Department of Conservation
Te Papa Atawhai

TONGARIRO FOREST KIWI SANCTUARY ANNUAL REPORT

July 2017– June 2018

TONGARIRO DISTRICT OFFICE, CENTRAL NORTH ISLAND REGION

Ngati Hikairo ki Tongariro

Report Compiled by: Jerome Guillotel, Jenny Hayward, Luke Tighe

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

September 2018

Contributors to Report: Alison Beath**,** Will Kahu, John Polstra**,** Mathew Howell, Malcolm Swanney (and Fern the dog), Jeff Willis and Renee Potae.

Cover photo: Top left: Kiwi Ranger Jenny Hayward holding 'Speedy'. Bottom left: Kiwi chick ready for release. Right: Kārearea (New Zealand Falcon) on an old spar, looking out at the Waione valley.

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 hatch of eggs lifted from nests via Operation Nest Egg™ (ONE). This season 2017/18, 34 kiwi eggs were taken to Kiwi Encounter and 22 chicks were released into TFKS.

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 and Ngati Hikairo made an agreement with Ngati Koroki-Kahukura to contribute 20 founders to the kiwi population at SMM and have so far gifted 15 kiwi. In return, since 2010, 14 kiwi (the offspring of some of the original founders) have been released into TFKS.

However, this year, SMM has been transitioning to a five-year wide scale 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 which eventually will allow translocations of any surplus offspring into predator controlled wild sites in the North Island. To stock SMM, which is the 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.
Five birds were caught this season at TFKS and at the time of writing, two of the males are confirmed breeders.

NATIONAL KIWI CAPTIVE MANAGEMENT PROGRAMME OTOROHANGA KIWI HOUSE

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. Eleven kiwi including one breeding pair have been released at TFKS since 2012. So far, all of these kiwi released into TFKS have been from the Otorohanga Kiwi House.

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 ™. This season, two chicks from 2016/17 reached safe weight and were released back into TFKS.

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. As the bridge over the Whakapapa river, linking the reserve to TFKS, is one of the main incursion route for pests, in particularly ferrets, the intensive trapping regime undertaken by the volunteers has become crucial in the battle against pests re-invading the Tongariro Forest.

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 has become clear this season, following other ferret episodes in 2016-17 and 2018 that the target 100+ pairs won't be achieved unless ferrets are controlled efficiently. Therefore, a long-term plan (Tongariro Forest Long-term Ferret Trapping Plan, June 2018) has been proposed this year to implement an effective ferret control regime before the end of the winter 2018.

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, this season, 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 a sole three-year 1080 may not be sufficient to prevent the TFKS kiwi population from becoming locally extinct. Implementing a permanent ferret trapping network in addition to 1080 operations has become essential.

Twenty-seven adult kiwi males were monitored in TFKS in 2017/18 (19 breeding males). There were 18 confirmed nests this season with a total of 34 eggs, resulting in 22 successfully hatched chicks being monitored at TFKS in the 2017/18 season. The survival rate was 81%, which is the best results ever achieved at Tongariro Forest and across the country.

Ten sub-adults were monitored this season for recruitment into the tagged breeding population. This monitoring also provides information about distribution of kiwi across the forest. Of these, two presumably died from ferret predation and two others lost their transmitters.

Small mammal tracking rates continued to be measured in TFKS this year and two weeks after the 2017 1080 operation in August 2017, rat numbers were knocked down to 0% for the first time since Small Mammal Index monitoring began in 2001. The rat tracking rate of 36% was still below the mice tracking rate of 47% when last measured in June 2018. As expected, mustelids were tracking at 0% and have remained low since, oscillating between 0 and 2%.

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).

This involves determining survival rates of kiwi chicks before and after aerial 1080 operations (Table1). 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 and 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).

Our research focus for the five years from 2014 onwards 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, monitoring chick survival in response (Table2).
However, the focus for testing and pushing for low sowing rates has been re-examined and it was decided, based on the latest results from TFKS and from the national predator control programme called “Battle For Our Birds” (BFOB), that the recommended sowing rate for the proposed 2017 1080 operation would be 1.5kg per ha, with even broadcast sowing.

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 continuing trialling a 21-day mustelid survey (repeated during the year).

A review of work led by Andy Cox in the TFKS was undertaken in October 2017, the key recommendations emphasise for the current kiwi research to continue and focus on the need for effective ferret control to be implemented. as it has 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 trapping regime to be applicable to other sites across the country (Table 1).

This report presents results from these key areas of work for the 2017/18 financial year.

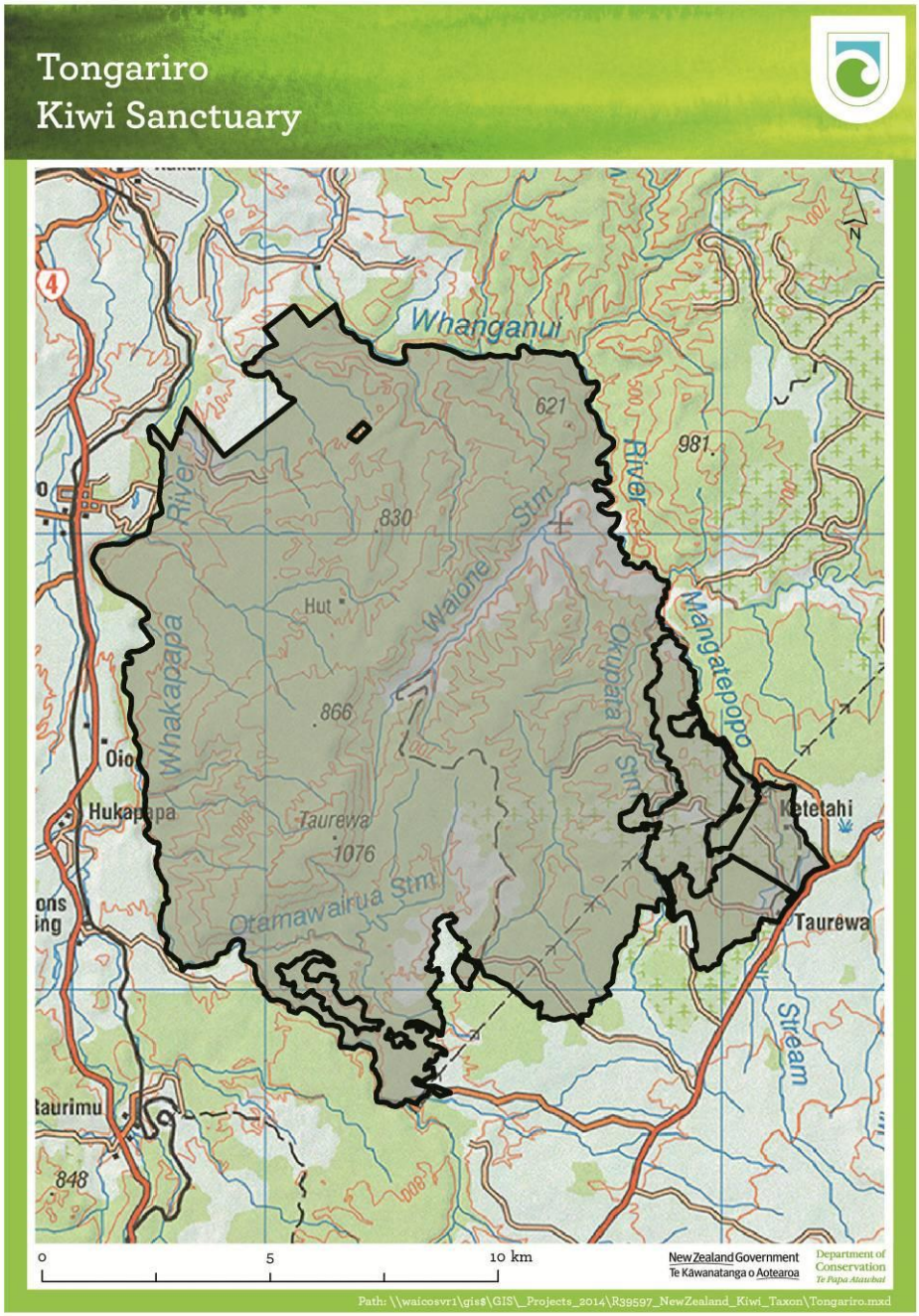


FIGURE 1: LOCATION MAP FOR TONGARIRO FOREST KIWI SANCTUARY, CENTRAL NORTH ISLAND REGION

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 Advise- 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 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	On track
4.2	Measure chick survival for the two seasons after the 2017 aerial 1080 operations.	TFKS	Essential	On track
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	Need to be confirmed for the 2019/20 season budget
4.5	Implement rabbit survey in the surrounding landscape annually. Collaborate with Landcare research on ferret research opportunities	TFKS, Regional Council	High	Need to be confirmed for next season budget

4.6	Complete and publish the study on sub-adult survival, dispersal, territoriality and breeding age by 2016.	TFKS	Essential	Ongoing
4.7	Publish research on benefits of aerial 1080 on kiwi chick survival by 2014/15	TFKS & KRG	Essential	Completed Been accepted December 18

SMALL MAMMAL INDEXING (SMI) USING TRACKING TUNNELS

Tracking tunnels for indexing rodent and mustelid (weasel, stoat and ferret) abundance were run on the 'Operation Ark' timing (i.e. 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 18th year of small mammal indexing data gathering, making one of 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, FIRST SEASON AFTER THE AUGUST 2017 AERIAL 1080 OPERATION USING 1.5 KG/ HECTARE OF PELLETS (Appendix 1).

The SMI results demonstrated a major decrease in both rat and mustelid tracking rates (Figure 2). Rats were knocked down from 57.7% in July to 0% after the 1080 operation, which is the best result obtained since the beginning of the experiment in 2001. The mustelid tracking rate peaked at 13.85% in July 2017, but none were detected during the two following SMI operations in September and December 2017.

Rats began to recolonise soon after but had still not reached pre-1080 levels by June 2018 (38.6%). Results are in line with previous 1080 operations which showed that it takes between 13 to 18 months for the rat population to recover to pre-1080 levels. The exception to this was the 2014 operation, when rats recolonised within eight months, possibly due to the use of a different distribution method (strip sowing) and a low sowing rate of 0.75kg/ha (TFKS Annual Report 2014/15).

Mouse tracking rates usually show a rapid increase after a 1080 operation due to the low numbers of rats and stoats, then decrease again once stoats start to recolonise and rats begin to reach pre-1080 levels. Mice began to increase after August 2017 and seem to have reached a peak at about 47% (Figure 2).

The mustelid population has been slow to recover in the 2017/18 season and the most recent results showed tracking at 1.43% (June 2018). The more sensitive outcome measure of kiwi chick survival also suggests that stoat numbers struggled to recover as quickly as they have done previously (see Chick Monitoring Section).

During 2016/17 and 2017/18 a new extended 21-day mustelid tracking index was trialled to assess whether this method would be a more sensitive monitoring method for mustelid tracking. The trial showed no significant improvement in sensitivity, although it was not less sensitive and does have the potential to be more sensitive based on the higher numbers of lines tracked in 3 of the 4 comparisons (Table 3). In the 2018/19 season, another trial lead by Craig

Gillies will be conducted to assess the feasibility and practicality of using camera traps to monitor relative abundances of feral cats and mustelids.

TABLE 3: COMPARISON BETWEEN THREE NIGHT TRACKING RATES AND 21 NIGHT TRACKING RATES

	3 night		21 night	
	mean % tracking per line	**% lines tracked**	**mean % tracking per line**	**% lines tracked**
Feb-17	13	33	8.83	53
Jul-17	13.85	23	18.67	60
Sep-17	0	0	0	0
Jan-18	1.43	7	1.43	14

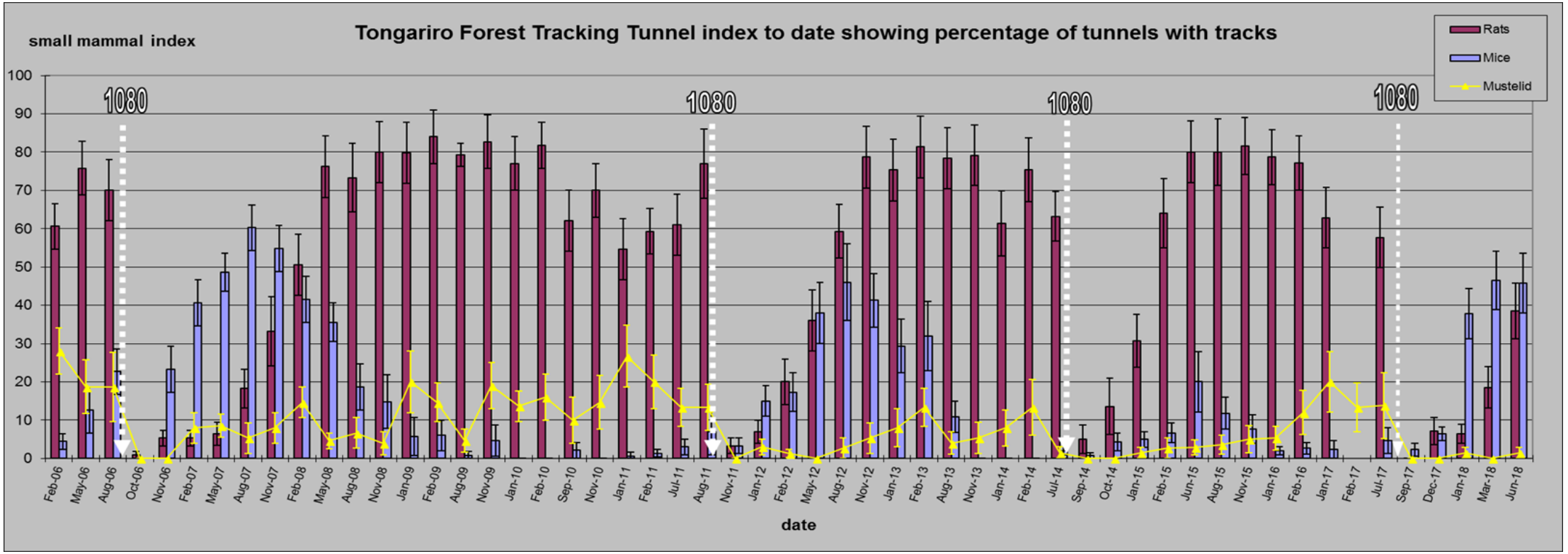


FIGURE 2: SMALL MAMMAL INDEXING RESULTS, TONGARIRO FOREST KIWI SANCTUARY, FEBRUARY 2005 – JUNE 2018

ADULT/SUB-ADULT KIWI MONITORING AND NESTING

In the 2017/18 season a total of 41 birds were tracked with radio transmitters. Of these, 31 were adults and 10 sub-adults. This season two sub-adult Kiwi (Ottoman & Ottawa) were released back into TFKS from Wairakei Golf & Sanctuary as they had reached the "stoat safe" weight of 1100g and two others dropped their transmitters. Of the 31 adults, 27 were male and four were female (Table 4). Nineteen of the males had nesting signals obtained and 15 of these resulted in confirmed nests with eggs lifted and taken to Rainbow Springs Kiwi Encounter (Table 6).

Five of the 41 birds were new to the programme and were caught outside of the breeding season by kiwi dog handlers contracted by Kiwis for Kiwi (Table 7). Another female called 'Ice' was discovered in the burrow with a tracked male.

This post-1080 season was marked by several simultaneous ferret incursions on the western side of the forest. This was the first time this has occurred within the first year following a 1080 drop. As a result, seven adult males and two subadults died (Appendix 3).

TABLE 4: MONITORED ADULT AND SUB-ADULTS 2017/18

Adult males		Adult females	Sub-adults
Speedy	Little moa	Oligo	Tokatoka ♂ **
Hiver	Fitz*	Mighty Dash	Haututu ♀
Zazu	Taika*	Pohonga**	Tail End Charlie ♀*
Dino	Te Hokinga	Ice**	Raumati ♂
Dani	Koroki		Hotoke ♀***
Max*	Matariki		Check ♂ *
Apollo*	Peter Pan		Makariri ♀
Fozzie*	Lego		Ottoman ♂
Rocket	Thunderbird		LTM5 ♀***
Murphy*	Vontrapp		Ottawa ♀
Gulliver*	Marohirohi**		
Comet	Kumara**		
Catamarca	Harley**		
Pumpkin			

** Died during season*

*** Newly tagged this season*

**** Dropped transmitter or transmitter failed*

FERRET INCURSION RESPONSE AND IMPLEMENTATION OF A LONG-TERM FERRET TRAPPING REGIME

During the three preceding 1080 cycles, ferret predations seemed to be episodic and were only recorded from year three after each operation, suggesting that adult mortality from ferrets was always suppressed during the first two years of an operation. However, this season hasn't followed this pattern and seven months after the last 1080 drop, ferret predations occurred in different parts of the western side of TFKS, resulting in seven confirmed kiwi deaths from ferrets and four suspected ones (including seven breeding males). This shows that ferret attacks could happen randomly at any stage of a 1080 operation and that it has become urgent to undertake further ferret control to prevent the population from becoming locally extinct. Since 2009, 50 monitored kiwi deaths (including 40 adults) have been attributed to ferret predation. It is unknown what impact ferrets have had on the unmonitored portion of the population.

The first adult killed by a ferret this season (a breeding male) died on the 12th of March 2018, the closest known breeding male along the 42T on the Owhango side, about 1 km west of the first "Mako crossing" (see map in Appendix 3). This was followed by eight more kiwi being killed over an approximate area of 1200 hectares encircling the Mako track, which had been the scene of most of the ferret predations in the past two years. This was not recognized as another ferret event until these birds were checked from the air on the 7th of April when five mortality signals were picked up at two different sites, the most recent kill at the time being on the 3rd of April.

A response plan was immediately undertaken (see DOC-5510459) and about 45 DOC250s and 25 live cage traps were deployed around the Mako area over a period of about four weeks and nearby kiwi were checked as often as possible. This resulted in the capture of a male ferret in a live trap on the 14th of May at the exact location where the last kiwi was killed ten days prior. Live traps were left open for another couple of weeks and more DOC 250s were set up. No further ferrets were caught on the "Mako" site, suggesting that the culprit was caught (Note that a cat was also captured on the 14th of May at a different live trap location, however, its responsibility for some of the kiwi deaths was not supported by Massey necropsy results).

In the meantime, nothing had been done yet at the less accessible second site, where one bird was killed on the 3rd of April, along the Whakapapa river, about one kilometer north of Quartz Creek. Although not many kiwi were monitored there due to the remoteness, two more mortality signals were picked up from aerial tracking on the 31th of May; one in Quartz Creek and another one more than 5 kms downstream of the Whakapapa river, suggesting the presence of a third ferret as the predations were only five days apart (one kiwi died at Quartz Creek on the 4th of May, the other died on the 9th of May). Consequently, On the 1st and 8th of June 34 DOC250s were flown to these sites and in places along the river where the helicopter could land. This resulted in the killing of one ferret male at the exact last known kiwi death location approximately two months later.

Three other ferrets were caught this season north of the Dominion road, on two different side tracks linking to the same farmland (west of Mariner's track). And recently, another male was caught on the Whangapeki farm bridge over the Whanganui river, north of TFKS.

In total, six ferrets were caught, including four males thanks to the response and the deployment of permanent traps inside and outside the kiwi sanctuary (Appendix 3).

Discussion:

Prior to the last 1080 operation in August 2017, the last predation attributed to a ferret was recorded two weeks before on the 3rd of August. For the third time consecutively, it appeared that ferret predations were halted immediately after a 1080 operation with the difference this season that the re-colonization occurred faster, suggesting a buildup in the ferret population on the nearby farms, in particular the one adjacent to the north margin of the Sanctuary. The farm is landlocked in between the Whakapapa and Whanganui rivers and ferrets can only disperse eastwards through two bridges over the Whanganui and southward through the Kiwi Sanctuary. Another incursion path has been identified through the Owhango water supply bridge over the Whakapapa river linking farmland to the forest (since March 2018, 15 ferrets were caught on a farm 2.5 km upstream from that bridge).

It appeared this season that even under a three-year 1080 regime, the population may become extinct locally if we do not start controlling ferrets efficiently. The decision has been made to deploy a long-term ferret trapping regime designed specifically for targeting ferrets by identifying hotspots within the core of the forest, protecting the boundaries by focusing on dispersal pathways into the forest and reducing the pressure on the boundaries by controlling ferrets before they reach the forest on the surrounding farmlands (Appendix 4).

In the absence of ferrets, the estimated annual adult survival rate (SR) is 96.9% (using the Mayfield method) and the mean life expectancy is 32 years. Since 2006, ferret pressure has increased greatly and reduced the mean adult life expectancy to 10.63 years (Table 5).

TABLE 5: IMPACT OF FERRETS ON KIWI ADULT LIFE EXPECTANCY

	Before Sept 2006 (no ferrets)	To date (ferrets)
Annual survival rate (%)	96.9	90.59
Life expectancy (years)	32	10.63

NESTING AND EGGS OUTCOME

During the 2017/18 season there were a total of 18 confirmed nests from 15 different males, to ensure a sample size of at least 16 chicks was achieved, a proportion of the eggs were lifted from nests in the wild and taken to Kiwi Encounter where they were incubated and hatched in captivity (kiwi eggs have a higher hatch rate in captivity than in the wild). Egg lifts took place after 60 days of incubation.

In total, 34 eggs were lifted, of which 22 hatched and the resulting chicks were released to TFKS. Ten eggs were not viable, while two chicks were euthanised soon after hatching due to complications (Table 6). All monitored chicks were fitted with chick mortality transmitters and returned to their natal territory, or to a pre-determined release site within TFKS, at hatch weight (approximately two weeks of age)

TABLE 6: NEST AND EGG OUTCOME SUMMARY

Male Kiwi (represents a breeding pair)	Unconfirmed nests*	Confirmed nests	Total eggs	Hatched in captivity & released to TFKS	Eggs not hatched	Chicks euthanised
Speedy		2	4	4		
Hiver	1	2	4	4		
Zazu*	1					
Dino		2	4	2	2	
Dani	1	1	2	1		1
Max**		1	2	2		
Apollo**		1	2		2	
Fozzie**	1					
Rocket		1	2	1	1	
Murphy**		1	2	2		
Gulliver**		1	2		2	
Comet		1	2	2		
Catamarca		1	2	2		
Pumpkin		1	1		1	
Little moa*	1					
Fitz**		1	1		1	
Taika**		1	2		1	1
Te Hokinga	1	1	2	2		
Peter Pan*	1					
Total	7	18	34	22	10	2

* Nesting signal obtained

** Died during the season

NEW KIWI CAPTURES USING CALL RECORDERS AND KIWI DOG HANDLERS:

Between March and May 2018 kiwi dog handler James McLaughlin and his dog Tui, were contracted by Kiwis for kiwi to locate and attach radio transmitters to previously unknown kiwi in TFKS. He was supported by fellow dog handler Martin Slimin, his dog Toby, a volunteer and local DOC staff. To assist in this process, local DOC staff had already analysed a number of automatic call recorders placed in strategic locations to gain some knowledge as to where breeding pairs were likely to have established territories.

This work was undertaken as part of a Kiwis for kiwi initiative to change the current 2% decline in kiwi numbers to a 2% increase within a 5-15 year period. Chicks of any new birds found will eventually be helping to stock the Kōhanga site at Sanctuary Mountain Maungatautari with a genetically diverse population of founder birds of which the offspring will one day be used to re-populate areas where kiwi have become locally extinct or have very low genetic diversity (Kiwis for kiwi strategic plan, 2017). TFKS will also benefit as the offspring will remain in the forest in years when chick monitoring is taking place and the adult birds will help to replace those which have been lost to ferret predation.

Over two trips consisting of a total nine days, James and the team caught 6 new kiwi. On the first trip in March, a breeding pair was located in the same burrow and both were found to have transponders (microchips) and could be identified as Harley (male) and Dan7 (female). Harley is the offspring of Hiver and Dan7 the offspring of Dani, both of which are well represented genetically in TFKS and SMM. Both birds received a health check and Harley was fitted with a radio transmitter while Dan7 was set free. Another adult male was also located on this trip and no transponder was detected, he was also fitted with a transmitter and named Kumara (Table 7).

James returned to TFKS in May and a further three kiwi were captured, none had transponders and all were fitted with radio transmitters. An adult male was named Marohirohi and is thought to be breeding with a local known female, Mighty Dash. An adult female was named Pohonga and was heard calling with a male the night before. She will be caught again before the 2019/20 breeding season in an attempt to capture her mate so she can have her transmitter removed. Lastly, a sub-adult male was caught and named Tokatoka. There was a potential sighting of another kiwi running from his capture site so there is a chance he may breed in the 2018/19 or 2019/20 season (Table 7).

TABLE 7: NEW KIWI CAUGHT THIS SEASON

Name	Date of Catch	Transponder Present	Transmitter attached	Age	Sex	Bill (mm)	Weight (gm)
Harley	24.03.18	Yes	Yes	Adult	Male	99	2070
Dan7	24.03.18	Yes	No	Adult	Female	121	2270
Kumara	26.03.18	No	Yes	Adult	Male	100	2040
Marohirohi	6.05.18	No	Yes	Adult	Male	98	1850
Pohonga	8.05.18	No	Yes	Adult	Female	120	2600
Tokatoka	10.05.18	No	Yes	Subadult	Male	78	1240

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 2017/2018 season was the first season of monitoring immediately 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 ten 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 22 chicks were monitored in the TFKS. All 22 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 22 chicks, 10 were released on the Western side of the forest, and 12 on the Eastern side.

The first chick was released into TFKS on 5/10/17 and the last chick was released on 15/3/18.

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 22 chicks being monitored this season there have been a total of four recorded mortalities (including one that died accidently from being mis-handled and was taken out of the survival experiment). The first chick was killed on 17/12/17; the cause of death was determined unknown by the Post-Mortem lab at the Massey University Wildlife Centre, but due to the situation in which the kiwi was found, it was consistent with mustelid predation. The second chick died 23/3/18; the cause of death was determined unknown by the Post-Mortem lab at the Massey University Wildlife Centre. It did however have a possible puncture wound in its neck. The latest mortality occurred on 12/4/18 during the same time, and within range, of a ferret predation event. The remains were located on 8/5/18. By this time the body was very decomposed, so cause of death could only be presumed.

Of the remaining 18 chicks, two dropped their transmitters, 5 were considered lost due to faulty transmitters and eleven chicks have survived to reach sub-adult status (>183 days of age) resulting in the best kiwi chick survival rate ever obtained of 81.05% (Figure 3).

Nine chicks are still being monitored and due to the predation of seven adult kiwi by ferrets this season, transmitters will be kept on all remaining chicks for recruitment and survivorship measurement.

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, this season's results contradict past correlations regarding chick survival on the east vs west (Figure 4). We have recorded three confirmed predations of chicks on the west and no predations on the east. This would be directly related to the ferret predation event on the western side, affecting not only the three western chicks but seven adults as well.

This suggests that even after a successful treatment year, both chicks and adults are susceptible to the unpredictable invasion of ferrets in TFKS from surrounding farmland. Trail cameras are to be deployed in August 2018 in conjunction with regular tracking tunnels to directly compare relative pest abundances. This includes ferrets and cats, not usually detected in regular tracking tunnels.

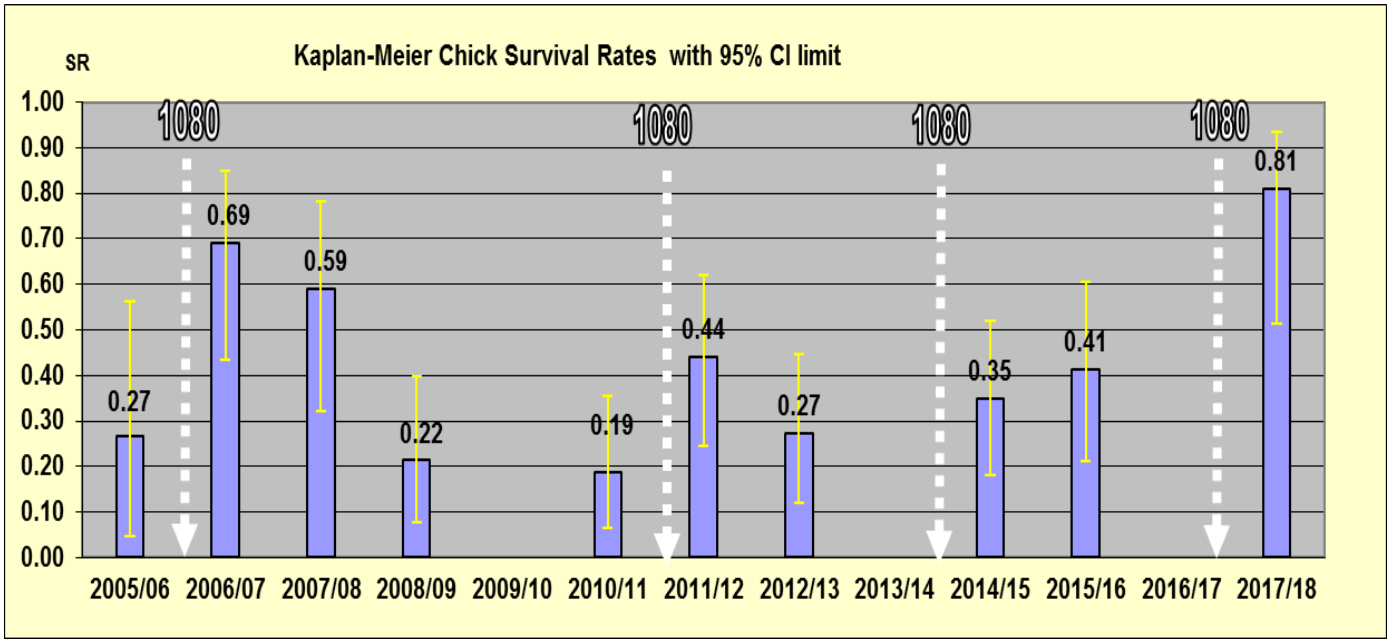


FIGURE 3: KAPLAN-MEIER KIWI CHICK SURVIVAL ESTIMATES FOR TEN BREEDING SEASONS, 2005-2018*

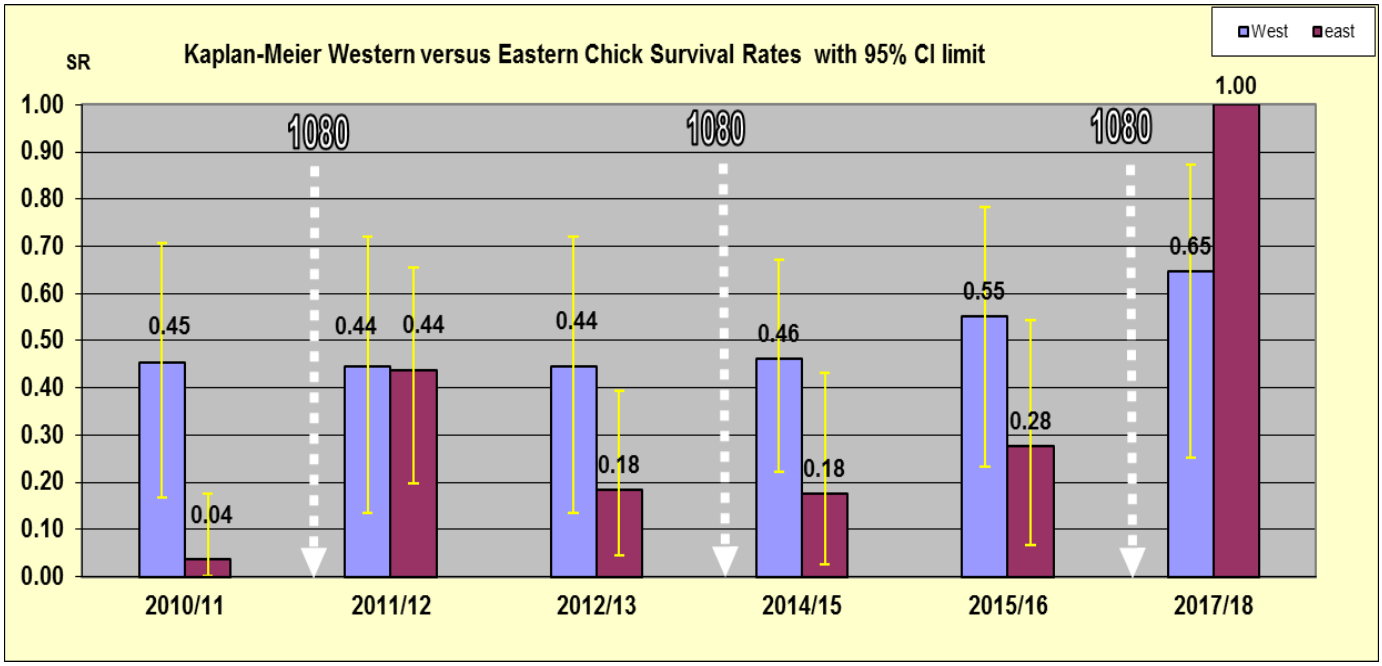


FIGURE4: COMPARISON KAPLAN-MEIER KIWI CHICK SURVIVAL ESTIMATES BETWEEN EAST AND WEST OF TONGARIRO FOREST*

**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

Ferret trapping will be implemented on a large scale along the boundaries of Tongariro Forest and on the surrounding landscape (possibly including a rabbit survey) and more scarcely within the Sanctuary.

Kiwi chick survival research will occur again next season 2018/19 and probably in 2019/20 to measure the possible impact of the increase in ferret trapping on chick survival. Ongoing chick monitoring will continue through the next 1080 operation in 2020 to allow solid comparison with previous data with no ferret trapping.

New kiwi will be caught in areas with no information about ferret impacts to have a wider representation of the forest and also to recruit new breeders to offset the recent kiwi losses from ferret predation. This will also help to stock Sanctuary Mountain Maungatautari.

Lastly, tracking tunnel monitoring will continue and camera trap trials will be undertaken.

REFERENCES

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

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.; 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 –2824987.

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

New Zealand Government

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.

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

It appears that ferret events could happen at any stage of a 1080 operation and that a sole three-year 1080 may not be sufficient 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 0.2% per year under a 3-year regime very much under 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 19.5% per year into eventual extinction (table 8).

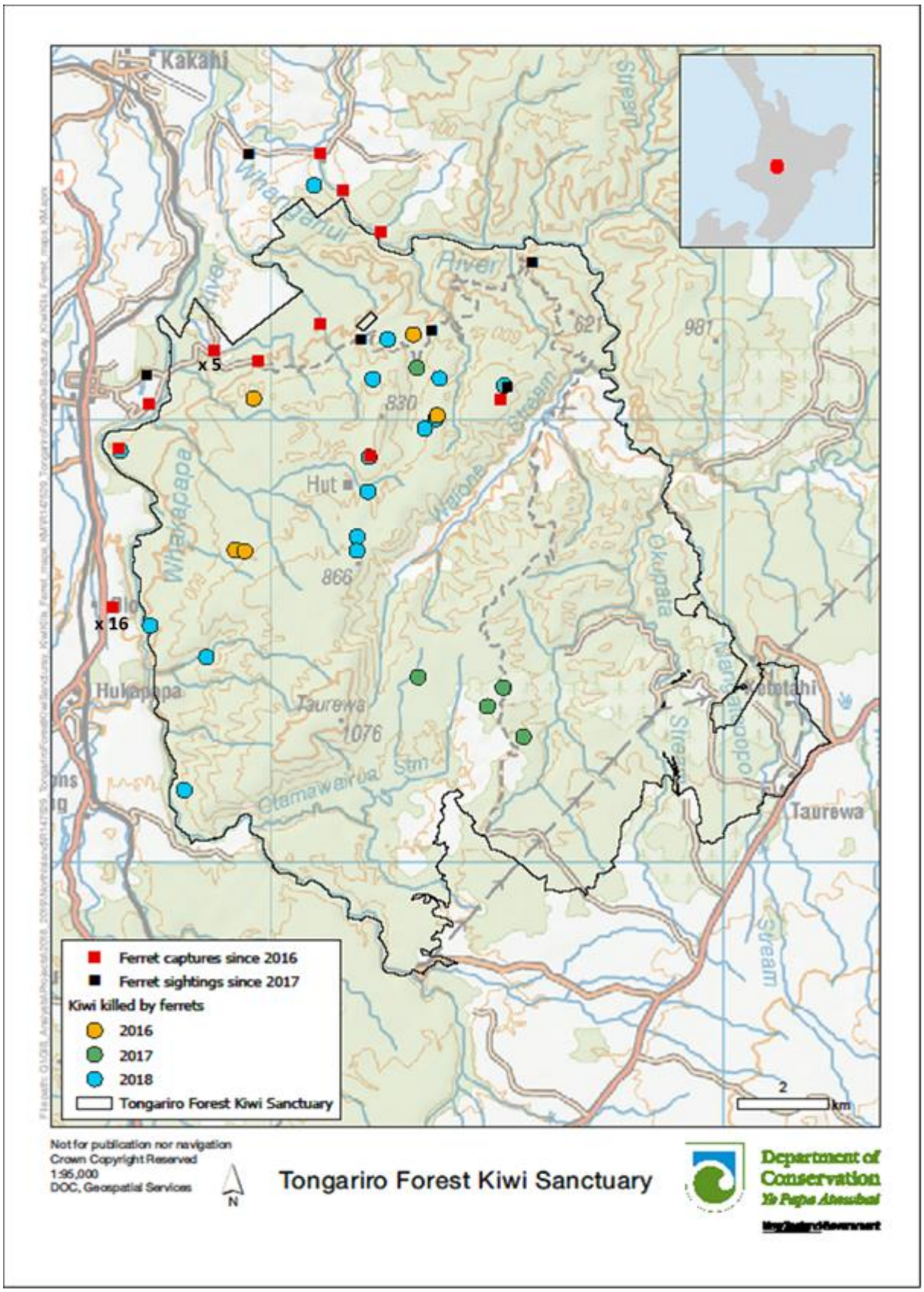
To increase the population, a three yearly-1080 cycle combined with an efficient ferret trapping regime are necessary. This should grow the population by about 6% per year (Figure 4).

TABLE 8: RECRUITMENT AND ANNUAL GROWTH UNDER DIFFERENT MANAGEMENT REGIMES

Management regime	Mean chick SR 0-6mths (%)	Adult SR (%)	Recruitment (%) for stable population	Actual recruitment (%)	Annual growth (%)
3y 1080 cycle	34.5	88.2	22.7	21.05	- 0.2
5y 1080 cycle	26.1	79	40.3	16.7	- 9
No management	13.5	72.5	52.9%	8.6	- 19.5
3y 1080 cycle + DOC 250s	34.5	96.9	6	23.4	+ 6

Appendix 3

KIWI KILLED BY FERRETS, AS WELL AS FERRET SIGHTINGS AND CAPTURES SINCE 2016*.



**map is current as at 01/10/18*

Appendix 4

FERRET DOC250 TRAPS AROUND AND INSIDE TFKS: