Department of Conservation
Te Papa Atawhai

TONGARIRO FOREST KIWI SANCTUARY ANNUAL REPORT

July 2021– June 2022

TONGARIRO DISTRICT OFFICE, CENTRAL NORTH ISLAND REGION





Save the kiwi · KIWI ENCOUNTER · NATIONAL KIWI TRUST · Ngati Hikairo ki Tongariro · PROJECT TONGARIRO · WAIRAKEI

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Cover photo: Clockwise from Top left: One of the numerous stoats caught on camera during the trail camera trial; Ranger Sam Highet tracking down the sub-adult male "Pumba"; the site of the bush fire in Tongariro Forest. Sam was part of the team who battled the blaze; there is nothing like a good old blob of kiwi poo! 😊; and finally, ranger Tim Hall next to the log that he spent 3 hours cutting into with a silky saw to extract the adult female kiwi "Pohonga".

This report and the previous ones are available from the departmental website in pdf form; **https://www.doc.govt.nz/nature/native-animals/birds/birds-a-z/kiwi/docs-work/reports-and-publications/**

PARTNERSHIPS

Partnerships between the Department of Conservation DOC) and Ngati Hikairo, The National Kiwi Hatchery Aotearoa (at Rainbow Springs), Sanctuary Mountain Maungatautari, Project Tongariro, Wairakei Golf + Sanctuary, and Save The Kiwi (formerly Kiwis for kiwi) trust continue to be an essential part of the work in the Tongariro Forest Kiwi Sanctuary (TFKS).

THE NATIONAL KIWI HATCHERY AOTEAROA AT RAINBOW SPRINGS

The National Kiwi Hatchery Aotearoa plays a crucial role in the success of the TFKS, through the incubation and successful hatching of eggs lifted from nests via Operation Nest Egg™(ONE). Operation Nest Egg was scaled back this season (2021/22) due to the delay in the 1080 operation.
Seventeen eggs were taken to Kiwi Encounter and ten chicks hatched successfully which were later released into Wairakei Golf + Sanctuary.

NGATI HIKAIRO

Ngati Hikairo plays an important part in the TFKS and has a role and responsibility as kaitiaki for the enhancement of Western North Island brown kiwi within their rohe. Ngati Hikairo support recovery efforts by the Department of Conservation and are intent on kiwi conservation goals and objectives being met within the Tongariro Forest.

PROJECT TONGARIRO

Project Tongariro are involved in ecological projects throughout Tongariro National Park and surrounding areas. Their volunteers assist the TFKS team regularly with work such as transporting kiwi eggs and chicks to and from the National Kiwi Hatchery Aotearoa and carrying out other advocacy work.

SANCTUARY MOUNTAIN MAUNGATAUTARI (SMM)

Maungatautari is a fenced mainland sanctuary (3,363 ha, surrounded by a 47 km predator "Xcluder" fence) situated in the Waikato. In 2006, the Department of Conservation and Ngati Hikairo made an agreement with Ngati Koroki-Kahukura to contribute 20 founders to the kiwi population at SMM. This target was met with a total of 21 gifted kiwi. In return, since 2010, 14 offspring of some of the original founders have been released into TFKS. Sanctuary Mountain

Maungatautari re-strategised their kiwi programme in 2017, when a five-year widescale ONE programme was launched by the national charity trust "Save the Kiwi" (STK) in order to establish a permanent kiwi breeding population of around 500 individuals. This is part of a long-term national project focusing on growing source populations (kōhanga) of brown kiwi in fenced sanctuaries and offshore islands. The goal is to eventually translocate all surplus offspring into predator-controlled wild sites in the North Island. To stock SMM with additional founders, which is a Kōhanga site for Western brown kiwi, the aim was to catch and put transmitters on at least 100 male kiwi in the Tongariro, Taranaki and Whanganui areas. However, after initially capturing 12 birds at Tongariro during the first two seasons of the STK kōhanga programme, Ngati Hikairo indicated in 2019 that they would not support any further transfers of kiwi from TFKS to SMM over and above the original 20 founder agreement.
Therefore, no new birds have been caught for this project since the 2019/20 season at Tongariro.

NATIONAL KIWI CAPTIVE MANAGEMENT PROGRAMME

Since 2010, there has been a nationwide initiative to release all brown kiwi of the Western taxon from captive breeding institutions into multiple wild sites, following the completion of the western provenance DOC translocation plan. This approach is to enable captive institutes to have increased capacity to work with other (more endangered) taxa of kiwi. Fifteen kiwi have been released at TFKS since 2012, mainly from the Ōtorohanga Kiwi House. Two of these kiwi were translocated from Willowbank Wildlife Reserve at Christchurch. This season, a pair from Ōtorohanga Kiwi House was released near "Mako Track".

WAIRAKEI GOLF + SANCTUARY

Wairakei Golf + Sanctuary is a privately-owned golf course situated north of Taupo. A five kilometre "Xcluder" predator proof fence has been installed around the perimeter. This has created a predator free environment which can be used to benefit threatened plants and animals. The sanctuary is utilised as a kiwi crèche when undertaking ONE. Out of the ten juveniles that were present within the sanctuary this season, five of them reached safe weight and were released back into TFKS, with the remaining five planned to be released from July 2022 onwards.

OWHANGO ALIVE

Owhango Alive is an association driven by the local community aiming at protecting the Ohinetonga Scenic Reserve near Owhango village, which is one of the two main gateways into

the Tongariro Forest. The bridge over the Whakapapa river, linking the reserve to TFKS, is one of the main incursion routes for pests, in particular ferrets. The intensive trapping regime undertaken by the volunteers has thus become crucial in the battle against pests re-invading the Tongariro Forest. This 2021/22 season, 8 ferrets (63 since July 2018) were captured in Ohinetonga reserve and nearby farms, mainly in autumn and early winter. 52 feral cats were also captured this season.

NEW ZEALAND FOREST MANAGERS (NZFM)

Extensive plantation forests are situated south and east of TFKS and are managed by New Zealand Forest Managers Limited. They allowed us access to develop and sustain a crucial network of DOC250 traps on their managed forests bordering the TFKS and this reduces the risk of ferret invasion from the NZFM side.

EXECUTIVE SUMMARY

Tongariro Forest Kiwi Sanctuary (TFKS, at 19,840 ha) was established in 2000 for the development and testing of landscape-scale (10,000 to 50,000 ha) kiwi protection techniques (ONE and aerial 1080 operations). Up until 2010, TFKS aimed to achieve and maintain a representative sample of 200+ pairs of Western North Island brown kiwi (*Apteryx mantelli*) by 2017, involve community, and enhance public awareness (Tongariro Forest Kiwi Sanctuary Operational Plan, 2009). However, ferret predation events within the Sanctuary between 2009 and 2017 made it clear that no target could be achieved unless ferrets were controlled effectively. A permanent ferret trapping regime was therefore implemented at the end of winter 2018. Since then, one confirmed ferret depredation on kiwi has been recorded, in September 2021.

A key research focus of TFKS is to assess the effectiveness of cyclic landscape-scale aerial 1080 operations (broadcast at 1.5kg/ha) on kiwi chick survival and long-term population growth.
Since August 2011, the programme has shifted from a five-yearly 1080 cycle to a three-yearly cycle, aimed at achieving an annual growth rate of 4 % (TFKS annual report 2015/16), and accounting for the ferret predation events that initially only occurred from years three after 1080 operations. However, since 2017, our observations have shown that ferret incursions can happen at any stage of a 1080 operation and that solely relying on three-yearly 1080 cycles are insufficient to prevent the TFKS kiwi population from becoming locally extinct. A combination of permanent ferret trapping and three-yearly 1080 operations became essential and this was implemented in the season 2018/19. This management regime would allow the kiwi population to increase by about 7 % annually (see last season TFKS annual report and Appendix 1). The 1080 operation, scheduled for 2020, was finally performed on 27th May 2022, two years overdue. This timing means that the predator control regime for this last cycle has essentially switched to a permanent ferret trapping/five-yearly 1080 cycle.

Nineteen adult kiwi males were monitored in TFKS in 2021/22 (18 breeding males). Operation Nest Egg was performed on a limited number of nests this season due to the delay in the 1080 operation. Nine nests were found with a total of 17 eggs, resulting in ten successfully hatched chicks, of which five were released back into TFKS this season (the other chicks are still in Wairakei and will be released next season).
Nine adult females and eight sub-adults were also monitored this season for recruitment into the tagged breeding population or as sentinel birds (which would provide an early warning for ferret incursion if preyed upon). This monitoring also provides information about the distribution of kiwi within the Tongariro Forest and their survivorship. One monitored sub-adult died this season due to unknown causes.

Three adult kiwi died this season, with one confirmed to be preyed upon by a ferret. A ferret incursion response plan was immediately implemented, with the deployment of live cage traps and additional DOC 250s around the kill site and known corridors of previous ferret predation events. No ferret was captured; nonetheless, no further ferret predations on monitored birds were reported. Nearly 50 % fewer ferrets were caught in traps this season compared to peak numbers in 2020/21 – hopefully an indication of the effectiveness of the trapping programme, but time will tell.

Small mammal indexing (SMI) continues to be measured using tracking tunnels in TFKS and the results showed a successful initial rat and stoat knock down (0 % tracking rate) four and a half weeks after the 1080 operation. As expected, mice were detected on most lines and are due to rapidly increase in number while rat abundance remains low.
Trail camera traps, which are more sensitive at detecting pests than tracking tunnels, were deployed along tracking tunnel lines and have detected the presence of rats on five out of 15 lines after the 1080 operation. Mustelid detection decreased from 53 % three weeks before the operation to 0% after the 27th of May.

Ongoing kiwi call surveys are used to measure the extent of the impact of ferret predations on breeding birds by detecting the presence or absence of pairs in areas where no kiwi are monitored and by detecting any potential recruitment at historical listening sites after the 2014 and 2017 1080 operations. On average, 4.3 calls per hour were heard on the eastern side this season, which is the highest count recorded since the start of the surveys in the mid-nineties.

INTRODUCTION

Tongariro Forest Kiwi Sanctuary (TFKS), which is approximately 20,000 ha (Figure 1), was established in 2000 for the protection and recovery of the Western North Island brown kiwi taxon (*Apteryx mantelli*) within the central North Island. It is one of five sanctuaries set up nationwide to maintain significant populations of different kiwi taxa, and to develop and improve techniques in kiwi protection, specifically aiming to increase the survivorship of young kiwi as they are extremely vulnerable to stoat predation (Robertson 2004; Table 1). In addition, since ferrets have been identified as a major threat to adult kiwi, it has become essential to develop management prescriptions that effectively control ferrets.

This research has involved determining survival rates of kiwi chicks before and after aerial 1080 operations (Tables 1 & 2). TB Free NZ, in conjunction with the Department of Conservation carried out aerial 1080 operations as part of their regional TB-vector/possum control regime and for kiwi protection research in 2001, 2006, 2011, 2014 and 2017. This research was of national importance, indicating whether 1080 could be used as an effective tool for maintaining kiwi in large and/or relatively inaccessible areas throughout the country. Results showed that aerial 1080 operations benefited kiwi chick survival for two consecutive seasons in TFKS. Other forest birds also benefited from aerial 1080 operations with increased nest success for fantails for one or two consecutive seasons after 1080 operations, depending on the timing of rat re-colonisation (Robertson *et al*. 2019).

Our research objective between 2014 and 2019 was to measure the benefits of low sowing rates of aerial 1080 to kiwi chick survival (Scrimgeour *et al.* 2015). We moved from distributing 4kg/ha of toxin bait in 2006, to 2kg/ha in 2011 and down to 0.75kg/ha (with strip sowing) in 2014, whilst monitoring chick survival in response to these various regimes.
However, the focus for testing and pushing for low sowing rates was re-examined in 2016 and it was decided (based on the results from TFKS and from the national predator control programme called Tiakina Nga Manu (TNM)/"Battle For Our Birds" that the recommended sowing rate for future 1080 operation would be 1.5kg per ha with even broadcast sowing.

Another key objective is researching the need for effective ferret control, as it had become crucial to re-establish a high survival rate among the adult population (i.e. > 95 %) to prevent the TFKS population from becoming locally extinct. This has been a research-based approach for it to be applicable to other sites throughout the country (Tables 1 & 2).

Other work within the TFKS involves ongoing monitoring of adult kiwi for survival and breeding purposes, monitoring of sub-adult kiwi for breeding recruitment, and carrying out

kiwi call surveys. Mustelid and rodent numbers are also monitored using the standard tracking tunnel methodology (small mammal indexing) and trialling a 21-night mustelid survey using trail camera traps along the existing tracking tunnel transects.

This report presents results from these key areas of work for the 2021/22 financial year.

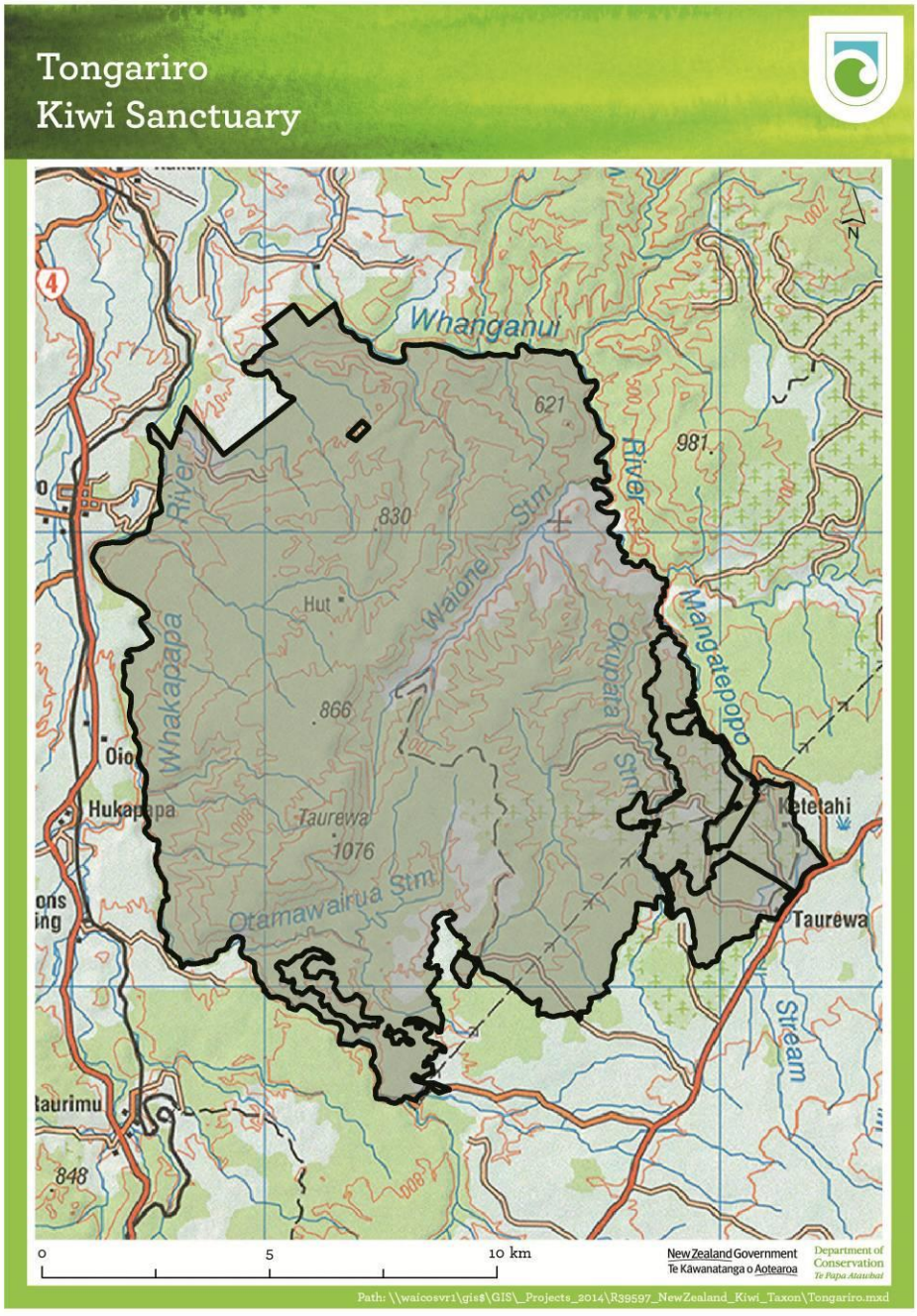


FIGURE 1: MAP OF THE TONGARIRO FOREST KIWI SANCTUARY, CENTRAL NORTH ISLAND

SANCTUARY OBJECTIVES AND ACTIONS

Five-year plan for Tongariro Forest Kiwi Sanctuary 2021-26, docCM-6415890

TABLE 1: TFKS VISION AND OBJECTIVES

Tongariro Forest is a whare wānanga – a place of learning – for conservation management	
Objectives	
We understand how to effectively protect kiwi	• The focus is to develop a transferable model of ferret control. • Developing result monitoring techniques to measure efficacy. Comparing camera traps with tracking tunnel results and kiwi chick survival. • Our understanding of the relationship between populations of rabbits and any future ferret incursions is improved to help predict and manage ferret risk. • The study is robust with adequate sample sizes and repetition to allow for clear conclusions.
What we learn teaches others to be successful	• This work informs national best practice for 1080, ferret control and outcome/result monitoring. • The method is tested in a way that can be transferred to other sites. • The team mentors/supports others with advice, leading transfer of knowledge.
We work successfully with our partners	• Tangata whenua feels a strong ownership of the sanctuary and the work that is done. • Community partnerships (e.g. private land owners allowing access, Owhango Alive catching ferrets) will be supported and sustained. • Sharing knowledge with stakeholders (e.g. Regional Councils, Manaaki Whenua) so that they can contribute to achieving the objectives of the plan.
If we are successful, kiwi will be protected, and the population will grow	

TABLE 2: TFKS ACTIONS

Protecting kiwi

#	Actions	Accountability	Priority
Predator Control and ONE			
1.1	Test the efficacy of protecting kiwi from ferrets by trapping dispersal pathways and hotspots.	TFKS	Essential
1.2	Record information on location of capture, gender, age and time of year of capture of ferrets and include in annual report. Collect tails for potential genetic analysis.	TFKS	High
1.3	Implement aerial 1080 every 3 years to supplement trapping.	Tiakina Nga Manu	Essential
1.4	Confirm with Tiakina Nga Manu certainty around aerial 1080 for the next two rounds.	TFKS	High
1.5	Undertake ONE in non-treatment years only if capacity and resources allow.	TFKS	Low
1.6	Work with DOC Compliance Officer and council if there are reports of wandering dogs, or if a kiwi is killed by a dog.	TFKS	High
1.7	Seek opportunities to improve signage highlighting rules about dogs in the sanctuary, and provide aversion training opportunities.	TFKS	Low
Outcome and result monitoring			
1.8	Monitor a minimum of 30 adult and/or sub-adult kiwi annually to ensure a large enough sample to determine efficacy of management, with good geographic spread across the sanctuary.	TFKS	Essential
1.9	Support the camera trap trial as an index of mustelid abundance by maintaining the tracking tunnels and analysing camera footage until 2023.	TFKS	High
1.10	Monitor chick survival in 2021/22 as a comparison against the camera index and to keep informing population models.	TFKS	High
1.11	Undertake territory mapping/call counts as an additional outcome measure.	TFKS	Medium
1.12	Develop a rabbit monitoring study design with Horizons in 2021. Undertake annual rabbit surveys. to determine if there is a link between rabbit numbers, rabbit management and subsequent ferret incursions.	TFKS	High

Capacity and resourcing			
1.13	Use the wider Biodiversity and Recreation teams to support trapping and tracking tunnels.	TFKS	Essential
1.14	Work with the Save Our Iconic Kiwi (SOIK) programme about support available for ferret management prescriptions, and seek other funding opportunities.	TFKS, KRG	High

Sharing knowledge

#	Actions	Accountability	Priority
2.1	Complete and publish the study on sub-adult survival, dispersal, territoriality and breeding age by 2025.	TFKS	High
2.2	Develop a ferret management resource that can be shared with kiwi practitioners (key lessons) – pro-active tips and tricks, as well as response plan.	TFKS	High
2.3	At least one presentation at the annual kiwi hui and western brown kiwi hui within the lifetime of this plan.	TFKS	High
2.4	Write an annual report and share with identified stakeholders by September each year (e.g. KRG, Manaaki Whenua, Regional Council, Conservation Board, Owhango Alive, landowners surrounding the sanctuary).	TFKS	Medium
2.5	Respond to re-active requests for advice depending on capacity at the time.	TFKS	Medium

SMALL MAMMAL INDEXING (SMI) USING TRACKING TUNNELS

Tracking tunnels for indexing rodent and mustelid (weasel, stoat and ferret) abundance are carried out during January, February, August and November every year to capture the peak in mustelid abundance. Methodology follows current DOC best practice (Gillies & Williams 2001). There are 15 tracking tunnel transects within TFKS; each line is 450 m long with ten tunnels, giving a total of 150 tunnels. TFKS is entering its 22nd year of small mammal indexing data gathering, making it the longest tracking tunnel data set in the country. This supports and increases our knowledge and understanding of small mammal population dynamics in relation to aerial 1080 use.

TRACKING TUNNEL RESULTS, FIFTH SEASON AFTER THE AUGUST 2017 AERIAL 1080 OPERATION USING 1.5 KG/ HECTARE OF PELLETS

Rat tracking reached its highest ever peak (95 %) in summer 2019/20, then reduced to under 40 % in January 2021 and fell to an all-time low (at this stage of a 1080 experiment, since the commencement of the monitoring in 2001) of just 21 % in January 2022 (Figure 5). As expected, mouse tracking has been extremely low and at times was undetected since January 2020, but peaked in May 2022 at 29 % as rat abundance plummeted (Figure 5). The reason why the rat population has decreased unexpectedly and has remained comparatively low for the last two seasons is unknown. Other sites are also experiencing this trend in rat numbers (e.g. Ruahine Range).

Mustelid tracking has remained very low during this 5-year 1080 cycle. It had risen to a mere 5 % in February 2020, to about 11 % in January 2021 and decreased to 7 % in January 2022, well under the usual 13-25 % reached during the third, fourth and fifth post-1080 summer (Figure 5).

The trail camera trial has nonetheless shown that the mustelid abundance within TFKS is high (Figure 2, Table 3), which was verified by the 2019/20 kiwi chick monitoring. The reason why tracking tunnels have not detected any increase in mustelid presence during this 1080 cycle as per previous 1080 operations is unknown. High interference from the high number of rats could have been the explanation during the 2019/20 season but this is no longer the case for the last two seasons.

Camera trap lines:

The TFKS is the only research site in the North Island where camera traps are trialled to monitor relative abundances of feral cats and mustelids (with kiwi chick survival and tracking tunnel data used as key comparisons against detection rates on the cameras). The cameras are

left for 21 consecutive nights. Camera trap lines are set along the 15 tracking tunnel lines comprising four camera stations set at 200 metre spacings. Each camera is directed to a lure (fresh rabbit meat) pegged to the ground about 60 cm in front of the device.

This technique has shown a real difference in mustelid detection sensitivity and has allowed us to accurately identify stoats and weasels (the latter seemed to have almost disappeared since January 2020) (Figure 2, Appendix 2). On the contrary, the use of the traditional three- night tracking ink cards detected either a few or no mustelid footprints (Table 3).

The camera traps also confirmed the decrease of rat detections observed during the tracking tunnel operations since January 2021 and the expected subsequent decline of stoat detections, which are the main predators of rats (Figure 2).

To date, no ferrets have been detected on the cameras.

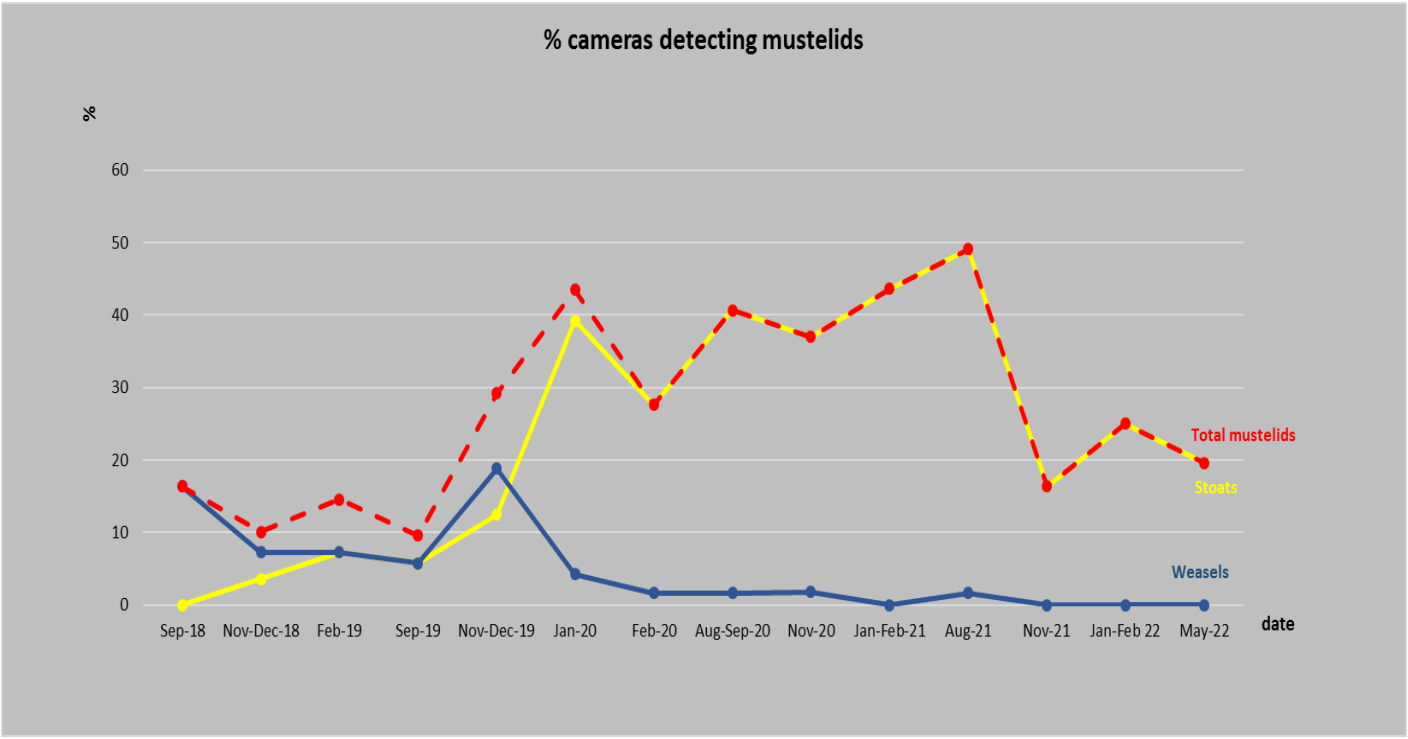


FIGURE 2: PERCENTAGE OF CAMERAS DETECTING MUSTELIDS

TABLE 3: MUSTELID COMPARISONS BETWEEN TRACKING CARDS AND CAMERA TRAPS

	3 nights (ink cards)		21 nights (cameras)	
	mean % tracking per line	% lines tracked	mean % tracking per line	% lines tracked
Sept-18	0	0	18.3*	46.7*
Nov-Dec-18	0	0	18.3*	46.7*
Jan-Feb-19	4	13.3	7.2*	26.7*
Sept-19	0	0	11.1	33.3
Nov-Dec-19	0	0	35.5	80
Jan-20	5	25	43.7	91.6
Feb-20	4	13.3	31.1	60
Aug-Sep-20	1.3	6.7	38.3	73.3
Nov-20	0	0	38.3	66.7
Jan-Feb 21	10.7	35.7	41.1	66.7
Aug-21	1.3	7	50.6	66.7
Nov-21	2.7	7	18.3	33.3
Jan-Feb-22	7.1	14	29.1	57.1

**10 nights*

Other detections:

Trail cameras are a useful tool to detect cats and possums in the forest and it appears that their numbers started picking up from year four after the 2017 1080 drop, which would suggest that with a 3-year 1080 cycle, cats and possums would have a minimal impact on native fauna and flora (Figure 3). The presence of cats is widespread as they have been observed in twelve out of the fifteen tracking tunnel/camera lines, predominantly on the western side of TFKS. They are often seen on the same cameras as monitored kiwi with some photos taken within hours of each other. This suggests that adult kiwi and feral cats can cohabitate.

Possums also have a widespread distribution as they were detected in 11 out of the 15 lines (Figure 3).

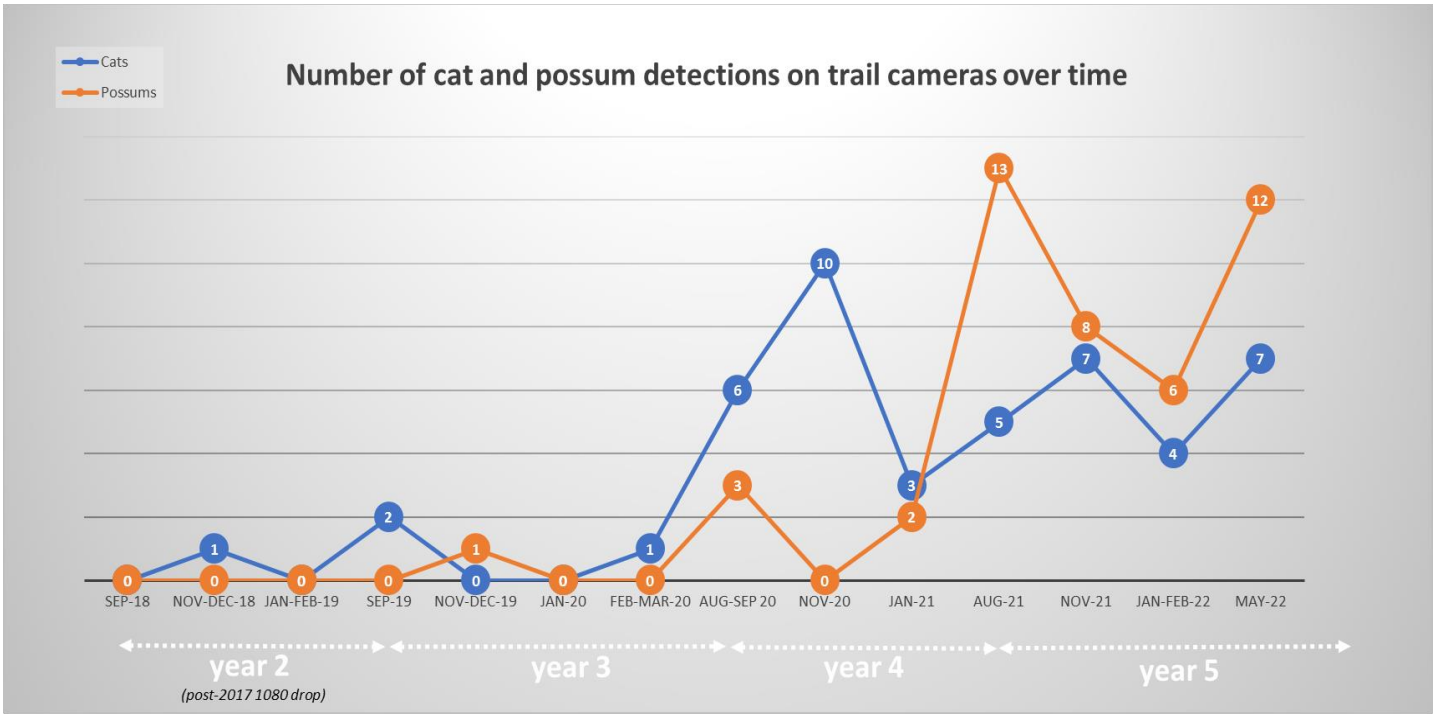


FIGURE 3: TREND OF CAT AND POSSUM DETECTIONS IN YEARS 2 TO 5 POST 2017 1080 OPERATION

Kiwi have been regularly observed on ten different lines and their detections have averaged at about four per camera operation since January 2020.

Other animals such as rats, dogs, red deer, goats, pigs, hedgehogs, rabbits, tomtits, robins, fernbirds, fantails, moreporks, riflemen, silvereyes, harrier and introduced birds were also detected.

The number of robin and tomtit detections continued to increase this year, being detected in 73.3 % and 60 % of the lines in May 2022 respectively (Table 4), probably benefiting from the rat tracking rates plummeting to 21 % in February 2022 from its highest peak of 95 % in January 2020 (Figures 4 & 5).

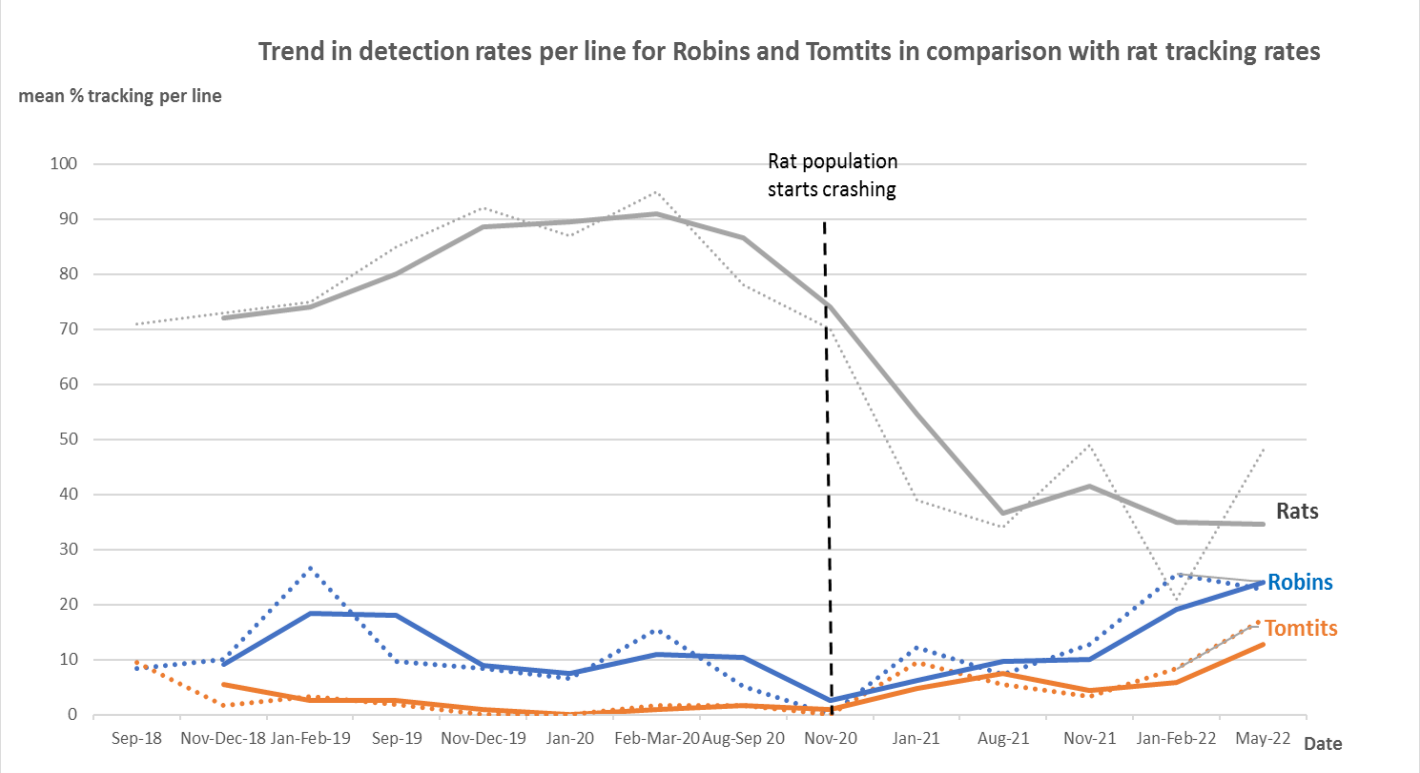


FIGURE 4: TRAIL CAMERA ROBINS AND TOMTITS DETECTIONS IN RELATION TO TRACKING TUNNEL RAT TRACKING RATES *(DASH LINES ARE ABSOLUTE VALUES AND SOLID LINES INDICATE MOVING AVERAGE).*

TABLE 4: ROBIN AND TOMTIT DETECTIONS ON CAMERAS

	Robins		Tomtits	
	mean % tracking per line	% lines tracked	mean % tracking per line	% lines tracked
Sept-18	8.3	41.7	9.4	41.7
Nov-Dec-18	10	26.7	1.7	6.7
Jan-Feb-19	26.6	73.3	3.3	13.3
Sept 19	9.6	33.3	1.9	6.7
Nov-Dec-19	8.3	26.7	0	0
Jan-20	6.5	13.3	0	0
Feb-Mar-20	15.51	46.7	1.7	6.7
Aug-Sep 20	5.1	13.3	1.7	6.7
Nov-20	0	0	0	0
Jan-21	12.2	46.7	9.4	26.7
Aug-21	7.2	26.7	5.5	20
Nov-21	12.8	33.3	3.3	13.3
Jan-Feb-22	25.5	57.1	8.3	28.6
May-22	**22.7**	**73.3**	**17.3**	**60**

TRACKING TUNNEL RESULTS, FIRST SEASON AFTER THE MAY 2022 AERIAL 1080 OPERATION USING 1.5 KG/ HECTARE OF PELLETS

After a delay of two seasons, making the previous 1080 cycle a five-year regime, the 1080 operation occurred late in this 2021/22 season, on the 27th of May. This makes the timing different to all the previous operations usually occurring towards the end of winter, immediately before kiwi chicks start hatching. It is unknown at this stage if this earlier timing will significantly change the beneficial impact that a 1080 operation usually has on the following two breeding seasons.

Department of Conservation (through the TNM programme) carried out the aerial 1080 operation over TFKS and undertook a conventional even broadcast method using 0.15% 1080 pellets in a cereal bait at a sowing rate of 1.5kg per hectare (excluding the 436 ha Owhango water catchment where baits were only trickled on the ridges away from the water courses).
The result targets for this operation were:

- Less than 5 % rat tracking; and
- 0 % stoat tracking.

The outcome target is for kiwi chick survival to exceed 50 % next season 2022/23.

SMI and trail camera operations/results:

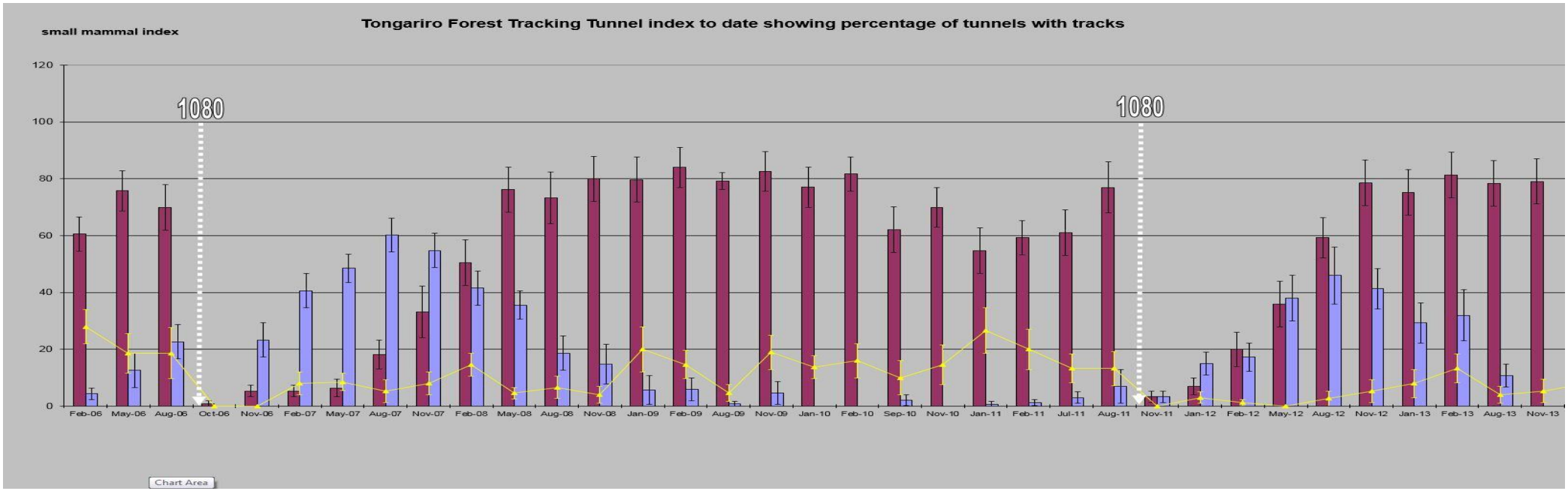
Two extra SMI operations were performed approximately three weeks prior to, and four weeks after the 1080 operation and the preliminary results are showing that our targets have been exceeded in terms of rat and stoat suppression. Excluding three SMI lines located within the Owhango water catchment, rat tracking rates went from 48% in May to 0% one month after the 1080 operation while mice tracking rates halved from 28% to about 14%. In comparison, within the water catchment, rat prints were found in all three lines and comprised a tracking rate of 23 %. This site provides one of the main sources of recolonisation of rats within TFKS.
As expected, no mustelids were detected after the operation, and the more sensitive trail cameras did not detect any stoat presence within TFKS, including the water catchment (Table5).

The cameras were set to take pictures continuously throughout the 1080 operation from the 6th of May to the 1st of August 2022. This allowed us to have confidence in the results obtained and it confirmed that rats have been suppressed to zero on the eastern side and to only fourteen rat detections on the western side (across five lines). Of these five lines, one was situated on the side of the exclusion zone along the first six kilometres of the 42 Traverse (eight detections on the 2 closest cameras to the track) and another line, where one rat was detected, was within the exclusion zone surrounding 10 Men Hut. Essentially, only five surviving rats were detected within the evenly broadcasted area. This is an outstanding result considering the high sensitivity of the cameras.

Mustelids, which were tracking at 22% just before the 1080 operation on the camera lines, were not detected by cameras up to the 1st of August 2022 (about eight weeks after the 1080 operation). This includes the water catchment, which demonstrates the efficiency of a 1080 operation at supressing stoats in a zone where 1080 baits were only trickled over the ridges (Table 5). Furthermore, no cats or possums have been detected on the trail cameras to date confirming the efficacy of this season's 1080 operation.

TABLE 5: MUSTELID COMPARISONS BETWEEN TRACKING CARDS AND CAMERA TRAPS BEFORE AND AFTER THE 2022 1080 OPERATION

	3 nights (ink cards)		21 nights (cameras)	
	mean % tracking per line	% lines tracked	mean % tracking per line	% lines tracked
Before 1080 (May 22)	1.43	7.1	22.2	53.1
After 1080 (July 22)	0	0	0	0



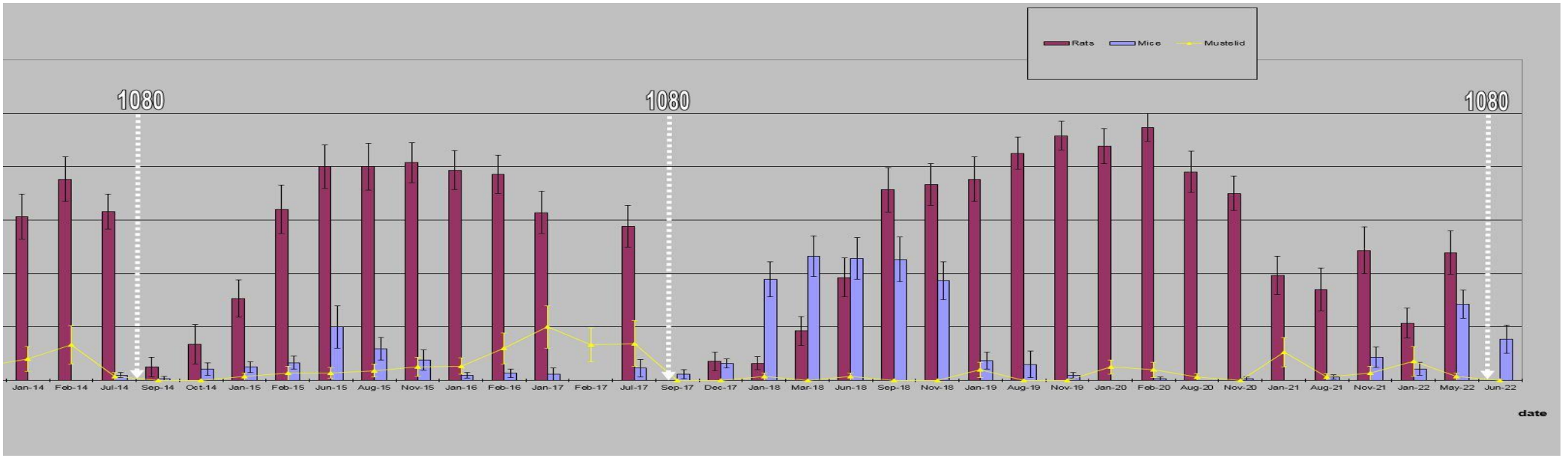


FIGURE 5: SMALL MAMMAL INDEXING RESULTS, TONGARIRO FOREST KIWI SANCTUARY, FEBRUARY 2006 – AUGUST 2022

ADULT/SUB-ADULT KIWI MONITORING AND NESTING

In this 2021/22 season, a total of 36 adult and sub-adult birds were tracked with radio transmitters, comprising 28 adults and eight sub-adults. Of the 28 adults, 19 were male (Table 6). Fifteen nested this year, with nine egg lifts undertaken. From the 17 eggs lifted, 11 were viable, resulting in 10 chicks destined to be released back into the TFKS (five were released this season with the remaining five to be released during the 2022/23 season).

This season experienced the first confirmed ferret depredation of kiwi (Ipo, in September 2021) since the permanent ferret regime was established in 2018. Traps could not be checked in the lead up to this predation event due to the August–September 2021 Covid-19 lockdown. One adult male (Hiver) and one sub-adult male (Emmet) also died, but they were too decomposed to know what the causes were. One adult female (Ruwhenua) died due to natural causes (had a bound egg which ruptured, leading to infection). Five birds had their transmitters removed this season (Comet, Oligo, Spike, Tapu, and Elara). Three birds dropped their transmitters (Eclipse, Georgie and Lima), and one had a failed transmitter (Jko4). A captive breeding pair from Ōtorohanga Kiwi House was released in March 2022 – only the male was tagged, thus Rata is a new addition to the monitored pool (Table 6).

TABLE 6: MONITORED ADULTS AND SUB-ADULTS 2021/22

Adult males		Adult females	Sub-adults
Speedy	Thunderbird	Pohonga	Elara ♀ **
Hiver*	Kumara	Oligo**	Emmet (Har2 ♂) *
Zazu	Harley	Georgie**	Pumba (Zaz1 ♂)
Dino	Strike	Irirangi	Lima (Ltm10 ♂) **
Dani	Jocko	Tapu	Kasca (Co4 ♀)
Rocket	Joe	Eclipse**	Dusty (Har7)
Comet**	Ipo*	Spike**	Jk04**
Pumpkin	Saros	Matata	Sunny (Yabba/Dn25)
Koroki	Rata	Ruwhenua*	
Lego			

**Died during the season*

*** Dropped transmitter, failed transmitter or transmitter removed*

Night Capture attempts:

To offset the loss of breeding males in our monitored population, kiwi night captures were undertaken in the first week of June 2022. As per last year, females seemed to be bolder and more responsive than males. As a result, no birds except for Tapu, a female who had been recently freed, were captured. It was decided to retain her as a monitored bird given that we

learnt that she had re-paired with an un-tagged male (which we nearly caught), following the death of her original mate Ipo in September 2021. Another unknown pair was also heard near Tapu's territory, on the other side of Top Track, but again, the female was very responsive while the male kept its distance. Finally, an additional night capture attempt was undertaken for another untagged male which had been heard whithin Elara's territory near where a recent bush fire had occurred (see next paragraph). This attempt was again unsuccessful as the male was very cautious and scarcely responded to our playback calls.

Bush fire:

On the evening of March 3rd 2022, an uncontrolled fire began along a section of the 42 Traverse on the western side (1 km north of the Top Track/42T junction) and spread into the gully which forms part of a formerly monitored female's territory (Elara, since cut free). This fire was either likely started by a discarded cigarette butt or unmanaged campfire. Over the next fortnight, the fire crew battled the blaze which proved difficult to extinguish because of the extended hot, dry conditions. By the 16th of March, the fire was officially extinguished, and up to 10 hectares of fern and scrub scorched on either side of the 42T. No birds could be monitored from the ground during this period due to safety concerns for staff; nonetheless, tracking from the plane on the 10th March confirmed that all monitored birds inhabiting the immediate and surrounding areas were still alive. Furthermore, kiwi probe holes were observed in the dampened ash, as well as kiwi calls heard by the fire crew during night monitoring duties (K Brocklehurst, pers. comms.). Elara was caught alive and well on the 22nd March only 125 m away from where the fire had been and as mentioned above, where her potential partner was heard during night catching sessions in early June.

FERRET TRAPPING

During the 2016-17 season, an unprecedented build up in the ferret population on surrounding farmland caused an increasing number of ferrets to disperse and expand their range further and further into TFKS. The invasion of ferrets inside TFKS resulted in 23 radio-tagged kiwi (17 adults) being preyed upon during that time. Therefore, the combination of a 3-yearly 1080 cycle and a reactive trapping approach in response to these predation events was ineffective to prevent ferret expansion within the TFKS. It appeared that a permanent trapping network would be more adequate to protect adult kiwi on a large scale, which is achievable within Tongariro Forest as the area is bordered by major rivers that act as natural barriers to ferrets (ferrets don't like swimming). To achieve this ground-breaking, landscape-scale ferret trapping operation with limited resources, trap locations needed to be strategically selected to target preferred ferret habitat such as open landscapes on surrounding farmland and boundaries of TFKS. Ferret dispersal pathways (directly linking the surrounding farms to the forest) and

"hotspots" (the locations being determined based on previous kiwi kills, ferret sightings and ferrets captures) within TFKS were also identified as a priority to trap. The main objective is to reduce the density of ferrets on bordering farmlands so that vacant territories outside the forest would be re-available for young ferrets in search of new territories to fill. This approach would considerably decrease pressure on the TFKS boundaries and should reduce, in the medium-term, ferret dispersal into the forest. The other important objective is to target ferrets that are already present within the forest by reinforcing the number of traps in known ferret "hotspots". Trail cameras could be a useful additional tool for detecting ferrets (although none have been detected so far).

Based on these objectives, the proposed permanent ferret management regime was decided during winter 2018. Traps have been added and moved as needed (i.e. if a ferret was caught at a site, more traps would be shifted into that area if not enough traps were present) and more traps were set up on surrounding farmlands, particularly those adjacent to the northern margin of the forest. The trapping on farmland directly south of the forest was also increased considerably as it provides an ideal ferret dispersal route that funnels into TFKS without encountering any major natural obstacles. And finally, DOC250s were also set up on the Hillary Outdoor Pursuit Centre side of the forest (east of the Mangatepopo Stream) as it was identified as another possible source from which ferrets can disperse (over the last 10 years, around twenty ferrets have been caught in DOC200 traps used in that area for whio protection) through river fords and the main SH47. To date, around 400 DOC250s have been set up and are checked at least once a month.

Outcome:

After four 1080 cycles during which ferret predation events occurred, a difference appeared in the frequency and extent of ferret incursions between the western and the eastern side of the forest (Taurewa ridge being the dividing line). Ferret incursions seem to be episodic in the east whereas predations in the west occurred severely for the first time during the 2016/17 season and again during the following season, seven months after the 2017 1080 operation. Ferret predations showed no sign of decline until a permanent trapping network was implemented in 2018. Trapping has had an immediate positive impact and reduced the number of roving ferrets within the sanctuary, preventing any further kiwi deaths between October 2018 and September 2021 when a kiwi was confirmed preyed upon by a ferret. To date, no more kiwi were proven killed by ferrets (Table 7). No ferrets were captured in the known hotspots since last season, suggesting that there may no longer be any resident ferrets within the TFKS.

Eastern side:

On this side, adult kiwi mortality from ferrets has always been suppressed during the first two years of a 1080 operation and predations would start from year three after each experiment. Since ferret predation was first noticed in the season 2008/09, the eastern side has experienced five seasons with high kiwi mortality caused by one or two individual ferrets each year, resulting in 31 kiwi known deaths (including 25 adults) over a period of nine years (Table 7).

This pattern seems to be confirmed by this current 1080 cycle where no birds died in the first two years and no ferrets were caught in the newly set up permanent trapping network until the third season after 1080, when a ferret was trapped in the middle of the "Frost Flats" (from where every incursion event began in the past) in January 2020. Although, during the last two seasons, no other ferrets were caught within the eastern side of the TFKS. Outside the Sanctuary, one ferret was caught on Kapoors Road (which borders forestry and the Taurewa Farm Station) and six in the forestry blocks, east of the Mangatepopo Stream.

Western side:

Ferret predation started for the first time during the third year of the 2014 1080 cycle and despite the effectiveness of the 2017 1080 drop the following season, ferrets re-colonised TFKS from the western side for the first time in year one of a 1080 cycle. This showed that the forest can be re-invaded by ferrets at any stage of a 1080 operation. It became urgent to undertake further ferret control to prevent the kiwi population from becoming locally extinct. In three consecutive seasons, 19 monitored kiwi deaths (including 14 adults) have been attributed to ferret predation and, during the 2018/19 season, at least three ferrets were dispersing simultaneously through TFKS. Since September 2018, only one kiwi has been proven to be killed by a ferret on 1st September 2021 (following the covid-19 lock down), suggesting that the trapping regime established on the nearby farms and within TFKS, has been very effective in controlling ferrets.

This season, the death of the single kiwi in September 2021 occurred at the start of Top Track (see map in Appendix 3) and despite the deployment of extra DOC250s and live capture cages during the following two months, no ferret was caught. This suggests that this was probably a roaming male, more focused on finding a female than hunting and its likely unsuccessful quest might have driven it outside the TFKS again.

During this 2021/22 season, only one ferret was trapped within the boundary of the Sanctuary on Mariner's Track, which links TFKS to the northern farms (see map in Appendix 3). All other captures occurred on the surrounding farms (n=8) and the adjacent Ohinetonga Scenic Reserve (n= 8).

Six additional ferrets were caught in DOC200s that comprise the whio protection security site. Of these, one juvenile ferret was caught on the Mangatepopo Stream, two in Maungakatote, and three on the Raurimu Landcorp Station.

Table 7: KIWI KILLED BY FERRETS THROUGH FOUR 1080 CYCLES WITHIN THE TFKS

		Kiwi killed by ferrets (n=51)	
1080 cycle	**Year in cycle**	**EAST**	**WEST**
2006	Year1	0	0
	Year2	0	0
	Year3	5	0
	Year4	12	0
	Year5	7	0
2011	Year1	0	0
	Year2	0	0
	Year3	3	0
2014	Year1	0	0
	Year2	0	0
	Year3	4	6
2017 Aug 2018	Year1	0	9
	Year2	0	4
	Year3	0	0
	Year4	0	0
	Year5	0	1

Start of permanent trapping network

Overall:

In total, 22 ferrets were caught this season, making a total of 196 ferrets captured since December 2016 (inside TFKS n=30, outside TFKS n=166) (Appendix 3).

Almost 50 % fewer ferrets were caught this season compared to 2020/21 (Figure 6) – hopefully ferret numbers continue to decline in the coming years.

In addition, 70 cats were caught in DOC250s this season, mainly on the farms north of TFKS.

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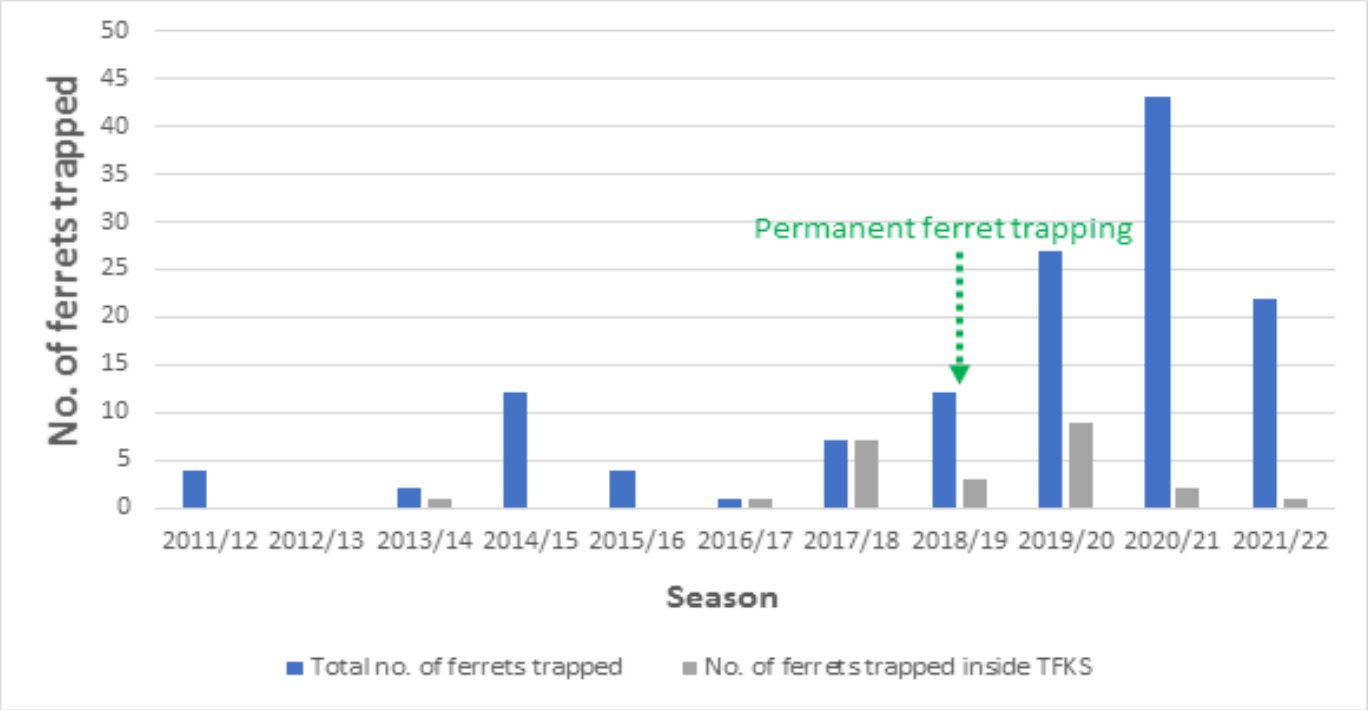

FIGURE 6: NUMBER OF FERRETS CAUGHT EACH SEASON, INCLUDING THOSE INSIDE TFKS (EXCLUDING OWHANGO ALIVE CAPTURES)

Based on the DOC250 trapping data for the last three years (2019–2022), peak numbers of ferrets occur in spring (breeding season) and autumn (juvenile dispersal). Ferret captures are expressed as percentages of captures per 100 trap nights (corrected trap nights, or CTN100), where trap nights is the number of nights a trap is set for a particular time period (the assumption being that when a trap is sprung the trap is set for half the nights since the previous check) (Figures 7 & 8). Another important learning has been the need to clear hedgehogs out of the traps during the critical peak periods for ferrets. Hedgehogs are very abundant on farmland and peak in numbers at a similar time as ferrets (Figure 9).

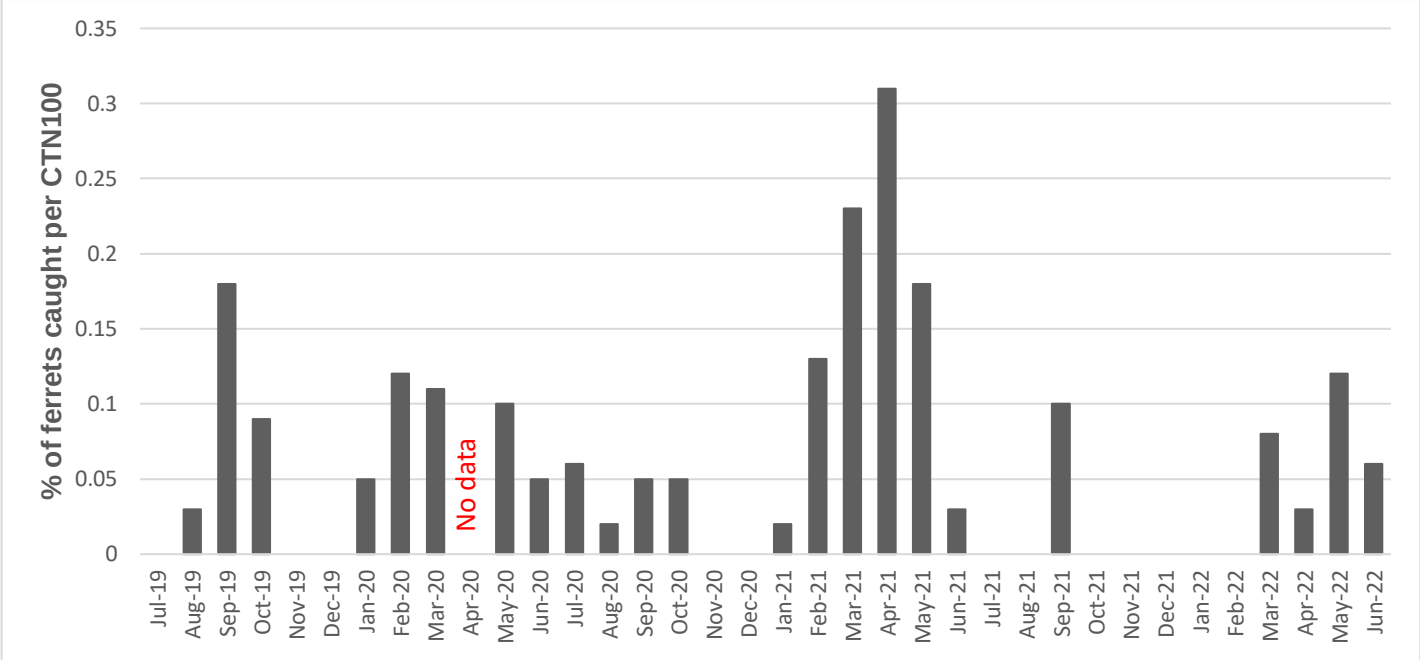

FIGURE 7: MONTHLY CORRECTED CATCH RATES (CTN100) FOR FERRETS TRAPPED FROM 2019 TO 2022. *(TRAPS COULD NOT BE CHECKED DURING THE APRIL 2020 COVID-19 LOCKDOWN, HENCE NO DATA)*

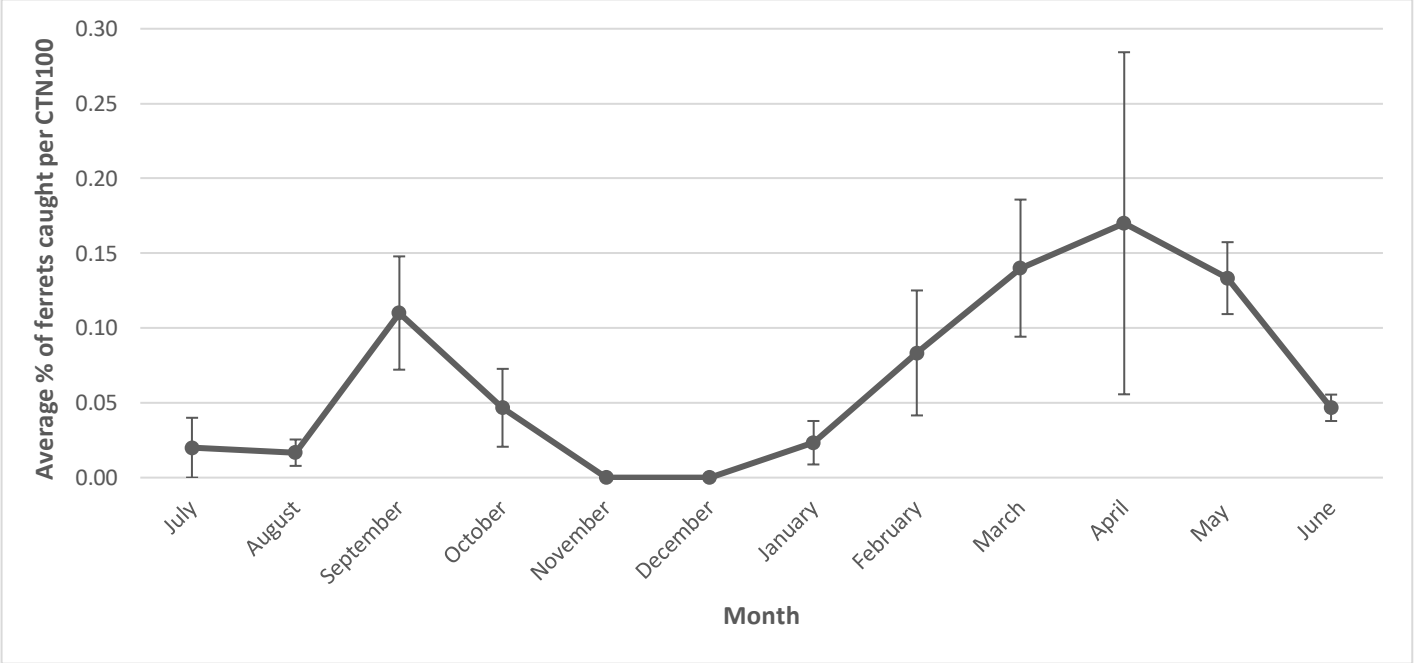

FIGURE 8: AVERAGE CORRECTED CATCH RATES (CTN100) FOR FERRETS PER MONTH, 2019-2022. STANDARD ERROR BARS ARE ALSO SHOWN

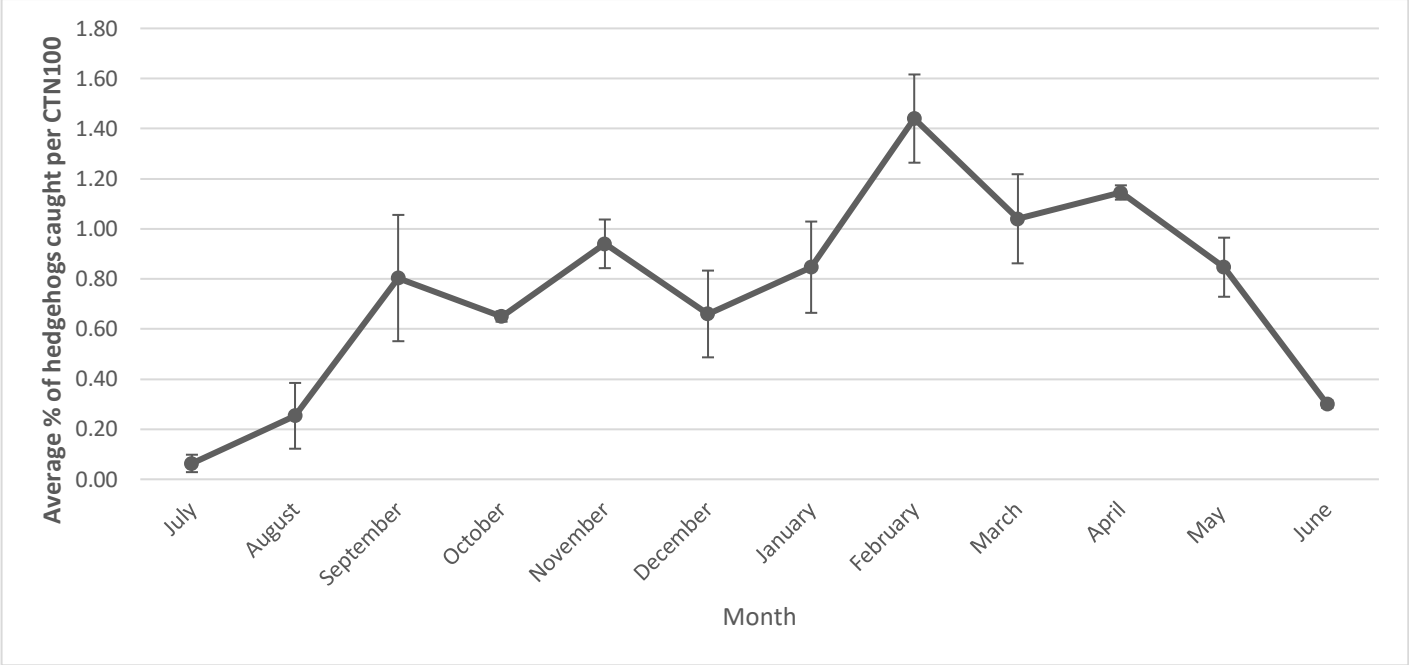

FIGURE 9: AVERAGE CORRECTED CATCH RATES (CTN100) FOR HEDGEHOGS PER MONTH, 2019–2022. STANDARD ERROR BARS ARE ALSO SHOWN

Key learnings so far:

- Increasing the size of the entrance hole in the DOC250 trap boxes has been a key learning; ferrets are much more likely to go into a trap where they don't have to squeeze into the box (cats also). This is a deviation from best practice, and we accept the increased risk of non-target catches as a result.
- The traps must be well placed; our best catching traps have been placed on either side of bridges (which forces the ferret to travel through that spot), along water courses, on sections of forest tracks linking farms and TFKS, at fence line intersections situated at the bottom or top of a hill, along bluff edges, on tracks that funnel through steep edges, near hay barns and more generally, on farmland with high rabbit populations.
- The Owhango community, through "Owhango Alive", have been key in the fight against ferrets; the town borders one of the main entrances into Tongariro Forest. Their work and the intensive trapping on the surrounding farmlands have been key in stopping ferrets before they get into the forest.
- We use fresh rabbit or horse meat as bait (big pieces), and the traps are checked and rebaited at least monthly, but generally more often as traps are cleared if we see something in them when we are travelling past. Fresh stoats (and rats to a lesser degree)

have also proved to be extremely good bait for ferrets- we have had good success leaving freshly caught stoats in the traps (especially for trapping female ferrets).

- Trap maintenance is important- keep the traps well maintained and cleaned (and ideally use stainless steel mesh)
- Moving traps in clusters to hot spots where ferrets were caught in the past is crucial as ferrets tend to follow paths used by conspecifics and as they can travel in family groups this would increase the chance of multiple simultaneous captures.
- Increase trap visits to clear hedgehogs out of the traps during the critical peak periods for ferrets (spring and autumn).

Key messages:

Three ferret incursions from year three after the 2006, 2011 and 2014 1080 operations on the eastern side and the various incursions on the western side since 2016 have had a detrimental impact on the adult kiwi of which survival is a crucial determinant factor for the population to be sustainable. With no management, the population would decline at a rate of 22 % per year and would become locally extinct within the next 15 to 20 years (Appendix 1, Table 10). This highlights the importance of removing ferrets from the environment. The projection for the three-year 1080 cycle combined with strategic ferret trapping shows that there is real potential for the population to grow remarkably at 7% per annum (see last season TFKS annual report and Appendix 1, Table 10). The population size of kiwi within the TFKS is currently estimated to be about 215 birds and could double in ten years provided consistent trapping and 1080 operations as mentioned above (Appendix 1, Figure 11).

MINI CALL SURVEY USING CALL RECORDERS

A total of eight automatic call recorders were placed on the eastern side of the forest. Four were placed at the same traditional locations used since the early 1990s and four were situated further within the sanctuary and along the 42 Traverse at sites that were used in 2013, 2014 and 2015.

For the traditional four-day kiwi call survey (using the two hours recorded just after dark), data were used from the period between the 25th and 28th of May 2022. This season, the acoustic recorders (n=4) detected on average 4.3 calls per hour which confirms the steady increase in call rates since 2015, when the call rate was at its lowest (1 call per hour) (Table 8).

TABLE 8: COMPARISON BETWEEN CALL RECORDERS RESULTS AT THE 4 TRADITIONAL SITES

	2011	**2013**	**2014***	**2015**	**2017**	**2020****	**2020**	**2022**
2h/night, 4 nights	1.15	1.27	1.92	1.03	2.31	2.5	3.63	**4.28**

**3 nights **3 sites*

The four other recorders placed further along the 42 Traverse were left in the forest between the 26th of May and the 15th of June and set to record from 1800 to 0000 each evening. The four first fine nights (the 26th, 27th, 28th of May and 4th of June) and the two hours recorded after dark were used to compare call rates between years. These results have also shown a large increase in call rate since they were first listened to in 2013, having reached a high of 4.7 calls per hour this season (Table 9).

TABLE 9: COMPARAISON BETWEEN CALL RECORDERS RESULTS AT EIGHT SITES USED SINCE 2013 (2H/NIGHT, 4 FINE NIGHTS*)

** except in 2014 when only 3 nights were used*

	2013 (48h listened)	**2014* (48h listened)**	**2015 (64h listened)**	**2021 (64h listened)**	**2022 (64h listened)**
Carcass hill*	15	14	14	34	45
Douglas fir*	7	12	4	18	12
Ponds*	7	19	8	6	32
Slip Way*	11	1	7	58	48
Opposite Canyon	2	0	14	38	49
Graffiti Bank	*Not surveyed*	19	27	47	48
Mamaku lookout	10	17	33	49	50
Waione	*Not surveyed*	7	9	21	16
TOTAL CALLS	**52**	**89**	**116**	**271**	**300**
CALLS/HOUR	**1.08**	**1.85**	**1.81**	**4.23**	**4.69**

The analysis of the overall data since 1993 confirm the population growth noted last year within the core area of the Sanctuary. It appears that the number of kiwi calls detected have reached a historical record this year and have bounced back since last season to numbers heard in the late 1990s when kiwi call rates were at their peak (Figure 10). The main difference though is that overall, kiwi range has shrunken dramatically in TFKS since the 1990s, particularly since the first ferret incursion occurred in 2009. Nonetheless, the number of kiwi within the core area should continue to increase and expand to vacated territories provided the current pest control regime supresses any further incursions from ferrets into TFKS.

Some evidence of reinforcement/strengthening of the population on the margin of their current range was observed around the start of Top Track (west side of TFKS) while attempting to capture wild birds in June 2022. Two unknown males were heard calling. On the eastern side, faeces and footprints are becoming more frequently observed in the Frost Flat area indicating a return to their once thriving kiwi habitat.

Kiwi sign and camera detections are also regularly seen near Tin Hut and the Owhango water catchment, showing that there are still kiwi in this area badly decimated by ferrets in the recent past.

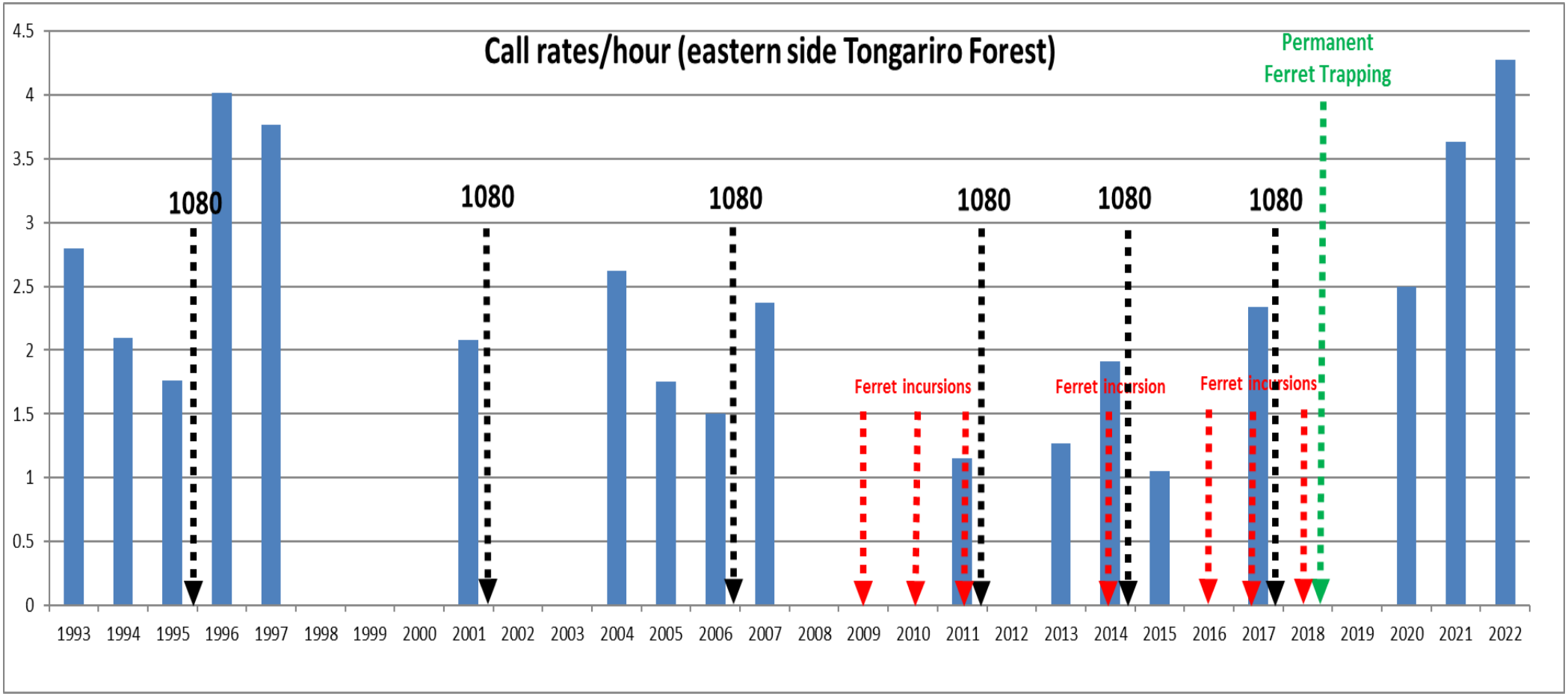

FIGURE 10: CALL RATES AND FERRET INCURSIONS SINCE 1993

FUTURE DIRECTIONS

The Kiwi Recovery Group and the DOC National Threats Advice team continue to explore funding and priorities in terms of ferret research nationally (understanding ferret movements, rabbit-ferret relationships, etc.) to fill the gaps around ferret knowledge, especially on a landscape scale (10,000-50,000 ha). Tongariro Forest is therefore an ideal place for this to happen. The focus around ferret trapping and monitoring sentinel birds has become vitally important and remains the priority in order to test whether ferret control can be achieved on a landscape scale using a strategic approach to protect kiwi.

Kiwi chick survival research will occur next season 2022/23 following the 1080 operation that occurred in May 2022.

Tracking tunnel indexes and the camera trap trial will also be continuing to keep refining this new method of monitoring mustelid abundance and to compare with kiwi chick outcome monitoring.

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APPENDICES

Appendix 1: POPULATION MODELLING

LESLIE MATRICES:

We used a population matrix model using data from different scenarios which were analysed in life tables (Leslie matrices) in PopTools (Microsoft Excel add-in) and translated into a population growth rate (Table 10).

Population modelling shows that the current three-year 1080 cycle management combined with an efficient ferret trapping regime has allowed the TFKS kiwi population to grow at about 7 % per year since 2019. It also shows that before 2006, when ferrets were absent and under five-year 1080 cycles, the population grew rapidly at about 5 % per year. On the contrary, during the period with multiple ferret incursions (2006-2019) the model confirms that the population declined dramatically under the five-year 1080 cycle at a rate of 10.5 % per annum (2006-2011) and continued to decrease, although at a much slower pace (- 0.94 % per year) after the switch to a three-yearly 1080 regime in 2011 (Figure 11).

TABLE 10: LIFE HISTORY PARAMETERS AND POPULATION GROWTH RATES

scenarios	**3 y. 1080 cycle with no ferret**	**3 y. 1080 cycle with ferret**	**5 y. 1080 cycle with no ferret**	**5 y. 1080 cycle with ferret**	**No management**
Chick survival (0-1y. old)	0.316	0.297	0.236	0.222	0.109
Sub-adult survival (1-2y)	0.842	0.831	0.842	0.831	0.831
Sub-adult survival (2-3y)	0.909	0.917	0.909	0.917	0.917
Sub-adult survival (3-4y)	0.968	0.919	0.968	0.919	0.919
Annual adult survival	0.982	0.878	0.982	0.777	0.708
Life expectancy (years) (*based on Adult survival only*)	**54.3**	**8.2**	**54.3**	**4.5**	**3.5**
Leslie Matrix, λ	1.071	0.991	1.053	0.895	0.781
Annual population growth	**7.1%**	**-0.94%**	**5.35%**	**-10.5%**	**-21.89%**

**productivity of 0.52 chick per adult per year was also used in the matrices.*

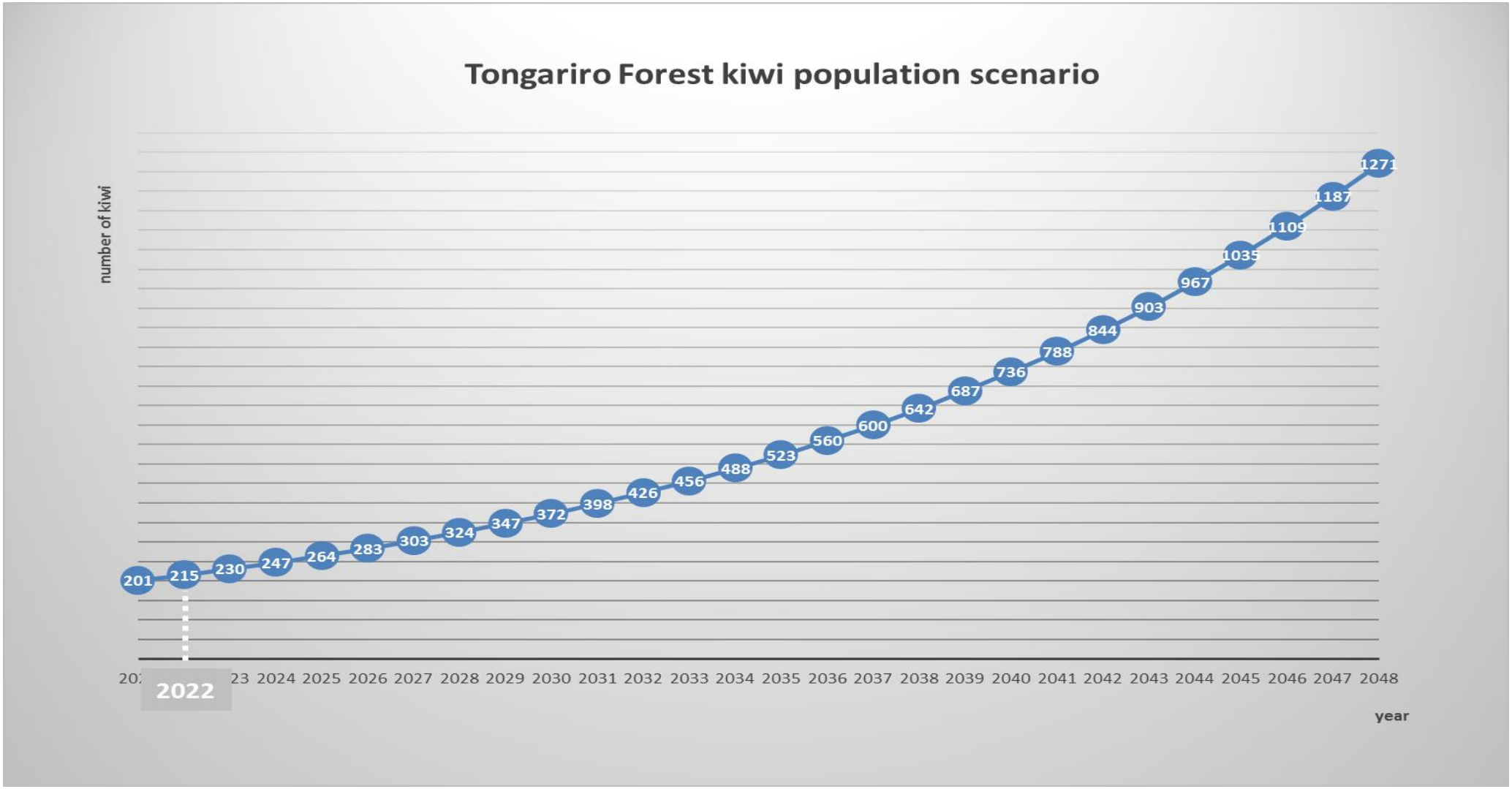

FIGURE 11: ESTIMATED KIWI POPULATION GROWTH AND COUNTS FOR THE NEXT 25 YEARS

Appendix 2: DETECTED MUSTELIDS ON TRAIL CAMERAS SINCE THE START OF TRIAL

	Stoats		Weasels		Total mustelids	
	Number of detections	% cameras detecting Stoats	Number of detections	% cameras detecting Weasels	Number of detections	% cameras detecting mustelids
Sept-18	0	**0**	31	**16.4**	31	**16.4**
Nov-Dec-18	6	**3.6**	15	**7.3**	21	**10.1**
Feb 19	9	**7.3**	7	**7.3**	16	**14.6**
Sept-19	6	**5.8**	63	**5.8**	69	**9.6**
Nov-Dec-19	8	**12.5**	26	**18.8**	34	**29.2**
Jan-20	60	**39.2**	2	**4.3**	62	**43.5**
Feb-20	28	**27.6**	1	**1.7**	29	**27.6**
Aug-Sep-20	64	**40.7**	1	**1.7**	65	**40.7**
Nov-20	77	**37**	1	**1.8**	78	**37**
Jan-Feb 21	131	**43.6**	0	**0**	131	**43.6**
Aug-21	105	**50.9**	1	**1.7**	106	**50.9**
Nov-21	12	**16.4**	0	**0**	12	**16.4**
Jan-Feb-22	45	**26.8**	0	**0**	45	**26.8**
May-22	72	**19.6**	0	**0**	72	**19.6**
July-22	0	**0**	0	**0**	0	**0**

Appendix 3: TRAPPED FERRETS FROM 2016 ONWARDS WITHIN TFKS, THE SURROUNDING FARMS AND OHINETONGA SCENIC RESERVE