RELATIVE PEST ABUNDANCES OF RANGITAHI/MOLESWORTH RECREATION RESERVE, SPRING 2024

Relative Pest Abundances of Rangitahi/Molesworth Recreation Reserve, Spring 2024.

Simon Lamb, Samantha Ray, Dan Burgin, Campbell Maclean, and Deleece Augustyn.

Wildlife Management International Ltd
PO Box 607
Blenheim 7240
New Zealand
www.wmil.co.nz

Document Quality Assurance:

<table>
<tr><td colspan="3">This report was prepared by Wildlife Management International Limited for Toitū Te Whenua/Land Information New Zealand (LINZ), Boffa Miskell, Environment Canterbury Regional Council/Kaunihera Taiao ki Waitaha (ECan) and the Department of Conservation/Te Papa Atawhai (DOC) as fulfilment of the tarapirohe/black-fronted tern conservation and management on the Waiau Toa/Clarence River under the residual predator monitoring/indexing component.</td></tr>
<tr><td colspan="3">Citation:
Lamb, S.; Ray, S.; Burgin, D.; Maclean, C.; & Augustyn, D. (2025) Relative Pest Abundances of Rangitahi/Molesworth Recreation Reserve, Spring 2024. Unpublished Wildlife Management International Technical Report to Toitū Te Whenua /Land Information New Zealand, Environment Canterbury Regional Council/Kaunihera Taiao ki Waitaha, Boffa Miskell and the Department of Conservation/Te Papa Atawhai.</td></tr>
<tr><td rowspan="3">Authors:</td><td>Simon Lamb (Ecologist)</td><td>Samantha Ray (Operations Manager)</td></tr>
<tr><td>Dan Burgin (Senior Ecologist)</td><td>Campbell Maclean (Ecologist)</td></tr>
<tr><td>Deleece Augustyn (Ecologist)</td><td></td></tr>
<tr><td>Externally reviewed by:</td><td colspan="2">Ellery Mayence (DOC); Frances Schmechel (ECan); Sian Reynolds and Pete Caldwell (Boffa Miskell)</td></tr>
<tr><td colspan="3">Use and Reliance:
This report has been prepared by Wildlife Management International Limited (WMIL) on the specific instructions of our Client. It is solely for their use for the purpose for which it is intended in accordance with the agreed scope of work. WMIL does not accept any liability or responsibility in relation to the use of this report contrary to the above, or to any person other than the Client. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from external sources, it has been assumed that it is accurate, without independent verification, unless otherwise indicated. No liability or responsibility is accepted by WMIL for any errors or omissions to the extent that they arise from inaccurate information provided by the client or any external source.</td></tr>
<tr><td colspan="3">All photographs in this Report are copyright © WMIL unless otherwise credited, in which case the person or organization credited is the copyright holder.</td></tr>
</table>

Version History:

Version	Authors	Date	Reason for edition
1	Lamb *et al*.	December 2024	First iteration.
2	Lamb *et al*.	January 2025	FINAL copy after client review and edits.

Cover image: *Remote trail camera set up by WMIL in the Molesworth Recreation Reserve, 2023 © WMIL.*

CONTENTS

EXECUTIVE SUMMARY

This report summarises the results of a camera monitoring survey that took place within a section of the Rangitahi/Molesworth Recreation Reserve along the Waiau Toa/Clarence River braided system. This is the third survey with previous surveys carried out in autumn-winter 2023 (May-June) and spring 2023 (September-October). The primary aim of the survey was to investigate and compare and contrast the changes in relative abundance of key predators that impact tarapirohe/black-fronted tern (*Chlidonias albostriatus*) breeding success, namely ngeru/feral cats *(Felis catus)*, and mustelids *(Mustela spp.)*, in areas receiving differing treatment applications (i.e., absence/presence of trapping and implementation/no implementation of an aerial 1080 operation).

The same methods for camera monitoring were utilised from both previous surveys, with 12 lines of four trail camera stations equally distributed at 200 m intervals, deployed for a 21-night period. Camera traps were baited with both fresh rabbit and dehydrated rabbit (Connovations Erayz™) and staked to the ground in mesh parcels. Each species photographed by the cameras was identified and an index of target species detections per 2000 camera hours (CH) was calculated for each camera line.

For the spring 2024 survey feral cats remained the most observed target pest species and had the highest relative abundance mean values, followed by tori hura/ferrets (*Mustela furo*). Feral cat relative abundance increased from the previous survey and were detected in all treatment types. Ferret detections decreased from the previous survey and no toriura/stoats (*Mustela erminea*) were detected in 2024. Tori uaroa/weasels (*Mustela nivalis*) were only detected in the no trapping and no 1080 areas.

The changes in relative abundance indices were not able to be disentangled from possible seasonal shifts in activity levels of predator species owing to the large variation in detection rates across sites, particularly for feral cats. The relative abundance changes in stoats, however, were suggestive of secondary poisoning and trapping whereby the largest declines were observed within the trapped aerial 1080 operation, and the trapped zone without 1080. Further monitoring would be needed to clarify this amongst the myriad factors involved.

Whilst this camera survey has provided a coarse index of relative abundance, it is important to note it can only provide a measure of target species activity rather than a direct measure of the population densities. For future work, Wildlife Management International Ltd. recommends the following be considered:

- Repeat surveys between the seasons for pre- and post-treatment, to observe comparable seasonal change for both treatment and non-treatment. This could also be undertaken annually, or during the rotation of 1080 application years and utilise the same methods reported here.
- Repeat surveys at other site boundaries where 1080 is administered along the Waiau Toa, thus creating site comparability between target pest species and treatment types.
- Further analysis of non-target pest species and prey species (noting some may fall into both categories such as kiore/mice (*Mus musculus*)) to observe if there is any correlation between predator-prey indices, and potentially analyse the efficacy of treatment regimens (both trapping and 1080).

Relative Pest Abundances of Rangitahi/ Molesworth Recreation Reserve, Spring 2024.

1. INTRODUCTION

The Waiau Toa/Clarence River is a braided river that flows through the Rangitahi/Molesworth Recreation Reserve, actively grazed public conservation land spanning southern Tauihu/Marlborough and northern Waitaha/Canterbury.

The area supports a myriad of native and endemic fauna and flora, including some of Aotearoa New Zealand's most diverse lizard species, notably the nationally threatened scree skink *(Oligosoma waimatense)* and spotted skink *(O. lineoocellatum)* (DOC 2024a). The reserve also provides important nesting habitat during the summer season for breeding shorebirds along the braided riverbeds. Most notably a significant proportion of the national population of tarapirohe/black-fronted tern (*Chlidonias albostriatus*), an endemic tern species which is classified as 'Nationally Endangered' (Robertson et al. 2021) breed along the Wairau, Awatere and Waiau Toa rivers in Rangitahi. Two other endemic shorebird species, tōrea/South Island pied oystercatcher *(Haematopus finschi)* and pohowera/banded dotterel *(Charadrius obscurus)* also nest along these rivers.

Unfortunately, a major cause of nest failure of both adult and/or egg/chick mortality for tarapirohe is predation, particularly by ngeru/feral cats (*Felis catus*), tori hura/ferrets (*Mustela furo*), kāhu/Australasian harriers (*Circus approximans*), karoro/southern black-backed gulls (*Larus dominicanus*), and hetiheti/European hedgehogs (*Erinaceus europaeus)* (Connor-McClean et al. 2023). Currently, a total of 770 kill traps are positioned in two lines running parallel to each side of the Waiau Toa, covering a 26 km stretch of riverbed and encompassing many sites where tarapirohe typically nest. These traps target feral cats, mustelids (*Mustela* spp.), and hedgehogs, and are spaced at 100 m intervals. Alongside kill traps, the application of large-scale aerial poison drops is a frequently used management tool for paihamu/common brushtail possum (*Trichosurus vulpecula)* control. It is important to note that these drops are being carried out for different reasons and is not technically part of the tarapirohe conservation programme. Aerial sodium fluoroacetate (i.e., 1080) operations were carried out in October 2023 to reduce possums in the area (OSPRI 2023). Possums are the main vector of bovine tuberculosis (TB) in New Zealand and thus pose a serious risk to livestock (OSPRI 2023). Additionally, the Department of Conservation/Te Papa Atawhai (DOC) recently trialled a new 1080 laced sausage-bait to target feral cats within the nearby Edwards Valley (DOC 2024b). Importantly, both of these 1080 applications are not sown at a rate or bait size that is optimal for kiore/rat (*Rattus* spp.) or kiore/house mice (*Mus musculus*) control.

This report expands on work completed by Wildlife Management International Ltd. (WMIL) for DOC, Boffa Miskell, Toitū Te Whenua /Land Information New Zealand (LINZ) and Environment Canterbury Regional Council/Kaunihera Taiao ki Waitaha (ECan), investigating introduced mammalian predator abundance to inform predator control activities (e.g., trap type and density) and ultimately tarapirohe conservation management in Rangitahi. The primary aim was to investigate the pest abundance within a series of treatment applications using trail camera traps along transects, to compare any changes in key pest species abundance, namely feral cats and mustelids, in areas receiving differing treatment applications (i.e., absence/presence of trapping and implementation/no implementation of an aerial 1080 operation). This round of residual predator monitoring represents the third survey over the past two years, and the second consecutive survey over the period September to October.

Te reo Māori names are used throughout the document for all bird species after the first use (e.g., tarapirohe/black-fronted tern). For all mammalian predator species, the common English names are used after the first use (e.g., paihamu/common brushtail possum).

2. METHODS

2.1 Site Selection and Camera Deployment

The camera trap survey was conducted in Rangitahi along the upper Waiau Toa, using the pre-exiting set up from the previous surveys (Larcombe 2023; Lamb & Augustyn, 2023). The protocol described in the '*Interim DOC trail camera guide v1.1.0*' (Gillies 2021) was followed with 12 camera lines each consisting of four cameras at 200 m spacing. The same 12 camera lines, consisting of 48 cameras (four cameras per line), were deployed across the landscape in the same locations as in past surveys (Figure 1). Each camera was set to survey for a total of 21 days. In this spring survey, cameras were deployed from the 25-28 September 2024 and retrieved from the field between the 21-25 October 2024. In the previous survey, the 12 camera lines were distributed amongst four treatment groups which were combinations of the presence/absence of a trapping regime and whether the camera line encompassed/did not encompass an aerial 1080 operation (Figure 1, Table 2).

Between 4 and 5 September 2024, DOC trialled a new 1080 bait to target feral cats in the nearby Edwards Valley (DOC 2024b). Two cameras along camera Line 8 were operating within the targeted drop area (previously assigned as a control i.e., no trapping and no 1080 applied).

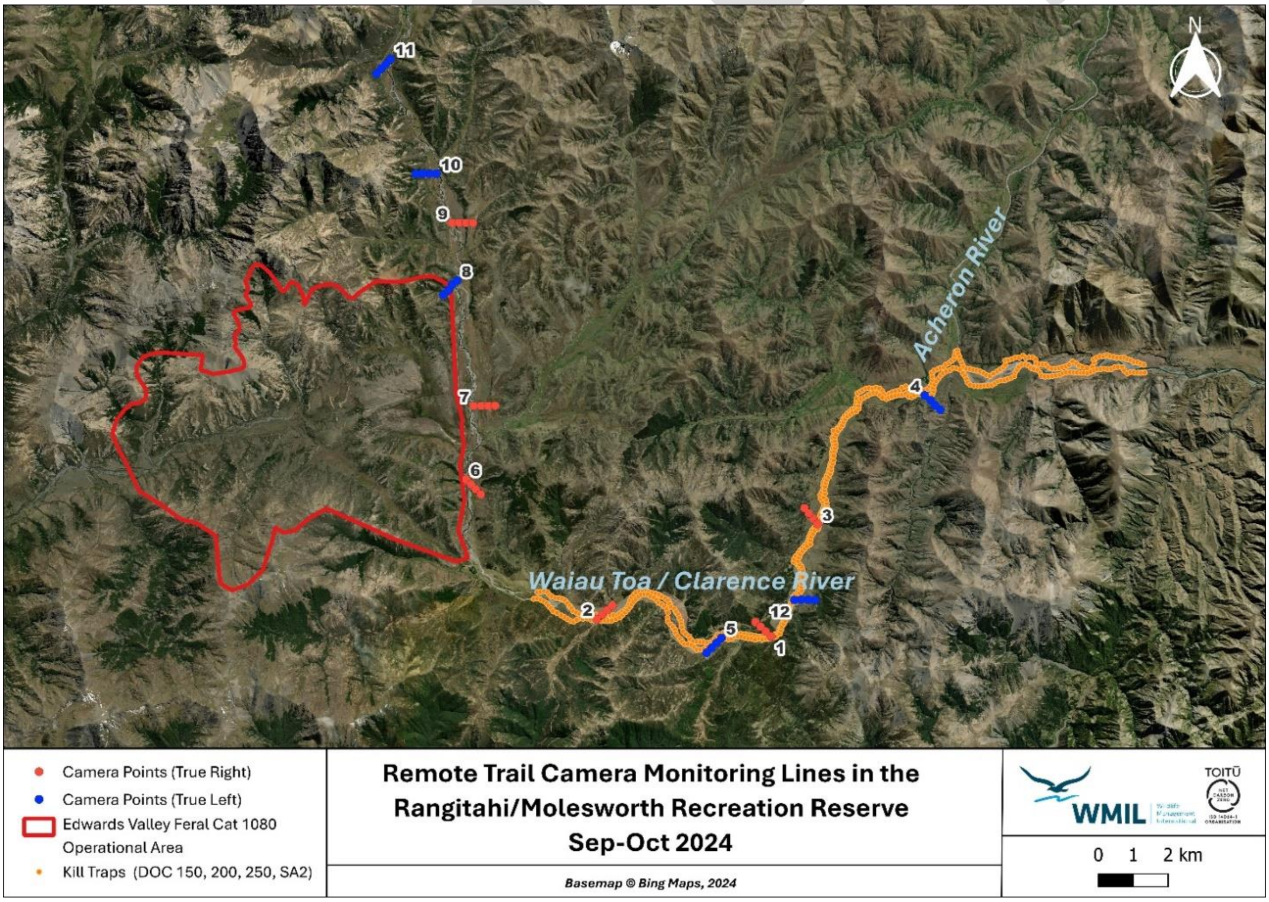


Figure 1: *Map showing the layout of the twelve camera lines along the Waiau Toa/Clarence River in the Rangitahi/Molesworth Recreation Reserve, Spring 2024 (September to October 2024). The Edwards Valley 1080 Operation area, and the established kill trap network are also shown.*

2.2 Camera Trap Protocol

Browning Dark Ops Pro XD trail cameras (model BTC-6PXD) were used for this survey. Each camera was fitted with six AA Powerex Pro 2700mAh rechargeable batteries and connected to a Browning Solar Power Pack (solar panel, model BTC-SBP12, six AA 2500mAh rechargeable batteries included). Cameras contained either a 32GB or 64GB SD card and were set as shown in Table 1.

***Table 1**: Remote camera settings used for this survey.*

Setting:	Option Selected:
Mode	*Trail*
Capture Delay	*5mins*
Pic Size	*High 12MP*
Multishot	*STD-3Shot*
Cap Start	*12:00AM*
Cap End	*12:00PM*
Smart IR	*Off*
Night Exp	*Power Save*
Temp Unit	*C*
Info Strop	*On*
SD Management	*Off*
Mode Detect	*Normal*
Motion Test	*OK*

At each site, cameras and solar panels were attached to a wooden stake using the camera straps or cable ties. A metal waratah was used to secure each stake in position. Cameras were oriented to face in a southerly direction, and solar panels were oriented to face north. Cameras were positioned between 6 and 50 cm above ground level and angled downwards so the field of view was confined to the lure and immediate surrounding area (Figure 2).

Any vegetation within the camera's field of view was cleared to ground level. A bait parcel, consisting of one piece of fresh rabbit meat between two pieces of dehydrated rabbit meat (Connovations Erayz™), was wrapped in wire and pegged into the ground with a 'U-shaped' bait stake (no.8 wire, 25 cm x 15 cm x 25 cm) at approximately 0.6 m to 1 m distance (Figure 2). Previously it was found that the wire used for the bait parcels (40 mm x 30 mm) was too large with bait pieces being easily removed by predators. This was remedied by adding a second layer of mesh to create cells sizes approximately half the size of the original.

Cameras were turned on and the motion test function was used to confirm that any movement within the desired field of view would trigger the camera.

Figure 2: *Layout of camera trap station, including solar panel, trail camera and bait parcel. © WMIL.*

2.3 Data Analysis

Camera trap footage from all stations was reviewed using the '*Timelapse*' software (Greenberg *et al*. 2019). Timelapse can incorporate '*EcoAssist*' (van Lunteren 2023), an open-source artificial intelligence (AI) tool to enable the processing of image recognition models on camera trap photos. For all photos the '*invasive species recognition for New Zealand*' model was applied to separate out between animal detections and false triggers (e.g., triggered by vegetation moving in the wind). The AI model then assigns a confidence value (between 0 and 100%) to each photo. Photos classified as an animal being detected within the photo between 50% and 100% confidence were then classified manually within *Timelapse* into different species and analysed further in Microsoft Excel™ and R Statistical Software (R Core Team 2022). WMIL did not classify those photos that had less than 50% confidence of an animal detection, as these were predominantly miss-classified false triggers.

The total number of detections of each target species (feral cats and mustelids) were calculated for each camera trap. Multiple images of an individual within a 30-minute period were classed as a single detection. The total number of detections of each target species was calculated for each camera line. Detections near the camera frame proved difficult to correctly identify for some species such as rāpeti/rabbit (*Oryctolagus cuniculus)* or hea/hare (*Lepus europaeus*), possum, or ferret due to blurred/obscured images. These were marked as unknown.

Each camera was assumed to have been operating from midday on the day that it was set, until midday on the 22nd day in the field (a 21-night period, i.e., 504 hours per camera), unless any issues with recording footage had been discovered (in which case the data was truncated to last operational night). Though all cameras were out in operation longer than 21-days, WMIL only include data within the 21-night period in keeping with the previous surveys. Unfortunately, after reviewing the footage, it was found that cameras had been unintentionally programmed to be active between 12:00am until 12:00pm, thus each camera had been operating for only 252 hours over the 21-night period.

The following equation (Equation 1) was then used to calculate a 'relative abundance index' of the number of target animal detections per 2000 camera hours (CH) for each camera trap line and target species (Gillies 2021).

Equation 1:

$$Detections\ per\ 2000\ CH = \frac{number\ of\ detections}{number\ of\ camera\ trap\ hours} \times 2000$$

The mean and standard error of the overall number of detections were calculated for each target species per line. As the detection rate is proportional to the number of operational camera hours, any drop in camera operational time becomes automatically compensated for and remains comparable across trials. However, because a target animals' behavioural tendencies may not be evenly distributed throughout the day (e.g., a target species may be more routinely active in the hours just after dusk than at dawn) a shortened time-window may introduce bias because of the behaviour of the target animal. Thus, WMIL re-examined the previous camera survey data and plotted the number detections of each target animal at each hour of the day to examine how detection activity is distributed throughout a 24-hour period (**6.1**Appendix 1**:** Density of detections of target species at each hour across the day between survey 1 and 2). There was not enough detection data across the previous two camera surveys to examine activity patterns of toriura/stoats (*Mustela erminea*) and tori uaroa/weasels (*Mustela nivalis*), but both feral cats and ferrets exhibited roughly symmetrical peaks in activity in each of the 12-hour time windows (12am to 12pm versus 12pm to 12am). Thus, despite the halved operational camera time WMIL considers the relative abundance index calculated for this survey comparable to the previous two (in terms of feral cat and ferret detections).

3. RESULTS

3.1 Relative Abundance Indices

Of all the target pest species, feral cats were the most frequently detected species and had the highest relative abundance detected by the camera traps in 2024. Feral cats were detected on four of the 12 camera lines (on six of the 48 cameras) with an average relative abundance of 2.0 ± 1.2 across all camera lines. The highest relative abundance of feral cats was recorded on one camera on Line 8, stationed within the Edwards Valley 1080 operational area (Table 2).

Ferrets were detected on two of the 12 camera lines (on three of the 48 cameras) with an average relative abundance of 0.8 ± 0.7 across all camera lines. The highest relative abundance of ferrets was recorded on Line 7 (Table 2).

Weasels were detected on two of the 12 camera lines (on two of the 48 cameras) with an average relative abundance of 0.3 ± 0.2 across all camera lines (Table 2). Weasels were detected in this survey after no detections in the previous 2023 survey.

No stoats or rats were recorded across the camera network in 2024.

Table 2: *Relative abundances index of target pest species by line, and mean abundances by species during the Sept-Oct 2024 camera survey. Values are presented as detections per 2000 camera hours. The former treatment (from the previous camera surveys) and current treatment per line are listed. No stoats or rats were detected.*

	Target Species				
Line	**Cat**	**Ferret**	**Weasel**	**Former treatment**	**Current treatment**
1	-	-	-	Trapped, 1080 applied	Trapped
2	-	-	-	Trapped, 1080 applied	Trapped
3	1.98	-	-	Trapped, 1080 applied	Trapped
4	-	1.98	-	Trapped, no poison	Trapped
5	1.98	-	-	Trapped, no poison	Trapped

6	-	-	-	Not trapped, 1080 applied	Not trapped
7	5.95	7.94	-	Not trapped, 1080 applied	Not trapped
8	13.89	-	1.98	Not trapped, no poison (control)	Not Trapped, two of four cameras within the Edwards Valley 1080 feral cat operation
9	-	-		Not trapped, 1080 applied	Not trapped
10	-	-	1.98	Not trapped, no poison (control)	Not trapped
11	-	-	-	Not trapped, no poison (control)	Not trapped
12			-	Trapped, no poison (control)	Trapped
Mean	**2.0**	**0.8**	**0.3**		
SE	**1.2**	**0.7**	**0.2**		

Examples of pest target species detected are shown in Appendix 2: Examples of target species captured during Spring 2024 survey.

For those non-target pest species detected on cameras, house mice were detected most frequently and had the highest relative abundance across the camera network. Followed by hedgehogs and possums.

Other non-target species detected on camera were poaka/pig (*Sus domesticus*), hare, tia/deer (*Cervus* sp.), kau/cows (*Bos taurus*), kāhu, miromiro/tomtit (*Petroica macrocephala*) korimako/bellbird (*Anthornis melanura*), pīhoihoi/New Zealand pipit *(Anthus novaeseelandiae)*, tōrea, pohowera, warou/welcome swallows (*Hirundo neoxena*), manu pango/Eurasian blackbird (*Turdus merula*), pahirini/chaffinch (*Fringilla coelebs*), dunnock (Prunella modularis), makipai/Australian magpie (*Gymnorhina tibicen*), kairaka/skylark (*Alauda arvensis*), manu-kai-hua-rakau/song thrush (Turdus philomelos), tāringi/common starling (*Sturnus vulgaris*), hurukōwhai/yellowhammer (*Emberiza citrinella*) and a single skink (likely of the grass skink complex).

3.2 Changes In Relative Abundance Indices

Feral cat relative abundance index increased whereas stoat and ferret relative abundance index declined between Survey 2 and Survey 3 (Table 3).

Table 3: *Relative abundances index of target pest species averaged (± standard error) by each survey and the percentage change (% change) between each survey. Values are presented as number of detections per 2000 camera hours.*

Species	Survey 1 (May-Jun 2023)	% change	Survey 2 (Sep-Oct 2023)	% change	Survey 3 (Sep-Oct 2024)
Cat	5.0 ± 1.3	-68	1.6 ± 0.7	+25	2.0 ± 1.2
Ferret	2.2 ± 0.9	-18.2	1.8 ± 1.0	-55	0.8 ± 0.7
Stoat	3.3 ±1.9	-97	0.1 ± 0.1	-100	-
Weasel	0.1 ± 0.1	-100	-	n/a	0.3 ± 0.2

During Survey 3 (Sep-Oct 2024), feral cats were detected on camera lines in all treatment groups. This was also seen during Survey 1; however feral cats were not detected on the trapped and 1080 camera lines during Survey 2 (Figure 3). During Survey 2, whilst there were feral no cats in the trapped and 1080 treatment zone, their abundance was also very low in the not trapped, no poison treatment, with more in the not trapped 1080 treatment zone, and highest in the trapped no poison treatment zone. In Survey 1 none of the treatments appear to make much difference due to overlapping confidence intervals, and so these differences are likely not significant.

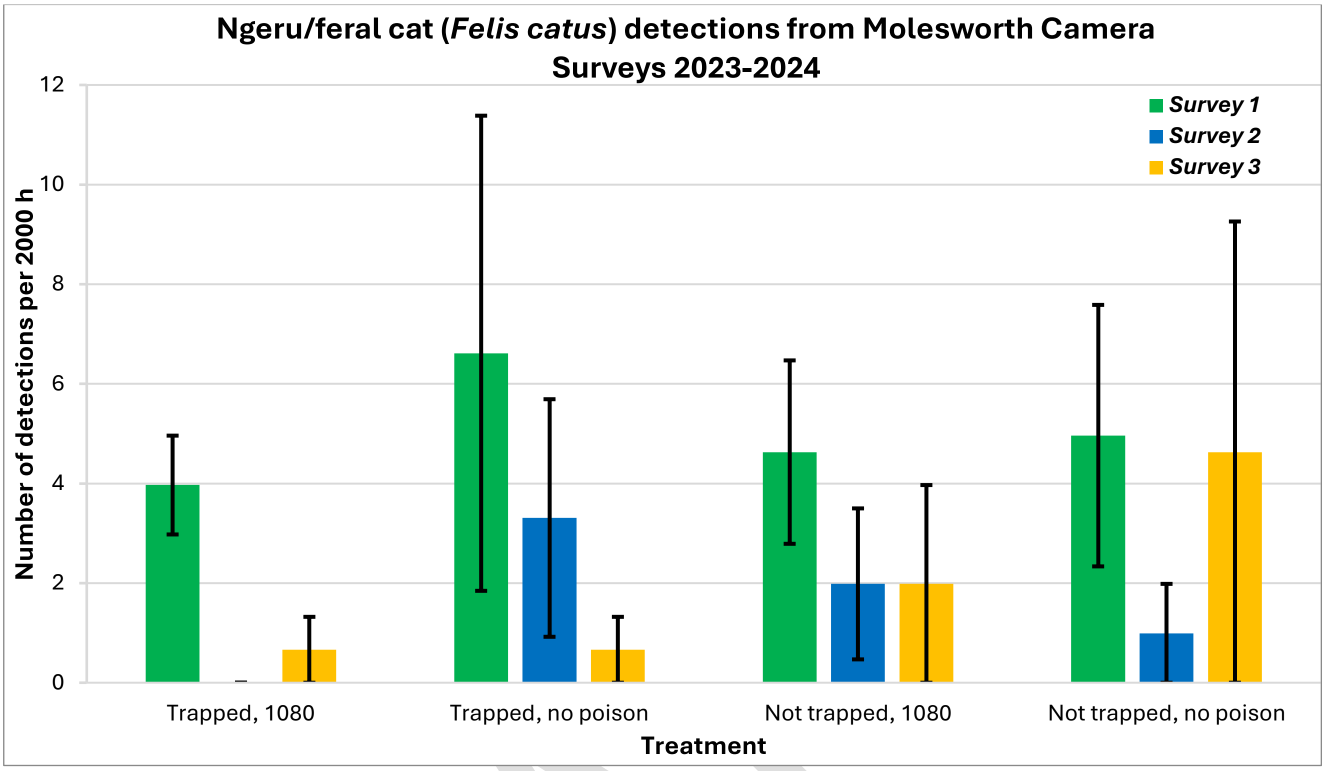


Figure 3: *Changes in the mean (±SE) ngeru/feral cat (Felis catus) relative abundance index for each treatment combination for each Survey. Where Survey 1 occurred in May-June 2023 (pre-aerial 1080 operation and pre-opening of the trapping network), Survey 2 occurred in Sep-Oct 2023 (post-aerial 1080 operation and post-opening of the trapping network), and Survey 3 (1-year post operation) occurred in Sep-Oct 2024. Note that one camera line in the 'not trapped, no poison' treatment (i.e., the control) partially overlapped with the Edwards Valley 1080 control program that targeted feral cats.*

Ferrets were the most frequently detected mustelid across all three camera surveys. However, no ferrets were detected on lines where trapping and 1080 were applied. Detection rates in other areas were comparable to one another across surveys with the only substantial drop being detected where neither trapping nor 1080 was applied between Survey 1, 2 and 3 (Figure 4). However, the confidence limits overlap for all surveys and treatments, and so these differences are likely not significant.

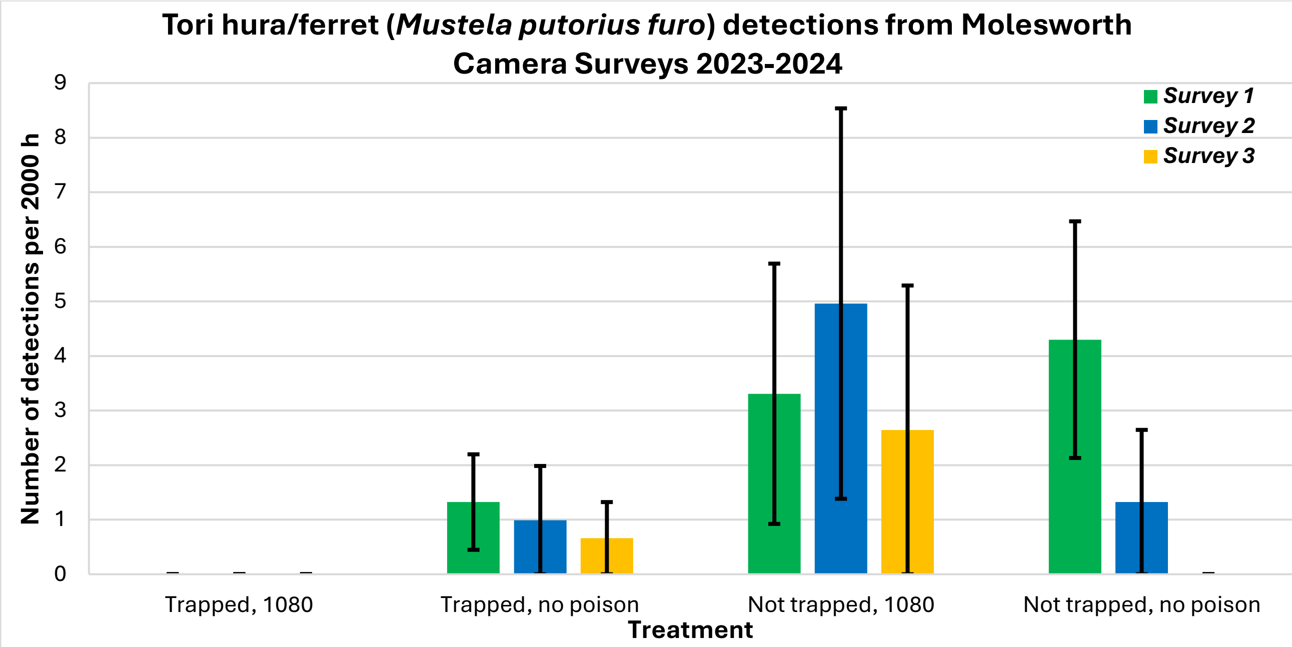


Figure 4: *Changes in the mean (±SE) tori hura/ferret (Mustela putorius furo) relative abundance index for each treatment combination for each Survey. Where Survey 1 occurred in May-June 2023 (pre-aerial 1080 operation and pre-opening of the trapping network), Survey 2 occurred in Sep-Oct 2023 (post-aerial 1080 operation and post-opening of the trapping network), and Survey 3 (1-year post operation) occurred in Sep-Oct 2024. Note that one camera line in the 'not trapped, no poison' treatment (i.e., the control) partially overlapped with the Edwards Valley 1080 control area for ngeru/feral cats (Felis catus).*

No stoats were detected on cameras during the 2024 survey (Figure 5).

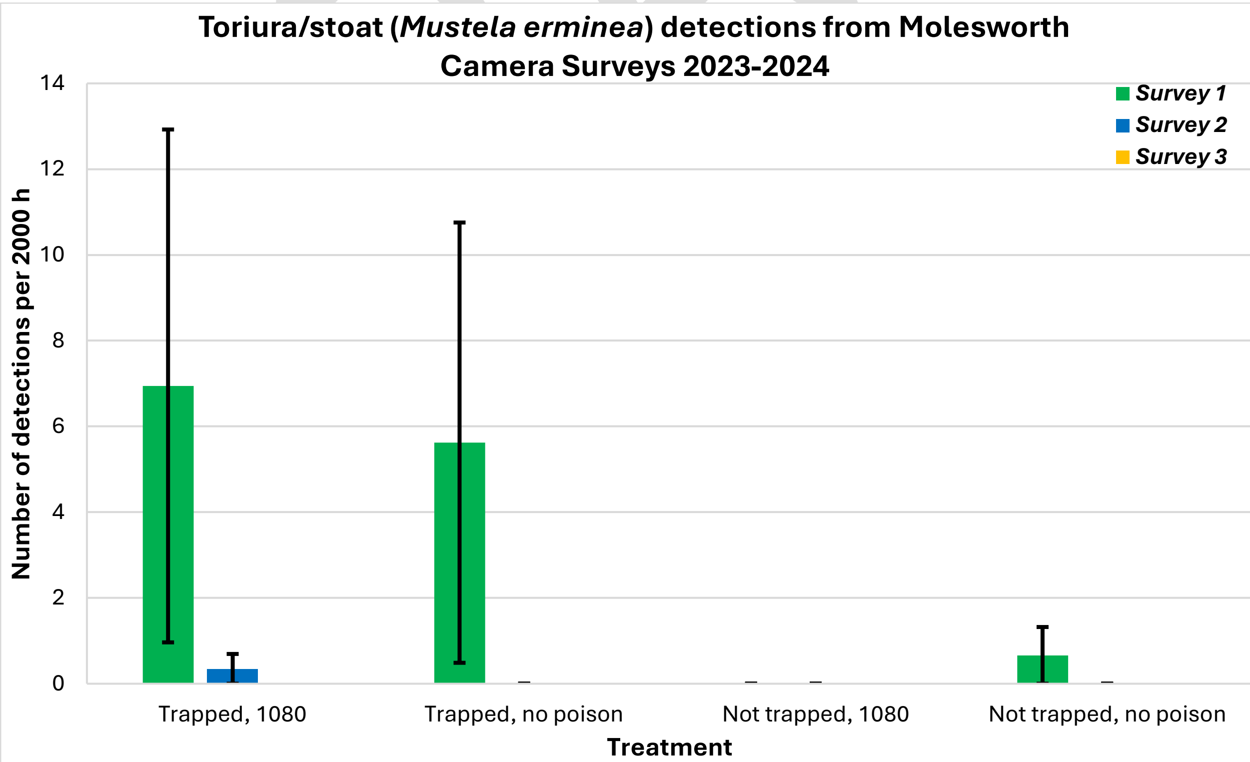


Figure 5: *Changes in the mean (±SE) toriura/stoat (Mustela erminea) relative abundance index for each treatment combination for each Survey. Where Survey 1 occurred in May-June 2023 (pre-aerial 1080 operation and pre-opening of the trapping network), Survey 2 occurred in Sep-Oct 2023 (post-aerial 1080 operation and*

post-opening of the trapping network), and Survey 3 (1-year post operation) occurred in Sep-Oct 2024. Note that one camera line in the 'not trapped, no poison' treatment (i.e., the control) partially overlapped with the Edwards Valley 1080 control area for ngeru/feral cats (Felis catus).

Weasel detections were confined to the treatment group that had either trapping and no 1080 or not trapped and no 1080 (Figure 6).

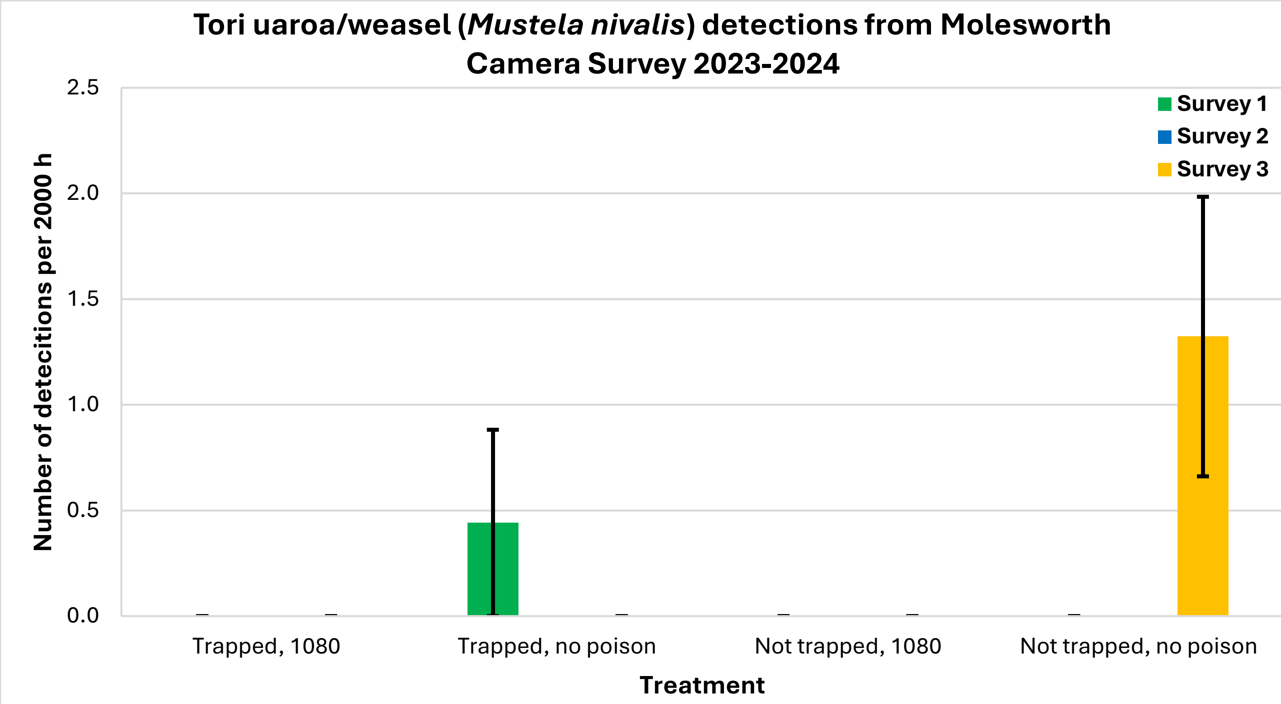


Figure 6: *Changes in the mean (±SE) tori uaroa/weasel (Mustela nivalis) relative abundance index for each treatment combination for each Survey. Where Survey 1 occurred in May-June 2023 (pre-aerial 1080 operation and pre-opening of the trapping network), Survey 2 occurred in Sep-Oct 2023 (post-aerial 1080 operation and post-opening of the trapping network [c. 2 months in operation when the camera Survey commenced]), and Survey 3 (1-year post operation, opened trapping network [c. 2 months in operation when the camera Survey commenced]) occurred in Sep-Oct 2024. Note that one camera line in the 'not trapped, no poison' treatment (i.e., the control) partially overlapped with the Edwards Valley 1080 control area for ngeru/feral cats (Felis catus).*

4. DISCUSSION

4.1 Target Species Detections

It is important to state that the relative abundance of trail camera monitoring provides a coarse index of relative abundance, rather than a direct measure of population density (Gillies, 2021).

Theoretically, the control area should remain relatively constant between surveys with a potential decrease in relative abundance in the trapped 1080 zone expected, albeit for a limited period of time. Interestingly, this survey potentially indicates limited effect of the aerial 1080 operation on feral cat relative abundance. Further work would be needed on this though, as it is not widely known if secondary poisoning of feral cats is achieved using cereal pellets targeted at rats or possums. The relative abundance of all target predators within the control area with neither trapping nor aerial 1080 applied, did not stay constant over time, and for feral cats decreased at largely the same rate in all treatment areas between Survey 1 (winter) and Survey 2 (spring). Therefore, changes in relative abundance indices were not able to be disentangled from other possible variables (e.g., seasonal shifts) in activity levels of predator species, owing to the large variation in detection rates across sites. The large overlap in the confidence limits for all surveys and treatments also indicates these differences are likely not significant.

Breeding amongst all mustelids is observed from September-March with dispersal of juveniles occurring between December-May, depending on the species (King & Forsyth, 2021). It could be assumed that the May-June period would be the prime time for detection rates to be captured as numbers expand without treatment (Table 3), and the opening of the traps and the implementation of the 1080 drop was undertaken before the breeding period began. A repeat monitoring session in the autumn/winter 2024 period would better determine the effects of the spring 2023 treatments on pest predator abundance post-dispersal. Mammalian predator behaviour is different between seasons, likely impacting detection rates, so further analyses may benefit from comparing at the same time of year rather than seasonally.

The largest decline in stoat relative abundance was observed within the trapped aerial 1080 operation and the trapped zone without 1080 compared to other treatment areas where stoat relative abundance indices were maintained at, or near to, zero between surveys. Changes in the relative abundance of stoats are suggestive that secondary poisoning (ingestion of contaminated species) and trapping may have had an effect. The observation that the not-trapped 1080 zone maintained low levels, might suggest a suppression of re-invaders. The results from this survey possibly infer that the ability to detect stoats (and by extension weasels) via camera traps is much reduced over the spring period. Given that Survey 2 and Survey 3 occurred at the same time of year (spring), compared to Survey 1 (winter), potential changes in their relative abundance index are unlikely to be comparable. Additionally, with only one monitoring period per year, WMIL are not able to account for the known seasonality of introduced mammalian predators, especially mustelids. Trapping results from this season clearly indicate that stoats and weasels are still present in the environment as shown in the Trap.NZ Upper Waiau Toa/Clarence River Trapping Project (Trap.NZ 2024). Detecting stoats and weasels, and therefore assessing their relative abundance, will benefit from implementing another monitoring period during the year. Testing the effectiveness of different lures may also be worth exploring in future monitoring.

Many variables are likely influencing the results of this, and the previous surveys, that would require further investigation and lie outside the scope of this project. Species behaviour is one factor that likely impacts detection rates on remote trail cameras.

Feral cats are extremely versatile in their nature. Feral cats were not able to be identified and confirmed to an individual level unless there were clear differences in features between individuals such as body size (e.g., adult vs. kitten) or coat markings. It appeared on occasion, the same individual often re-visited lures hours, days, or sometimes consecutive nights after first discovering the lure especially where the lure was discovered early in the survey period and the fresh rabbit bait remained present.

Interestingly, for both ferrets and stoats, the treatment zones where relative abundance was found to be low in the initial survey, remained at low levels. This might suggest that within the landscape, the species is more patchily distributed than feral cats, however further work would be needed to clarify what factors are at play to substantiate this finding.

As with feral cats, mustelids boast a similar versatility and ability in targeting a diverse range of food during both the day and night and respond rapidly to changing prey densities and shift accordingly (Murphy & Dowding, 1994). Stoats reportedly partition resources and occupy alternative niches, for example by becoming more nocturnally active when higher order predators such as cats and ferrets are in the same environment (Garvey *et al,* 2022) either through direct agonistic behaviour or reduction in resource availability (Ritchie & Johnson, 2009). However, not much is known about the seasonal shift in the diet of stoats in large-open braided river systems, especially when prey species may be more patchily distributed. Relative abundance indices for mammalian predators have been shown to respond effectively to treatment applications overseas and within Aotearoa New Zealand within closed, forested environments, using trail camera monitoring (Foresman & Pearson, 1998; Bengsen *et al*. 2011; Dilks *et al*. 2020). However, when these techniques are applied to wide-open, non-forested landscapes, such as Rangitahi, the low densities and seasonal changes in activity patterns of target species may significantly hamper an effective assessment of their relative abundance. There is known merit of using more than one technique to detect an introduced mammalian predator species (Pickerell *et al*. 2014), and this may be worth exploring in future monitoring. As new camera monitoring techniques or protocols come into use, WMIL recommends reviewing these and possibly incorporating them into the project in the future if appropriate.

4.2 Non-Target Pest Species Detections

No specific analysis was conducted on non-target species for this reporting. Further monitoring and analysis would be required to determine if there is any effect on the relative abundance for these species between treatment types. However, it is important to remember that the 1080 treatment and trapping regimes do not target non-target pest species effectively, so it is unlikely that detectable changes will be able to be substantiated from this monitoring technique.

4.3 Additional Non-Target Non-Pest Species Detections

Non-target non-pest species detected during the spring survey were similar to those detected during previous surveys. Kāhu were detected on some of the cameras. No banded individuals were detected during this survey which continues to be of particular interest as the WMIL team have banded kāhu over the past four years as part of the tarapirohe management project with DOC and ECan (Ray & Burgin, 2024).

5. RECOMMENDATIONS

WMIL have the following recommendations:

- Repeat surveys between the seasons for pre- and post-treatment, to observe comparable seasonal change for both treatment and non-treatment. This could also be undertaken annually, or during the rotation of 1080 application years and utilise the same methods reported here.
- Repeat surveys at other site boundaries where 1080 is administered along the Waiau Toa, thus creating site comparability between target pest species and treatment types.
- Further analysis of non-target pest species and prey species (noting some may fall into both categories such as kiore/mice (*Mus musculus*)) to observe if there is any correlation between predator-prey indices and potentially analyse the efficacy of treatment regimens (both trapping and 1080).

4. ACKNOWLEDGMENTS

Thanks to LINZ, ECan and DOC for providing the funding which enabled WMIL to undertake this project. Thanks to Boffa Miskell and DOC for management of this contract. Thanks to Pat Crowe (DOC Renwick) for designing the camera trap line layout and providing additional support. Thanks to Te Rūnanga o Kaikōura and Jim Ward (Rangitahi/Molesworth Station Manager) for supporting this work. A huge thanks to the WMIL field team (Baylee- Connor-McClean, Arthur Bensana, Martina Post and Hinewai Bell) for contributing to the deployment and retrieval of the cameras, as well as analysis of camera images.

5. REFERENCES

Bengsen, A.; Butler, J.; & Masters, P. (2011) Estimating and indexing feral cat population abundances using camera traps. *Wildlife Research*. 38: 732-739.

Connor-McClean, B.; Lamb, S.; & Bell, E. (2023). *Waiau Toa/Clarence and Wakaputawatea/Acheron River black-fronted tern monitoring project- 2022/23 operational report*. Client report prepared for the Department of Conservation by Wildlife Management International Ltd, Blenheim.

Department of Conservation (DOC). (2024a). Molesworth Recreation Reserve. Accessed 9 December 2024 online via https://www.doc.govt.nz/parks-and-recreation/places-to-go/marlborough/places/molesworth-reserve/nature-and-conservation/

Department of Conservation (DOC). (2024b). "*Notification of trial of a new bait to control feral cats in the St James*" factsheet. Accessed 9 December 2024 online via https://www.doc.govt.nz/globalassets/documents/parks-and-recreation/places-to-visit/canterbury/st-james-bait-trial-factsheet.pdf

Dilks, P.; Sjoberg, T.; Murphy, E.C. (2020). Effectiveness of aerial 1080 for control of mammal pests in the Blue Mountains, New Zealand. *New Zealand Journal of Ecology*. 44 (2): 3406.

Foresman, K.R.; & Pearson, D.E. (1998). Comparison of proposed survey procedures for detection of forest carnivores. *Journal of Wildlife Management*. 62 (4): 1217-1226.

Garvey, P.M.; Alistair, G.; Clout, N.M.; Nichols, M.; & Pech, R.P. (2022). Niche partitioning in a guild of invasive mammalian predators. *Ecological Applications*. 32(4). Pp 1-16.

Greenberg, S.; Godin, T.; Whittington, J. (2019). Design patterns for wildlife-related camera trap image analysis. *Ecology and Evolution*. 2019 (9): 13706–13730. https://doi.org/10.1002/ece3.576

Gillies, C. (2021). *Interim DOC trail camera guide v1.1.0: Using camera traps to monitor feral cats, mustelids and rats*. Department of Conservation Biodiversity Group, Hamilton. https://www.bionet.nz/assets/Uploads/A8-Pest-Mustelids-2018-04-LR.pdf

King, C.M.; Veale, A. J.; Murphy, E.C.; Garvey, P.; & Byrom, A.E. (2021). *Mustela erminea*. In King, C.M. & Forsyth, D.M. (*eds*). The handbook of New Zealand mammals. 3rd Edition. Clayton, CSIRO Publishing. Pp. 285–341.

Lamb, S. & Augustyn, D. (2023). Molesworth Pest Abundance Camera Trap Survey: A Preliminary Survey of Relative Pest Abundances in the Molesworth Recreation Reserve, Spring 2023. Unpublished Wildlife Management International Technical Report to Boffa Miskell and the Department of Conservation.

Larcombe, S. (2023). Molesworth Pest Abundance Camera Trap Survey: A Preliminary Survey of Relative Pest Abundances in the Molesworth Recreation Reserve, Autumn-Winter 2023. Unpublished Wildlife Management International Technical Report to Boffa Miskell and the Department of Conservation. 22p.

OSPRI. (2023). *Bush Gully and Tarndale TB free Aerial Factsheet*. Accessed online November 2023 via https://www.ospri.co.nz/assets/AerialOpsFactsheets/Bush-Gully-and-Tarndale-TBfree-Aerial-Factsheet.pdf

Pickerell, G. A.; O'Donnell, C. F.; Wilson, D. J.; & Seddon, P. J. (2014). How can we detect introduced mammalian predators in non-forest habitats? A comparison of techniques. *New Zealand Journal of Ecology*. 86-102.

Ray, S. & Burgin, D. (2024). Kāhu/Australasian harrier (*Circus approximans*) banding on Waiau Toa/Clarence River 2024. Unpublished Wildlife Management International Technical Report to the Department of Conservation. 9p.

R Core Team. (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. Vienna Austria. https://www.R-project.org

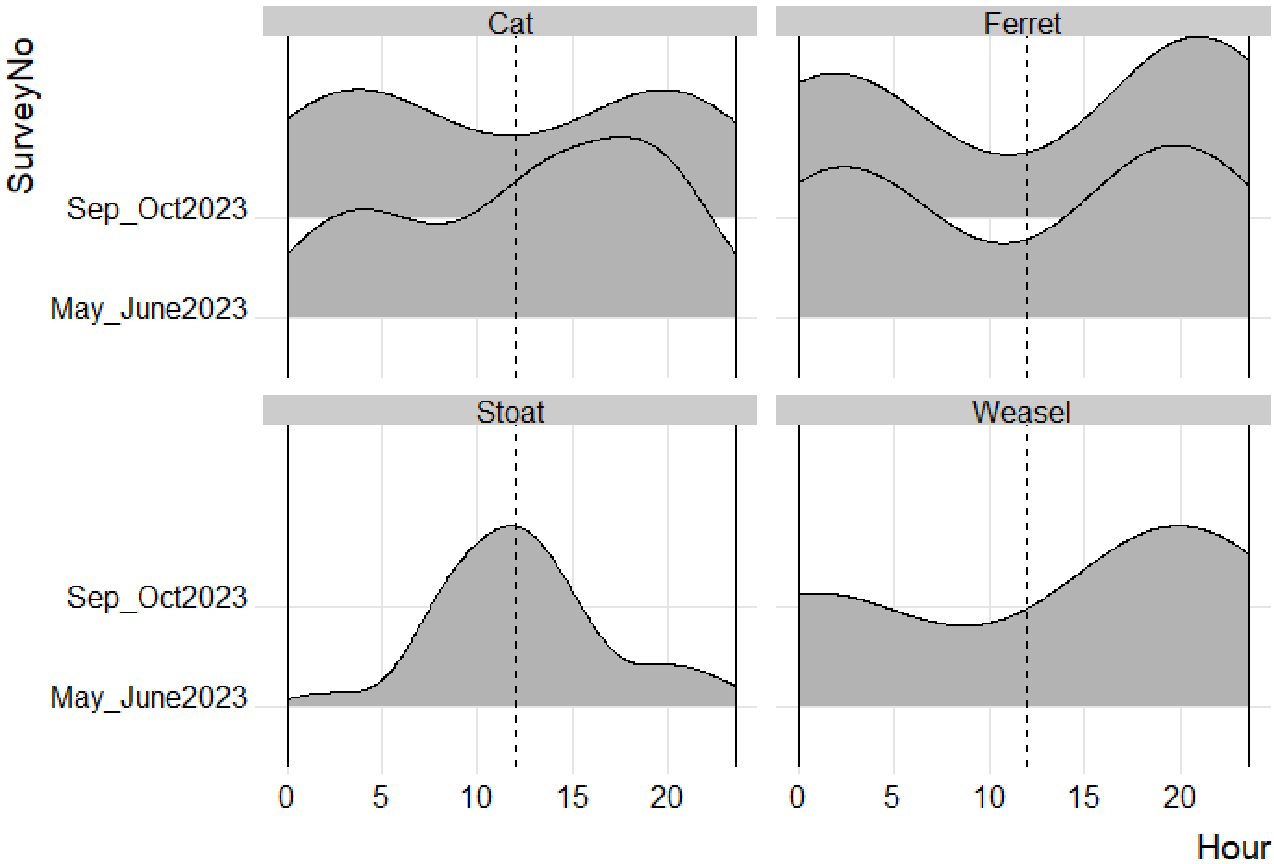
Robertson, H.A.; Baird, K.; Elliott, G.; Hitchmough, R.; McArthur, N.; Makan, T.; Miskelly, C.; O'Donnell, C.; Sagar, P.; Scofield, P.; Taylor, G. & Michel, P. (2021). Conservation status of birds in Aotearoa New Zealand, 2021. *New Zealand Threat Classification Series 36*. Department of Conservation, Wellington.

Trap.NZ. (2024). Upper Waiau Toa/Clarence Trapping Project, Trap.NZ. Accessed online 8 December 2024 via https://trap.nz/node/1414435.

van Lunteren, P. (2023). EcoAssist: A no-code platform to train and deploy custom YOLOv5 object detection models. *Journal of Open Source Software*. 8 (88): 5581.

6. APPENDICES

6.1 Appendix 1: Density of detections of target species at each hour across the day between survey 1 and 2



Dotted line indicates 12PM. Solid lines indicate 12AM. Groups with fewer than two data points have been dropped (e.g., only one stoat detected during the Sep-Oct survey, and no weasels detected during the Sep-Oct survey).

6.2 Appendix 2: Examples of target species captured during Spring 2024 survey

Appendix 2, Figure 1: *Ngeru/feral cat (Felis catus) captured by remote camera, September 2024. © WMIL.*

Appendix 2, Figure 2: *Tori hura/ferret (Mustela putorius furo) captured by remote camera, September 2024. © WMIL*

Appendix 2, Figure 3: *Tori uaroa/weasel (Mustela nivalis) captured by remote camera, September 2024. © WMIL.*