Department of Conservation
Te Papa Atawhai

Establishing a kiwi population at Otanewainuku

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Summary

Otanewainuku Kiwi Trust established predator control over 1000 ha to protect the local kiwi population. This report addressed several questions asked by the Trust, specifically focussing on predator control, size of management, kiwi management by volunteers, survival rates of sub-adult kiwi, sub-adult vs. adult transfers, consistency with national kiwi strategy and long-term goals for the Trust.

The pest control regime was found to be more than adequate, although the size of the managed area will produce challenges for establishing a kiwi population, predominantly due to dispersal. Kiwi management by volunteers requires no improvement, and is appears to operate at a high standard. Fifteen sub-adult kiwi have been released in to Otanewainuku, although survival rate has been low at 17%. Compared to sub-adult survival work done at Tongariro Forest, Boundary Stream, Pukaha Mount Bruce and Waimarino Forest, it would be expected that around 60-65% of sub-adults should survive to breeding age (or 4.5 years, whichever comes first). There is no obvious reason why Otanewainuku kiwi have had such a low survival rate, and it is suggested that small sample size may have a part to play.

The Trust could expect kiwi to disperse on average 2.5 to 3.5km from release point, and start to settle down at around 1.5-2 years of age. These distances mean that birds are likely to leave the managed area. Boundary Stream has found that retrieving birds dispersing out of the managed area (anywhere between 1 to 11 times) have resulted in the majority of juveniles remaining within the 900ha fragment. Other sites have found that sub-adults are attracted to territorial adults. However, releasing adult pairs has not been done frequently in the past, and their behaviour is not well understood. It is suggested however that this technique is considered to help anchor sub-adult birds to the site.

Consistent with national advice on establishing kiwi populations, it is recommended that at least 30 unrelated founders are required to maintain genetic diversity for the site. This may require multiple sources and multiple transfers. The ultimate aim is for the population to become self-sustaining, and if conservative estimates of 40ha per pair is used, a minimum of 25 breeding pairs could eventually establish within Otanewainuku within the next 20 years.

Recommendations

- Consider the feasibility of growing the size of the stoat trapping area
- Explore the possibility of releasing several pairs of adult 'rescued' kiwi in an attempt to anchor birds to the site
- Increase number of sub-adults released to determine whether poor survival rate is accurate
- Investigate several source sites to obtain 30 founders for the population
- Write a five year strategy outlining the plan for establishing a kiwi population, which would include an exit strategy if kiwi do not establish

Background

The Otanewainuku Kiwi Trust (OKT) was formed in 2002 in response to concern around the decline of eastern brown kiwi in the Otanewainuku Forest. To help protect the remaining kiwi population at the site, OKT established a stoat trapping network over 1000 ha in 2003. However, further monitoring found that the population had gone locally extinct. To establish a new population at Otanewainuku, the Trust undertakes BNZ Operation Nest Egg (ONE) at Whirinaki Forest, and half the chicks are released back to Whirinaki, with the other half released at Otanewainuku. To date 15 birds have been introduced to the site.

The majority of the releases (11) have occurred over the last two years. However, the survival rate of the released birds has not been high. Of the 15 birds that have been introduced, only two are still known to be alive. This higher than expected mortality rate has prompted a request to review the project to determine whether the management of the site and kiwi are as good as it can be.

The purpose of this document is therefore to determine whether the sub-adult survival rate experienced at Otanewainuku is higher than would be expected at other sites, and if so, why. It specifically explores:

- Suitability of Otanewainuku for translocations of kiwi, looking at predator control and size of management
- Review the onsite management by volunteers
- Comparison with similar projects of mortality of sub-adult kiwi
- Sub-adult vs. adult transfers
- Consistency with national and taxon kiwi strategy
- Long-term goals for the Trust

Suitability of Otanewainuku for translocations of kiwi

Predator control

Otanewainuku Conservation Area is 1200ha in size, with approximately 1000ha of trap lines to manage stoat numbers, mainly consisting of two Conibear traps in each tunnel (n=226 tunnels). The trap lines were established at 300m by 150m spacing, and are cleared once a month over winter, and twice a month over the breeding season, which equates to 18 checks.

In 2000, the Department established five kiwi sanctuaries with the main aim of researching different management techniques to increase kiwi populations. Three of these sanctuaries specifically focussed on the effectiveness of stoat trapping to increase chick survival. The following information was extracted from their work.

Sanctuary	Size (ha)	Traps	Checks	Chick survival
Whangarei	8000	1/9ha	Monthly	62%
Moehau	16700	1/11ha	Monthly	67%
Haast	11400	1/17ha	Monthly	32%

It should be noted that Moehau is aided by being surrounded by water on three sides and a number of community projects protecting kiwi south of the sanctuary. These

projects checked traps monthly (n=12), with one checking twice in January – March (n=15) to correspond with peak numbers in stoats at this time of year. This information helped support the current standard recommendation for stoat control to protect kiwi at 1km by 100m spacing (i.e. 1 trap every 10ha), with 12 checks as a minimum.

Therefore the density of traps (1 trap every ~3ha) and the number of trap checks a year at Otanewainuku is more than enough to maximise the number of chicks that survive to 'safe weight' of 1200g once a breeding population is established, and should reduce the likelihood of the occasional sub-adult from being predated by stoats. The density of traps is on par with what can be found at Boundary Stream (1 trap every ~1.5ha) and Pukaha Mount Bruce (1 trap every ~2ha), both fragments of close to a 1000ha who are also trying to establish a self-sustaining kiwi population.

The Trust can be confident that according to our current knowledge, there are no further improvements to be made.

Size of managed area

The limitation of this site is the small size of the trapping area. There are two papers that separately reached the conclusion that at least 10 000ha of area needs to be protected to ensure that enough dispersing sub-adults eventually settle as part of the breeding population (Basse and McLennan 2006; Westbrooke 2007). This worked on the assumption that sub-adults on average would disperse 5km from nest or release site before becoming territorial. Dispersing sub-adults are considered as a loss to the breeding population (once established), since it is unlikely that equal immigration can be expected from outside the managed area.

A study of sub-adult movements at Tongariro Forest Sanctuary has shown an average distance from release point or nest of 4.4 km (n=25) for females, although three females dispersed much further (7.2km, 15km and 16.4km) and died before becoming territorial, which would have increased the dispersal distance significantly if they had been included in the sample. Males on average dispersed 2.7km from the release point or nest (n=33). In general though, kiwi remained within 5000ha once released. If a rough circle was drawn around the release site, only about 30% of birds remained within 1000ha of the release point (taken from data provided by Ruapehu Area Office). In general, it appeared that sub-adults clustered around known territorial kiwi, with three distinct clusters now identified (Sutton *et al.* 2012).

This behaviour was also noted in the Kaweka Ranges, where birds once released moved towards other clustered kiwi. Released females moved on average 3.3km (n=3) and males 2.9km (n =7). Again, based on individual travel distances, only about 30% of individuals remained within 1000ha of the release point (taken from data provided by Hawkes Bay Area Office). According to Forbes (2009), Moehau Kiwi Sanctuary had notably higher dispersal distances, with the average net distance (from nest or release site) to territory being 7.2km for females (n=19), compared to males at 4.2km (n=17).

Please note that the examples used above were taken from existing populations, and likely influenced dispersal seen there. Because territories have been taken, sub-adults would have had to disperse further to find their own territories. Therefore the quoted dispersal distances are influenced by the context.

If the modelling is correct, Tongariro and Kawekas would require less than 10 000ha to capture enough dispersing kiwi as part of the breeding population, although Moehau might need more (which they have at 16700ha). Does this mean that 1000 ha of stoat control is a waste of time?

Kiwi populations have been established in small fragments at Boundary Stream (900ha) and Pukaha Mount Bruce (950ha), adding to the distribution and number of kiwi populations under protection. In Northland, high densities of pairs have been recorded in very small fragments, with 25 pairs in 55 ha at Rarewarewa and 30 pairs in 70 ha at Purua (Hugh Robertson, pers comm.). These densities have not been observed for eastern brown kiwi, but it does indicate that 1000ha has the potential to hold a good number of pairs. The question is whether enough sub-adults will remain within the site to help grow the population, which has not been conclusively answered by sites like Boundary Stream or Pukaha Mount Bruce yet.

The larger area under protection, the higher the likelihood of protecting the dispersing sub-adults and adding them to the population. Expanding the current predator control much more may not be feasible due to rough terrain and volunteer capacity (Dave Wills, pers.comm). However, there may be an opportunity to grow the site to include 1200ha of trapping by the Trust. In addition, an adjoining forest block managed by the Tauranga City Council is part of a 10-year strategy to be protected through trapping. It currently has no funding attributed to it, but it is encouraging that the City Council has recognized the site's value. If at some point the Council implements predator control, it will more than double the size of the managed area for kiwi.

Kiwi management

Kiwi are released into Otanewainuku once they reach ~1000 g in weight. Currently each kiwi is monitored weekly through radiotracking to determine whether it is still alive and its relative location. Missing birds are located by helicopter until found, and volunteers undertake retrieval operations, where kiwi that disperse out of the managed area are brought back and released again. This has been shown to be successful at Boundary Stream, where only two kiwi have been lost from the population due to dispersal after numerous retrievals failed to deter them from dispersing.

This regime of monitoring is sufficient to ensure that the whereabouts and outcome of the released birds are known, and there are no improvements that can be suggested. Monitoring however is appearing to be a significant drain on volunteer efforts, and this level of monitoring can only be sustained for a small number of birds. It may be necessary to explore options for reducing checks to every two weeks to be more sustainable. This may however compromise the Trust's ability to detect birds that have dispersed and retrieve them.

Mortality of sub-adults at Otanewainuku and other sites

Fifteen kiwi have been released in to Otanewainuku, for which the fates are known for 11. The outcomes are listed in Table 1.

TABLE 1: FATE OF 15 KIWI MONITORED AT OTANEWAINUKU

Survived to breeding	2
Death – Misadventure	6
Death – Predation	1
Death - Unknown	2
Total fate known	**11**

Of those killed by misadventure, one was run over by a car, one fell off a cliff, two drowned and two were entangled. Using the Kaplan-Meier Analysis, the survival rate of all 15 kiwi within the block was calculated to be 25%, and the survival of only sub-adult/non-breeding birds 17% (Confidence intervals of 1-50%).

When compared to survival of non-breeding kiwi at other sites, this is considered lower than expected (Table 2).

TABLE 2: COMPARISON OF SURVIVAL RATES AT OTHER SITES

Site	**N**	**Dead**	**Survival rate**	**95% CI**
Tongariro Forest	125	34/68	58%	45-67%
Boundary Stream*	39	13/34	64%	45-77%
Waimarino Forest	28	5/13	65%	43-81%
Pukaha Mount Bruce	69	32/43	58%	46-71%

*Up until 2009

More detail about each site can be found in Appendix 1.

Implications

Otanewainuku appears to have a higher than expected mortality rate in released kiwi, predominantly due to misadventure. As can be seen in Appendix 1, misadventure does account for a proportion of deaths at other populations. This may appear to be proportionally lower when compared to Otanewainuku, which could be for one or more reasons:

- Small sample size. With only 15 kiwi, the number of misadventures may seem disproportionately higher compared to other sites. Increasing the sample size may result in a more comparable statistic.
- A high proportion of deaths at other sites were due to predators. If predators had not killed them, a few more outcomes may have been attributed to misadventure. Admittedly, this does not change the lower survival rates at Otanewainuku
- Habitat is not suitable for kiwi. I don't believe this is a valid concern as kiwi are known to have existed at Otanewainuku historically, and are known to be able to survive and breed (as demonstrated by at least one established pair).
- Pure bad luck. This seems the most likely reason for a comparably low survival rate, but a larger sample size would determine the validity of this.

Sub-adult vs. adults

When establishing a new kiwi population, generally sub-adult kiwi are released. Because of the prevalence of sub-adult releases, we have more information on their behaviour than we have for adults. We know for instance that sub-adults will tend to disperse once

released. In an established population like Tongariro Forest, Kawekas and Moehau, the dispersal distance has been shown to be a number of kilometres, which may be affected by existing territorial kiwi. However, we frequently observed sub-adults dispersing towards other territorial kiwi rather than dispersing at random. In Otanewainuku, some evidence of this has already been shown, with some sub-adults moving towards the only territorial pair or territorial male present at the time (Dave Wills, pers. comm.). To date the kiwi from Otanewainuku have behaved as one would expect, with eight of the 15 kiwi dispersing from the managed area. Despite multiple returns however, some still continued to disperse or died before forming a territory.

The mean age of territoriality at Tongariro Forest (n=40) is 1.65 ±0.25 years old (Sutton *et al.* 2012). Therefore when releasing sub-adults at roughly 6 months of age, it can be expected that they will be moving around for at approximately a year before settling down. Whetu and Maui were released at 11 months of age, and became territorial at 1.7 years old. Age of territoriality may be even shorter at a site like Otanewainuku where available territories are readily available.

The behaviour of adults after release is less well known. It is Best Practice to release an existing pair if possible, although it is generally acknowledged that the pair is unlikely to stay together. There does appear to be anecdotal evidence that males will not disperse far from the release site if a territory is available. For instance, when Tongariro Forest released a captive pair the female disappeared within a few days, and the male has remained near the release site (Nicole Sutton, pers. comm.) Similarly, Maungatautari has recently released a few adults and although none of them were tagged, they reported that they now have a male calling near his release site (Mark Lammas, pers comm.). Pukaha Mount Bruce also reported that adults generally remained close to the release site (Silberry, 2007). Otanewainuku appeared to have a similar experience with Mamaku, who set up his territory within three months of his release.

This behavioural trait might aid in anchoring kiwi to Otanewainuku until the population is established. With territorial adults or pairs, the sub-adults might be anchored, or temporarily disperse and return if no other calling kiwi are found. A strategy to consider may be to obtain pairs from a site that is considered a 'rescue situation', which has generally been defined as no possibility of predator control at that site within the lifetime of the adult birds. The Kiwi Recovery Group has supported this approach in Taranaki and Waimarino, although adults were released in to predator proof enclosures which have restricted dispersal. However, only a few pairs would be required to hopefully have a few males establish, which may then anchor further sub-adults to the site. This approach has appeared to work well at Pukaha Mount Bruce.

Consistency with national or taxon kiwi strategy

The Kiwi Recovery Plan (Holzapfel *et al.* 2008) has set a goal of a minimum of 500 breeding pairs to be protected for each taxon. For eastern brown kiwi, this has been not yet been achieved.

An action of the recovery plan is to develop more specific goals for each taxon. The Eastern Brown Kiwi Taxon Plan is in its first draft, with the aim:
"*To restore, and wherever possible, enhance the abundance, distribution and genetic diversity of the taxon*" .

Specifically, its goal is to eventually reach 500 pairs under protection, and grow this to 1000 pairs (Burns, 2012). Otanewainuku Kiwi Trust could eventually contribute to reaching this goal if a population is successfully established.

Long-term goals for the Otanewainuku kiwi population

The advice given to all sites wanting to establish a new population of kiwi is that ideally the founder population should consist of a minimum of 30 unrelated individuals that begin to contribute to the new population. This is loosely based on genetic modelling undertaken by Otago University for establishing a closed population within a fenced site. A managed kiwi population in the wild is generally considered to be a relatively closed, as immigration from outside the area is thought to be low. To achieve this goal does usually require sourcing birds from multiple sites, and usually multiple tranfers. Since the kiwi captive population will consist entirely of eastern brown kiwi in the near future, a potential source may be available there (pending captive coordinator recommendations).

Ultimately the goal for the Trust will be that the population will become self-sustaining within the next 10 years. Self-sustaining is defined by recruitment equals or exceeds adult loss. If this is achieved, the population is guaranteed to grow, and will not require further additional management through ONE. Neither of the other two small sites (Boundary Stream or Pukaha Mount Bruce) has achieved this yet, mainly due to ongoing ferret predations and dispersal from the site. A small site does make this a challenging objective to achieve, and it is yet unknown whether it can be achieved.

To have a self-sustaining population makes aiming for a number of pairs within the site relatively arbitrary, since such a population will grow to reach carrying capacity (whatever that might be). If it is useful though, Mclennan et al. (1987) found paired eastern brown territory sizes of 20 to 40 ha, taken from a small number of tagged birds. Using these numbers, the Trust could aim for at least 25 breeding pairs within the site, which is a conservative estimate of one pair every 40ha. The territory size is likely to be smaller due to rat control, which would provide more food. However, kiwi do not tend to universally spread themselves at equal spacing, and this conservative estimate is likely to allow for some uneven distribution.

To summarise, a valid long-term goal for the Otanewainuku kiwi population could be:

"Establish a viable, self-sustaining population of eastern brown kiwi from at least 30 unrelated founders, and grow the population until it has at least 25 breeding pairs within the first 20 years."

The timeframe of 15-20 years is based on a quick population modelling exercise, assuming 65% of chicks will survive, 65% of sub-adults will survive, and 98% of adults will survive. This does not take in to account loss from the population through immigration. If 25 pairs is reached quicker than expected, then the goal could be re-evaluated.

Recommendations

- Consider the feasibility of growing the size of the stoat trapping area
- Explore the possibility of releasing several pairs of adult 'rescued' kiwi in an attempt to anchor birds to the site

- Increase number of sub-adults released to determine whether poor survival rate is accurate
- Investigate several source sites to obtain 30 founders for the population
- Write a five year strategy outlining the plan for establishing a kiwi population, which would include an exit strategy if kiwi do not establish

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Appendix 1 – Detail of comparison of survival rates at other sites

Tongariro Forest Kiwi Sanctuary (TFKS)

TFKS is a 20 000ha podocarp forest with no other predator control in place other than aerial 1080 application every four to five years. Since 2000, 77 ONE birds have been closely monitored, as well as 43 wild hatched sub-adults and five wild caught (n=125). Of the 125 sub-adults, we know the outcome of 68, of which 34 have died before reaching adulthood and 34 have bred or reached 4.5 years of age. The causes of mortality can be seen in Table 2.

TABLE 2: FATE OF SUBADULTS MONITORED AT TFKS

Survived to breeding or 4.5 yrs	34
Death – Misadventure	10
Death – Predation	12
Death – Unknown	12
Alive at <4.5 yrs	25
Total fate known	**68**

Transmitter losses occurred for a large proportion of the sample, which means their final outcome is unknown.

TABLE 3: SURVIVAL RATE OF SUB-ADULTS WITHIN TONGARIRO FOREST (KAPLAN-MEIER ANALYSIS)

	Survival Rate (SR %)	Female SR (%)	Male SR (%)
ONE (n=77)	61.6	22	72.6
Wild-hatched (n=43)	57.8	53.8	61.8
Wild caught (n=5)	N/A	N/A	N/A
Overall (n=125)	**57.9**	**30.5**	**64.7**

* Cumulated monitoring time from 2001 to 2012

Boundary Stream

Boundary Stream is a 900 ha fragment with intensive predator control, in which 39 ONE sub-adults (at 800g) have been released between 2000 and 2009. Of these, the fates are known for 34 (Table 4).

TABLE 4: FATE OF SUBADULTS MONITORED AT BOUNDARY STREAM

Survived to breeding or 4.5 yrs	19
Death – Misadventure	5
Death – Predation	8
Dispersed from site	2*
Total fate known	**34**

* When sub-adults dispersed from the site, they were recaptured and returned to Boundary Stream until they became established. Of these, only two sub-adults still dispersed outside of the management area.

The rest were lost due to transmitter failure.

The survival rate for Boundary Stream was calculated at 64% (Kaplan-Meier Analysis), with no discernible difference between female and males.

Waimarino Forest

Waimarino is roughly 13000ha of exotic pine forest interspersed with native forest fragments. Between 2005 and 2011, 28 ONE kiwi have been released and tagged to determine survival in an area with no predator control. Unfortunately due to a high rate of transmitter failures, the fate is only known for 13 with a further four dispersing out of range (Table 5).

TABLE 5: FATE OF 28 SUBADULTS MONITORED AT WAIMARINO

Survived to breeding or 4.5 yrs	4
Death – Misadventure	4

Death – Predation	4
Death – Unknown	1
Dispersed from site	4
Total fate known	**17**

The survival rate for Waimarino was calculated at 65% (Kaplan-Meier Analysis), with no discernible difference between gender.

Pukaha Mount Bruce

Pukaha Mount Bruce is approximately 950ha with intensive predator control, and since 2003, 90 birds have been released in to the site. Of these, the outcomes are known for 43 birds, as some birds had been released without transmitters, or transmitters were subsequently removed (Table 6).

TABLE 6: FATE OF 43 SUBADULTS MONITORED AT PUKAHA MOUNT BRUCE

Survived to breeding or 4.5 yrs	11
Death – Misadventure	3
Death – Predation	15
Death – Unknown	14
Total fate known	**43**