Department of Conservation
Te Papa Atawhai

TONGARIRO FOREST KIWI SANCTUARY ANNUAL REPORT

July 2012 – June 2013

TONGARIRO DISTRICT OFFICE, CENTRAL NORTH ISLAND REGION

Ngati Hikairo ki Tongariro

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Cover Photo: Clockwise from left: Tongariro Forest East with view of Mt. Tongariro and Mt. Ngauruhoe; Kiwi egg box, Loggerross' territory; Renee Potae; Mr14 with Jerome Guillotel.

PARTNERSHIPS

Partnerships between the Department of Conservation and Ngati Hikairo, The National Kiwi Trust at Kiwi Encounter, Maungatautari Ecological Island Trust, Project Tongariro, and The Kiwi Trust continue to be an essential part of the work in the Tongariro Forest Kiwi Sanctuary (TFKS). Wairakei Golf + Sanctuary has taken up an important role as a kiwi crèche for our area.

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. This season (2012/13), 22 kiwi eggs were taken to Kiwi Encounter and 19 of these successfully hatched.

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 small mammal indexing, transporting kiwi eggs to The National Kiwi Trust at Kiwi Encounter and other advocacy work.

MAUNGATAUTARI ECOLOGICAL ISLAND TRUST (MEIT)

Maungatautari is a forested volcanic cone in the Waikato, and is the site of an ecological restoration project headed by the Maungatautari Ecological Island Trust, aiming to eliminate all mammalian predators and re-introduce native species, including kiwi. TFKS and Ngati Hikairo gifted kiwi to Maungatautari and Ngati Koroki-Kahukura to be part of a founder population there. Since 2010, 14 kiwi (the offspring of some of the original founders) have been released into TFKS.

OTOROHANGA KIWI HOUSE

There has been a nationwide initiative to release brown kiwi of Western Taxa from captivity into multiple wild sites, following the completion of a new western provenance DOC translocation plan. This is so that captive institutes will have more capacity to work with other (more endangered) species of kiwi. Five kiwi were released this season (one pair and three females) from Otorohanga kiwi house into Tongariro Forest.

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 was officially opened in 2011. .

During the 2012/13 season, with support from Ngati Rangi and Ngati Hikairo, one kiwi chick from Southern Ruapehu and one chick from Tongariro Forest were released at Wairakei Golf + Sanctuary. It is hoped that Wairakei will continue to be utilised as a crèche for Operation Nest Egg™ in the future. DOC staff are responsible for monitoring the kiwi who reside at Wairakei with assistance from Wairakei Golf + Sanctuary staff.

EXECUTIVE SUMMARY

Tongariro Forest Kiwi Sanctuary (TFKS) was established in 2000 for the development of kiwi protection techniques, namely the use of BNZ Operation Nest Egg™ (O.N.E) and aerial 1080. TFKS aims to achieve and maintain a representative sample of 200+ pairs of Western North Island brown kiwi by 2017, and to involve the community and enhance public awareness.

Twenty four adult male kiwi and eleven adult female kiwi were monitored in TFKS in 2012/13. There were no recorded adult kiwi deaths for the 2012/13 season. This follows on from the previous season where there were no adult kiwi deaths recorded after the September 2011 aerial 1080 operation. This is in contrast to the period between February 2009 and September 2011, when there were a series of ferret predations in TFKS and the total number of monitored dead adult and sub-adult kiwi was 26.

There were 28 nests this season, with a total of 35 eggs. A total of 22 viable eggs were taken to The National Kiwi Trust at Kiwi Encounter. Of these, 19 eggs hatched at Rainbow and the resulting 17 chicks were returned to be monitored at TFKS. Eleven eggs were found to have hatched in the wild. Ten of these were monitored.

Eighty eight O.N.E sub-adult kiwi have been released into TFKS since 2000. Of these, 77 have been closely monitored, along with 53 wild hatched sub-adults. The survival rate as at the end of the 2012/13 season was 62.8%, with a higher mortality in females than males (although female survival rate is improving overtime). The average age of first breeding is 3.75 years old. The dispersal of sub-adults released on the western side of TFKS revealed previously unknown pockets of kiwi and areas attracting a high density of kiwi, in particular along the Mako stream. Nineteen sub-adults are currently monitored.

Kiwi chicks were monitored in TFKS as part of an ongoing study to assess whether aerial 1080 possum control operations can benefit kiwi populations through secondary poisoning of stoats. Aerial 1080 operations were carried out in September 2006 and 2011. Twenty seven chicks were monitored this season. The survival rate (Kaplan Meier) was 27.2% compared to 44% last season. However the survival rate still remains higher than the pre-1080 levels. This experiment has shown that the use of aerial 1080 in Tongariro Forest has significantly increased kiwi chick survival for two consecutive years.

Two years after the September 2011 aerial 1080 operation, the rat tracking rate was back at approximately 75-80% in November 2012, after initially been knocked down to just 3%. As expected, the mustelid tracking rate has been steadily increasing since May 2012 (along the line of previous 1080 operations) and mice, reflecting an increase in rat abundance, are disappearing rapidly.

The percentage of fantail nests which successfully produced fledglings in the 2012/13 remained higher than pre-1080 levels season (18%). Five-minute bird count monitoring was also carried out in 2012/13.

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).

One of the key current research projects in TFKS is the assessment of the effect of a large scale 1080 operation on kiwi chick survival. This involves determining survival rates of kiwi chicks before and after aerial 1080 operations carried out in September 2006 and 2011. These were Animal Health Board operations as part of their regional TB-vector/possum control regime, but done in conjunction with the Department of Conservation for kiwi protection research. This research has 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 (McLennan 2006).

In addition to this research, other work includes ongoing monitoring of adult kiwi for survival and breeding purposes, and monitoring of sub-adult kiwi for survival, dispersal and breeding. In addition, mustelid and rodent numbers are monitored using tracking tunnels (small mammal indexing), and passerine monitoring is carried out including fantail nest monitoring and five-minute bird counts. This report presents results from these key areas of work for the 2012/13 financial year.

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

SANCTUARY OBJECTIVES

1. To achieve and maintain a representative sample of 200+ pairs of western North Island brown kiwi in Tongariro Forest by 2017.

2. To answer three important management questions
- Do aerial 1080 operations benefit kiwi chick survival?
- If so, what frequency of aerial 1080 application is needed to maintain and expand the kiwi population?
- Can aerial 1080 operations (at the required frequency) benefit other forest birds preyed upon by rats?

3. To involve local communities and associates in the management of the TFKS.

4. To enhance public awareness and support for kiwi conservation.

ADULT KIWI MONITORING AND NESTING

Tongariro Forest Kiwi Sanctuary aims to monitor 30 male kiwi for breeding outcomes. The male kiwi are fitted with 'smart' mortality transmitters, known as chick timers. These transmitters provide an 'output' (information on kiwi activity levels which can be graphed) which informs the user when a kiwi is incubating, and for how long, in addition to other information such as when there is a hatch event and what time the male emerged from the nest the previous night. This technology assists us to make accurate assessments as to when to lift eggs or intercept chicks.

Since February 2009 there have been 26 adult and sub adult kiwi deaths; 13 of these confirmed ferret predations. It is likely that many of the "unknown" deaths were due to ferret predation, but in some cases the condition of the carcass was such that the cause of death was unable to be confirmed. Fortunately, there have been no further adult deaths since the aerial 1080 operation in September 2011.

A total of 35 adult kiwi were monitored in TFKS in 2012/13, consisting of 24 males and eleven females (see Appendix 1 for map showing known adult kiwi locations).

One pair of adult kiwi was released into Tongariro Forest from Otorohanga Kiwi house this season. Transmitters were fitted so they could be monitored; unfortunately the female's transmitter failed (she will be re-caught using kiwi acoustic recorders and a specially trained kiwi dog). The male was found to be nesting in July 2013.

Three adult kiwi dropped their transmitters during the 2012/13 season; two females and one male. Three adults were re-captured using kiwi indicator dogs; one female and two males. These kiwi were re-fitted with transmitters.

During the latter part of the season transmitters were removed from six of the adult kiwi. These were predominantly female kiwi who are paired with males who still have transmitters fitted. One male adult, "Fuzzpop" was also cut free as he has had a transmitter for a number of seasons, has not been successful at breeding and is difficult to catch. Females and non-breeding males residing in areas of the forest where the danger of ferret re-invasion is greatest did not have their transmitters removed.

Egg lifts took place after 55 days of incubation. Lifted eggs were taken to The National Kiwi Trust at Kiwi Encounter where they were incubated and hatched in captivity in order to ensure a sample size of at least 16 chicks was achieved (kiwi eggs have a higher hatch rate in captivity than in the wild). Seventeen chicks were fitted with chick mortality transmitters and returned to their natal territory in TFKS at hatch weight (approximately two weeks of age).

Chick interceptions were timed to intercept both chicks (this can usually be ascertained by assessing the birds activity output), with the aim of intercepting the oldest chick between 10 and 15 days (a second chick will usually hatch within one week of the first). Ten chicks were intercepted in the wild and were fitted with chick mortality transmitters and left in the nest.

NESTING AND EGG OUTCOMES

There were 28 nests this season (Table 1), with 30 chicks hatching in total. Seven of these nests were unconfirmed.

TABLE 1: NEST AND EGG OUTCOMES FOR 2012/13

Kiwi	Eggs (not hatched)	Number of chicks	Confirmed nests	Unconfirmed nests*	Current status
LoggerRoss	-	4	2	-	Alive
Dino	1	2	2	-	Alive
Rocket	-	2	1	1	Alive
Taika	-	1	1	1	Alive
Peter Pan	-	1	1	-	Alive
Lucky	-	2	1	1	Alive
Doug	-	2	1	1	Alive
Te Whare	-	2	1	-	Alive
Murphy	1	2	2	-	Alive
Fozzie	1	1	1	1	Alive
Max	-	3	2	-	Alive
Hiver	-	2	1	1	Alive
Gulliver	-	2	1	1	Alive
Pumpkin	2	1	2	-	Alive
Koroki	-	2	1	-	Alive
Dani	-	1	1	-	Alive
Totals	5	30	21	7	

*An unconfirmed nest was when the transmitter output indicated that the bird was nesting, but the nest was abandoned prior to being located

There were a total of 35 eggs this season (Table 1). Five of the eggs did not hatch. This is a good outcome. In previous seasons, before the losses of radio-tagged breeding males to ferret predations eggs were left in the wild and a greater number of eggs did not hatch. Since the 2010/11 season, eggs have been taken to The National Kiwi Trust at Kiwi Encounter where the hatch rate is very high so as to achieve a sample size of at least 16 chicks. Egg outcomes for the three seasons since eggs have been lifted and hatched in captivity are shown in Table 2.

During the 2012/13 season 19 viable eggs were taken to Kiwi Encounter. Two of these did not hatch. Two chicks remained at Rainbow. One of these had a slight curve in the bill and remained for observation. She was then moved to Wairakei Golf + Sanctuary. The other hatched very late in the season and therefore remained at Rainbow until she had reached 1000 – 1100g. Eleven eggs hatched in the wild (one chick was missed) and a further two eggs were found in the wild but were not viable.

TABLE 2: EGG OUTCOMES FOR THREE BREEDING SEASONS SINCE 2010/11

	Hatched	Infertile	Broken	Embryonic death	Too rotten to tell	Total eggs
2010/11	28	7	2	3	3	**43**
2011/12	25	1	0	0	2	**28**
2012/13	30	0	0	4	1	**35**

KIWI CALL COUNT MONITORING

Introduction:

Call surveys have been undertaken in Tongariro Forest Kiwi Sanctuary (TFKS) in 1993-1997, 2001, 2004-2007, 2011 and 2013 in an effort to detect long term population trends amongst Tongariro Forest kiwi. The Kiwi Best Practice Manual (2003) recommends that the call surveys be done annually for three years, and then once every five years after that, to detect any large, long term changes in population density and distribution. However due to the deaths of 26 radio-tagged kiwi since 2009, it was considered advantageous to carry out the 2011 survey to better understand population dynamics, in order to repeat the 2008 territory mapping exercise. The 2008 territory mapping gave us a conservative population estimate of 180 kiwi.

In the years previous to 2013 these surveys were solely performed by human observers. For the 2013 survey, the seven human observer points were used in conjunction with automatic acoustic recording devices to make a comparison of the calls per hour and male to female ratio using the two different methods. Twelve additional acoustic recording devices were placed throughout the forest to more clearly ascertain kiwi distribution over a greater area. The data collected will be used as a base line reference point to compare with future call survey results.

Method

Kiwi calls were recorded by human observers in TFKS at the seven locations previously used to conduct the kiwi call survey in 2011. Observers were to remain at their designated location and conduct the survey for two hours per night from 1830 to 2030 for four consecutive nights (20th to the 23rd of May 2013) giving a total of 8 hours spent at each site. During the survey the weather was mainly fine with light to no wind with moderate rainfall on the 22nd May. Data and site location details at DOCDM-1256124. Nineteen acoustic recorders were left in the forest for ten consecutive nights from the 20th to the 29th of May and set to record from 1830 to 2030 each evening giving a total of 20 hours to be analysed from each site.

Results

The human observers recorded 42 calls over a total of 53.6 hours giving a rate of 0.78 calls per hour. This was similar to 2011 results (0.77) and had decreased when compared with 2007 results (1.21 calls per hour). The male to female ratio heard by human observers was 7.2:1.The acoustic recorders positioned at the human observer sites picked up 23 calls over the 53.6 hours, giving a rate of 0.43 calls per hour. This represents only 55% of the calls heard by humans, which is considerably lower than what was expected (about 80%) (Table 3). All acoustic recorders combined gave a total of 91 calls over 376 hours giving a rate of 0.24 calls per hour. The male to female ratio was 3.8:1 (Table 4)

Using a map of known kiwi territories in conjunction with estimated bearings and distances the number of known and unknown kiwi has been established for the human observations, a total of 21 individual kiwis were heard, 11 known and ten unknown. Regarding the automatic recorders, if it is assumed that a kiwi heard on a single recorder is always the same individual bird unless there is strong evidence to suggest otherwise, there were at least 19 individual birds in the listening area.

For the purposes of this study it has been assumed that the hearing distance for the human observers and the recorders is 1 km giving a circular listening area of 314 hectares. This gives a

total combined listening area of 2198 hectares for the human observers and 5966 hectares for the recorders (Appendices 2 & 3)

TABLE 3: COMPARISON BETWEEN HUMAN OBSERVERS AND ACOUSTIC RECORDERS

Human Observers

Calls Per Hour - Total = 42 / 53.6 = **0.78**

Total individual kiwi heard by human observers = 21
Number of known kiwi heard = 11 (which is 73% of the known kiwi living within the area)
Number of unknown kiwi heard= 10

Acoustic recorders

Calls Per Hour - Total = 23 / 53.6 = **0.43**

Total individual kiwi heard by acoustic recorders = 19

TABLE 4: ALL ACOUSTIC RECORDERS COMBINED

Calls Per Hour - East =	72 / 240 =	0.30	(11 recorders out of 12 heard calls)
Calls Per Hour - West =	19 / 136 =	0.14	(3 recorders out of 7 heard calls)
Calls Per Hour - Total =	91 / 376 =	**0.24**	

The use of acoustic recorders for kiwi call survey in TFKS is an on-going trial that will require some fine tuning. Some of the results have caused us to rethink the locations and positioning of recorders. For example, on the western side of TFKS, 12 kiwi were known to be present in the area where acoustic recorders were positioned and only four kiwi were heard over a period of ten days.

Therefore we will again use acoustic recorders in conjunction with human observers next year (May 2014) and aim to be more consistent in terms of their exact position in the trees and in relation to the human observers to reduce discrepancy between results.

SUB-ADULT KIWI MONITORING

Juvenile[1] and sub-adult[2] kiwi lifted from Tongariro Forest Kiwi Sanctuary (TFKS) as eggs, as part of the BNZ Operation Nest Egg™ (O.N.E) program, were released back into TFKS at between 1100g-1200g. A number of them have been radio-tagged to give data on the overall picture of population dynamics of kiwi (Robertson 2004), providing information on age at first breeding, survival and dispersal.

Eighty eight O.N.E sub-adults have been released since the creation of TFKS in 2000 (122 since the launch of O.N.E in the 1990's). Of these, 77 have been closely monitored, as well as 53 wild hatched sub-adults, which have been followed and treated as a separate sample in the study to determine if they behave differently. Nineteen sub-adults are currently monitored.

[1] 50 days < age > 183 days
[2] 183 days < age > 4.5 years

SURVIVAL RATE

Of the 135 (77 O.N.E., 53 wild hatched and five wild caught) continuously monitored sub-adults, 32 have died since 2000 (no deaths since last 1080 operation in September 2011). The causes of mortality were predation (n=12), natural causes/misadventure (n=9) and unknown causes (n=11).

This season, seven birds dropped their transmitters and four had their transmitters removed. As with previous seasons, O.N.E female survival rate is the lowest at 41.25% (95% C.I. 0.130-0.681), but as we progress through the study (eight years) and as the sample size increases, the results are becoming more conclusive (Table 5) The survival rate was calculated using Kaplan-Meier procedure. Twenty two males and eleven females have been confirmed as reaching adulthood (4.5 years old or age of first breeding).

TABLE 5: SURVIVAL RATE OF SUB-ADULT KIWI IN TONGARIRO FOREST

	Survival Rate (SR %)	Female SR (%)	Male SR (%)	Sample size in transmitter years*
O.N.E (n=77)	62.91	41.25	72.82	138
Wild-hatched (n=53)	62.18	56.8	65.58	81
Wild caught (n=5)	N/A	N/A	N/A	9
Overall (n=135)	**62.8**	**48.84**	**68.04**	**228**

* Cumulated monitoring time from 2001 to 2013

TERRITORIALITY AND AGE AT FIRST BREEDING

We have sufficient information on territoriality for 47 kiwi, and age at first breeding for 26 kiwi (18 O.N.E. and eight wild hatched). We currently monitor 19 sub-adults and two adults that have not started breeding yet.

Overall we have a sample size of 47 kiwi (25 O.N.E and 22 wild hatched kiwi) that can give us information on age at first breeding, as long as we keep on monitoring the remaining 19 (plus the 2 adults) which have yet to breed.

At present, the mean age at first breeding (n=26) is 3.75 ± 0.43 years old with no difference between O.N.E and wild hatched kiwi .This is possibly an underestimate for O.N.E kiwi, as there are two which are 8.5 and 9.6 years old which have not yet started breeding, if they do the average

would markedly increase. Also five O.N.E. kiwi over 4.5 years of age died before they started breeding.

The mean age of territoriality (n=47) is 1.64 ±0.20 years old, with no difference between wild hatched and O.N.E kiwi, but a slightly higher age for females (1.84±0.21) than males (1.55±0.28).

Seven chicks from this treatment season (2012/13) have survived to sub-adulthood.

DISPERSAL PATTERNS

The study of O.N.E sub-adult movements has shown most kiwi remain within an approximate 5000 ha area, situated in the eastern side of the forest, which is where O.N.E kiwi were initially released between 2002 and 2006 (Appendix 4). Approximately 10% of kiwi have dispersed out of TFKS. The kiwi from this sample that are still alive are now adults and not likely to disperse widely anymore.

The dispersal patterns of released birds on the western side since 2011, along with dispersal by wild hatched sub-adults, continually reveal new pockets of kiwi on the western side in areas that were previously thought to be unpopulated. For example, between Top Track and Pony Club Track, four kiwi appear to have settled (although two are still quite young), and two have died from misadventure (both fell into the same natural tomo, at different times, and could not get out). The southwest corner of the western side, around and south of Quartz Creek, also seems to support a kiwi population, as it has attracted five sub-adults from the eastern and western side (two O.N.E. and three wild hatched) who have settled there (two have nested). Three Maungatautari Ecological Island Trust females released two seasons ago have moved into the area also (one dropped its transmitter) and one wild hatched kiwi have also settled there. Another wild-hatched male, possibly settled, dropped his transmitter in 2003). The sub-population between the 42nd traverse and Top Track, along the Mako stream is growing rapidly with an extra five birds settling down there. (Appendix 4)

One wild-hatched sub-adult dispersed out of TFKS last season. It has settled near the confluence of the Mangatepopo and Wanganui Rivers, and paired with a re-captured ONE bird released in 2005 from the eastern release site (they were found in the same burrow this season).

KIWI CHICK MONITORING

Kiwi chicks have been monitored 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 September 2006 and 2011 respectively for possum control and also targeted rats and thus stoats via secondary poisoning.

The 2012/13 season was the second season of monitoring after the 1080 operation carried out in September 2011.

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 to one of three preselected release sites, at hatch-weight (approximately two 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 (when not able to differentiate between weasels, stoats and ferrets, the family group name "mustelid" has been used (Appendix 5).

In order to compare chick survival over seven seasons, survival rates to 183 days were calculated for each season using the Kaplan-Meier procedure (Appendix 6), as recommended by Robertson and Westbrooke (2005), with 95% confidence intervals.

KIWI CHICK OUTCOMES AND SURVIVAL

This season, a total of 27 chicks were monitored within TFKS. Of these, 17 were hatched in captivity at Kiwi Encounter, and ten were intercepted at the nest and radio tagged.

The first chick was released into TFKS on October 10th 2012, and the last chick was radio-tagged on 3rd March 2013.

Seven chicks survived to reach sub-adult status (>183 days of age, Appendix 4). One chick dropped its transmitter.

Nineteen chicks died this season; one death was classed as misadventure - probable drowning (diagnosed by the NZ Wildlife Health Centre), seven were classed as cause of death unknown as there were not sufficient remains present for diagnosis, 11 were classed as having died as a result of predation by mustelid or stoat (Appendix 5).

The first predation event was recorded on the 6th November 2012, and the most recent on the 30th of April 2013 (Appendix 5).

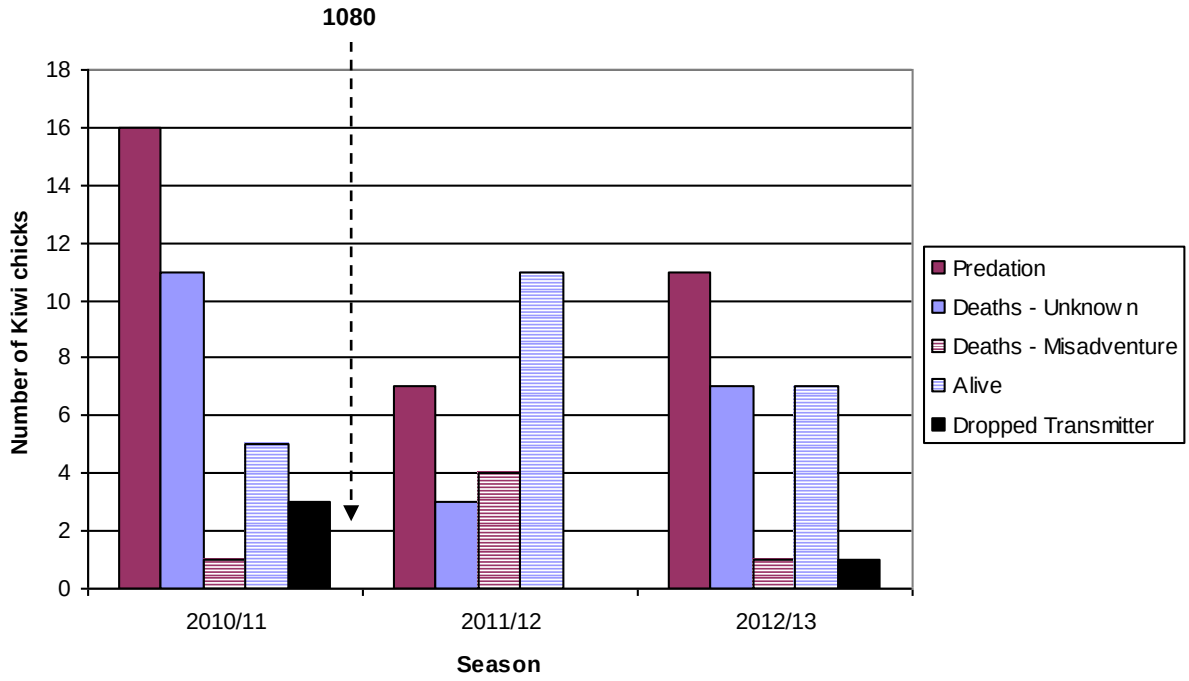

FIGURE 2: TONGARIRO FOREST KIWI SANCTUARY KIWI CHICK OUTCOMES FOR THREE SEASONS

Kiwi practitioners in TFKS note that after 1080, there are more remains present when a bird has deceased. This is likely due to the reduction in the numbers of scavengers (see tracking tunnels section below). This explains the decrease in the unknown deaths and consequently the increase in deaths classed as misadventure.

Kiwi chick survival was high for two seasons following the 2006 aerial 1080 operation (Figure 3), but by 2008/09 it had returned to pre 1080 levels (22%). For the 2011 aerial 1080 operation, the pre-1080 survival rate was 19% and increased to 44% post 1080. For the 2012/13 season, the survival rate dropped once again (27%) but did not yet reach pre-1080 levels (similar result from 2005/06 pre-1080 seasons (26.7%) was considered statistically un-reliable as sample size was un-sufficient, n=11)

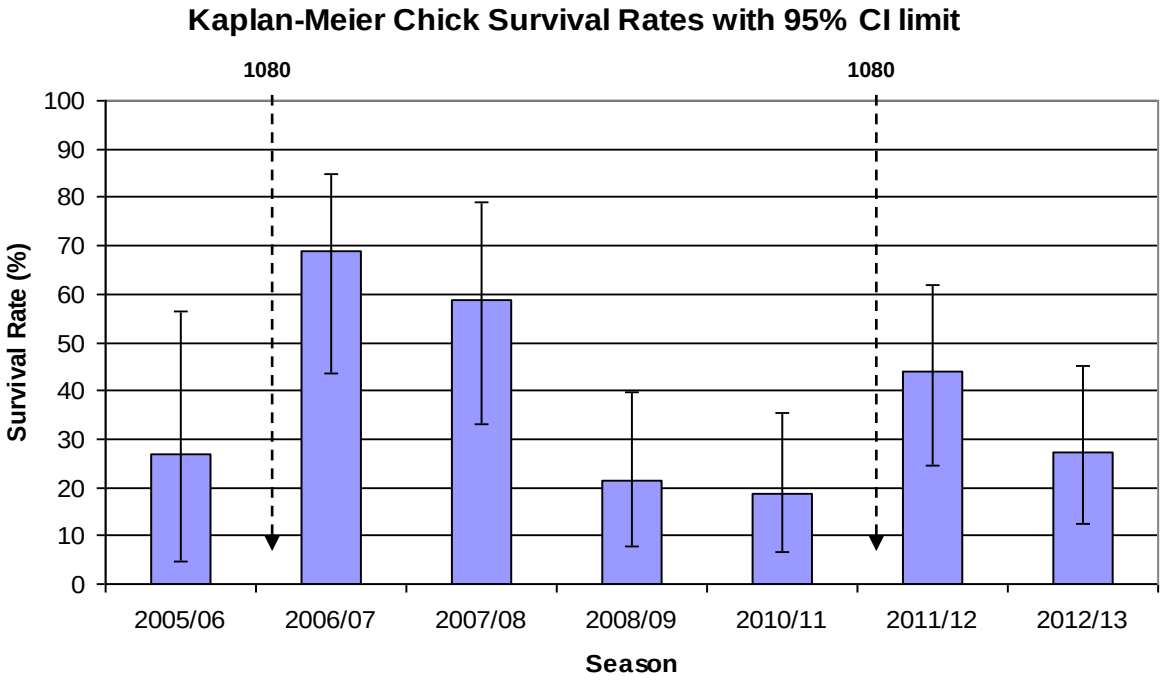

FIGURE 3: KAPLAN-MEIER KIWI CHICK SURVIVAL ESTIMATES FOR THE SEVEN BREEDING SEASONS, 2005-2013*

**Data from the 2009/10 season is not included as chicks were crèched in Warrenheip, a 16ha predator proof fenced area of bush near Cambridge, Waikato.*

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 stoat abundance. Methodology follows current DOC best practice (Gillies & Williams 2001). There are 15 lines within Tongariro Forest Kiwi Sanctuary (TFKS); each line is 450m long with ten tunnels, giving a total of 150 tunnels. Tracking tunnels have been run in TFKS since 2001.

TRACKING TUNNEL RESULTS AFTER AERIAL 1080 OPERATIONS

In September 2011 TFKS was aerially treated with 1080. The result was a major decrease in both rat and mustelid tracking rates (Figure 4), rats were knocked down to 3.3%; they were tracking at 60% or greater prior to the operation. The mustelid tracking rate peaked at 27% in January 2011, but none were detected in any of the tunnels after the aerial 1080 operation (0% tracking rate).

At this stage of the experiment (two seasons after the last 1080 operation), tracking rates are consistent with the two previous 1080 operations (2001 and 2006); rat numbers are very high (about 75-80%) and mice are slowly disappearing while the mustelid population increases steadily over time.

This long term SMI study (12 years) has given us a great insight into population dynamics within Tongariro Forest For instance, it takes about between 12 to 18 months for the rat population to recover after a 1080 operation and this would dictate whether or not the passerine population experience a second year of good nest success rate. It also appears to take four to five years after a 1080 operation for stoat abundance to reach a threshold (about 25% of tracking rates) where they have a controlling effect on the rat population (rat tracking rates go from about 80% to about 60%).

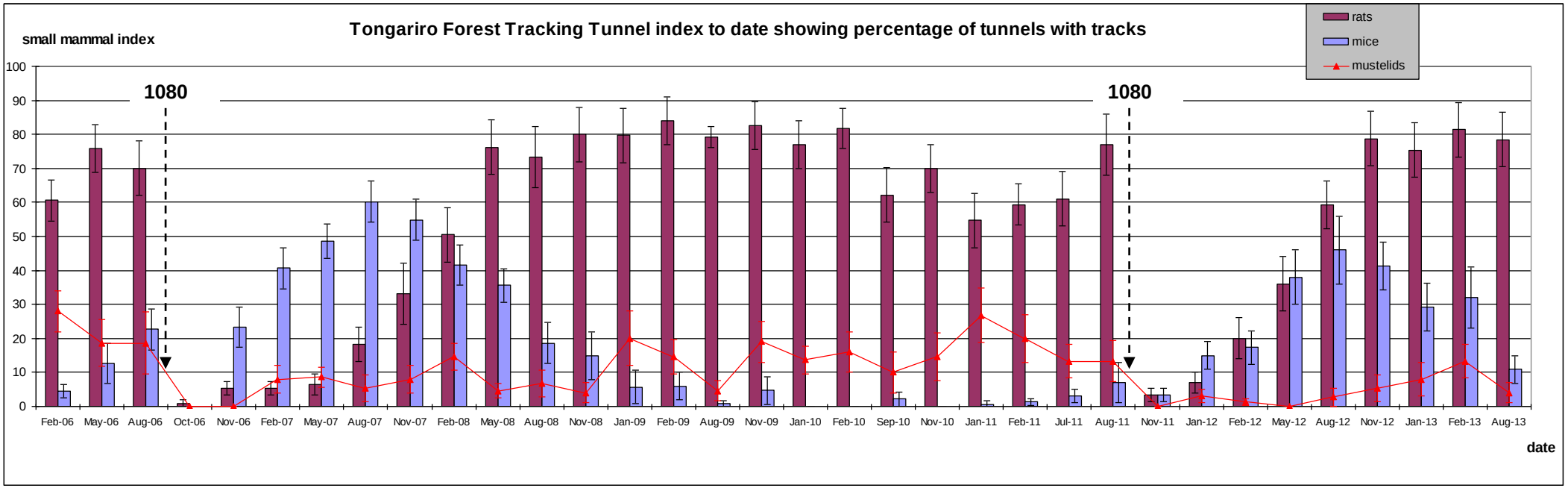

FIGURE 4: SMALL MAMMAL INDEXING RESULTS, TONGARIRO FOREST KIWI SANCTUARY, FEBRUARY 2005 – AUGUST 2013

FANTAIL NEST MONITORING & FIVE-MINUTE BIRD COUNTS

FANTAIL NEST MONITORING

Results from fantail nesting success were used as part of the outcome monitoring following aerial 1080 operations in Tongariro Forest Kiwi Sanctuary (TFKS). These results give a picture of the benefits that the 1080 operation provides to all forest birds by reducing the number of rats, which prey on eggs and nestlings and are also large enough to kill adult birds (King 1990). The 2012/13 season is the eleventh season since fantail nest monitoring began in TFKS in 2002.

The 2012/13 season was particularly successful for finding nests. A total of 43 nests were found of which 37 of these were active and could be used in the final results. Historically the first two nesting seasons following the application of aerial 1080 in TFKS had been correlated with relatively high rates of fantail breeding success compared with subsequent nesting seasons in the five yearly 1080 cycle. This season the percentage of fantail nests which successfully produced fledglings was 18% (calculated using the Kaplan-Meier method), this was considerably lower than the 29% success rate recorded from the 2011/12 season. This is probably due to the fact that rat numbers recovered more quickly (about 12 months) after the last 1080 operation than after the two previous ones in 2001 and 2006 (about 18 months) (Figure 5).

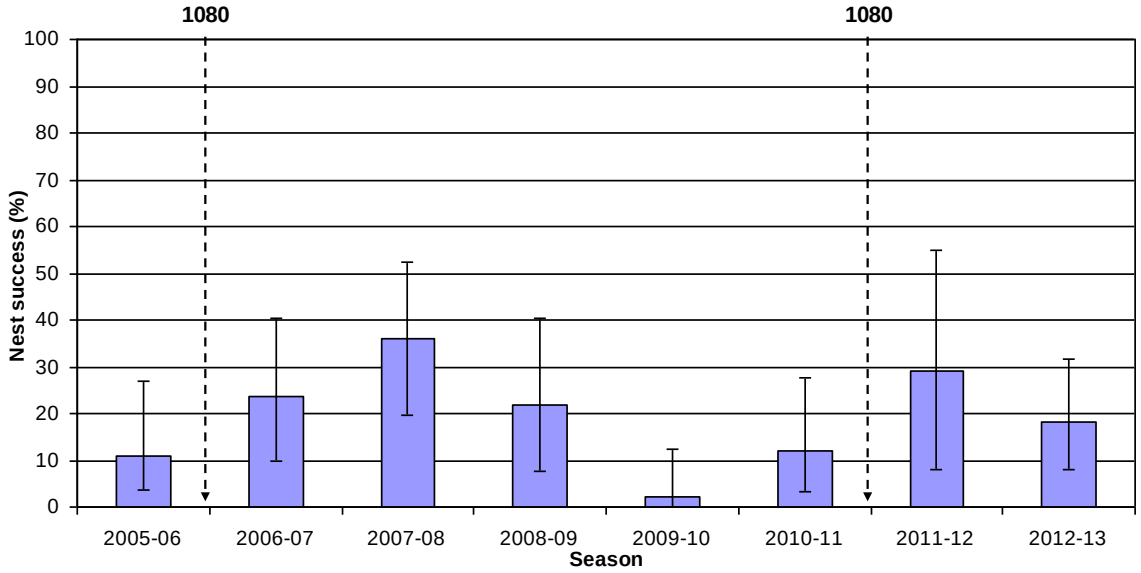

FIGURE 5: TFKS FANTAIL NESTING SUCCESS RATE 2002 – 2013 USING KAPLAN-MEIER

TFKS was monitored in two parts, Tongariro Forest East and Tongariro Forest West. As in previous years nests were harder to locate on the Eastern side than the Western side and thus resulting in a lower sample size on the East (Table 4).

TABLE 6: TFKS WEST AND EAST FANTAIL NEST OUTCOMES FOR 2012/13.

	TF West	TF East	Total
Abandoned after laying	2	1	3
Abandoned before laying	5	1	6
Failed	16	8	24
Successful	7	3	10
Total	30	13	43

Signs of rat predation in the form of egg fragments and disturbed nest linings were found at five of the failed nests, one of the nests was predated by a long-tailed cuckoo as recorded by a

motion sensor video camera and resulted in a 'clean take' in which no physical evidence is found. Fourteen other failed nests were also found to be clean takes. It cannot be conclusively stated that all clean take failures were the result of long-tailed cuckoos but it is highly likely especially given that the success rate was higher in the second half of the season when the majority of the cuckoos had left to return to the Pacific Islands.

There were also a number of fledglings and juveniles seen around TFKS in areas or at times not consistent with any of the nests being monitored which shows that there were nests which successfully produced fledglings that were not located for the study. This season the first nest was found on the 25th of September 2012 and the last was located on the 28th of December 2013.

FIVE-MINUTE BIRD COUNTS

In 2013 five minute bird counts were conducted in two areas: TFKS and Pukepoto/OPC. TFKS was treated with aerial 1080 in late September 2011 and Pukepoto/OPC forests were treated with aerial 1080 on the 11th of October 2012. The first bird count was conducted on the seventh of February 2013 the last on the fifth of April 2013. Half of the Pukepoto bird counts were delayed until April because the Rotoaira forest through which Pukepoto is accessed was closed during late February and most of March due to extreme fire risk which would have had some effect on counts.

A total of 216 counts over 54 listening stations were conducted at TFKS with a bird number of 1457 giving an average of 6.7 birds per count. At Pukepoto/OPC a total of 224 counts over 56 listening stations resulted in a bird number of 1857 giving an average of 8.3 birds per count. Bird counts are known to fluctuate widely from place to place and year to year making it difficult to draw concise conclusions from results although some trends can be observed.

Some of differences between the bird count results from this season and those from last season for TFKS were that the number of fantails, tomtits and grey warblers recorded were higher in 2013. However it should be noted that these increases were also observed in Pukepoto/OPC. The average number of fantails recorded per count was very similar between areas for both 2012 and 2013. The most abundant birds in TFKS for the 2013 bird counts were tomtits, silvereyes, whiteheads and bellbirds (Appendix7).

TONGARIRO FOREST KIWI SANCTUARY 2006 AND 2011 AERIAL 1080 OPERATION RESULTS AND OUTCOME MONITORTING

Kiwi and fantails benefited for two seasons following the Tongariro Forest September 2006 aerial 1080 operation (Figure 6). Kiwi chick survival and fantail nest success rates increased in the 2006/07 season, and remained high for a second season (2007/08). Between 2008 and 2011 rates dropped back down to pre-1080 levels as mustelid and rat populations recovered. However, following the aerial operation in September 2011, both rates more than doubled. In the 2012/13 season both kiwi chick survival and fantail nesting success have begun to decline with the fantail nesting success not following the rising trend of the 2007/08 season. However, kiwi chick survival and fantail nest success rates have not yet dropped to pre – 1080 levels (i.e.: 2010/11 season levels). Rat and mustelid tracking rates have risen as the populations begin to recover after the September 2011 1080 operation.

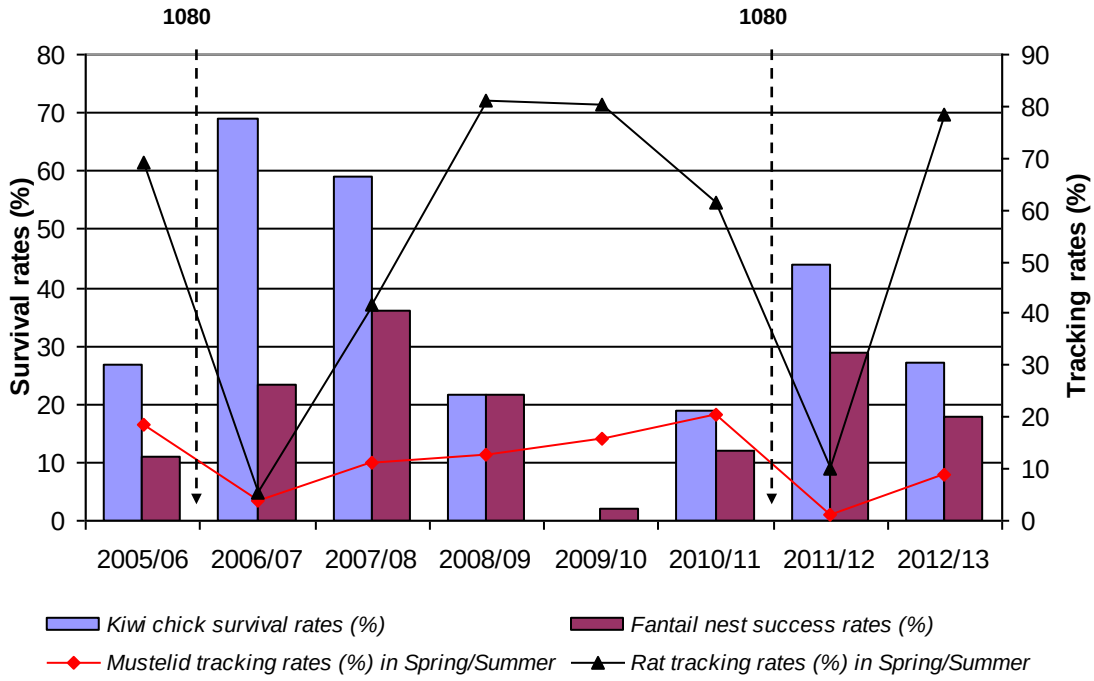

FIGURE 6: SMALL MAMMAL INDEXING TRACKING RATES, WITH KIWI CHICK SURVIVAL AND FANTAIL NEST SUCCESS, BEFORE AND AFTER AERIAL 1080*

**Kiwi chick survival data from the 2009/10 season is not included, as chicks were crèched in Warrenheip, a 16ha predator proof fenced area of bush near Cambridge, Waikato.*

FUTURE DIRECTIONS

Kiwi chicks have been monitored within Tongariro Forest Kiwi Sanctuary (TFKS) for seven seasons, before and after aerial 1080 operations, which have occurred every five years. TFKS was set up to answer some important management questions and it appears we have achieved that goal. Aerial 1080 operations have benefited kiwi chick survival for two consecutive seasons. Other forest birds also benefited from aerial 1080 operations with increased nest success for fantails for one or two consecutive seasons after 1080 operations. Sufficient data has been collected to write up the results for this study.

Our proposed research focus for the next five years is to measure the benefits of lower sowing rates of aerial 1080 to kiwi chick survival (kiwi sanctuaries strategy draft 2014-2019). The next proposed aerial 1080 operation is scheduled for 2014; this timing is based on our previous research. Kiwi chicks will be monitored for two seasons after Aerial 1080 operations, but chicks will no longer be monitored during pre – 1080 seasons (non-treatment years) as we have established a good set of data showing results for kiwi chick survival in the absence of predator control (</= 22%).

As a result, there is an opportunity for Operation Nest Egg™ in the 2013/14 season (non treatment). This would involve lifting eggs or chicks from kiwi nests in TFKS, and releasing the young chicks into a predator proof kiwi crèche such as Wairakei Golf + Sanctuary. They would then be released into Tongariro Forest when they reach 1100g ("stoat proof" weight). The 2013/14 season also provides an opportunity to fulfil the original agreement with Maungatautari Ecological Island Trust to provide them with 20 western brown kiwi founders. So far we have gifted them with 12 kiwi, and they have gifted us 14 kiwi; the off-spring of the original founders.

The sub-adult population will continue to be monitored in the 2013/14 season, to ensure a robust data set is collected.

As it is unclear whether a ferret incursion event will occur again within TFKS, the Kiwi Recovery Group is considering the implementation of surveillance trap lines (DOC250s) along the perimeter of the Sanctuary (between farmland and forest).

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