Department of Conservation
Te Papa Atawhai

TONGARIRO FOREST KIWI SANCTUARY ANNUAL REPORT

July 2019– June 2020

TONGARIRO DISTRICT OFFICE, CENTRAL NORTH ISLAND REGION

Ngati Hikairo ki Tongariro

Report Compiled by: Jerome Guillotel, Jenny Hayward

Tongariro District Office, P.O. Box 71029, State Highway 48, Whakapapa Village,
Mt Ruapehu

September 2020

Contributors to Project/Report: Luke Tighe, Alison Beath**,** Will Kahu, John Polstra**,** Mathew Howell, Jeff Willis, Danial Van der Lubbe and Lois Allison-Cooper.

Cover photo: Clockwise from Top left: Young volunteer Anouk Guillotel holding Rau2 the chick in a very professional way (the only known surviving chick this season), aerial tracking antenna attached to a small "Mountain air" plane overviewing Tongariro Forest and the surrounding ferret inhabited farmland, ferret caught in one of the known Tongariro Forest hotspot along Mako track.

PARTNERSHIPS

Partnerships between the Department of Conservation and Ngati Hikairo, The National Kiwi Trust at Kiwi Encounter, Sanctuary Mountain Maungatautari, Project Tongariro, Wairakei Golf + Sanctuary and Kiwis for Kiwi Trust continue to be an essential part of the work in the Tongariro Forest Kiwi Sanctuary (TFKS).

THE NATIONAL KIWI TRUST AT KIWI ENCOUNTER

The National Kiwi Trust at Kiwi Encounter 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). This season (2019/20), 33 eggs were taken to Kiwi Encounter and 27 chicks hatched successfully. Of these, one was taken to Massey University for operation to remove an ingrown whisker and was released directly into TFKS at safe weight.

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 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 Trust at Kiwi Encounter and carrying out other advocacy work.

SANCTUARY MOUNTAIN MAUNGATAURI (SMM)

Maungatautari is a forested volcanic cone in the Waikato and has been the site of an ecological restoration project aiming to eliminate all mammalian predators and re-introduce native species. In 2006, the Department of Conservation (DOC) and Ngati Hikairo made an agreement with Ngati Koroki-Kahukura to contribute 20 founders to the kiwi population at SMM. This has been completed this year as two more chicks were supplied making a total of 21 gifted kiwi. In return, since 2010, 14 kiwi (the offspring of some of the original founders) have been released into TFKS. However, since 2017, SMM has been transitioning to a five-year widescale ONE programme launched by the national charity trust “Kiwis for kiwi”, which should see its permanent kiwi

breeding population boosted to 500 in the next five years. This is part of a long-term national project focusing on growing source populations (Kōhanga) of brown kiwi in fenced sanctuaries and offshore islands. This will eventually allow the translocation of all surplus offspring into predator controlled wild sites in the North Island. To stock SMM, which is a Kōhanga site for Western brown kiwi, the aim is to catch and put transmitters on at least 100 male kiwi in the Tongariro, Taranaki and Whanganui areas.

In total, 12 birds were caught in the two previous seasons at TFKS, among which five are male breeders.

However, Ngati Hikairo indicated in 2019, that at that stage they would not support further transfers of kiwi from TFKS to Maungatautari over and above the original 20 founder agreement. Thus, no more new birds were caught this season 2019/20.

NATIONAL KIWI CAPTIVE MANAGEMENT PROGRAMME

Since 2010, there has been a nationwide initiative to release brown kiwi of Western Taxon from captive breeding institutions into multiple wild sites, following the completion of a new western provenance DOC translocation plan. This is to enable captive institutes to have increased capacity to work with other (more endangered) species of kiwi. Thirteen kiwi including one breeding pair have been released at TFKS since 2012, mainly from Otorohanga kiwi house (two kiwi were translocated from Willowbank Wildlife Reserve at Christchurch). Five birds were due to be released this year, but the transfers were postponed to next season.

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 pest free environment which can be used to benefit threatened plants and animals. The sanctuary is utilized as a kiwi crèche when undertaking Operation Nest Egg ™. Three chicks from this season reached safe weight and were released into TFKS, whilst one still remains within the safe enclosure and will be released in spring 2020.

OWHANGO ALIVE

Owhango Alive is a community driven association aiming at protecting the Ohinetonga reserve by the 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. Thus, the intensive trapping regime undertaken by the volunteers has become crucial in the battle against pests re-invading the Tongariro Forest. Last season, 20

ferrets (38 since July 2018) were captured in Ohinetonga reserve and the nearby farms, mainly in autumn and early winter.

EXECUTIVE SUMMARY

Tongariro Forest Kiwi Sanctuary (TFKS) was established in 2000 for the development and testing of kiwi protection techniques, namely the use of Operation Nest Egg™ (ONE) and aerial 1080 operations. Up to 2010, TFKS aimed to achieve and maintain a representative sample of 200+ pairs of Western North Island brown kiwi by 2017 (Tongariro Forest Kiwi Sanctuary Operational Plan, 2009) and to involve the community and enhance public awareness. This target has been significantly compromised by ferret predation events in 2009-10-11 and 2014 leading to the revised objective in 2014 of growing the population to 100+ pairs by 2019 (National Kiwi Sanctuaries management plan 2015-2020). However, it became clear in 2018, following other ferret episodes in 2016/17 and 2017/18 that the target 100+ pairs would not be achieved unless ferrets were controlled efficiently. Therefore, a long-term ferret trapping regime (Following Tongariro Forest Long-term Ferret Trapping Plan, June 2018) was implemented at the end of the winter 2018. Since then, no ferret predations have been recorded.

A key research focus of TFKS is to assess the effectiveness of cyclic landscape-scale aerial 1080 (19,840 ha) operations on kiwi chick survival and long-term population growth. The population stopped declining in response to five-yearly aerial 1080 operations undertaken between 1995 and 2011, although this appeared insufficient for population recovery (TFKS annual reports 2013/14 and 2015/16). Therefore, the programme shifted to a three-yearly cycle from August 2011, aimed at achieving an annual growth rate of 4% (Population Modelling, TFKS annual report 2015/16), taking in account the ferret predation events that seemed to occur in year three after 1080. An additional regime of continuous ferret trapping was also recognized as a possibility to further increase population growth to 6 % (TFKS annual report 2017/18).

However, after the August 2017 1080 operation (third drop since the new 3-year cycle experiment was initiated in 2011), ferrets re-invaded the west side of the Tongariro Forest within seven months and killed 11 kiwi. This shows that ferret incursions could happen at any stage of a 1080 operation and that solely three-yearly 1080 may not be sufficient to prevent the TFKS kiwi population from becoming locally extinct. A permanent ferret trapping network in addition to 1080 operations had become essential and this was implemented last season 2018/19.

Twenty-four adult kiwi males were monitored in TFKS in 2019/20 (15 breeding males). There were 18 confirmed nests this season with a total of 33 eggs, resulting in 27 successfully hatched chicks, of which 20 were monitored at TFKS this season. The survival rate was 11%, which is the lowest ever recorded. This result shows that the increase of ferret trapping within TFKS has no impact on chick survival.

Eight sub-adults were also monitored this season for recruitment into the tagged breeding population. This monitoring also provides information about distribution of kiwi across the forest and survivorship. Of these, one died from unknown reason (far too decomposed when found) and one went missing.

Small mammal tracking rates continued to be measured in TFKS this year. After the initial rat knock down (0% of tracking rate) after the 2017 1080 operation in August 2017, rat tracking rate reached pre-1080 levels in September 2018 (70%), 13 months after the operation. This caused the mice to decline dramatically from above 40% tracking rate at its peak, to 7 % in January 2019 and 0% in January 2020. Mustelids tracking prints have been mostly undetected since the 2017 1080 drop, with tracking rates only reaching 4% in January 2019 and 5% in January 2020 (tracking rate was reaching 20% at the same stage of the operation in January 2017, the third year following the 2014 1080 operation). This would suggest that stoats are taking longer to recover compared to previous operations, but chick survival rate was at its lowest this year which shows a discrepancy between the two results. The additional pest mammal monitoring method using camera traps deployed along the SMI lines since September 2018 has shown much more sensitivity than tracking tunnels to detect mustelids and is supporting the fact that tracking tunnels haven't been working in a satisfactory manner during the last three post-1080 years. This is possibly due to a very high number of rats this season (tracking rate reached a peak of 95%) interfering with the rabbit meat baits present in the tracking tunnels.

Kiwi call surveys are also an ongoing undertaking and is 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, 2.5 calls per hour were heard on the eastern side which is the highest count since the start of the 3-year cycle in 2011.

INTRODUCTION

Tongariro Forest Kiwi Sanctuary (TFKS) is a 20,000ha area in the central North Island (Figure 1) established in 2000 for the protection and recovery of Western Brown Kiwi (*Apteryx mantelli*). It is one of five sanctuaries set up throughout the country to maintain significant populations of the different kiwi taxa, and to develop and improve techniques in kiwi protection, specifically aiming to increase the survivorship of young kiwi (Robertson 2004). In addition, since ferrets have been identified as a major threat to adult kiwi, it has become vitally important to develop management prescriptions to control ferrets effectively.

This involves determining survival rates of kiwi chicks before and after aerial 1080 operations (Table 1). 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 August 2017 (Appendix 1). This research is of national importance, indicating whether 1080 can be used as an effective tool for maintaining kiwi in large and/or relatively inaccessible areas throughout the country. Initial results have shown that aerial 1080 operations have benefited kiwi chick survival for two consecutive seasons in TFKS. Other forest birds have 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 the rat re-colonisation (Robertson *et al*. 2019).

Our research focus for the five years since 2014 was to measure the benefits of low sowing rates of aerial 1080 to kiwi chick survival (Scrimgeour *et al.* 2015). We have 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 (Table 2).
However, the focus for testing and pushing for low sowing rates was re-examined and it was decided (based on the results from TFKS and from the national predator control programme called "Battle For Our Birds" [BFOB] or Tiakina Nga Manu) that the recommended sowing rate for the 2017 1080 operation would be 1.5kg per ha with even broadcast sowing.
For the next drop, which has been postponed to 2021, the sowing rate and method of application should remain the same.

The other focus is 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%) in order for the TFKS population not to become extinct. This needs to be a research-based approach to be applicable to other sites across the country (Table 1).

Other work includes 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 tunnels methodology (small mammal indexing) and trialling a 21-night mustelid survey using camera traps along the existing tracking tunnel transects.

This report presents results from these key areas of work for the 2019/20 financial year.

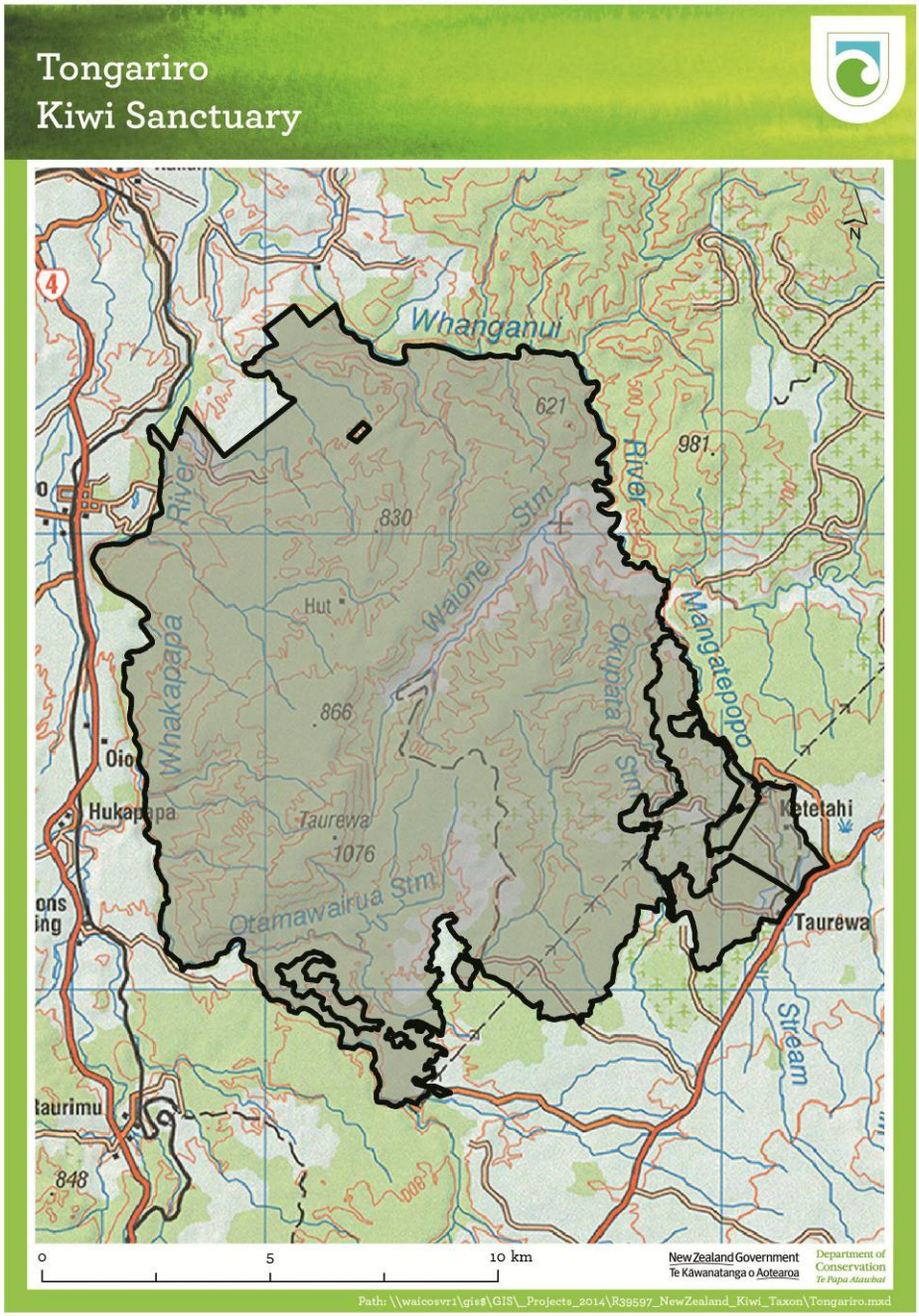


FIGURE 1: LOCATION MAP FOR TONGARIRO FOREST KIWI SANCTUARY, CENTRAL NORTH ISLAND REGION

SANCTUARY OBJECTIVES AND ACTIONS*

(National Kiwi Sanctuaries Management Plan 2015-2020 -DOC-1570100, Tongariro Forest Kiwi Sanctuary Ferret Trapping Plan -DOC-5510459, Kiwi Recovery Group Advice– Tongariro Forest Ferret Trapping -DOC-5541741, Tongariro Forest Kiwi and Whio review -DOC- 3207066)

TABLE 1: TFKS OBJECTIVES FOR 2020

Purpose
1. Investigate the efficacy of 1080 (1.5kg/ha) as a tool to protect and recover kiwi populations (mainly by measuring chick survivorship). 2. Investigate ferret control techniques to protect the TFKS adult kiwi breeding population. 3. Protect a population of Western brown kiwi at Tongariro Forest.
Objectives
1. The benefits to kiwi populations of low sowing rates for aerial 1080 operations are measured and understood. 2. The study is robust with adequate sample sizes and repetition to allow for clear conclusions and is applicable to other sites in New Zealand. 3. Our understanding of the relationship between rabbit populations and any future ferret incursions is improved. 4. Adult survivorship has improved by minimizing ferret impact.

TABLE 2: TFKS ACTIONS FOR 2020

#	Actions	Accountability	Priority	Progress
4.1	Continue 3-yearly aerial 1080 with the next operation in 2020	DOC	Essential	Postponed to 2021 due to higher priorities
4.2	Measure chick survival for the two seasons after the 2017 aerial 1080 operations.	TFKS	Essential	achieved
4.3	Implement permanent trapping regime to control ferret inside TFKS and on surrounding farmlands	TFKS	Essential	On track
4.4	Measure chick survival during the 3rd year after the 2017 aerial 1080 operation in relation to ferret trapping.	TFKS	High	achieved
4.5	Implement rabbit survey in the surrounding landscape annually. Collaborate with Landcare research on ferret research opportunities	TFKS, Regional Council	High	Possibly implemented in late summer during next financial year

4.6	Complete and publish the study on sub-adult survival, dispersal, territoriality and breeding age by 2016.	TFKS	Essential	On hold
4.7	Publish research on benefits of aerial 1080 on kiwi chick survival by 2014/15	TFKS & KRG	Essential	Achieved- Published January 2019

* *A 5-year plan 2020-25 is currently under review*

SMALL MAMMAL INDEXING (SMI) USING TRACKING TUNNELS

Tracking tunnels for indexing rodent and mustelid (weasel, stoat and ferret) abundance are run during January, February, August and November to catch the peak in mustelid abundance. Methodology follows current DOC best practice (Gillies & Williams 2001). There are 15 lines within TFKS; each line is 450m long with ten tunnels, giving a total of 150 tunnels. TFKS is entering its 20th 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, THIRD SEASON AFTER THE AUGUST 2017 AERIAL 1080 OPERATION USING 1.5 KG/ HECTARE OF PELLETS (Appendix 1).

The post-1080 season immediately after the August 2017 operation was a great success in terms of rat reduction as for the first time, rats were knocked down to a 0% tracking rate. This allowed mice to increase rapidly with tracking rates staying well above 40% until September 2018, when rats reached pre-1080 levels (about 13 months after the 1080 operation) and caused the mice population to decline. In January 2020 results showed mouse tracking at 0% and rat tracking rate was at its highest peak (95%) since the commencement of the monitoring in 2001 (Figure 2).

Mustelids were also well suppressed immediately after the drop and their tracking rate has remained very low since (no prints were detected in five of the eight tracking tunnel operations that followed the 1080 drop). The mustelid tracking rate has risen to a mere 5% in February 2020, well under the usual 13-20% reached during the third post 1080 summer (Figure 2). This is likely due to interference by the high number of rats in the environment taking the meat lures from the tunnels before the stoats get a chance, which reduced the ability of the TT's to detect stoats.

Camera trap lines:

The TFKS is the only site in the North Island where camera traps are trialled to monitor relative abundances of feral cats and mustelids (with chick survival and tracking tunnel data used as key comparisons against detection rates on the cameras). As an adjustment this year, the cameras were left longer for 21 consecutive nights. Camera trap lines were set along the 15 tracking tunnel lines consisting of four camera stations set at 200 metre spacings. Each camera was directed to a lure (fresh and dry rabbit meat) pegged to the ground about 60 cm in front of the device.

This has shown a real difference in mustelid detection sensitivity and has allowed us to accurately identify weasels (which seem to be more abundant in the winter/spring period) and stoats (Table 3), whereas the traditional three- night tracking cards had detected none or few mustelid prints (Table 4).

TABLE 3: DETECTED MUSTELIDS ON CAMERAS SINCE THE START OF TRIAL ON SEPT-18

	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

TABLE 4: MUSTELIDS COMPARISON BETWEEN THREE NIGHT TRACKING RATES AND 21 NIGHT CAMERA TRAPS:

	3 nights (papers)		21 nights (cameras)	
	mean % tracking per line	% lines tracked	mean % tracking per line	% lines tracked
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

This year, cameras proved to be a good tool to detect the presence of kiwi as they were seen in the four SMI runs. In February 2020, kiwi were detected on eight different cameras over four different lines. Other animals such as cats, dogs, red deer, goats, pigs, possums, rabbits, tomtits, robins, fernbirds, moreporks, riflemen, silvereyes and introduced birds were also detected.

The number of robin and tomtit detections have decreased this year, probably as the direct consequence of the high number of rats present in the system (Table 5).

TABLE 5: ROBIN AND TOMTIT DETECTION RATES 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

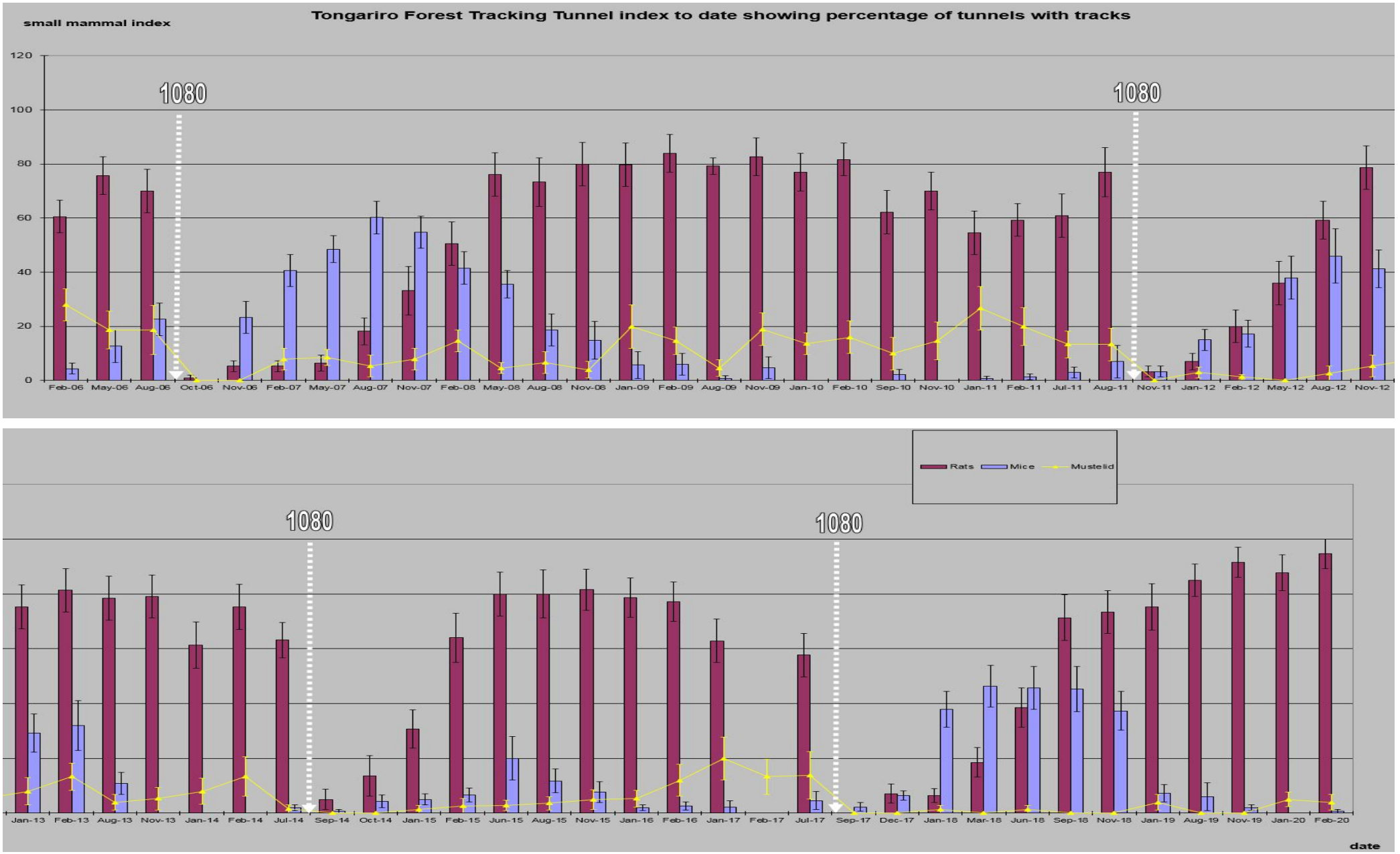


FIGURE 2: SMALL MAMMAL INDEXING RESULTS, TONGARIRO FOREST KIWI SANCTUARY, FEBRUARY 2006 – FEBRUARY 2020

ADULT/SUB-ADULT KIWI MONITORING AND NESTING

In the 2019/20 season a total of 37 adult and subadult birds were tracked with radio transmitters, comprising of 29 adults and 8 sub-adults.

Of the 29 adults, 24 were male (Table 6). Fifteen males nested this year resulting in 18 nests being monitored with eggs lifted and taken to Rainbow Springs Kiwi Encounter (Table 7).

This season two adult kiwi died; one was very decomposed when found so the cause of death could not be ascertained and one breeding male was found dead in a tomo so was recorded as "misadventure". Also, two females dropped their transmitters and one male went missing with transmitter failure being the likely cause. Of the subadults, one male died from unknown cause (too far decomposed) and one went missing.

Since October 2018, there was no confirmed predation from ferrets which corresponds with the start of the implementation of the permanent ferret trapping regime (Tongariro Forest Long-term Ferret Trapping Plan, Beath 2018) towards the end of the winter 2018.

TABLE 6: MONITORED ADULTS AND SUB-ADULTS 2019/20

Adult males		Adult females	Sub-adults
Speedy	Lego	Pohonga	Ottoman* ♂
Hiver	Thunderbird	Oligo	Elera ♀
Zazu	Marohirohi	Tailgate**	Saros ♂
Dino	Kumara	Georgie	Har2 ♂
Dani	Harley	Zette**	Zaz1
Rocket	Strike		Ltm10 ♂
Comet	Jocko		Co4
Raumati*	Joe		Mtk1**
Pumpkin	Matata		
Little moa	Ruwhenua		
Koroki	Te Aukaha Junior*		
Matariki	Von Trapp**		

**Died during the season*

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

OUTCOME OF THE IMPLEMENTATION OF A LONG-TERM FERRET TRAPPING REGIME

In the last five years, an unprecedented buildup in the ferret population on the surrounding farm landscape caused an increasing number of ferrets to disperse and expand their range further and further into TFKS. This resulted in 23 radio-tagged kiwi (17 adults) being preyed upon during that time. Therefore, the combination of a 3 yearly 1080 drop and a re-active trapping approach in response to these kill events were not effective enough to stop ferret expansion within the TFKS, and dispersal into TFKS. It appeared that a permanent trapping network would be more adequate to protect adult kiwi on a large scale and this seems to be achievable within Tongariro Forest as it is well bordered by major rivers which are likely to be natural barriers to ferrets (ferrets don't like swimming). In order to achieve this ground-breaking landscape-scale ferret trapping operation (this has never been attempted over an area of 20000ha before) with limited resources, the trap locations needed to be strategically selected to target preferred ferret sites such as open landscapes on surrounding farmland and boundaries of TFKS. Ferret dispersal pathways (directly linking the surrounding farms to the forest) and "hotspots" within TFKS were also identified as a priority. The main focus is to reduce the density of ferrets on bordering farmlands so that vacant territories outside the forest would be available again for young ferrets (in search of new territories) to fill. This would considerably decrease pressure on the TFKS boundaries and should reduce, in the medium-term, ferret dispersal into the forest. The other important focus is to target ferrets that are already present in the forest by reinforcing the number of traps in known ferret "hotspots" (the locations being decided based on previous kiwi kills, ferret sightings and ferrets captures). The camera traps (trail cams) that have been used on existing tracking tunnel lines since August 2018, could be a useful additional tool for monitoring ferrets (although none were detected so far).

Based on this, the proposed permanent ferret management regime was decided during winter 2018 and about 280 DOC 250s were deployed by October 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 already in place) and more have been set up on surrounding farmlands, in particular the farms adjacent to the northern margin of the forest. The trapping on farmland directly south of the forest has been also increased considerably as it provides an ideal ferret dispersal route that funnels into TFKS without encountering any major obstacles. More DOC250s are being set up on the Hillary Outdoor Pursuit Center side of the forest (east of Mangatepopo river) as it has been identified as another possible source from which ferrets can disperse (over the last 10 years, around twenty ferrets have been caught in DOC200 traps set up for whio protection) through river fords and the main SH47. To date more than 400 DOC 250s 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 has appeared 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 massively for the first time during the 2016/17 season and again during the following season, seven months after the last 2017 1080 drop. It showed no signs of decline until a permanent trapping network was implemented in 2018. Rapidly, the traps had a positive impact and reduced the number of roving ferrets within the sanctuary preventing any further kiwi deaths since October 2018 and for the first time any deaths from ferret in year three after a 1080 operation (Table 7).

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 (Table7).

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 this third season after 1080, when a ferret was trapped in the middle of Frost Flat (from where every incursion event started in the past) in January 2020. This would have probably prevented another ferret predation event on this side this season. Two other ferrets were caught along Danahars road which runs off Mc Donald road along the Mangatepopo stream.

Western side:

Ferret predation started for the first time on the third year of the 2014 1080 cycle and despite the effectiveness of 1080 the following season, ferrets re-colonized TFKS from the western side for the first time in year one of a 1080 cycle and showed, on this side, that the forest can be re-invaded at any stage of a 1080 operation. It became then urgent to undertake further ferret control to prevent the population from becoming locally extinct. In three consecutive seasons, 19 monitored kiwi deaths (including 14 adults) have been attributed to ferret predation and during last 2018/19 season, at least three ferrets were dispersing simultaneously through TFKS. This season 2019/20, no kiwi were proven killed by ferrets suggesting that the trapping regime put in place on the nearby farms and sanctuary has been efficient at suppressing ferrets.

This season one ferret was caught in February 2020 in the middle of Mako track where previous ferret attack episodes occured in the past and this capture, along with seven others that were caught along the start of the 42T, likely contributed to no kiwi adult deaths this year (Appendix 3).

Overall:

Since the beginning of the season 11 ferrets were caught within the sanctuary, 22 were caught in the surrounding farms and pine forests, whilst 20 were caught by Owhango Alive members within Ohinetonga reserve and adjacent farms. In total, 55 ferrets were caught this year making a total of 114 ferrets caught since August 2016 (inside TFKS n=27, outside TFKS n=87). (Table 7).

Table 7: KIWI KILLED BY FERRET THROUGH FOUR 1080 CYCLE

		Kiwi killed by ferrets (n=50)	
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

Start of permanent trapping network

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 haybarns 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 to the forest.
- We use fresh rabbit meat as bait (big pieces), and the traps are checked and rebaited a minimum of 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

NESTING AND EGGS OUTCOME

During the 2019/20 season there were a total of 18 confirmed nests from 15 different males. The eggs were lifted from nests in the wild and taken to Kiwi Encounter where they were incubated and hatched in captivity. Egg lifts took place after 60 days of incubation.

In total, 33 eggs were lifted, of which 27 hatched successfully. Of these, 20 chicks were fitted with chick mortality transmitters at hatch weight (approximately two weeks of age) and returned to their natal territory, or to a pre-determined release site within TFKS. Four were crèched at Rainbow Springs Kiwi Encounter until they were over 1kg then released into TFKS, and one is currently being crèched at Wairakei Golf and Sanctuary until Spring 2020. An additional two chicks were released to Sanctuary Mountain Maungatautari to fulfil our original agreement for 20 founders (Table 8).

TABLE 8: NEST AND EGG OUTCOME SUMMARY, 2019/20 SEASON

Male Kiwi (represents a breeding pair)	Confirmed nests	Total eggs	Hatched & released to TFKS	Hatched & released to Maungatautari	Eggs not hatched	Chicks that died at Rainbow
Harley*	2	4	3		1	
Jocko	2	4	2	1	1	
Dani	2	4	4			
Speedy	1	2	1			1
Dino	1	2	2			
Little Moa	1	2	2			
Strike	1	2		1	1	
Zazu	1	2	2			
Matariki	1	2	2			
Rocket	1	1			1	
Pumpkin	1	1	1			
Hiver	1	2	2			
Raumati	1	2	2			
Thunderbird	1	2	1		1	
Lego	1	1	1			
Total	18	33	25	2	5	1

*Harley - one of these chicks is being crèched at Wairakei Golf & Sanctuary until Spring 2020.

MINI CALL SURVEY USING CALL RECORDERS

A number of automatic call recorders were placed in strategic locations to gain more knowledge as to where breeding pairs were likely to have survived (or established new territories) following successive ferret incursions. Call counts were also carried out to detect any recruitment from the 2014 and 2017 1080 operations, essentially within the core area of the eastern side of the sanctuary for which we have the longest most reliable call count data.

A total of 12 listening sites were selected, three on the western side, in the recent ferret devastated area, and nine on the eastern side (four of these were at the same traditional locations used since 2011 and five were situated on the outskirt of the core area) . These recorders were left in the forest from the 26th of May to mid-July and set to record from 1800 to 0200 each evening.

Results:

Western side:

At the first listening site, along the last section of Top Track leading to 10 men hut, no calls were recorded, confirming that this area was badly hit by ferret predation and showing that kiwi haven't recovered yet. The second site was located around the second Mako crossing and a new pair was heard proving that kiwi are pushing westwards from the more populated area situated east of Top Track. The third site was located at the top of the "skid" (water track) where another new pair was heard. This came as a surprise as this area is close to Owhango and has experienced several waves of ferret incursions (some kiwi footprints were also sighted there and near the Owhango water catchment).

Eastern side:

The recorders placed on the outskirt of the sanctuary at five different sites have detected at least four new pairs, two pairs in the Frost Flat and two pairs near the end of Kapoors road and the pumice pit. This confirms that kiwi haven't completely disappeared from those areas highly vulnerable to ferret and kiwi might have even started re-colonizing theses territories.

Data from the four other sites were recorded from the 26th to 29th of May and used for the traditional four-day kiwi call survey using the two hours listened just after dark. The acoustic recorders (n=3, at the 4th site the call recorder failed) detected on average 2.5 calls per hour which is a significant increase from previous call counts and particularly since 2011, when the three yearly 1080 cycle was first implemented (Table 9).

TABLE 9: COMPARISON BETWEEN CALL RECORDERS RESULTS

	2011	2013	2014*	2015	**2017**	**2020****
2h/night, 4 sites	1.15	1.27	1.92	1.03	2.31	**2.5**

**3 nights **3 sites*

Through analysing the overall data since 1993, it appears that the number of kiwi calls detected have bounced back to numbers heard in the mid-2000s and this should continue to increase as the trapping regime put in place in 2018 (in combination with a 3 year 1080 cycle) supresses any further incursions from ferrets into TFKS (Figure 3).

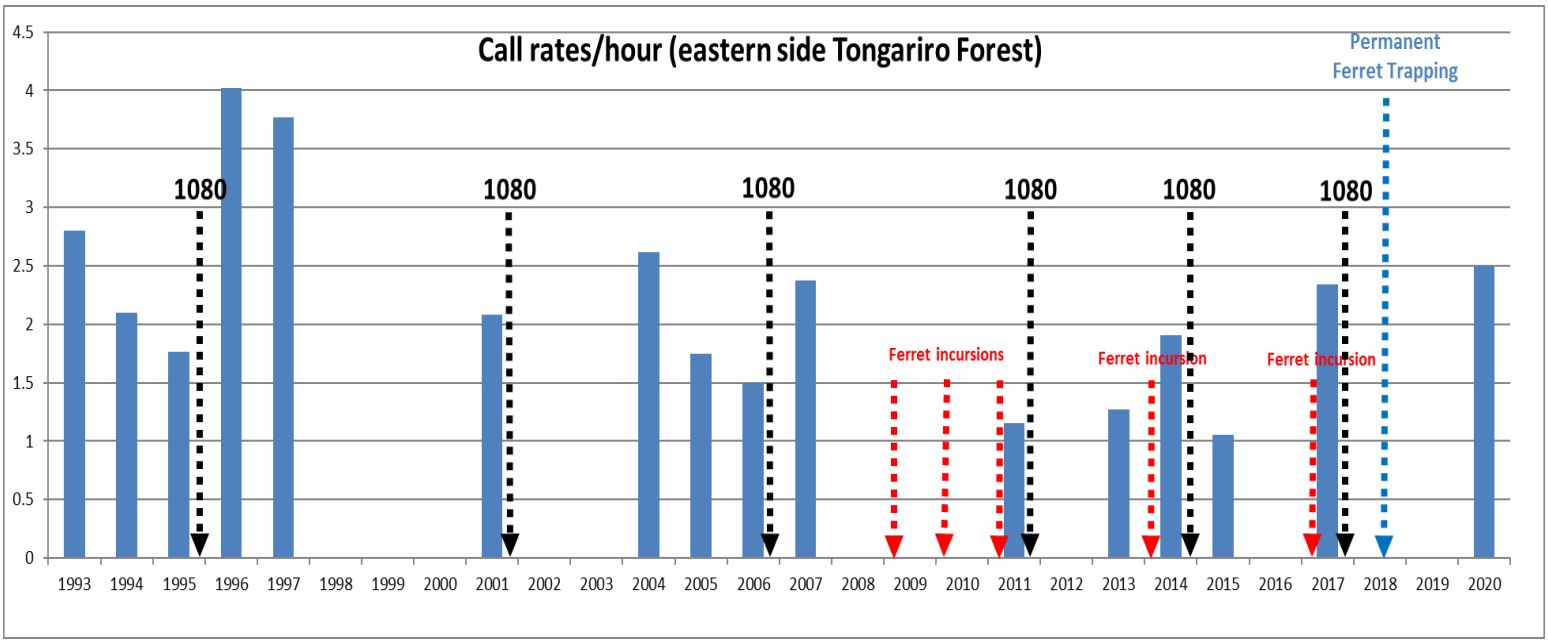


FIGURE 3: CALL RATES AND FERRET INCURSIONS SINCE 1993

KIWI CHICK MONITORING

Kiwi chicks have been monitored in Tongariro Forest Kiwi Sanctuary (TFKS) since 2005 to assess the effect of large-scale pest control operations (aerial 1080) on kiwi chick survival. Kiwi chicks are exceptionally vulnerable to stoat predation (McLennan *et. al.* 1996). Aerial 1080 operations were carried out in 2001, 2006, 2011, 2014 and 2017 for possum control and also targeted rats and thus stoats via secondary poisoning.

The 2019/20 season was the third season of monitoring after the 1080 operation carried out in August 2017.

MONITORING METHODS

Since the 2010/11 season, eggs have been lifted from nests in TFKS and hatched in captivity during the early stages of each season to ensure a sample size of no less than 16 kiwi chicks. This is in response to a ferret predation event that occurred between February 2009 and September 2011, where the number of radio-tagged breeding male kiwi was greatly reduced. Chicks hatched in captivity were returned to their natal territory, or preselected release sites, at hatch-weight (approximately two to three weeks of age).

Chicks had radio-transmitters fitted and were monitored by obtaining a signal for them at least weekly. They were captured every three to four weeks to have their transmitter strap replaced (as they grew) and to undergo health checks with weight and bill measurements taken.

If a mortality signal was received from the transmitter during the weekly check, the carcass was located, and cause of death ascertained through scene investigation and examination of the remains by staff. Remains were sent to NZ Wildlife Health Centre – Massey University, for necropsy.

To compare chick survival over twelve breeding seasons, survival rates to 183 days were calculated for each season using the Kaplan-Meier procedure, as recommended by Robertson and Westbrooke (2005), with 95% confidence intervals.

KIWI CHICK OUTCOMES AND SURVIVAL

This season, a total of 20 chicks were monitored in the TFKS. All the chicks were hatched in captivity and brought back to TFKS when they reached their hatch weight, at approximately 2-3 weeks of age. Of the 20 chicks, eight were released on the Western side of the forest, and twelve on the Eastern side.

The first chick was released into TFKS on 25/10/19 and the last chick was released on 12/2/20.

Where possible, the birds were released back into their natal territories. In cases where this was not feasible, an appropriate release site was chosen.

Of the 20 chicks being monitored this season, there have been a total of sixteen recorded mortalities. The first chick was killed on 3/11/19 from misadventure and the first possible predation occurred on the 25/11/19. The causes of death were determined by the Post-Mortem lab at the Massey University Wildlife Centre whenever possible and eight were deemed to be due to mustelid predation. There were five cases where the cause of death could not be confirmed (birds were too decomposed or there were not enough remains left at death site). The remaining three deaths were due to misadventure.

Of the remaining four chicks, two were lost due possibly to faulty transmitters, one dropped its transmitter and one chick has survived to reach sub-adult status (>183 days of age). This resulted in the lowest kiwi chick survival rate ever recorded in non-treatment years (third season of a 1080 operation); 10.9 % (Figure 4). This shows that despite the permanent network of ferret traps deployed around and within the Sanctuary, kiwi chicks do not survive better than when there were no traps at all.

In summary, following the August 2017 1080 operation, 81% chick survival was achieved in 2019/20 (one season post 1080), 51% survival was achieved in 2018/19 (two seasons post 1080) and 10.9% survived in 2019/20 (three seasons post 1080).

Despite the low success rate this year, this still makes the 2017 aerial 1080 operation the most successful one yet, in terms of kiwi chick survival over the two years after 1080. This indicates that a BFOB best practice regime of even bait sowing and 1.5kga/ha sowing rate, is the most effective one for kiwi chick survival.

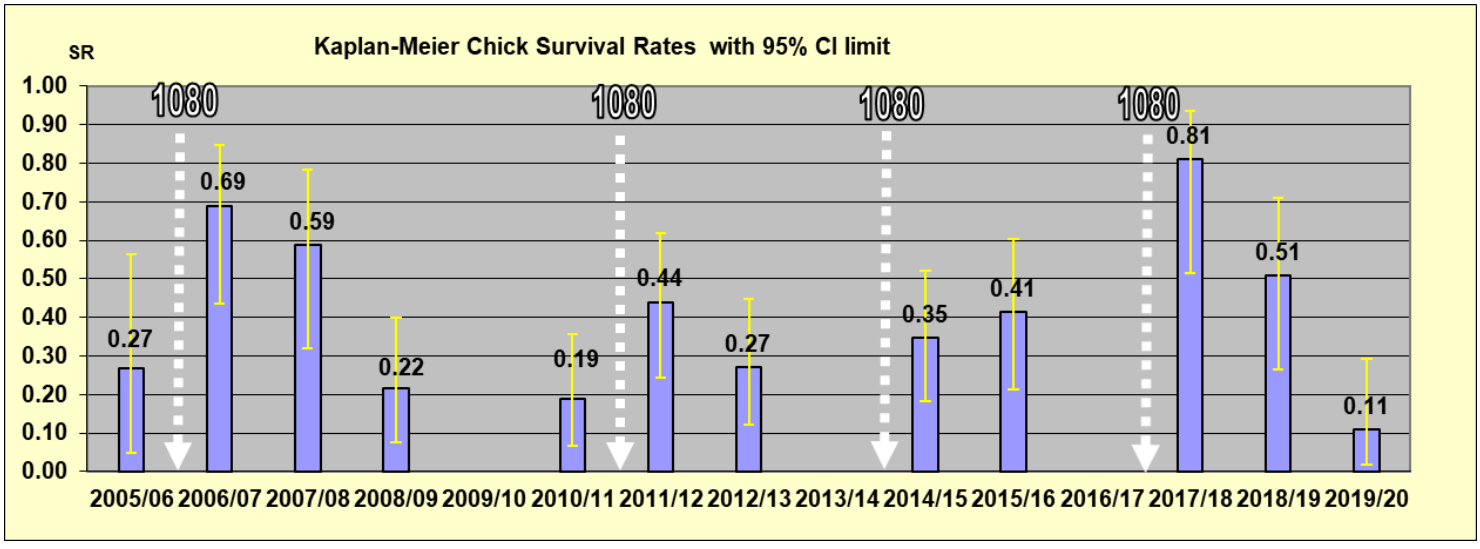


FIGURE 4: KAPLAN-MEIER KIWI CHICK SURVIVAL ESTIMATES FOR twelve BREEDING SEASONS, 2005-2020*

Traditionally there has been a marked difference between the eastern and western sides of Tongariro Forest, with the western side usually having a higher survival rate. However, the first two post-1080 season's results after the 2017 1080 drop contradicted past correlations regarding chick survival between the east and west (Figure 5). This would be directly related to the ferret predation events on the western side.

This season though, the western side survival results are consistent with previous non-treatment years (43%) as the eastern chick survival rate collapsed to 0% (Figure 5). This is possibly due to the lower density of ferrets living in the surrounding environment of the eastern side of TFKS (considerably less ferrets are caught in the traps on this side). This allow stoats (which compete with ferrets) to thrive and therefore, after a 1080 operation, to re-colonize easily accessible forest (fewer wide rivers to cross) more rapidly and in higher numbers.

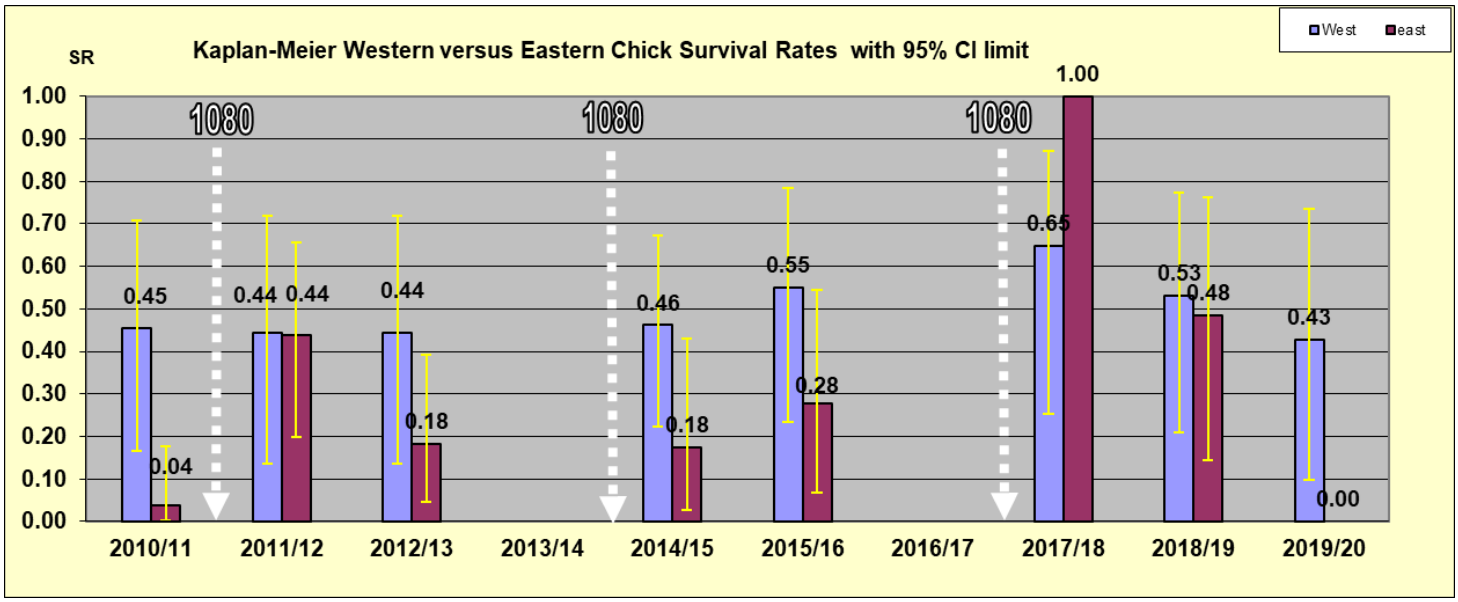


FIGURE 5: COMPARISON KAPLAN-MEIER KIWI CHICK SURVIVAL ESTIMATES BETWEEN EAST AND WEST OF TONGARIRO FOREST*

**Data from the 2009/10 and 2013/14 seasons are not included as chicks were crèched in predator proof fenced areas (Warrenheip or Wairakei Golf+ Sanctuary)*

FUTURE DIRECTIONS

The Kiwi Recovery group and the DOC National Threats Advice team continue to look at 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) and Tongariro Forest is 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.

Our research priorities around 1080 operations and kiwi chick monitoring are currently being reviewed and a five-year plan 2020-25 will be written
Kiwi chick survival research won't occur next non-treatment season 2020/21 as the next 1080 drop that was schedule to happen this coming season has been postponed to next year around August 2021.

Tracking tunnel monitoring will continue in the lead-up to the next scheduled Tongariro Forest aerial 1080 operation in spring 2021. The camera trap trial will also be continuing to keep refining this new method of monitoring mustelid abundance.

REFERENCES

Beath, A.M. 2018. Tongariro Forest longterm ferret trapping plan. DOCCM-5510459

Dawson, D.G., Bull, P.C. 1975. Counting birds in New Zealand forests. *Notornis 22*: 101-109.

Gillies, C.; Williams, D. 2001. Using tracking tunnels to monitor rodents and other small mammals. Department of Conservation. Unpublished best practice protocol.

Gillies, C. 2018. Interim DOC trail camera guide v1.0.1: Using camera traps to monitor feral cats and mustelids. DOCCM- 5489451

Haigh, A.; Poutu N.; Sutton N. 2014. Rat, Possum and Stoat control in Tongariro Forest Kiwi Sanctuary 2014. Unpublished operational plan. Department of Conservation, Whakapapa. DOCDM-1334298

Kiwis for kiwi investment strategy. Target: 2%, Working with New Zealanders to Grow Kiwi Populations, 2017

Kiwi Sanctuaries Management Plan, 2015-2020. Unpublished report. Kiwi Recovery Group. DOCDM-1570100

Kiwi Recovery Plan 2018-2028. Kiwi Recover Group, 2018.

McLennan, J. 2006. Western North Island brown kiwi (*Apteryx mantelli*): pathways to conservation and recovery. A technical report prepared for the Wanganui, Tongariro/Taupo and Waikato Conservancies of the Department of Conservation.

McLennan, J.A.; Potter, M.A; Robertson, H.A.; Wake, G.C.; Colbourne, R.; Dew, L.; Joyce, L.; Mccann, A.J.; Miles, J.; Miller, P.J.; Reid, J. 1996. Role of predation in the decline of kiwi, apteryx spp., in New Zealand. New Zealand Journal of Ecology 20 (1): 27-35

Robertson, H.A.; Guillotel, J. ; Lawson, T. ; Sutton, N. 2019. Landscape-scale applications of 1080 pesticide benefit North Island brown kiwi (*Apteryx mantelli*) and New Zealand fantail (*Rhipidura fuliginosa*) in Tongariro Forest, New Zealand. *Notornis 66* : 1-15.

Robertson, H.A. ; Colbourne, R.; McLennan, J. 2003. Kiwi Best Practice Manual.

Robertson, H.A.; Westbrooke, I.M. 2005: A practical guide to the management and analysis of survivorship data from radio-tracking studies. Department of Conservation Technical Series 31. Department of Conservation, Wellington. 47p.

Robertson, H. 2004. Research and monitoring plan for the kiwi sanctuaries. Science for Conservation 241. 24p.

Robertson, H.A.; Demonchy, P.J. 2012: Varied success from the landscape-scale management of kiwi *Apteryx* spp. in five sanctuaries in New Zealand.

Scrimgeour, J.; Germano, J.; Robertson, H.; Colbourne, R.; Sporle, W.; Beath, A.; Booth, A.; Livingstone, J.; Tawa, D.; Whitwell, L. National Kiwi Sanctuaries Management Plan 2015-2018. Unpublished report. Department of Conservation, Taupo. DOCDM-1570100.

Tongariro Forest Kiwi Sanctuary Operational Plan. July 2009-June 2014. Unpublished report. Department of Conservation, Whakapapa. DOCDM-207772

Tongariro Forest Kiwi Sanctuary Annual Reports 2013/14, 2014/15 and 2015/16. Unpublished reports. Department of Conservation, Whakapapa. DOCDM-1472890, DOCCM -2569795 and DOCCM–2824987.

Wairakei Golf + Sanctuary Kiwi Report 2017. Unpublished report. Department of Conservation, Taupo. DOCCM-3035169

Appendix 1

AERIAL 1080 OPERATION AUGUST 2017 (OPERATIONAL DETAILS)

Department of Conservation and TB Free NZ carried out a jointly funded aerial 1080 operation over TFKS in August 2017. This operation used 0.15% 1080 pellets in a cereal bait at a sowing rate of 1.5kg per hectare. Based on TFKS and "Battle For The Birds" programme research, the sowing rate was lifted from 0.75kg/ha to 1.5kg/ha and reverted from a strip sowing method (2014/15 TFKS Annual Report) to a more conventional even broadcast method (i.e. aiming for even coverage of baits throughout the forest with no gaps in bait coverage).

The result targets for this operation were:

- Less than 5% rat tracking September/October 2017; and
- 0% stoat tracking September/October 2017.

The outcome target was for kiwi chick survival to exceed 50% the season immediately after the operation.

Appendix 2

KIWI RECRUITMENT AND POPULATION GROWTH *(updated in June 2020)*

It appears that ferret events could happen at any stage of a 1080 operation and that a sole three-year 1080 regime may not be sufficient to grow the population as expected in the past years. It has become crucial to combine this with an effective ferret trapping regime to prevent the TFKS kiwi population from becoming locally extinct**.**

At this stage of the study, the population modelling shows a decline of 0.6% per year under a 3-year regime, much lower than what was predicted in the past (+4.3%).

If we were to have no management of the kiwi in Tongariro Forest, the population would decline at a rate of 20.5% per year into eventual extinction (Table 10).

To increase the population, a three yearly-1080 cycle combined with an efficient ferret trapping regime are necessary. This should grow the population by about 5.5% per year (Table 10).

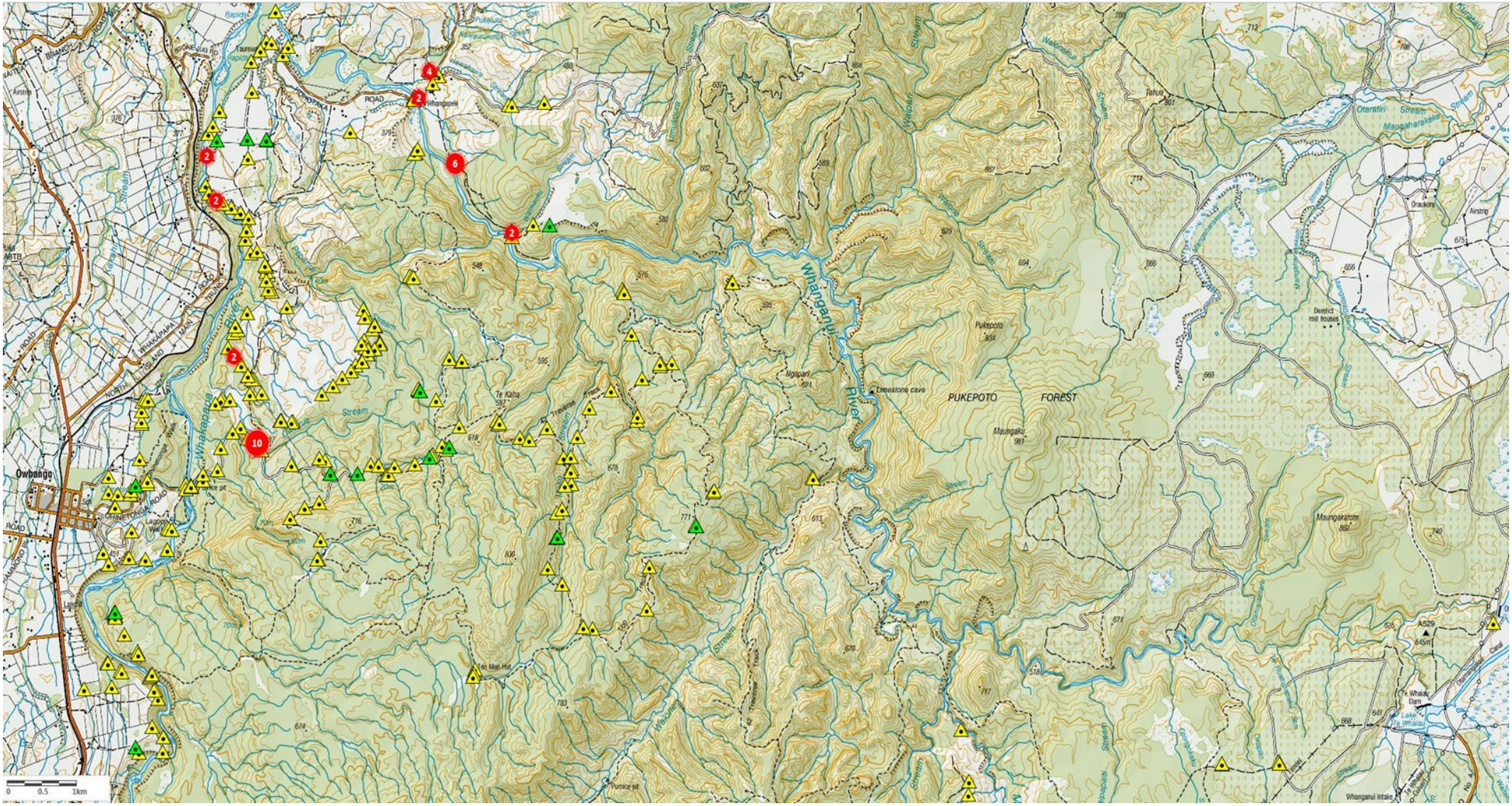
TABLE 10: RECRUITMENT AND ANNUAL GROWTH UNDER DIFFERENT MANAGEMENT REGIMES (*using June 2020 updated sub-adult survival rate (SR)=60.9%)*

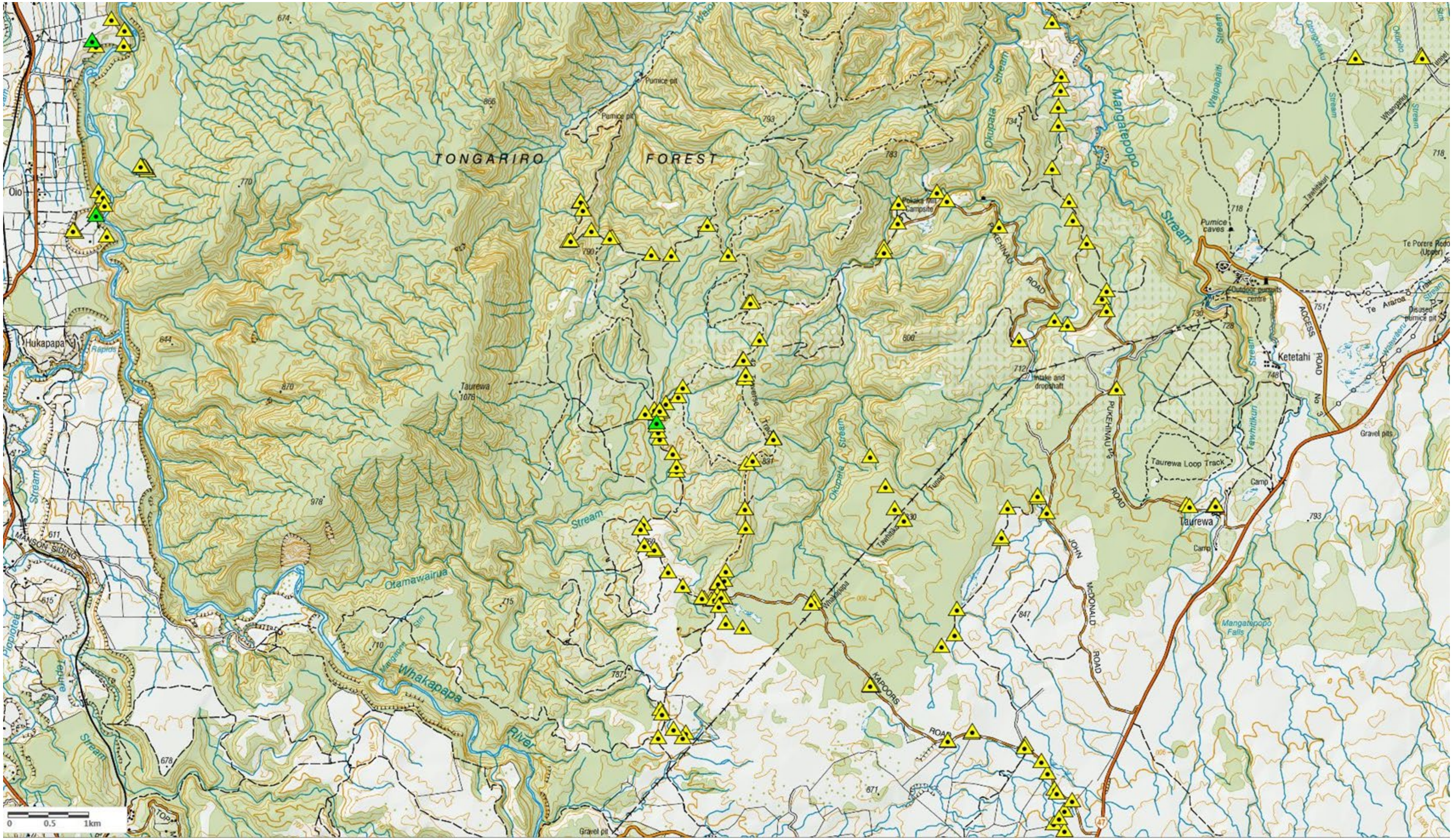
Management regime	Mean chick SR 0-6mths (%)	Adult SR (%)	Recruitment (%) for stable population	Actual recruitment (%)	Annual growth (%)
3y 1080 cycle	34.5	88.2	23.9	21	- 0.6
5y 1080 cycle	25.7	79	42.6	15.7	- 9.5
No management	12.6	72.5	53	7.7	- 20.5
3y 1080 cycle + DOC 250s	34.5	96.9	6.4	23.5	+ 5.5

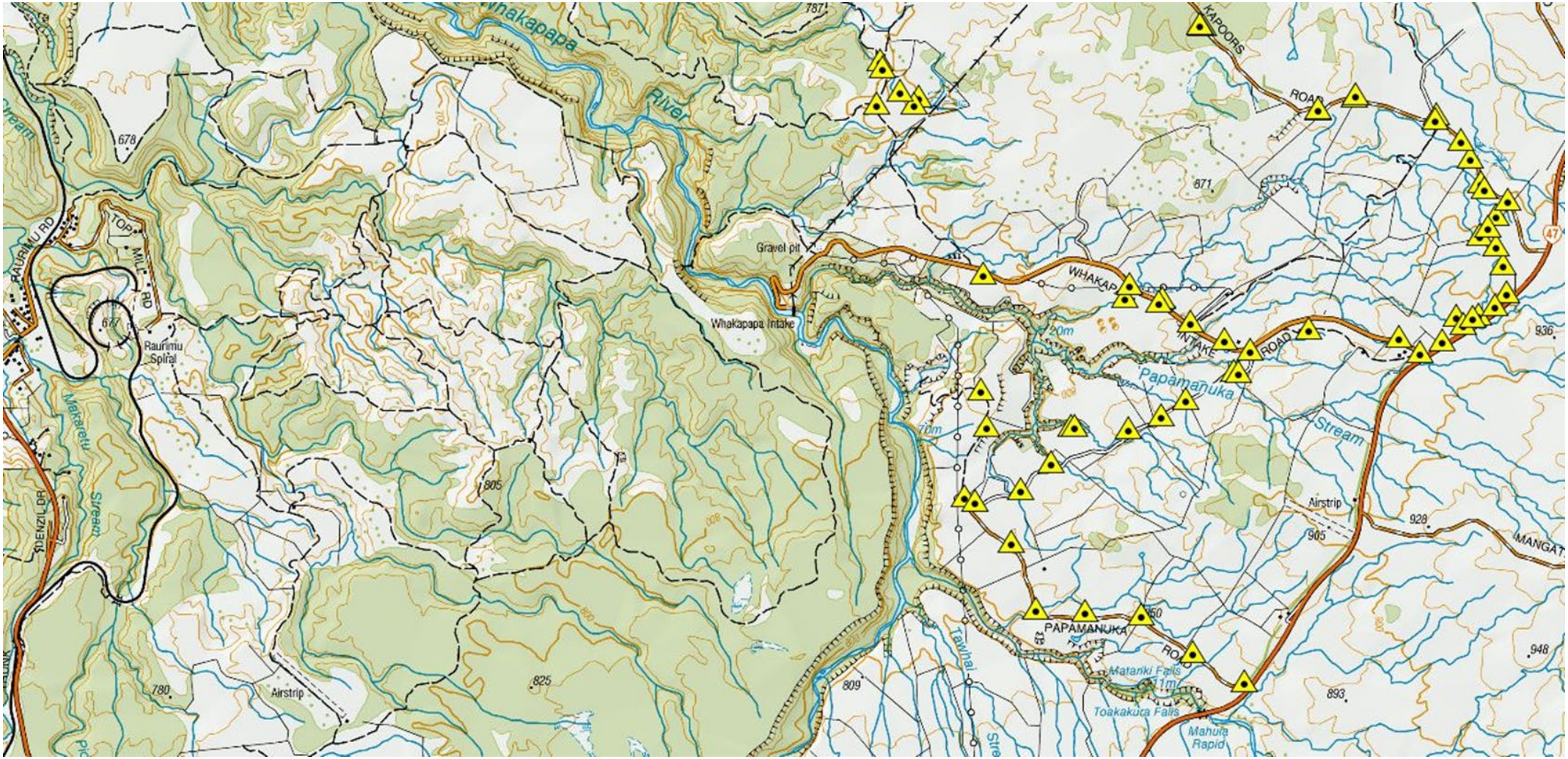
TABLE 11: IMPACT OF FERRETS ON KIWI ADULT LIFE EXPECTANCY (*July* 2020)

	Before Sept 2006 (no ferrets)	To date (ferrets)
Annual survival rate (%)	96.9	90.8
Life expectancy (years)	32	10.9

Appendix 3: FERRET DOC 250S TRAPPING NETWORK WITH CAPTURED FERRETS SINCE 2016 (SINGLE CAPTURE IN GREEN TRIANGLE, MULTIPLE CAPTURES IN RED CIRCLE.




TONGARIRO FOREST
Oio
Hukapapa
Rapids
Taurewa
1076
Pumice pit
Stream
Otamawairua
Whakapapa
River
Okupata
Stream
Mangatepopo
Stream
Pumice caves
Outdoor pursuits centre
Te Araroa Trail
Disused pumice pit
Ketetahi
ACCESS ROAD No 3
Intake and dropshaft
PUKEHINAU ROAD
Taurewa Loop Track
Camp
Taurewa
JOHN McDONALD ROAD
KAPOORS ROAD
Gravel pits
Gravel pit
Mangatepopo Falls
0 0.5 1km


Whakapapa River
Gravel pit
Whakapapa Intake
Raurimu Spiral
RAURIMU RD
TOP MILL RD
Makaretu Stream
Airstrip
Papamanuka Stream
PAPAMANUKA ROAD
Matariki Falls
Toakakuta Falls
Mahuta Rapid
Airstrip
MANGA
KAPOORS
ROAD
WHAKAP
INTAKE ROAD
Tawhai
678
677
805
825
780
809
787
671
936
928
905
948
893
47