Rotoehu Kōkako Survey Report 2023

Summary report prepared for the Rotoehu Ecological Trust

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1. Introduction

The North Island kōkako (*Callaeas cinerea*) is a charismatic bird species endemic to New Zealand. Prior to human habitation, kōkako were common in forests throughout the North Island and Aotea / Great Barrier Island. The North Island kōkako (hereafter kōkako) experienced major declines across its range during the 20th century, reduced dramatically to around 330 pairs by 1999, spread across 11 relic sites, primarily as a result of nest depredation by ship rats (*Rattus rattus*) and brushtail possums (*Trichosurus vulpecula*), following the historic declines caused by forest clearance (Innes et al., 2020). All extant populations are protected against introduced mammalian predators by the effective and sustained control of introduced mammalian predators (Flux et al., 2019). Effective pest control and conservation translocations carried out to reestablish the species in areas where they were previously extirpated, to establish safe populations on islands free of mammalian predators, and to genetically bolster small relict populations has resulted in an increase in the national population to 2,000 breeding pairs by 2020 (Innes, 2013). The status of the North Island kōkako has improved to 'vulnerable - nationally increasing' (Robertson et al., 2021).

While there are 11 relic kōkako populations, only five of these (Mapara, Mokaihaha, Pureora, Rotoehu, and Te Urewera) avoided a demographic bottleneck below 40 individuals, and these sites are accordingly assigned Priority One status by the Kōkako Recovery Group (KRG), as the most genetically diverse populations (Innes et al., 2020). Rotoehu, comprising Rotoehu Forest Conservation Area (including Pongakawa Ecological Area) and Rotoehu Forest West encompasses approximately 3,500 hectares of native forest. From 1994 onwards, the Department of Conservation (DOC) has controlled ship rats, possums and stoats (*Mustela erminea*) at Rotoehu using a range of methods at varying intervals (Appendix One). The Rotoehu Ecological Trust (RET), was established in 2013 and manages a bait station network at Rotoehu to control mammalian predators over an increasing area (currently 1,367 hectares) in partnership with DOC and Ngāti Mākino.

Effective long-term monitoring of threatened species is essential to inform appropriate management and enable better conservation outcomes (Robinson et al. 2018). In March-April 2023, RET coordinated a kōkako survey following the standard territorial adult census methodology (see Flux et al., 2019), to determine the change in the number and distribution of territorial kōkako at Rotoehu since the previous survey, undertaken in 2019 (Bryden et al., 2019).

2. Background

Rotoehu Forest (37°58'S, 176°32'E) covers an area of approximately 3,500 hectares and is approximately 30 kilometres northeast of Rotorua. Rotoehu Forest Conservation Area, Rotoehu Forest West, and adjacent native forests owned by Ngāti Mākino included in this survey, were mostly logged for podocarps, principally rimu (*Dacrydium cupressinum*), in the early 1940s (Leathwick et al., 1983). The area is now dominated by tawa (*Beilschmiedia tawa*) with areas of unlogged podocarp emergents, and associated kohekohe (*Dysoxylum spectabile*), rewarewa (*Knightia excelsa*) and pukatea (*Laurelia novae-zelandiae*). Patches of eucalypt (*Eucalyptus spp.*) and regenerating kamahi (*Weinmannia racemosa*) forest are also present. Survey areas are largely surrounded by pine (principally *Pinus radiata*) plantations. The area surveyed encompassed an elevation range from approximately 180 to 578 metres above sea level.

The forest understory at Rotoehu includes pate/five-finger (*Pseudopanax arboreus*), nīkau (*Rhopalostylis sapida*), *Coprosma spp*., māhoe (*Melicytus ramiflorus*), porokaiwhiri/pigeonwood (*Hedycarya arborea*), kareao/supplejack (*Ripogonum scandens*), makomako/wineberry (*Aristotelia serrata*) and the tree ferns (*Dicksonia squarrosa, Cyathea smithii, C. dealbata* and C. *medullaris*). Dama wallabies (*Macropus eugenii*), deer (*Cervus spp.*) and pigs (*Sus scrofa*) are all present at the study site.

The Rotoehu kōkako population was the subject of an intensive 'Research by Management' (RbM) predator control study between 1990 and 1997. Much of what we know and implement as evidence-based management results from this research done at Rotoehu and other RbM sites. Monitoring during 1997–2004 showed that more than 80% of mainland nesting attempts failed at Mapara Wildlife Management Reserve, Rotoehu and Kaharoa, predominantly due to predation by ship rats and possums (Innes et al., 2020).

A key outcome of this phase of kōkako recovery is that as well as clarifying the causes of decline of kōkako, the RbM studies contributed to the knowledge that the sustained control of the key predators of kōkako eggs and chicks - ship rats and possums - can result in the recovery of mainland kōkako populations (Innes et al., 1999). Appropriate levels of management required to allow high levels of kōkako nesting success were also determined. Where acute toxins (e.g. 1080) are used, operational targets of a 1% trap catch for possums (RTC) and a 1% tracking index for ship rats (RTI) on 1 November each year using DOC national standard monitoring methods are appropriate for the recovery of kōkako

populations. When pest control is ongoing (such as through the use of anticoagulant baits in bait stations), operational targets are the maintenance of ship rat abundance below 5% through the kōkako breeding season (October-November to March-April).

Predator control at Rotoehu, utilising the ground-based application of toxins across a 100m by 100m bait station network over 450 hectares, was instigated by the Department of Conservation in 1994, and control has been undertaken at varying frequencies since, using different toxins and trap types (see Appendix One). The area managed through ground control was expanded to 440 hectares in 1995-96 to 650 hectares in 2008.

The Rotoehu Ecological Trust (RET) was established in 2013 and managed subsequent ground-control operations. RET increased the area under management to 996 hectares in 2019, and to 1,367 hectares in 2022. Ground control has been supplemented with aerial 1080 operations over the entire Rotoehu Forest in 2004, 2017, and 2020. The next aerial 1080 operation is planned to occur over 2,756 hectares in spring 2023.

A total of 24 kōkako have been translocated from Rotoehu to other sites since 2009 in attempts to establish or genetically bolster kōkako populations at Ōtanewainuku, Ka Tū-waewae-o-Tū/Secretary Island (possibly failed), and Manawahe (Bryden and Rogers, 2021; Innes et al., 2013).

The previous Rotoehu kōkako survey was undertaken in 2019 (Bryden et al., 2019). That survey encompassed the 996 hectares of Rotoehu Forest under management by RET at that time, including the 600 hectare area surveyed in 2013 (Hunt and Jones, 2013). In addition, a wider area survey was conducted less intensively over a further 2,200 hectares of adjacent or linked native forest, mostly comprising Rotoehu Forest, administered by the Department of Conservation, but also including Ngāti Mākino land, and Ngāti Mākino land managed by Timberlands and PF Olsen.

3. Methodology

The 2023 survey was completed over 19 days between March 31 to April 28, mostly with between three and five experienced surveyors working each day, to total 75 person days.

The methodology used for this survey followed the territorial adult population census methodology detailed in Kōkako Standard Management Techniques document (Flux et al., 2019). The survey covered the 1,367 hectares of native forest currently under management by RET, as well as 786 hectares of proposed expansion areas within Rotoehu Forest (RF3 nd RF4 blocks), and a further 361 hectares of PCL not managed by RET but receiving regular 1080 operations, to total 2,450 hectares of PCL within Rotoehu Forest and Rotoehu Forest West surveyed.

In addition, approximately 500 hectares, comprising Timberlands managed land, Ngāti Mākino land, other PCL, and private land beyond Rotoehu Forest was also surveyed to determine the distribution of kōkako beyond Rotoehu Forest.

930 of the 1,367 hectares of forest currently under RET management was surveyed comprehensively, but a sub-sampling technique was used in the 437 hectare PEA1 block, with a count within a 100 hectare circular plot (comprising 23% of the block) used to extrapolate the number of kōkako in this block. The sub-sampling procedure used for surveying PEA1 block following Flux et al., 2014. Using a NZTopo50 map we superimposed a 500m grid over the map and numbered all grid intercept points (centre points). Circle outlines of 464 m (inner circle) and 564 m (outer circle) were created around each centre point. We rejected any circle which extended beyond PEA1. Five circle outlines met the criteria for inclusion, one of which was selected using a random number generator, and was uploaded to GPS units for use in the field. Playback was only used within the 464 inner circle. Any kokako first detected within the outer circle were followed for 20 minutes regardless of where they then moved. Observers did not initiate any follows of kokako that first called beyond the outer circle.

In both the management area (including the sub-sample area of PEA1) and wider area surveys, transects were walked from dawn until approximately noon on fine mornings whilst listening for kōkako. When kōkako were not heard, pre-recorded mews and song were broadcast using Foxpro NX4 playback units at 200 metre intervals along each transect to try to elicit a response. As the dialect of kōkako varied

across the study site, recordings of kōkako pairs from each block were made using a Sony Linear PCM recorder and an Azden shotgun microphone.

Playback at each survey point consisted of:

1) 3 Rotoehu mew calls, followed by a 5 minute listening period;
2) 3 Rotoehu mew calls, followed by a 5 minute listening period;
3) 30 seconds of Rotoehu song, followed by a 5 minute listening period.

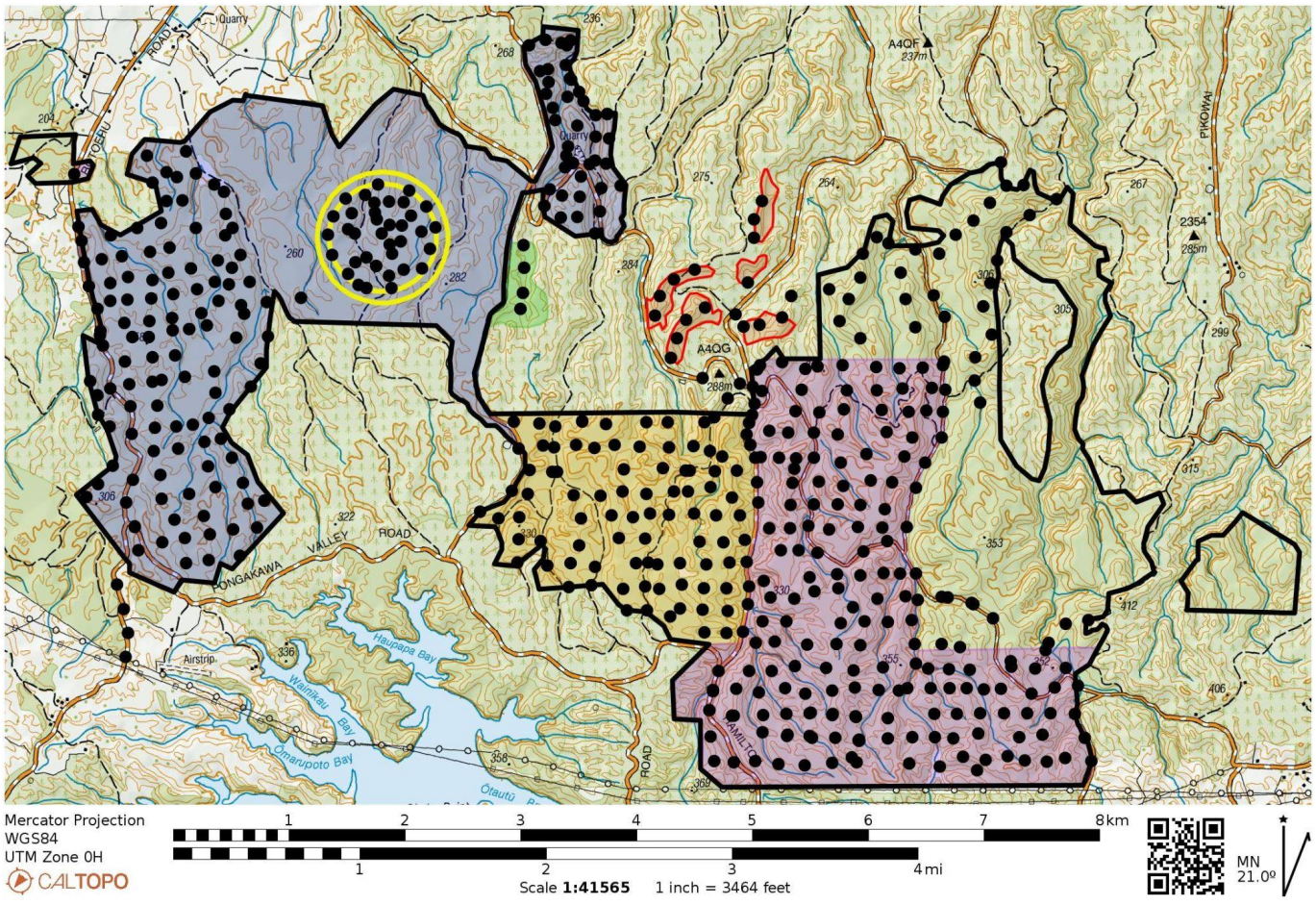

Figure One: Playback points during 2023 Rotoehu survey. PCL is indicated by the black outline. RET area under management since 2019 or earlier (blue), RF1 and RF2 blocks managed since 2022 (orange), proposed RF3 and RF4 blocks (purple), Timberlands (red) and Ngāti Makino land (green) are shown. Not all playback points to the east of Rotoehu Forest are shown.

All birds seen or heard were followed to determine whether they were territorial, to identify whether they had any distinguishing characteristics, and to determine whether they were single or paired. All follows were recorded using handheld GPS units to delimit territory boundaries.

Following Flux et al. (2019), birds were determined to be territorial if the following was achieved:

a) One follow of at least 20 minutes, during which a territorial single bird or pair sang full song, or;
b) Two follows of at least 10 minutes each on two different days in the same location, during which a territorial single bird or pair sang full song, or;
c) One follow of at least 20 minutes by an experienced observer in which at least one typical pairing behaviour was exhibited (mutual preen, mutual feed, bill tap, roosting side by side, moving closely).

As the Rotoehu population is dense and birds are unbanded, additional methods were used to delineate pairs to reduce the likelihood of inaccuracies stemming from the double counting or clumping of sightings. First, surveyors worked in parallel along transects, and were in radio communication. Where adjacent pairs were followed concurrently they could be determined to be separate. Second, distinguishing characteristics such as tail moult matterns and wattle descriptions were noted to delineate sightings or suggest that two sightings were in fact of the same bird(s). As all follows were saved on GPS units, in instances where surveyors could not determine whether the kōkako being followed were different to previously located birds, attempts were made to ‘drag’ them across the previous follow using playback. If the kōkako being followed sung full adult song in an area where another follow had previously been recorded, and no other kōkako were encountered, these two follows were conservatively counted as the same bird(s).

In areas where pairs or territorial singles could not be differentiated during the initial survey period, a team of surveyors returned on a subsequent morning to conduct a ‘stake-out’ to determine whether these observations were of one or multiple pairs or singles.

4. Results

4.1 Kōkako Within RET Management or Proposed Management

Weather conditions were mostly favourable during the survey period, and three scheduled survey days where rain was forecast were rescheduled to deliver an accurate survey result.

147 pairs and 4 territorial singles were recorded within the areas currently under management by RET; a total of 298 territorial adult kōkako (Appendix Two). 25 pairs and 1 single were recorded in the 100 hectare circular plot sub-sample of PEA1. Extrapolation of these numbers gives an estimated 110 pairs and 4 singles in PEA1, meaning the total estimated Rotoehu kōkako population within the 1,367 hectares currently managed by RET is 471 individuals, comprising an estimated 232 pairs and 7 territorial singles. Of these, an estimated 205 pairs and 5 singles are within the 996 hectares under management when the population was last surveyed in 2019, representing a mean growth rate of 13% per annum in these areas (Figure Two, below).

The average kōkako density across the RET managed areas was 5.9 hectares per pair. However, kōkako density varied by block, with the highest density in PEA1 (4 ha/pr), which has the longest history of pest control, and the lowest densities in the RF1 and RF2 blocks installed in 2022 (10.2 and 14.5 ha/pr, respectively).

Kōkako were present at lower densities within the proposed RET expansion blocks of RF3 and RF4 than in the managed areas. A total of 25 pairs and 4 singles were recorded in these blocks, with a mean density of 27.6 and 59.3 hectares per pair in each of these blocks, respectively. As the survey through these areas followed the standard territorial adult survey methodology, rather than the walk-through methodology employed during the 2019 survey, direct comparisons cannot be made between these two surveys in these areas.

Fledgling and subadult kōkako were frequently observed during the survey, both accompanying territorial pairs and independently. However, the adult census methodology differs from the standard fledgling survey methodology (Flux et al., 2019). Fledgling surveys require longer follows of known kōkako pairs (up to two hours), to confirm the presence of fledglings. Further, independent fledglings and sub-adults are highly mobile and as such it is possible to count an individual multiple times in

different locations. Therefore, the counts provided in this report are of territorial adults only, and do not include fledglings or other non-territorial birds.

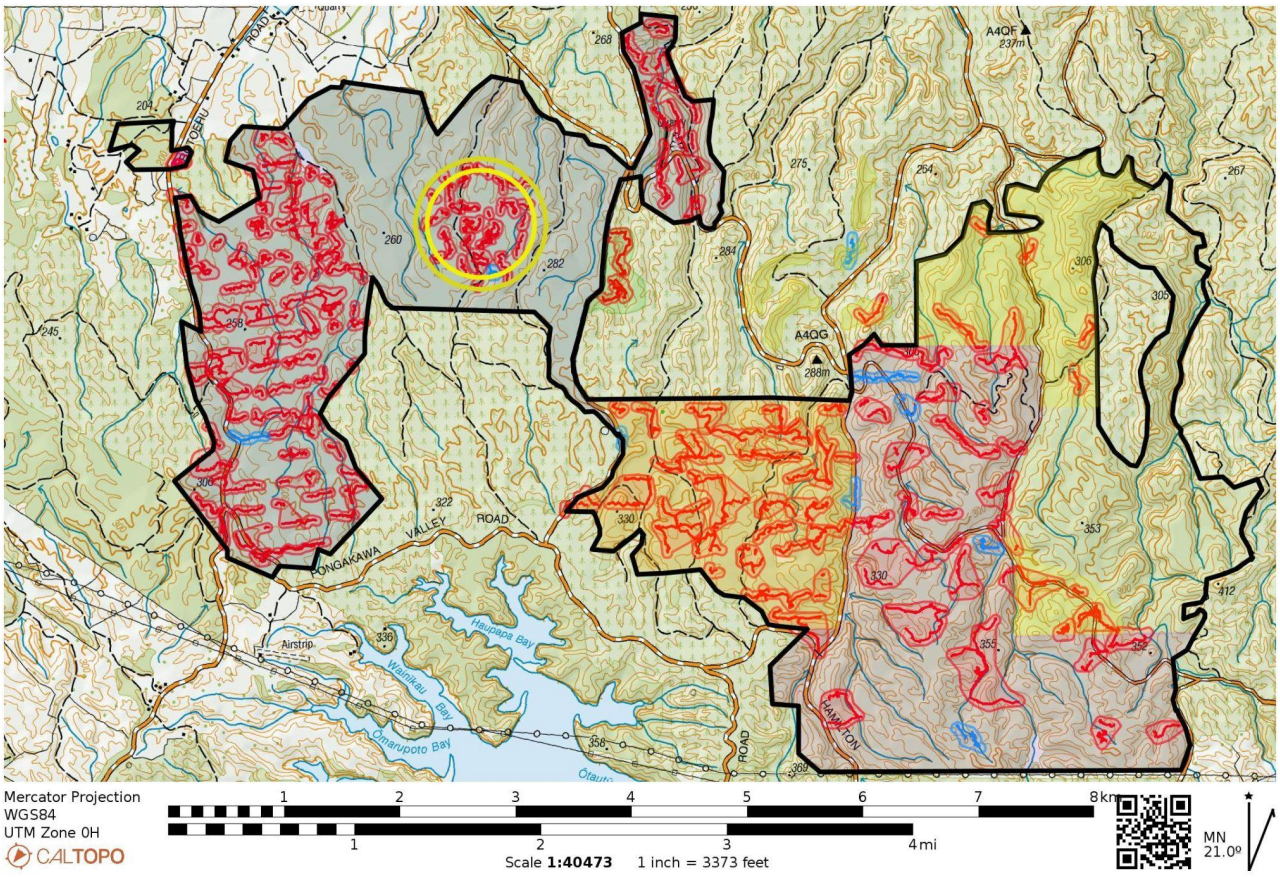

Figure Two: Territorial kōkako pairs (red tracks/polygons) and singles (blue tracks/polygons) recorded in 2023 on PCL and adjacent Ngāti Makino and Timberlands managed land. PCL is indicated by the black outline. RET areas are indicated by blue shading (managed from 2019 or earlier), orange shading (managed from 2022) and purple shading (proposed RF3 and RF4 blocks). Wider area surveys of Timberlands native covenants and Rotoehu Forest are indicated in yellow shading and Ngāti Mākino land is indicated in green shading. Kōkako detected on other areas of private land are not shown.

4.2 Kōkako Within Rotoehu Forest PCL

A further 9 pairs were recorded during wider area walk-through surveys of approximately 295 hectares of Rotoehu Forest east of the current and proposed RET management areas (shown in yellow in Figure Two above). As such, the total estimated number of kōkako recorded within Rotoehu Forest (and therefore benefitting from regular 1080 operations) is 266 pairs and 11 singles over the 2,450 hectares surveyed. This figure is likely to be lower than the actual number of territorial kōkako within Rotoehu Forest as some eastern areas of Rotoehu Forest were not surveyed, and the wider area survey methodology used over the 295 hectares may not have detected all territorial kōkako within these areas.

4.3 Kōkako Wider Area Results Beyond Rotoehu Forest

3 pairs were recorded on the 27 hectare native forest block of Ngāti Mākino land adjacent to PEA1; an increase from 2 pairs in the same area in 2019. 1 pair and 1 territorial single were recorded across the 5 small forest fragments totalling 39 hectares that are administered by Timberlands, a decline from 2 pairs in 2019.

A further 17 pairs and 2 territorial single kōkako were recorded during walk-through surveys of Timberlands managed forestry areas, and PCL and private land to the west of Rotoehu Forest. The most distant kōkako were located up to 3.4 kilometres west of the current management area on private land, but as this was the westernmost transect surveyed, kōkako may have established territories further west still. Matawhaura North Scenic Reserve was also surveyed, with no kōkako recorded.

5. Discussion

The results of kōkako population surveys are important for ecological managers. Understanding population trends and the distribution of kōkako can allow managers to continue to make changes to management, to both improve adult survival and boost productivity to allow for rapid population growth (Parker et al., 2013). Where populations are able to grow rapidly from a bottleneck, loss of genetic diversity through drift is minimised (Jamieson et al., 2008). Recent genetic work indicates that rapid population growth from a bottleneck of no fewer than 40 unrelated founders until a target of 500 territorial kōkako is reached is necessary to maximise the likelihood of long term population persistence (Weiser, 2015).

Within the 1,367 hectares currently receiving predator control by RET, the kōkako population falls just short of this target with an estimated 471 territorial kōkako (including 232 pairs), but with a mean growth rate of 14% per annum over the past four years in these areas, it is expected that this objective will be surpassed by 2024. Within the broader Rotoehu Forest, which receives predator control at least once every three years, the population has now exceeded this genetic target with an estimated 543 adult kōkako across the surveyed area. As the Rotoehu kōkako population is founded by approximately 50 individuals (Innes et al., 2020), it can now be considered genetically robust and has a high probability of long-term persistence, provided that effective predator control is sustained at the site.

Target rat indices set by the Kōkako Recovery Group are the reduction of ship rats to a 1% tracking index (RTI) by November 1 when acute toxins such as 1080 are used, or when pest control is ongoing, such as through the use of anticoagulant baits in bait stations, ship rats should be maintained below 5% RTI through the breeding season from October-November to March-April. Rat monitoring data from Rotoehu (Appendix One) indicates that these targets have not been met at the start of the breeding season when anticoagulant baits have been used in bait stations. No further rat monitoring has been done through the breeding season. We recommend that RET implements regular rat monitoring (6-8 weekly) over the kōkako breeding season (October to March) when anticoagulant baits are used, in order to improve understanding of how rat numbers recover over this period. We also recommend that RET continues to adapt predator control methodologies to meet targets in non-1080 years, to maximise productivity. Anticoagulant toxins can be maintained in bait stations through the kōkako breeding season to suppress rats, because there is reduced risk of bait aversion with these toxins compared to 1080 (D. Williams, pers. comm.)

As studies at Rotoehu and other sites have indicated that in years where predator control is not undertaken, female mortality increases four-fold (Flux et al., 2006), and nest success is reduced to between 17-32% (Innes et al., 1999), the breeding output of birds established beyond the RET managed areas is expected to be low in years where aerial 1080 operations are not carried out. As competition for territories increases within the management areas, and as the population tends towards carrying capacity, the proportion of birds establishing in the wider area is expected to continue to increase. This is reflected in the much higher mean annual growth rates within the proposed RF3 and RF4 blocks between 2019 and 2023 compared to growth rates within areas under RET management over the same period. Continued regular landscape scale predator and browser control will support the continued expansion of the range of the kōkako across the wider Rotoehu landscape, encouraging dispersal through corridors to other forests, and will provide broader ecosystem benefits.

The average density of kōkako within the current RET management areas is now 5.9 hectares per pair, which is the greatest average density recorded at any site on the mainland of Aotearoa, exceeding that of the previously densest known mainland sites Tunawaea (7.1 hectares per pair) and Mangatutu (7.2 hectares per pair) in Pureora (Bryden et al., 2020). Rotoehu contains several lowland tree species not found at Pureora such as kohekohe, pukatea, kawakawa (*Piper excelsum*) and pūriri (Vitex lucens), which may support a higher density kōkako population. The exact habitat requirements of kōkako are complex, and although well studied, aspects remain poorly understood (Collen et al., 2016). As such, the carrying capacity of the management area in Rotoehu is unknown.

Although the results of this survey show an increase in abundance of kōkako throughout Rotoehu Forest, it is likely an underrepresentation of the total number of territorial kōkako present. This is because not all of Rotoehu Forest was surveyed, and because the survey methodology used in the wider area (shown in yellow shading, Figure Two) utilised transects further apart than the standard territorial adult methodology used in other parts of the survey, and included less time spent at each survey point. Kōkako with territories between transects therefore may have been missed, and kōkako may also have established territories beyond the surveyed area.

We note that while Rotoehu still supports a good diversity of understory species, the continued presence of introduced browsers, particularly deer and wallabies, is inducing changes to the forest composition and successional pathways by preventing the recruitment of entire age classes of palatable plant species, such as kanono, māhoe and pate. Trials using exclosure plots at Okataina between 1984 and 1994

(Williams, 2015) isolated the browsing impacts of wallabies from those caused by deer, showing that plant species diversity increased by 142% where both deer and wallabies were excluded, by 57% where wallabies were excluded but not deer, and continued to decline by 7% where browsing was unrestricted.

Continued browsing may permanently prevent the regeneration of palatable species (Coomes et al., 2003). These changes will likely limit the potential further increases in kōkako density. The substantial influence of introduced browsers on the vegetation structure in tawa-podocarp forests is likely to have important effects on broader ecosystem processes, beyond solely kōkako recovery (Husheer, 2007). As such, we recommend that browser control targeting deer and wallabies in particular is enhanced to allow for recruitment of seedlings of palatable plant species, and that any long term view of ecosystem management at Rotoehu takes into account the ongoing effects of introduced browsers. Past aerial 1080 operations at Rotoehu have resulted in significant bykill of wallabies (96.9% +/- 2.4%) (Commins, 2017), and as such, continued 1080 operations will have additional benefits beyond the control of introduced mammalian predators.

The KRG recommends that sites with at least 25 kōkako pairs should be surveyed every 4 years. Surveys at each site are typically conducted either before or following the breeding season, but timing is often determined by the availability of kōkako surveyors. Whilst kōkako surveys can be conducted in any month, results may be harder to interpret between November and March, when kōkako may be nesting or moulting, leading to a reduction in responsiveness (Flux et al., 2019). As such we recommend the next survey is undertaken in April 2027, and quadrennially thereafter. As the total Rotoehu kōkako population exceeds 500 breeding adults and can now be considered genetically robust, with a high probability of long-term persistence, it is recommended that future surveys utilise and expand on the sub-sampling methodology used this survey to estimate the population within PEA1 block. Extrapolation using the standard sub-sampling technique (Flux et al., 2013) will inevitably lead to wide but tolerable margins of error in population estimates, but have the advantage of being a relatively quick and cost-effective way to assess population trends.

This sub-sampling methodology can be complemented by wider area surveys to determine the spread of kōkako beyond Rotoehu Forest, particularly through potential linking corridors towards Kaharoa and/or Manawahe. Working with landowners, managers and kaitiaki to survey areas of adjacent forest on private land may have advocacy benefits and may also help to inform land management decisions that affect kōkako survival and dispersal, such as initiating predator control and creating forest corridors.

6. Key Recommendations

- Continue and enhance annual predator control, with a target of reducing ship rat indices to 1% RTI by 1 November when one off operations (such as 1080) are used, or continued suppression of ship rats below 5% through the kōkako breeding season (monitored via 6-8 weekly RTIs).
- Advocate for enhanced browser control to reduce deer and wallabies in particular to undetectable levels within Rotoehu.
- Conduct the next kōkako survey in 2027 following a sub-sampling methodology.
- Advocate for the continued regular landscape scale predator control over the wider Rotoehu Forest to supplement ground control within the management areas, to support the increasing kōkako population and to maximise genetic diversity.

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Ngā mihi maioha,
Dave and Amanda.

8. References

Bryden, D.; Rogers, A.L.; Henton, J. 2019: *Kōkako Survey Report, Rotoehu 2019*. Internal Report prepared for the Rotoehu Ecological Trust.

Bryden, D.; Henton, J.; Quinnell, A.; Rogers, A.; & Sanders, A. 2020: *2020 Mangatutu and Tunawaea Kōkako Survey Report*. Internal report prepared for the Department of Conservation.

Collen, R.; Flux, I.; Innes, J.; Speed, H.; Thurley, T.; Wills, S. 2016: B*est practice techniques for the translocation of North Island kōkako (Callaeas wilsoni)*. Department of Conservation, Wellington.

Coomes, D.A.; Allen, R.B.; Forsyth, D.M.; Lee, W.G. 2003: Factors preventing the recovery of New Zealand forests following the control of invasive deer. *Conservation Biology* 17: 450-459

Flux, I.; Innes, J.; Barea, L.; Burns, R.; Corkery, I.; Parker, K.A.; Speed, H.; Thurley, T.; Wills, S. 2019: *Kōkako Standard Management Techniques*. Wellington, Department of Conservation– doc-5897165.

Flux, I.; Bradfield, P.; Innes, J. 2006: Breeding biology of North Island kokako (Callaeas cinerea wilsoni) at Mapara Wildlife Management Reserve, King Country, New Zealand. *Notornis* 53: 199–207.

Flux, I.; Thurley. T.; McKenzie, K.; McAulay, J. 2014: *A kokako (Callaeas wilsoni) population estimate for Little Barrier Island (Hauturu): a trial of a novel sub-sampling design June 2013.* Unpublished Report.

Husheer, S.W. 2007: Introduced red deer reduce tree regeneration in Pureora Forest, central North Island, New Zealand. *New Zealand Journal of Ecology* 31 (1): 79-87.

Innes, J. 2013 [updated 2022]. North Island kokako. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online*. www.nzbirdsonline.org.nz

Innes, J.; Barea, L.; Burns, R.; Corkery, I.; Flux, I.; Overdyck, O.; Parker, K.; Speed, H.; Thurley, T.; Weiser, E.; Wills, S. 2020: *Priorities for Kōkako (Callaeas wilsoni) Conservation: Draft.*

Innes, J.; Hay, R.; Flux, I.; Bradfield, P.; Speed, H.; Jansen, P. 1999: Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations by adaptive Management. *Biological Conservation* 87: 201-221.

Innes, J.; Molles, L.; Speed, H. 2013: Translocations of North Island Kōkako 1981-2011. *Notornis* 60: 107-114.

Jamieson, I.G.; Grueber, C.E.; Waters, J.M.; Gleeson, D.M. 2008. Managing genetic diversity in threatened populations: a New Zealand perspective. *New Zealand Journal of Ecology* 32: 130–137.

Leathwick, J.R.; Hay, R.; Fitzgerald, A.E. 1983: The influence of browsing by introduced mammals on the decline of North Island kokako. *New Zealand Journal of Ecology* 6: 55-70.

Parker, K.A.; Ewen, J.G.; Seddon, P.J.; Armstrong, D.P. 2013: Post-release monitoring of bird translocations: why is it important and how do we do it? *Notornis* 60(1): 85-92.

Robinson, N.M.; Scheele, B.C.; Legge, S.; Southwell, D.M.; Carter, O.; Lintermans, M.; Radford, J.Q.; Skroblin, A.; Dickman, C.R.; Koleck, J.; Wayne, A.F.; Kanowski, J.; Gillespie, G.R.; Lindenmayer, D.B. 2018, How to ensure threatened species monitoring leads to threatened species conservation. *Ecological Management and Restoration*, 19: 222-229.

Robertson, H.A.; Baird, K.; Elliott, G.P.; Hitchmough, R.A.; McArthur, N.; Makan, T.D.; Miskelly, C.M.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A.; Michel, P.; 2021: Conservation status of birds in Aotearoa New Zealand, 2021. New Zealand Threat Classification Series 36. Department of Conservation, Wellington. 43 p.

Weiser, E. 2015. *Management strategies for establishing and maintaining genetically robust populations of kōkako*. Unpublished report for Kōkako Recovery Group, Department of Conservation.

Appendix One: Pest Control History at Rotoehu

Year	Method [Area covered]	Rat Index (Pre)	**Rat Index (Post)**	Possum Index (Pre)	**Possum RTC (Post)**
1994-95	1080 - bait stations [150 ha]	n/a	**n/a**	n/a	**n/a**
1995-96	Brodifacoum - bait stations, cyanide, possum traps [440 ha]	n/a	**n/a**	n/a	**n/a**
1996-97	Brodifacoum - bait stations [440 ha]	n/a	**n/a**	n/a	**0.7%**
2004-05	1080 - aerial [3000+ ha]	69%	**0%**	23.2%	**2.5%**
2007-08	1080 - bait stations [440 ha]	n/a	**0%**	23.3%	**0.7%**
2008-09	1080 - bait stations [650 ha]	n/a	**3%**	n/a	**0%**
2011-12	1080 - bait stations [600+ ha]	56%	**1%**	4.6%	**0%**
2014-15	1080 - bait stations [600+ ha]	n/a	**6%**	4%	**1.5%**
2015-16	DOC200 traps [94 ha]	n/a	**n/a**	n/a	**n/a**
2016-17	DOC200 traps [94 ha]	n/a	**n/a**	n/a	**n/a**
2017-18	1080 - aerial [2867 ha], DOC200 traps [94 ha]	83%	**3%**	4%	**1.5%**
2018-19	Pindone - bait stations [700+ ha], DOC200 traps [94 ha]	73%	**11%**	n/a	**n/a**
2019-20	DOC200 traps [94 ha]	n/a	**n/a**	n/a	**n/a**
2020-21	1080 - aerial [2821 ha], DOC200 traps [94 ha]	74%	**0%**	3.66%	**0.42%**
2021-22	Pindone- bait stations [998 ha]	40%	**7%**	n/a	**n/a**
2022-23	Pindone/diphacinone [1367 ha]	22.5%	**17.5%**	n/a	**n/a**

Appendix Two: 2023 Rotoehu Survey Results

Block	Area surveyed (ha)	Pairs	Territorial Singles	Total Kōkako	Density (hectares/pr)	% Population Change 2019-23
PEA1	437	25 (110)	1(4)	51 (224)	4.0	57.1
PEA2	168	35	0	70	4.8	59.1
PEA2B	261	42	1	85	6.2	90.9
Otari	94	12	0	24	7.8	33.3
RFW	36	6	0	12	6.0	100.0
RF1	51	5	1	11	10.2	150.0
RF2	320	22	1	45	14.5	120.0
Subtotal (RET Managed)	**1367**	**147 (232)**	**4 (7)**	**298 (471)**	**5.9**	**68.1**
RF3	608	22	4	48	27.6	N/A
RF4	178	3	0	6	59.3	N/A
Subtotal (RET Proposed)	786	25	4	54	29.1	N/A
Timberlands Covenant	39	1	1	3	39.0	-50.0
Rotoehu Forest (Excl RET Managed or RF3/RF4)	295	9	0	18	32.7	N/A
Ngāti Mākino	27	3	0	6	9.0	50.0
Other	434	17	2	36	25.5	N/A
Subtotal- Wider Area	795	30	3	63	26.5	N/A
TOTAL RET Managed and Proposed	**2153**	**172 (257)**	**8 (11)**	**356 (529)**	**8.3**	**N/A**
TOTAL Rotoehu PCL (incl wider)	**2450**	**266**	**11**	**543**	**9.2**	**N/A**
TOTAL (incl private)	**2948**	**289**	**14**	**592**	**10.2**	**N/A**

Comments:
Figures in parentheses are extrapolated from the sub-sample of PEA1.
Grey shaded cells indicate areas without bait stations at the time of this report.

Appendix Three: Kōkako Recovery Group Reporting

	2023	**2019**	**2013**	**1995 (at project start)**
Date of Survey Period	Mar 31- Apr 28	Apr 4- May 8	Oct 1- 18	?
Area Surveyed (ha)	1367 (+1581)	998 (+2200)	Ca. 600	Ca. 440
Number of person hours used to survey	450	378	258	?
Number of Surveyors	mostly 4-5 teams	3+ volunteers	4+ volunteers	?
Total Pairs	232 (+57)	126 (+31)	50	17
Total Singles	7 (+7)	8 (+5)	29	8
Total Juveniles	N/A	N/A	N/A	N/A
Did you follow Standard methods*?	Yes	Yes	N/A	No
Survey type used*	Territorial adult census +walk-through	Territorial adult census (+walk-through)	Territorial adult census	
Did you record and use new/this year's song/calls?	Yes	Yes	?	?

Comments:
Figures in parentheses are in addition to current RET management areas at time of survey.

2023 Survey Team: Dave Bryden, Mark Fisk, Chris Hannent, Chris Lowe, Maddy Powers, Amanda Rogers, Su Sinclair.
2019 Survey Team: Dave Bryden, Chris Hannent, Joel Henton, Amanda Rogers