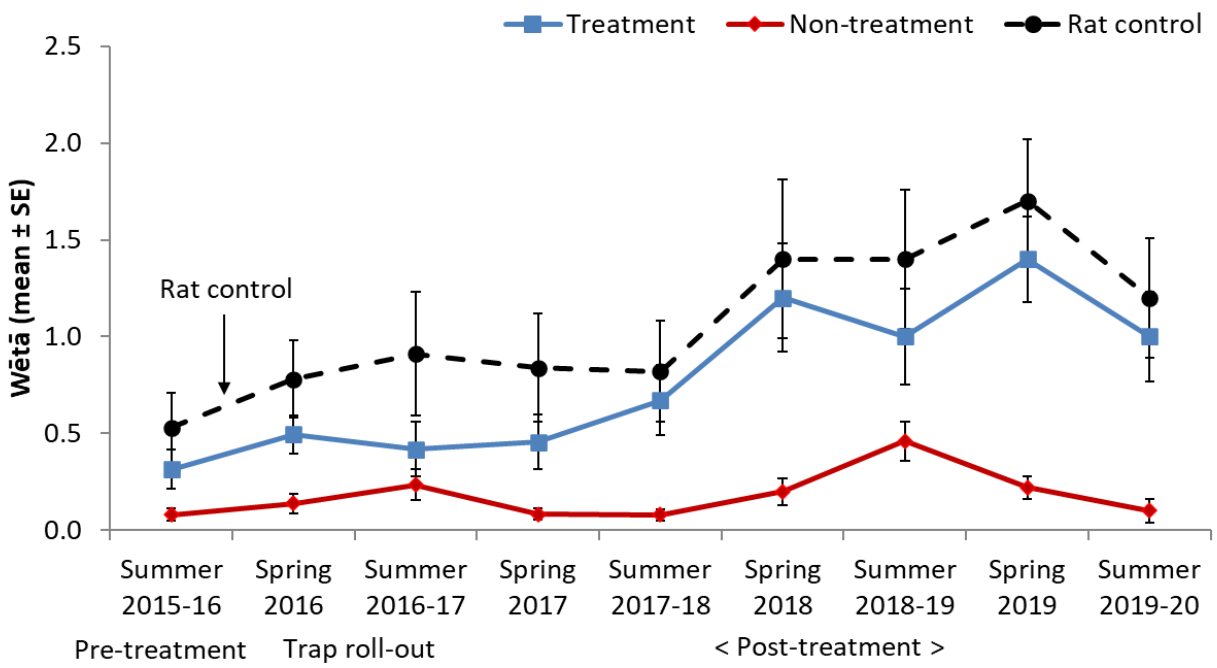
Figure 4 Percentage (± 95% CI) of tracking tunnels detecting (a) rats, (b) mice, (c) wētā, (d) skinks, and (e) geckos in the treatment area (blue), non-treatment area (red), and rat control area (black), which is within the treatment area.

4.3 Wētā houses

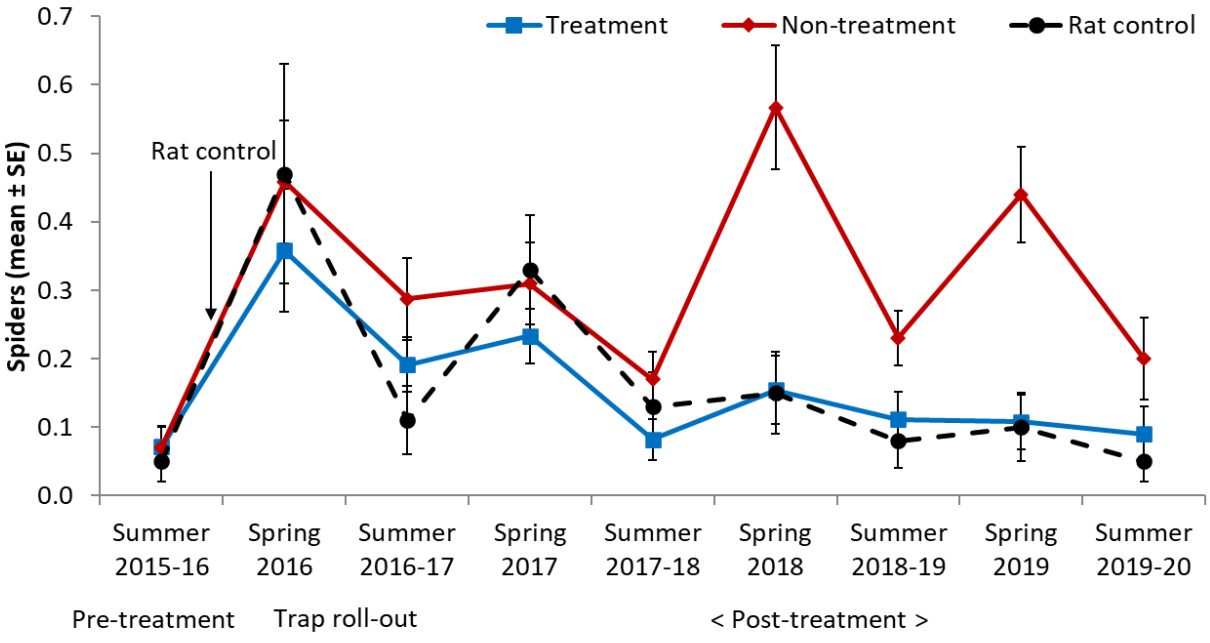
In Summer 2015/16, before predator control, mean numbers of wētā per wētā house were three times higher in the treatment than the non-treatment area (t = 2.12, p = 0.04) (Fig. 5a). Since summer 2017/18 there has been an upward trend in numbers of wētā in the treatment area, but not in the non-treatment area. In the most recent sampling season (Summer 2019/20), there was a ten-fold difference between the two areas (t = 3.85, p = 0.0001). Wētā numbers were slightly higher in the rat control area before rat control began, and have remained so in every subsequent monitoring period (Fig. 5a).

Numbers of spiders were initially similar in all areas, but have since fluctuated widely (Fig. 5b). Since Spring 2018 there has been an apparent trend towards higher numbers of spiders in the non-treatment area. Numbers of spiders remain similar in the rat control area and the wider treatment area (Fig. 5b). Numbers of other invertebrates have fluctuated widely in all areas with no apparent trend (Fig. 5c).

(a)


Treatment
Non-treatment
Rat control
Wētā (mean ± SE)
2.5
2.0
1.5
1.0
0.5
0.0
Rat control
Summer 2015-16
Spring 2016
Summer 2016-17
Spring 2017
Summer 2017-18
Spring 2018
Summer 2018-19
Spring 2019
Summer 2019-20
Pre-treatment
Trap roll-out
< Post-treatment >

(b)


Treatment
Non-treatment
Rat control
Spiders (mean ± SE)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Rat control
Summer 2015-16
Spring 2016
Summer 2016-17
Spring 2017
Summer 2017-18
Spring 2018
Summer 2018-19
Spring 2019
Summer 2019-20
Pre-treatment
Trap roll-out
< Post-treatment >

(c)

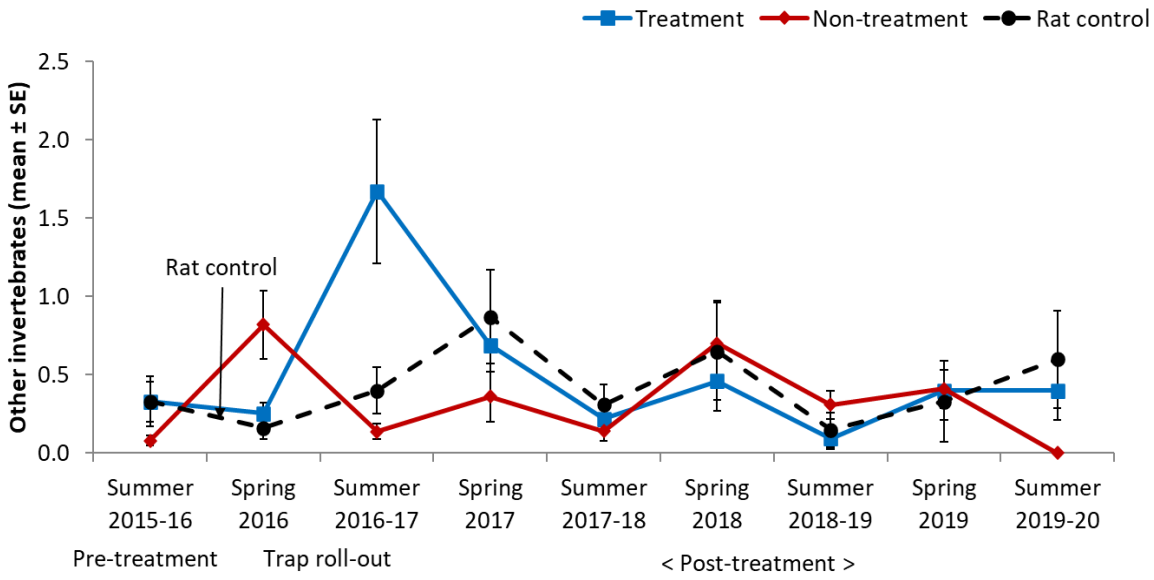


Figure 5 Mean (± SE) numbers of (a) wētā, (b) spiders and (c) other invertebrates found in wētā houses in the Cape to City treatment area (blue), non-treatment area (red) and rat control area (black), which is within the treatment area.

4.4 Tree wraps

No lizards have been recorded under the tree wraps in either the treatment or non-treatment area. However, invertebrates are frequently recorded. Numbers of invertebrates under the tree wraps have fluctuated in the treatment area (including the rat control area) with no apparent trend. However, a slight upward trend is evident in the non-treatment area (Fig. 6). In the most recent sampling period (Summer 2019-20) the mean number of invertebrates was significantly higher in the non-treatment area (t = 2.43, p = 0.02).

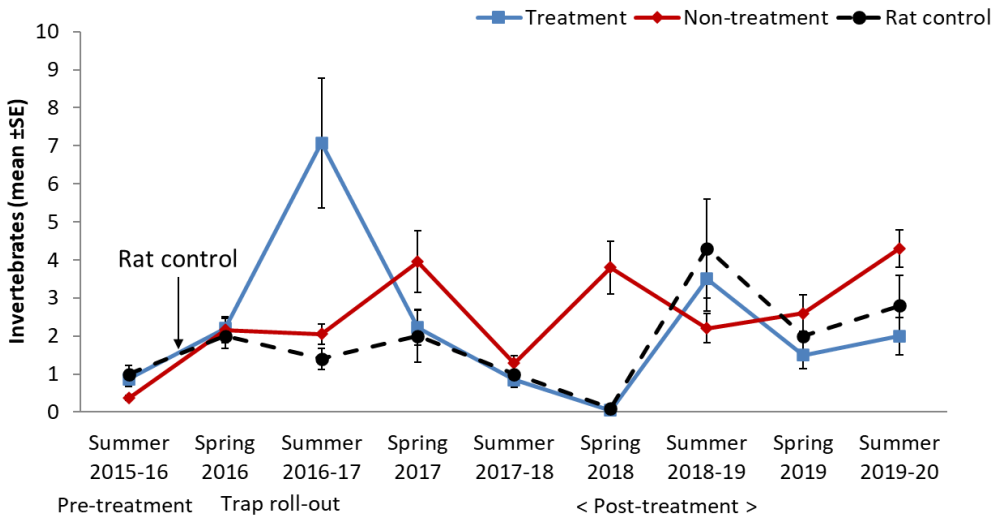


Figure 6 Mean (± SE) numbers of invertebrates recorded using tree wraps in the treatment area (blue), non-treatment area (red), and rat control area (black), which is within the treatment area.

4.5 Frass funnels

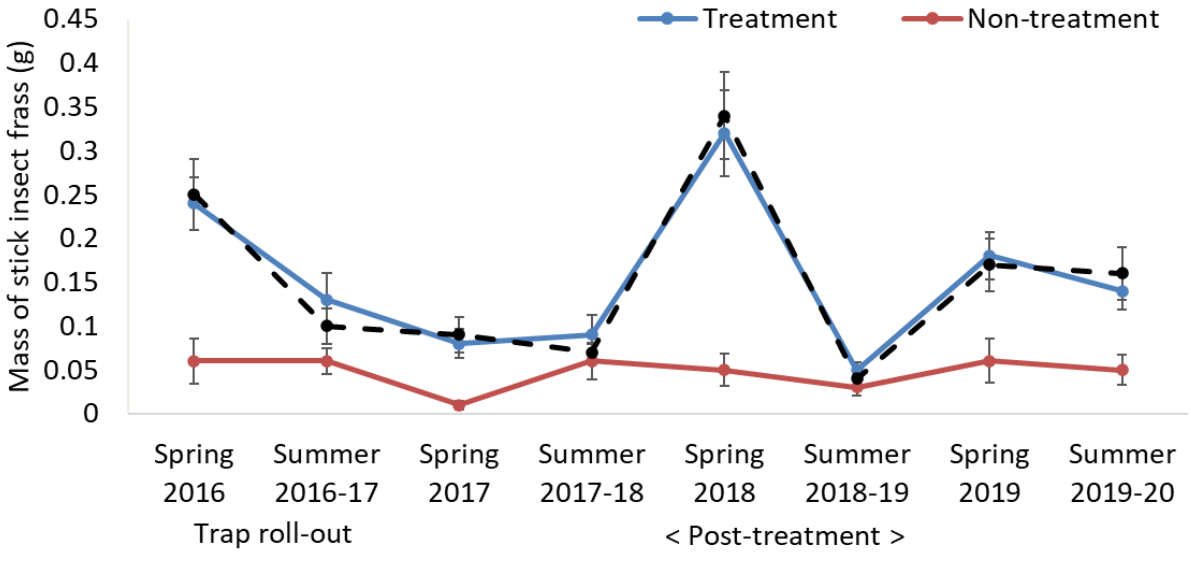
The funnels have most often collected frass from arboreal stick insects and tree wētā. Frass from other taxa including molluscs and cockroaches have occasionally been collected, as well as seeds and fruit of trees such as tawa (*Beilschmiedia tawa*) and hīnau (*Elaeocarpus dentatus*).

Although the frass funnels were in place before predator control, the first frass samples were collected in Spring 2016, by which time rat control had started in Mohi Bush. As 16 of the 20 frass funnels in the treatment area are in Mohi Bush, this may have influenced the results.

Both arboreal stick insects (t = 4.43, p <0.001; Fig. 7a) and tree wētā (t = 1.7, p = 0.01; Fig. 7b) were more abundant in the treatment area in Spring 2016. Indices have since fluctuated in both areas, but have generally been higher in the treatment area. Relative abundance of stick insects in the rat control area has been similar to that in the wider treatment area (Fig. 7a). In the most recent sampling period (Summer 2019/20), relative abundance of stick insects was again higher in the treatment area (t = 3.24, p = 0.002).

Relative abundance of tree wētā was initially similar in the rat control area and the wider treatment area but has been slightly higher in the rat control area since Spring 2018 (Fig. 7b). In Summer 2019-20, there was no significant difference in relative abundance of tree wētā between the treatment and non-treatment areas (t = 1.77, p = 0.08), but tree wētā were significantly more abundant in the rat control area than in the non-treatment area (t = 2.26, p = 0.03).

(a)



(b)

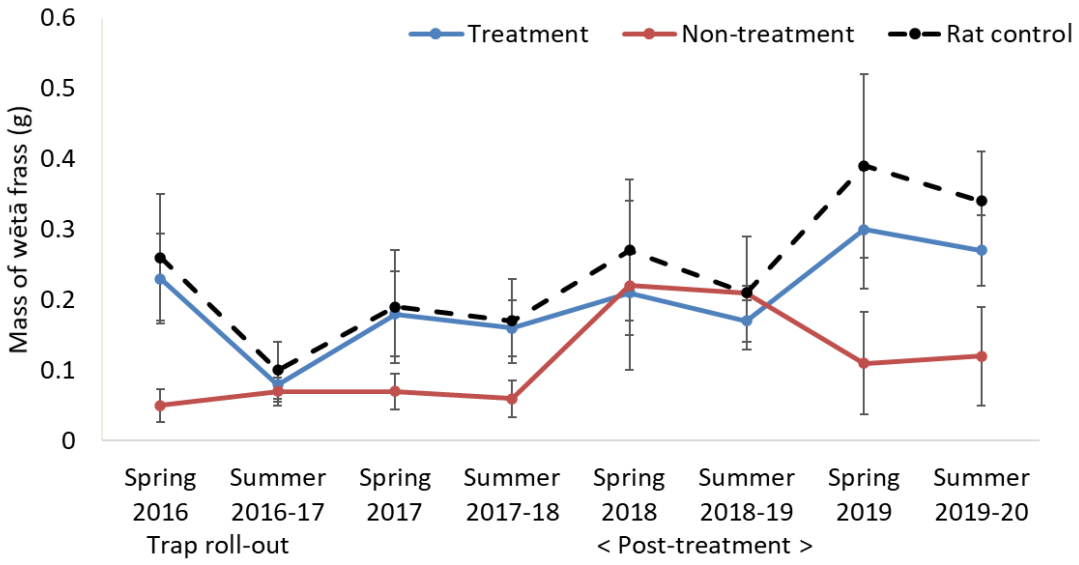
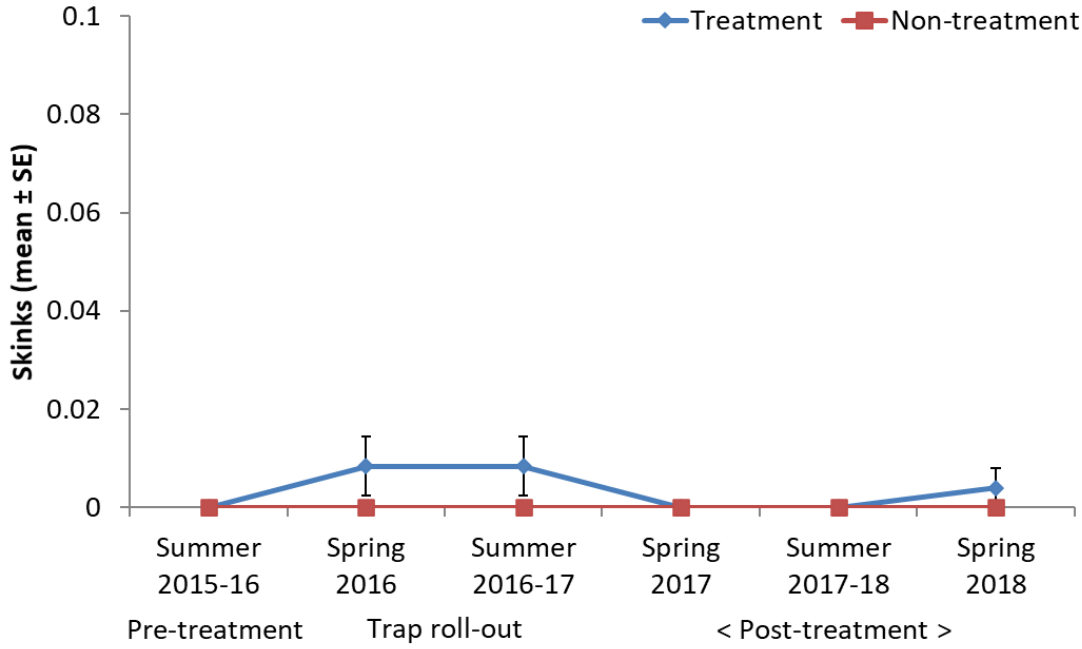


Figure 7 Mean mass (± SE) of stick insect frass (a) and wētā frass (b) recorded in frass funnels in the treatment area (blue), non-treatment area (red), and rat control area (black), which is within the treatment area.

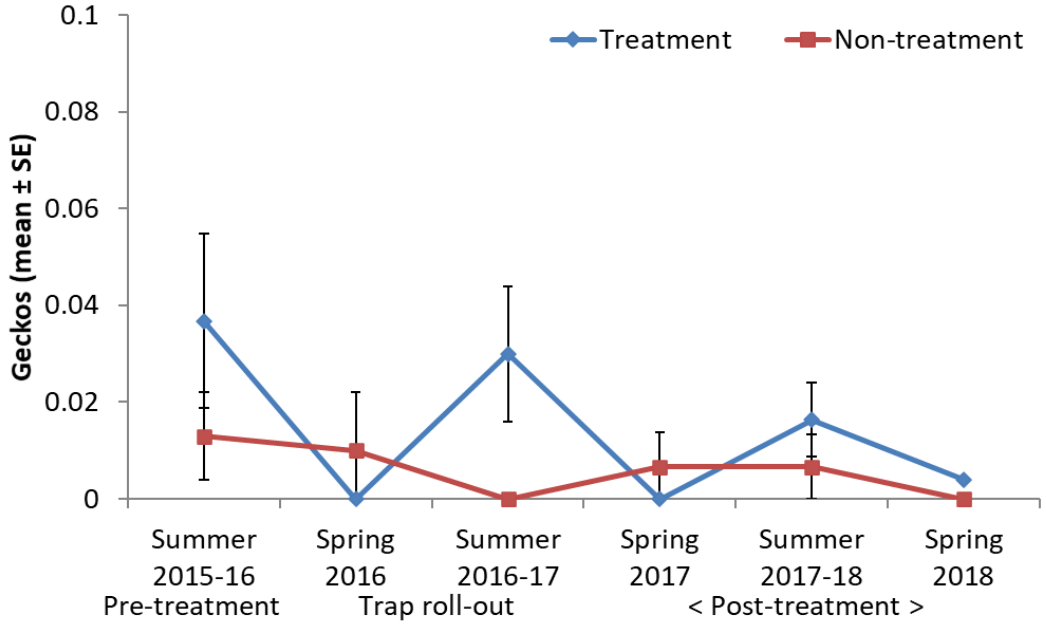
4.6 Artificial cover objects

In the treatment area, the mean number of skinks found in ACOs ranged from zero to 0.01 (Fig. 8a). No skinks were recorded in ACOs in the non-treatment area. Mean numbers of geckos ranged from zero to 0.04 in the treatment area, and zero to 0.01 in the non-treatment (Fig. 8b). Invertebrates were frequently recorded in ACOs, but their numbers fluctuated widely with no apparent trend (Fig. 8c). Because they detected few lizards compared with tracking tunnels, the use of ACOs was discontinued after Spring 2018.

(a)


Treatment
Non-treatment
Skinks (mean ± SE)
0.1
0.08
0.06
0.04
0.02
0
Summer 2015-16
Spring 2016
Summer 2016-17
Spring 2017
Summer 2017-18
Spring 2018
Pre-treatment
Trap roll-out
< Post-treatment >

(b)


Treatment
Non-treatment
Geckos (mean ± SE)
0.1
0.08
0.06
0.04
0.02
0
Summer 2015-16
Spring 2016
Summer 2016-17
Spring 2017
Summer 2017-18
Spring 2018
Pre-treatment
Trap roll-out
< Post-treatment >

(c)

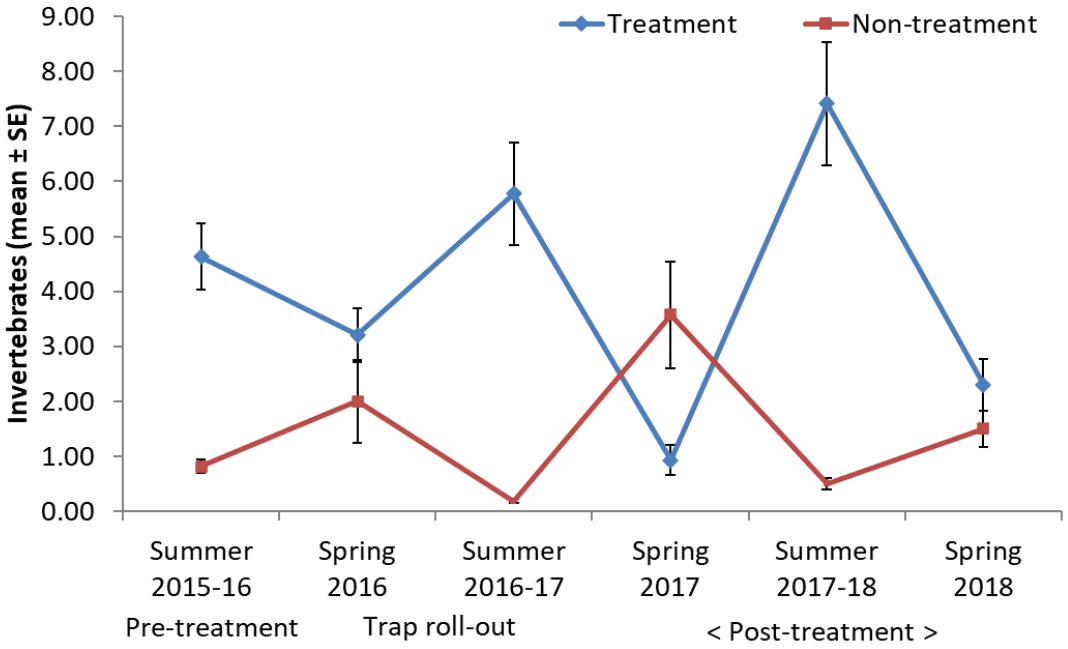


Figure 8 Mean numbers (± SE) of (a) skinks, (b) geckos and (c) invertebrates found in ACOs in the treatment (blue) and non-treatment area (red).

5 Conclusions

5.1 Predator control

Our results tentatively support the expectation that predator control has reduced the relative abundance of feral cats, stoats, and ferrets. However, because of a lack of replication (we have only one treatment and one non-treatment), we cannot firmly conclude that the observed differences result from predator control rather than natural variation in predator populations.

The relative abundance of feral cats was significantly lower in the treatment than the non-treatment area for the two years after knock-down control, but was similar between the two areas in the most recent sampling season. This suggests that the knock-down control was effective, but the feral cat population has now recovered to pre-control levels.

Due to low detection rates, relative abundance estimates of stoats and ferrets are imprecise, which limits our ability to make statistical inference. However, no stoats or ferrets have been detected in the treatment area for the last 2 years. This could be a result of predator control and/or natural variation.

Rat control in Mohi Bush appears to have been effective, reducing the relative abundance of rats to near zero each Spring, and restricting relative abundance each summer to less than half the pre-control level. There is evidence of a short-term increase in relative abundance of mice after rat control began, but tracking rates of mice have since returned to pre-control levels.

5.2 Biodiversity response

Again, our ability to draw firm conclusions regarding cause and effect is limited by lack of replication. However, our results suggest that native lizards and invertebrates are more abundant in the treatment than the non-treatment area. Although pre-existing differences were apparent, trends suggest increasing abundance of these taxa in the treatment area.

Together, tracking tunnels and wētā houses suggest that relative abundances of wētā, skinks and geckos have increased in the treatment area relative to the non-treatment since predator control began.

6 Recommendations

Our predator monitoring suggests that additional cat control is required if sustained reductions in feral cat populations are to be achieved. Although no stoats or ferrets have been detected in the treatment area since 2017, continued monitoring is required to determine whether their abundance is significantly lower than in the non-treatment area.

Monitoring of lizards and invertebrates should also be continued using tracking tunnels, wētā houses, tree wraps, and frass funnels. Although tree wraps have yet to detect any lizards, it may be too soon to expect any population response to predator control.

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8 References

Agnew W 2009. What Made These Tracks? A guide to assist in interpreting the tracks of small mammals, lizards and insects. Warkworth: Chappell Printing.

Bell TP 2009. A novel technique for monitoring highly cryptic lizard species in forests. Herpetological Conservation and Biology 4: 415-425.

Cumming G 2009. Inference by eye: Reading the overlap of independent confidence intervals. Statistics in Medicine 28: 205-220.

Garvey PM, Glen AS, Clout MN, Wyse SV, Nichols M, Pech RP 2017. Exploiting interspecific olfactory communication to monitor predators. Ecological Applications 27: 389-402.

Gillies C, Williams D 2002. A short guide for identifying footprints on tracking tunnel papers. Wellington: Department of Conservation.

Glen AS, Perry M, Yockney I, Cave S, Gormley AM, Leckie C, Dickson R, Rakete-Stones W, Rakete-Stones P, Norbury GL, Ruscoe WA 2019. Predator control on farmland for biodiversity conservation: a case study from Hawke's Bay, New Zealand. New Zealand Journal of Ecology 43: 3358.

HBRC 2020. Cape to City. https://www.pfhb.nz/cape-to-city/. [Accessed 9 June, 2020].

NPCA 2014. Pest Detective. http://www.pestdetective.org.nz/. [Accessed 29 August, 2018].

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, Barron M 2016. Frass drop for monitoring relative abundance of large arboreal invertebrates in a New Zealand mixed beech forest. New Zealand Journal of Ecology 40: 321-329.