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Roroa / great spotted kiwi (*Apteryx maxima*) species plan 2019–2029

Roroa Practitioner Group, collated by Robin Toy and Sandy Toy

Department of Conservation
Te Papa Atawhai

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Cover: Roroa / great spotted kiwi (*Apteryx maxima*). *Photo: Jo Halley*.

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Abstract

Roroa / great spotted kiwi (*Apteryx maxima*) inhabit c. 800 000 ha of remote, generally mountainous habitat in the top half of the South Island of New Zealand, where they form four genetically distinct populations: Northwest Nelson, Westport, Paparoa Range and Arthur's Pass–Hurunui. There are an estimated 14 000 roroa left in the wild, and the species is thought to be declining at a rate of 1.6% per annum across its range. This species plan has been developed following publication of the national Kiwi Recovery Plan 2018–2028, which requires a separate action plan to be developed and approved for each kiwi species. There are three long-term recovery goals for roroa: to grow all four populations by an average of at least 2% per annum, to expand the distribution of the species across its former range and to maintain the genetic diversity of the species. These goals will be achieved primarily through the periodic suppression of animal predators, especially mustelids, using aerial control methods across large areas (> 50 000 ha) and complementary ground trapping as required. Engagement and advocacy actions are also identified to reduce the risk of predation by dogs and to minimise the effects of land-use activities. The removal of eggs and chicks through Operation Nest Egg (ONE), translocation, kōhanga sites and captive breeding are considered low-priority actions for roroa because they will not contribute significantly to these recovery goals. Actions have been identified to ensure that the limited resources of all those involved in roroa management and research are directed towards the highest priority areas.

Keywords: roroa, great spotted kiwi, *Apteryx maxima*, species recovery, genetic diversity, predator control, mustelids, advocacy, South Island

Roroa Practitioner Group 2021: Roroa / great spotted kiwi (*Apteryx maxima*) species plan 2019–2029. Department of Conservation, Nelson. 42 p.

1. Introduction

Roroa / great spotted kiwi (*Apteryx maxima*, formerly *Apteryx haastii*) inhabit c. 800 000 ha of remote, generally mountainous habitat in the top half of the South Island. The current population is estimated at c. 14 000 birds (Germano et al. 2018), which are found in four discrete areas: Northwest Nelson, Westport, Paparoa Range and Arthur's Pass–Hurunui. Long-term call count and territory mapping studies have shown that this species is declining at a rate of 1.6% per annum across its range (Innes et al. 2015), primarily as a result of mustelids, which reduce chick survival. Several long-term studies have monitored roroa under a variety of mustelid control regimes (Appendix 1), which together have shown that effective mustelid control leads to a 5.6% roroa population increase (Appendix 2). However, ground-based predator control covers only 10% of the population.

Publication of the Kiwi Recovery Plan 2018–2028 (KRP, Germano et al. 2018) marked a new phase of kiwi conservation as, for the first time, there was a focus on increasing the populations of all kiwi species by at least 2% per annum and a plan in place to achieve this. However, this will require reversing the decline in the South Island kiwi species, including roroa, which is a major challenge given their distribution across vast areas of difficult terrain. Therefore, there will need to be a focus on in situ management that involves predator control at a landscape scale. An injection of Treasury funding occurred in 2015 under the banner 'Save Our Iconic Kiwi', which is specifically aimed at applying landscape-scale predator control for South Island taxa, meaning that the recovery actions outlined for roroa in this species plan have associated funding to achieve them. The recovery principles for roroa are the same as were identified in the KRP and are detailed in Appendix 3.

This species plan for roroa shares the goals, objectives and strategic directives of the kiwi recovery plan but provides the detail required to deliver these. The actions in this species plan are underpinned by supporting evidence (Appendices 1 & 2), which has been compiled from the collective experience and collated data of roroa practitioners over many years. There have been many contributors to this plan (Appendix 4), all of whose contributions are gratefully acknowledged.

1.1 Goals

The long-term recovery goals for roroa are to:

- Grow all four populations by an average of at least 2% per annum
- Expand the distribution of the species across its former range
- Maintain the genetic diversity of the species

1.2 Implementation

The actions required to deliver the three recovery goals for roroa are grouped under the implementation themes and topics identified in the kiwi recovery plan (Germano et al. 2018). For each topic, the objectives and recovery plan actions that are relevant to roroa are identified and issues relating to these are discussed, resulting in succinct application actions. In addition, new actions have been identified for some topics where the KRP, which takes a broad, national approach, lacks the detailed action required for roroa. Accountable groups that will lead and support the required work and the relative priority of each action are identified, as in the overarching KRP.

The priority for each action was determined using the following criteria:

- Essential: Necessary to achieve the goals for kiwi recovery over the term of this species plan. Highest risk for kiwi recovery if not carried out within this timeframe and/or at the frequency specified.
- High: Necessary to achieve the long-term recovery goals. To be progressed and ideally completed within the term of this species plan, with moderate risk if not carried out within this timeframe and/or at the frequency specified.
- Medium: Necessary to achieve the long-term recovery goals. To be progressed within the term of this species plan, but with less risk if not completed within this timeframe and/or at the frequency specified.

The accountable groups for the actions are as follows:

- Tiakina Ngā Manu – a predator control programme administered by the Department of Conservation (DOC) that was previously known as 'Battle for Our Birds'
- DOC Biodiversity – a unit within DOC that provides science and technical advice
- DOC Operations – a unit within DOC that undertakes on-the-ground conservation work; in this context, it refers specifically to relevant DOC operational Districts within the roroa range
- DOC Permissions – a unit within DOC that processes permit applications
- Kiwis for kiwi (K4K) – a trust that provides funding for community groups
- Kiwi Recovery Group (KRG) – a group of research and operational experts (within and external to DOC) administered by DOC that work at a strategic level to coordinate and focus efforts for kiwi recovery nationally
- Roroa Group – roroa practitioners working collaboratively as a formal collective
- Save Our Iconic Kiwi (SOIK) – a funding banner administered by DOC which supports projects that aim to increase primarily South Island kiwi species numbers
- Species Lead – the identified lead of the Roroa Group
- Zero Invasive Predators Ltd (ZIP) – a company that develops and tests new tools to remove possums, rats and stoats from large mainland areas

2. Management

2.1 Topic 1 – Pest control

Context

Roroa are found in four main populations over some 800 000 ha of remote, mountainous South Island habitat extending from alpine areas down to sea level and from the drier eastern parts to the wetter western South Island beech ecosystems. To achieve 2% growth in roroa numbers, current modelling predicts that sustained, effective predator management will be required over almost the entire range of roroa in each of the four populations. Since the demographics of the suite of mammalian pests that occur in New Zealand can differ between localised regions/ habitats and through beech mast[1] cycles (which drive beech ecosystems), the prescription to control predators to levels that will achieve at least 2% growth (ideally more) of the roroa population may vary among regions.

Predation by mustelids is the main agent of decline for roroa. Although ferrets (*Mustela putorius furo*) can kill adult kiwi and have a devastating impact on the adult population, they are not considered a major agent of decline because much of the roroa distribution is distant from the preferred farmland habitat of ferrets. However, there is a lack of information on roroa predation in areas adjacent to farmland. Kiwi chicks are vulnerable to stoats (*M. erminea*) and possibly weasels (*M. nivalis*) until they reach a safe weight of 1000 g, which can be achieved as early as 6 months of age but may take over 1 year. Rodents (rats and mice) are important drivers of mustelid plagues during beech masts and may also affect roroa by reducing the availability of invertebrates in the ecosystem, which may increase the time required for kiwi chicks to reach a safe weight, increasing the period of vulnerability to mustelid predation. The importance of cat (*Felis catus*) predation on roroa is unknown, but this is also likely to contribute to population decline. Possums (*Trichosurus vulpecula*) may also have a detrimental impact on roroa through incubation disturbance, and both weka (*Gallirallus australis*) and kea (*Nestor notabilis*) are known to affect roroa recruitment through incubation disturbance and egg predation, as observed from camera traps, with weka in particular having an impact on roroa nesting success.

The only feasible method that is currently available for predator control in remote, mountainous habitat is landscape-scale aerial 1080 application, so public support for the use of this tool is vital. Only a small proportion of roroa habitat is currently under sustained landscape-scale predator management. This is primarily achieved through DOC's Tiakina Ngā Manu programme, which focuses on mustelid suppression through secondary poisoning (by consuming poisoned rodents), and TBfree / Operational Solutions for Primary Industry (OSPRI) operations, which target possums but are also likely to result in effective mustelid control. The eradication of tuberculosis (TB) from New Zealand is anticipated within the next 10 years, so DOC plans to increase the areas in which it carries out sustained management to 1 million hectares nationwide as other stakeholders reduce their contribution.

DOC and K4K received significant Treasury funding between 2015 and 2019 to reverse the current decline and secure an increase in the numbers and distribution of kiwi. K4K is focusing on working with North Island communities to protect North Island brown kiwi (*A. mantelli*), while DOC's SOIK project focuses on landscape-scale protection of more remote South Island species, including roroa. From 2019, DOC has $4.506m funding per annum on an ongoing basis. SOIK is managed by a Project Manager and its funds will be allocated according to the SOIK

[1] Beech mast is the mass fruiting of beech trees and is triggered by a warmer summer than in the previous year. The high abundance of seed during a beech mast leads to much higher rodent and stoat (*Mustela erminea*) numbers, increasing predation pressure on New Zealand's endangered birds and reptiles.

Implementation Plan (Willians 2017), which aligns with the goals of the KRP (Germano et al. 2018) and the various species plans that fall beneath this. This funding will supplement current aerial 1080 efforts through a close partnership with Tiakina Ngā Manu.

The aerial 1080 prescription that will be required to achieve 2% roroa growth is not yet known. Studies were initiated in the Upper Roaring Lion valley (hereafter 'Roaring Lion') in Kahurangi National Park and Te Wharau in the Paparoa Range in 2016/17 and are still in progress to determine the effect of aerial 1080 without trapping on roroa population recruitment. Roaring Lion will receive aerial 1080 treatment reactively based on suitable rodent thresholds while Te Wharau will receive aerial 1080 prescriptively every 3 years, regardless of rodent numbers. These studies need to be continued over at least two beech mast cycles. However, the effort required to provide information on the predator control prescription required for roroa population growth and subsequent costs limits the number of treatment sites.

Untreated pockets occasionally remain within aerial treatment areas that could act as reservoirs for pest reinvasion, so actively trapping these pockets and the margins of 1080 treatment blocks would slow re-incursion. Therefore, ground-based control programmes (including ground-based toxin delivery) should be undertaken to support landscape-scale aerial operations to maximise the effectiveness and/or size of the operational areas.

Given the extent of the roroa range, there is a need to prioritise where management occurs. In the north Northwest Nelson and Arthur's Pass–Hurunui areas, roroa occur at a high density in core areas that are surrounded by large areas with a low density of birds (Appendix 2), and the same is likely to be true in other geographic areas. Therefore, prioritising management in the high-density core areas will benefit a large proportion of the population, while treating lower density fringe areas will have less impact on overall numbers but is important for maintaining genetic diversity and opportunities for natural expansion. It will also be necessary to treat areas within the former range of roroa and areas with very low kiwi numbers to allow the re-colonisation needed to contribute to the recovery plan goal of restoring the species' former distribution. Historic records combined with call-rate distribution studies using acoustic recorders will need to be considered to determine core, fringe and recently vacated areas of kiwi distribution to inform management (Appendix 2 & section 2.4: Topic 4 – Measuring management effectiveness).

Objectives

Objective 1.1 To have sufficient roroa habitat under sustained effective in situ management to grow all four kiwi populations by at least 2% per annum.

Objective 1.2 To develop and maintain a suite of pest control tools that improves the cost-effectiveness and efficacy of predator management for roroa over the long term.

Objective 1.1 To have strong coordination of effort and geographical connectivity between national and regional pest control operations for the benefit of roroa and their ecosystems.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
1.1	Identify and prioritise high-density core populations in each geographical area for predator control.	SOIK, DOC Operations, Roroa Group, DOC Biodiversity	Essential
1.2	Identify and prioritise low-density fringe areas to maintain genetic diversity.	Roroa Group, DOC Operations, KRG	High
1.3	Treat at least one priority area (> 50 000 ha) for each of the four populations and coordinate the treatment of adjacent blocks at the optimal frequency for roroa recruitment.	SOIK / Tiakina Ngā Manu, DOC Operations, DOC Biodiversity, mana whenua	Essential

Continued on next page

Topic 1 – Pest control actions continued

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
1.4	Coordinate the timing and area of DOC's 1080 applications with other agencies.	Tiakina Ngā Manu, DOC Operations, OSPRI, ZIP	Essential
1.5	Identify areas where ground-based control can be undertaken to support landscape-scale aerial operations. Coordinate trapping in 1080 exclusion areas and the margins of treatment blocks.	Roroa Group, DOC Operations, DOC Biodiversity, KRG	High
1.6	Support existing and new ground-based trapping groups in working to best practice to protect parts of the high-priority sites in non-aerial-treatment years and/or in reducing pest re-incursion from aerial treatment exclusion zones (e.g. around huts, rivers, roads and aerial treatment boundary areas).	DOC Operations, Roroa Group	High
1.7	Review and develop prescriptions for new landscape-scale tools as they become available (e.g. aerial para-aminopropiophenone (PAPP), self-resetting traps with long-life lures).	DOC Biodiversity, SOIK, Tiakina Ngā Manu	High
1.8	Promote integrated pest management using a range of traps and toxins for the full range of predators (mustelids, possums, cats, rats) to manage untrappable pests, and build the use of a diversity of control methods into all pest control plans, prioritising mustelid control.	DOC Operations, Roroa Group	High

2.2 Topic 2 – Threat of dogs to kiwi

Context

Much of the roroa range is within designated national parks where dogs are not permitted. However, on other public conservation lands, the DOC District Offices vary in their approach to managing the risk to kiwi from dogs, with only some Districts having all or most tracks with kiwi / no dog signs and declining applications for dog permits. Regardless of the approach taken, there are compliance issues associated with unpermitted dogs being taken to places with kiwi and the risk of signage being removed.

Kiwi that live close to settlements are at greater risk from dogs, although hunting dogs are a threat in the backcountry. The paucity of information on the distribution of roroa has resulted in the incorrect perception that roroa do not occur in the front country, and consequently little effort has been put into safeguarding them from dogs. Kiwi aversion training works well for some dogs and provides dog owners with an opportunity to become better educated about the risk dogs pose and assists with behaviour management. However, there are few aversion training programmes in the roroa range and it is possible that aversion training could give some dog owners a false sense of security. Therefore, this should be complemented with other tools for dog control, such as the provision of information through the permit process and signage.

Objectives

Objective 2.1 To ensure that a range of stakeholders (e.g. councils, farmers, hunters) work collaboratively to address the threat of dogs.

Objective 2.2 To use current and new tools proactively and reactively to reduce the threats dogs pose to kiwi.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING	PRIORITY
2.1	Provide information on the current roroa range to all DOC offices and regional councils so they can update no dog access areas.	DOC Operations, Roroa Group	High
2.2	Provide clear and consistent messaging regarding dog access between DOC offices and on the public DOC website.	DOC Operations	Medium
2.3	Ensure the consistent permitting of dog access throughout the roroa range.	DOC Operations, regional/ district councils	Essential
2.4	Have a consistent approach to signage across the entire roroa range (e.g. walking tracks, subdivisions) warning of the hazards posed by dogs, and check for continuity across DOC operational Districts with regard to signage and messaging.	DOC Operations, regional/ district councils, Roroa Group	High
2.5	Advocate and provide support for aversion training for dogs to be available at locations within the roroa range, and check for consistency of the aversion training offered across DOC operational Districts.	DOC Operations, regional/ district councils, Roroa Group	High
2.6	Reinforce the 'dogs and kiwi don't mix' message at every opportunity.	Everyone	High

2.3 Topic 3 – Genetic management

Context

Roroa exhibit wide genetic diversity and appear to show isolation by distance or barrier (Appendix 2). Therefore, to maintain this genetic diversity, it will be necessary to conserve this species right across its range. The protection of large, natural populations in each of the four geographical areas is of greatest priority for achieving the long-term recovery goals, not least because alternative management strategies, such as translocation and Operation Nest Egg (ONE) (which is costly), conserve only a small subset of the original genetic diversity. There is also concern that many roroa are old and may be past breeding age – therefore, it is important to consider how many individuals actually contribute to population growth rather than how many kiwi are present.

To maintain the current genetic structure of roroa, birds should not be moved from one end of their population range to the other or between the four identified populations but rather should only be moved within realistic 'neighbourhood' distances that individuals would naturally be able to navigate themselves. All previous translocations occurred prior to this being understood and all translocated birds were moved over greater distances. It is important to note that there is evidence from other species (including those with 'isolation by distance' genetic structures) that genetic mixing could significantly improve the fitness and evolutionary potential of inbred populations (see Frankham at al. 2017). Note that section 2.7 (Topic 7 – Translocations) directs that no new translocations should be undertaken except in a conservation emergency situation.

Objectives

Objective 3.1 To maintain the existing genetic diversity of roroa.

Objective 3.2 To ensure that people have a clear understanding of the importance and practical application of genetic principles in kiwi management.

Objective 3.3 To clarify the remaining uncertainties in the taxonomy of roroa and the roles of hybrid and mixed provenance populations in roroa management.

Objective 3.4 To have strong collaboration between organisations and individuals holding genetic samples.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
3.1	Prioritise predator control (in situ management) across the roroa range over translocations and ONE.	DOC Operations, Roroa Group	Essential
3.2	Investigate methods to determine the effective population size from existing roroa genetic samples and repeat in the future to determine whether it is increasing with management.	DOC Biodiversity	Medium
3.3	Ensure birds used to complete re-introductions or translocations are sourced from genetically appropriate area/s (see section 2.7 (Topic 7 – Translocations for further actions).	DOC Operations, Roroa Group	High
3.4	Publish the taxonomy of roroa, including the recognition of conservation management units / evolutionary significant units.	KRG	High
3.5	Develop a national genetic database as per the kiwi recovery plan that incorporates roroa samples.	KRG	Medium

2.4 Topic 4 – Measuring management effectiveness

Context

A good understanding of the distribution and approximate density of roroa is required to direct where management resources should be focused and to provide a baseline for demonstrating status recovery. Any such baseline must include negative as well as positive records (i.e. absence and presence). Tier 1 acoustic recordings can provide positive records, although these need to be double-checked for false positives. Casual reports (both positive and negative) for roroa are generally unreliable, as the scats, probe holes, footprints and calls of roroa can all be easily mistaken for those of other species. However, casual reports are valuable for identifying areas in which to place acoustic recorders for verification.

Repeated territory mapping over a long period of time, such as the programmes being undertaken in Saxon (including Saxon Hut (Robertson et al. 2005) and surrounds (Robertson et al. 2014)) and North Hurunui, can be used to effectively determine population changes at a local scale. Using call rates to determine changes in population density is complicated because the relationship between the two is unknown. However, call counts or acoustic recorder call rate monitoring that are conducted over a long period and consider many sites collectively can be used to demonstrate population trends. The use of acoustic recorders to record call rates is currently the most cost-effective method for extensive monitoring programmes, while performing life-table analyses (population modelling) using fecundity and survival data from transmittered roroa can demonstrate population change. However, the development of a low-cost indirect measure (such as sensitive mustelid monitoring thresholds or % change in call rates) is required to monitor the effectiveness of predator control.

Data management and analysis are rarely resourced appropriately but are essential for measuring management effectiveness and informing future management. The roroa projects conducted to date (see Appendix 2) have collected large amounts of data that can inform effective management of the species, so this effort needs to be maintained into the future. These data have been collated for preparation of this species plan and stored in a spreadsheet (DOC 2019). However, having large numbers of projects with staff turnover and no dedicated lead have led to inconsistencies in data entry and quality. Therefore, while the data from the last 13 years of monitoring have been cleaned as effectively as possible, continuing attention is needed to ensure the data are fit for purpose.

Sustained predator management and climate change may result in long-term changes in predator demographics. Therefore, site-specific prescriptions (trigger thresholds, sowing rates, sizes of operations) will need to be continually reviewed in relation to result/outcome monitoring to ensure they remain cost-effective.

Objectives

Objective 4.1 To measure management effectiveness and the state of the roroa populations.

Objective 4.2 To have an accurate understanding of roroa distributions for management.

Objective 4.3 To manage and analyse data in a way that allows robust measurement of management effectiveness and informs future roroa management.

Objective 4.4 To understand the response of roroa to key management practices.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
4.1	Develop a roroa monitoring plan that incorporates call counts (including acoustic recorders), territory mapping and chick recruitment studies to determine whether 2% growth is being achieved across the species' range.	DOC Biodiversity, SOIK	Essential
4.2	As part of 4.1, continue long-term territory mapping studies at Saxon and North Hurunui.	SOIK, DOC Biodiversity	High
4.3	As part of 4.1, consider expanding the number of long-term call-rate monitoring sites to include low-density areas across the roroa range.	SOIK, DOC Biodiversity	High
4.4	As part of 4.1, incorporate the long-term call count studies at Stockton, Orikaka, Taramakau, North Hurunui, Gouland Downs, Heaphy valley and South Hurunui into a national monitoring plan.	DOC Biodiversity, SOIK	High
4.5	Complete distribution/call-rate surveys at Northwest Nelson, Westport, Paparoa Range and Arthur's Pass–Hurunui.	DOC Operations, SOIK	High
4.6	Identify regional survey priorities and strategically fill information gaps.	Roroa Group, DOC Operations	Essential
4.7	Continue life-table studies at Roaring Lion (Kahurangi,) and Te Wharau (Paparoa Range) to assess the effects of 1080 treatment without trapping on roroa recruitment.	DOC Biodiversity, SOIK	High
4.8	Examine chick, juvenile and subadult encounter rates in transmittered study populations at Roaring Lion and Te Wharau as a potential tool to determine recruitment in less intensively managed populations.	DOC Biodiversity, SOIK	High
4.9	Determine the relationship between roroa call rate and population density by collecting call-rate data for sites with known population sizes (e.g. the Flora Stream catchment area (hereafter 'the Flora'), Rotoiti, the Nina River Valley (hereafter 'the Nina'), Roaring Lion, Te Wharau, southern Paparoa Range, Stockton, North Hurunui, Saxon).	SOIK	Medium
4.10	Collate breeding and survival data from all projects annually and update life-table analyses.	Species Lead, DOC Biodiversity	High
4.11	Complete write-up of the Hawdon River valley (hereafter 'Hawdon') and North Hurunui study.	DOC Operations	Medium

2.5 Topic 5 – Planning and coordination for regional, species or topic-based groups

Context

Roroa are widely distributed across various regional and district councils and DOC operational Regions and Districts, and many different organisations, community groups and individuals are involved in roroa conservation efforts. To date, roroa practitioners have met regularly to share experience and best practice, but greater coordination will be required in the future to turn around the current decline in this species. The development of this species plan is only the beginning – the challenge now is to ensure its effective implementation.

One of the key ways to implement this plan effectively is to create a formal Roroa Group that consists of roroa practitioners and stakeholders involved with roroa conservation and has a single national Species Lead who coordinates the group and has an overview of all roroa recovery efforts. It is noted that a group of roroa practitioners currently meets regularly to discuss roroa conservation; however, they have not had the benefit of formal recognition or a species plan.

Specifically, the Roroa Group would:

- Maintain an overview of roroa management and monitoring trends
- Advise all involved in roroa management (including SOIK, Tiakina Ngā Manu, OSPRI, K4K, DOC planners and community groups) on priorities as established by the Roroa Group and KRG
- Coordinate between trapping groups and agencies to fill any gaps in predator management in roroa habitat
- Identify and advocate for opportunities where community ground-based trapping programmes can support landscape-scale predator management
- Organise group hui and foster connections within the group
- Collate survival and breeding data from the group annually for inclusion in life-cycle analyses, and collate information on roroa behaviour
- Facilitate communication with the KRG
- Facilitate the development of an engagement strategy for roroa (see section 3.2: Topic 13 – Engagement and advocacy)
- Advocate for roroa conservation and community engagement
- Disseminate changes in roroa best practice and outcomes from monitoring and research
- Formalisation of the Roroa Group would see the group continue to meet regularly to ensure a coordinated approach to roroa recovery. The knowledge gained from practitioners working with roroa would also need to be shared and consolidated, starting with through a biannual practitioners meeting.

Objectives

Objective 5.1 To use regional, species and topic-based plans that address the relevant issues at a more detailed level for local kiwi recovery.

Objective 5.2 To ensure strong communication and links between species, regional and topic-based groups and the KRG.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
5.1	Identify a national Species Lead to coordinate the Roroa Group and have an overview of all roroa recovery efforts.	DOC Operations, Roroa Group	Essential
5.2	Retain an overview of all roroa recovery efforts and tasks as outlined above.	Species Lead	Essential
5.3	Formalise a Roroa Group to assist with implementing and undertaking regular reviews of this species plan and to coordinate/communicate/resolve issues for roroa.	DOC Operations, Roroa Group	High
5.4	Make this species plan available on the DOC and K4K websites.	Species Lead, KRG	Medium

2.6 Topic 6 – DOC implementation

Context

The success of roroa recovery depends on DOC undertaking landscape-scale pest control (e.g. Tiakina Ngā Manu, SOIK). Much of the roroa range is in remote parts of public conservation land where there are limited opportunities for community groups and private landowners to undertake active management. Roroa are spread across the jurisdiction of three DOC Regions and six separate District Offices within these. Long-term management and monitoring projects are threatened by ongoing budget pressures, and institutional and local knowledge and key skill sets are at risk of being or have been lost due to staff turnover.

Objectives

Objective 6.1 To successfully implement this species plan to ensure effective roroa recovery.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
6.1	Ensure that the actions in this species plan are incorporated into the 4-year and annual business plans of all DOC groups to secure the required DOC staff and funding requirements.	DOC Operations, DOC Biodiversity, SOIK	Essential
6.2	Ensure that the roroa species lead position is included in the annual business plan.	DOC Operations	High
6.3	Maximise opportunities for roroa from the management plans for key ecosystem and species management units, Tiakina Ngā Manu, and other landscape-scale initiatives (e.g. philanthropic projects).	SOIK, DOC Operations	High
6.4	Ensure that the SOIK Implementation Plan refers to the roroa species plan where it relates to this species.	SOIK, Species Lead	Essential

2.7 Topic 7 – Translocations/reintroductions

Context

Wild-to-wild translocations of adult and subadult roroa have been undertaken a number of times (Appendix 1) and effective best practice has been developed, although this has not been consolidated. However, predator control over the roroa range is preferred over translocation because:

- The cost of translocations is very high for both capture and subsequent monitoring due to the low density of kiwi in mountainous terrain.
- Logistical constraints on the numbers of kiwi that can be translocated mean that translocations will make a minimal contribution to meeting the recovery plan goal of a 2% per annum increase in population size.
- The factors underpinning the distribution and decline of roroa are not well understood, so assessing the suitability of potential recipient sites is challenging even if the area is within the historic range of the species.
- There is no reliable method for aging roroa once they have reached adulthood. Consequently, even if ≥ 40 kiwi are translocated as part of a reintroduction, there may be a small effective number of founders if the kiwi at the unmanaged source sites are old and have low reproductive capacities. Furthermore, kiwi are also likely to occur at low densities in such areas, making their capture more challenging.
- The long-term success of translocations in re-establishing roroa populations has yet to be successfully demonstrated due to the low productivity of this species.

Considering these factors, it will be challenging to complete the establishment of roroa populations at Rotoiti and the Nina, as both sites require additional founders for a genetically sustainable population and there is presently insufficient predator control at the Nina. Ideally, any translocation project that has been started should be completed provided predator control is sufficient, as failing to do so makes it unlikely that the population will persist in the long term. The value of translocations would be maximised if kiwi were taken from sites with little or no predator control and no likelihood of predator control in the near future – i.e. where there is certainty that there will be no successful recruitment, or where there will be significant habitat damage. It is also worth noting, however, that harvesting individuals from areas with high productivity and good predator control has been shown to have minimal negative impacts. For example, roroa territories at Hawdon that were vacated as a result of harvesting were reoccupied within 2 years of the harvest.

A further implication of these factors is that the recovery plan goal of restoring the species' former distribution should not be delivered through translocation for roroa but rather by the slow process of natural range expansion as a result of predator control at existing sites. Post-translocation monitoring is associated with considerable effort and cost (Robertson & Colbourne 2017), but every translocation results in new lessons. Therefore, these costs need to be factored into every translocation proposal as it is vital that the outcomes are documented and available to the KRG to inform best practice.

Objectives

Objective 7.1 To ensure that reintroductions occur only in areas with suitable habitat and sufficient predator control to allow the population to establish and grow.

Objective 7.2 To complete unfinished reintroductions by ensuring a good genetic foundation.

Objective 7.3 To increase tangata whenua involvement in translocations.

Objective 7.4 To clearly understand the outcome of reintroductions as part of an emergency conservation measure.

Actions

ACTION		ACCOUNTABLE GROUP (SUPPORTING/AFFECTED)	PRIORITY
7.1	Consider further translocations only as an emergency conservation measure (e.g. mining mitigation, genetic rescue) and then only according to the genetic actions detailed in section 2.3 (Topic 3 – Genetic management).	DOC Operations, Roroa Group, KRG	Essential
7.2	Ensure that sufficient preparation and planning occurs prior to reintroductions so that the release site has sufficient habitat (in terms of quality and quantity) and predator control to enable a population to establish and grow.	DOC Operations, Roroa Group,	Essential
7.3	Document the methods and long-term monitoring results from all roroa translocations in a translocation report that is submitted to the KRG and Species Lead.	Roroa Group	Essential
7.4	Complete the Nina re-introduction by sourcing kiwi from the nearest valleys where kiwi are present.	DOC Operations, Roroa Group	High
7.5	Complete the Rotoiti translocation by sourcing kiwi from Northwest Nelson populations.	DOC Operations, Roroa Group	High
7.6	Ensure that no birds are moved from mixed-provenance areas (such as Nelson Lakes and the Flora).	Roroa Group	Essential

2.8 Topic 8 – Kōhanga kiwi / translocated source site populations

Context

Kōhanga kiwi involves establishing translocated source populations at secure sites from which kiwi can be 'harvested' for release into the wild. This management option is not suitable for roroa because:

- There are no fenced or island sanctuaries that are sufficiently large for a sustainable source population (at least 20 unrelated kiwi pairs would require a minimum of 1000 ha of prime habitat)
- Genetic considerations associated with the pattern of isolation by distance (see section 2.3: Topic 3 – Genetic management) mean that release sites would need to be in the vicinity of the original source site
- It is an intensive and therefore expensive technique (Innes et al. 2016)
- The low productivity of roroa (Appendix 2) would mean a long lag time and small 'harvest'

2.9 Topic 9 – Operation Nest Egg (ONE)

Context

ONE techniques for roroa have been developed through projects in the Paparoa Range, Hawdon, North Hurunui, Rotoiti and Stockton areas in collaboration with Willowbank Wildlife Reserve, the Paparoa Wildlife Trust and Roa Mining Company Ltd. ONE aims to increase recruitment by circumventing predation on chicks and potential issues associated with hatching, incubation and brooding in the wild, and involves the collection of eggs from the wild followed by the captive incubation and rearing of chicks for release back into the wild once they reach a predator-proof weight. ONE has been developed over the years to become an effective method for recruiting roroa individuals into the population. However, while this method has been used successfully (see Wildlands 2013 for review), the goals of the roroa species plan are intended to be achieved primarily through the suppression of animal predators or *in situ* management rather than through the use of ONE.

Several factors indicate that a focus on *in situ* management would be more beneficial than ONE for roroa conservation, including the following:

- Roroa juveniles remain with their parents for 1 or more years, so there is a risk that ONE removes juveniles from their parents prematurely, the long-term implications of which (if any) are unknown. Therefore, since little is currently known about the behavioural traits or social cues that are passed from parents to juvenile roroa, it could be risky to encourage substantial growth of the population through ONE. The Paparoa Wildlife Trust monitoring will provide more information on this.
- The cost of ONE and subsequent monitoring is high.
- There are logistical constraints on the numbers of eggs that can be harvested from the wild, which may have implications for genetic representation in the population (as per the third recovery goal) and may also affect the potential for ONE to meet the recovery plan goal of a 2% per annum increase in population size.
- ONE tends to select kiwi pairs that are accessible and amenable to handling (which are typically more timid individuals), which may result in a narrow and potentially suboptimal genetic base in ONE offspring and a loss of a range behavioural traits that contribute to survival and adaptation in the wild.
- ONE does not address the underlying causes of roroa decline.
- In situ management, such as predator control and outcome monitoring, may assist the population in becoming self-sustaining with minimal hands-on intervention.

It is acknowledged that ONE may be useful in certain circumstances, such as for offsetting development actions, in situations where predator control is inadequate or unavailable for extended periods, or when responding to a rapid population decline (e.g. due to a disease outbreak). ONE could also be used as a tool to assist in maintaining or re-establishing roroa at reintroduction sites or in areas where kiwi pairs may be old and unable to produce viable offspring together, which would provide the additional benefit that younger introduced roroa may breed with older individuals, thereby retaining the genes of the older kiwi in the population.

There is a concern that if ONE is not used regularly, skills at the incubation and crèche facilities will be lost. Willowbank has developed effective management practices that are specific for roroa, and Action 9.2 below covers the need to document these skills.

Objectives

Objective 9.1	To utilise the national ONE programme as an effective tool for kiwi recovery, where appropriate.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD, SUPPORTING)	PRIORITY
9.1	Use ONE only in clearly defined circumstances where required as an emergency roroa conservation tool.	DOC Operations, Roroa Group, KRG	Essential
9.2	Collate and document current ONE best practice for roroa, including crèche and post-release recommendations.	Roroa Group	High
9.3	Document and share the results of long-term monitoring of ONE-sourced kiwi to inform future decisions.	Roroa Group	Medium

2.10 Topic 10 – Captive coordination and husbandry

Context

The national kiwi captive programme is directed by the national Captive Management Plan for Kiwi (Barlow 2018), which specifies that only North Island eastern brown kiwi are to be managed in captivity, and this has been endorsed by the KRG. Therefore, since DOC's captive policy states that only birds that are part of a coordinated captive management programme are allowed to be kept in captivity, no other species or taxa should be kept permanently in captivity, so this management option is not suitable for roroa.

The challenges around ONE also apply to captive breeding.

2.11 Topic 11 – Protecting kiwi within the human landscape

Context

Although most roroa live in national parks and other areas of public conservation land, they also occur around the fringes of these areas and use production landscapes, particularly along the West Coast, in the Aorere River valley and in the Arthur's Pass–Hurunui area. Much of the front-country kiwi habitat adjoins areas of human habitation and farmland, so mining, forestry and developments such as roads may have significant adverse impacts on roroa, with kiwi having been killed on roads in the Westport, Paparoa Range and Arthur's Pass populations. Experience has shown that enforcing effective mitigation measures for roroa over the long periods of development projects is difficult. However, development proposals involving roroa habitat should (but do not always) have:

- A roroa plan accompanying the resource consent application that has been drafted by an independent roroa practitioner
- An independent roroa practitioner to oversee the implementation of the roroa plan throughout the consent period
- Predation of kiwi by domestic animals, particularly dogs, is likely to increase with further land development. In particular, pet owners pose a risk when bringing pets on holiday, and the risk of roadkill and predation by pets will increase as kiwi populations grow in rural–urban transition areas (see section 2.2: Topic 2 – Threats from dogs).

Objectives

Objective 11.1 To make roroa management a key consideration within all production management practices.

Objective 11.2 To advocate effectively for roroa in all applications for production and development activities in their current or former range.

Objective 11.3 To minimise threats to roroa and their habitat in areas where roroa habitat and human populations overlap.

Actions

ACTION		ACCOUNTABLE GROUP (SUPPORTING/ AFFECTED)	PRIORITY
11.1	Use the principles outlined in this species plan when responding to all applications for production and development activities that may affect roroa.	DOC Permissions, DOC Biodiversity, DOC Operations, regional/district councils	Essential
11.2	Continue to raise awareness of kiwi threats associated with land use and pet ownership in areas where kiwi habitat and human populations overlap or abut.	DOC Operations, regional/ district councils	High
11.3	Collate and update a best practice document that includes all appropriate measures to avoid, remedy and mitigate effects on roroa.	Species Lead, K4K	Medium
11.4	Share the best practice document developed under Action 11.3 with DOC staff and land developers.	Species Lead, K4K	Medium
11.5	Develop initiatives that raise local awareness to complement national programmes.	DOC Operations, regional/ district councils	Medium
11.6	Have a consistent approach to signage across the entire range that warns of the hazards posed by dogs and cars (see section 2.2: Topic 2 – Threat of dogs to kiwi).	DOC Operations, regional/ district councils	High

3. Engaging people with kiwi and their recovery

3.1 Topic 12 – Tangata whenua

Context

There is currently a lack of adequate support for tangata whenua in establishing and managing ongoing projects and engaging on an equal footing with other partners (e.g. DOC, regional councils) over matters of kaitiakitanga/guardianship for kiwi and their environment. The capacity of iwi, hapū and whānau to undertake kiwi management is stretched due to conflicting obligations (e.g. sustaining marae, reviving te reo, developing youth, improving community health and employment, and engaging with local and central government), and much of the current engagement with tangata whenua is not carried out in a way that allows all parties to play an active role in decision-making. Mātauranga Māori / traditional knowledge is not widely understood, acknowledged or utilised, and there is a lack of understanding of tangata whenua values around kiwi and how those values are provided for under current legislation. There is also a need for opportunities to engage younger generations in kaitaikitanga and kiwi management.

Objectives

Objective 12.1 To ensure that tangata whenua are actively involved in kiwi conservation through both iwi-led and co-managed projects and sites.

Objective 12.2 To ensure that the role of tangata whenua as kaitiaki of kiwi is acknowledged and incorporated into management plans and actions.

Objective 12.3 To ensure that mātauranga Māori is understood and used in kiwi management.

Actions

ACTION		ACCOUNTABLE GROUP (SUPPORTING/ AFFECTED)	PRIORITY
12.1	Increase awareness of tikanga/customs that guides species management and understanding of the timeframes, roles and responsibilities required for all kiwi practitioners.	DOC Operations, Roroa Group	Essential
12.2	Incorporate the role of tangata whenua as kaitiaki into management plans and actions.	DOC Operations	Essential
12.3	Inform iwi, hapū and whānau of new information, significant events and potential opportunities for involvement as they arise.	DOC Operations, Roroa Group	Essential

3.2 Topic 13 – Engagement and advocacy

Context

Engagement and advocacy are important tools for encouraging behavioural change (e.g. predator control, responsible dog ownership) and for building public and financial support for kiwi conservation. There are a variety of audiences, including children, landowners, community groups, DOC staff, hunters, dog owners, businesses, philanthropists, visitors to captive facilities and the general public, each of whom will require different tools to ensure effective engagement with kiwi messages. The consistent use of tools and messages is likely to achieve the best results.

The flighty nature and remote habitat of roroa (see Appendix 2) mean that the traditional approach to advocacy of displaying kiwi is challenging and of limited efficacy. Therefore, other tools are required, such as the use of nest camera videos and providing the ability to hear wild birds at night and see footprints and probe holes in the daytime, which can be enormously rewarding and have the added benefit of increasing public engagement within the environment of roroa.

There is a need for an effective, roroa-specific engagement plan that identifies aims and objectives, messages, tools (including the use of videos), and activities.

Objectives

Objective 13.1 To effectively use advocacy and engagement to achieve clear conservation outcomes for roroa.

Actions

ACTION		ACCOUNTABLE GROUP (SUPPORTING/ AFFECTED)	PRIORITY
13.1	Develop and implement an engagement plan for roroa and ensure that community members have a role in its implementation.	Species Lead, Roroa Group	Essential
13.2	Support others in advocating the landscape use of aerial 1080.	DOC Operations, Roroa Group	Essential

4. Research

4.1 Topic 14 – Monitoring and research planning

Context

One of the actions within the kiwi recovery plan is to develop a research portfolio that identifies prioritised research needs for roroa and to ensure that these are communicated regularly to the research community (Germano et al. 2018: action 18.1).

Objectives

Objective 14.1 To understand and communicate key research needs for roroa recovery.

Objective 14.2 To maintain a strong collaboration between researchers, managers and practitioners to improve our understanding of roroa biology, ecology and conservation.

Objective 14.3 To understand the life histories and population demographics of all kiwi species and ensure that any information obtained is published.

Actions

As taken from the previous topics and issues raised in this document, current priorities for roroa research are to:

- Undertake studies at Roaring Lion (Kahurangi) and Te Wharau (Paparoa Range) to identify the effect of 1080 treatment without trapping (including in non-mast years) on roroa recruitment (See section 2.1: Topic 1 – Pest Control):
  - The Roaring Lion study has been completed and the Te Wharau study is still underway at the time of writing (June 2020). Data from the Roaring Lion study will be analysed and preliminary conclusions drawn by 2021. It is hoped that another non-mast-timed 1080 drop will occur in 2021 at Te Wharau.
  - Once both studies have been completed, all of the data will be reviewed and a final report will be produced. There may be benefit in considering establishing Te Wharau as a long-term acoustic monitoring site.
- Update and publish the taxonomy of roroa, including the recognition of conservation management units / evolutionary significant units (as per Action 3.6).
- Expand the number of long-term call-rate monitoring sites to include low-density areas across the roroa range (as per Action 4.3). Studies at new locations should be performed using acoustic recorders.
- Investigate the relationship between the roroa call rate and population density (as per Action 4.9).
- Examine chick, juvenile and subadult encounter rates in transmittered study populations at Roaring Lion and Te Wharau as a potential tool to determine recruitment in less intensively managed populations (as per Action 4.8).
- Develop indirect and sensitive monitoring tools for mustelids to correlate their densities with the roroa recruitment rate (see section 2.4: Topic 4 – Measuring management effectiveness).
- Investigate an alternative toxin that can be applied aerially.
- Estimate the effective population size from existing roroa genetic samples and repeat this assessment in the future to determine whether it is increasing with management (as per Action 3.2).
- Develop best practice trapping methods, particularly excluder mechanisms for self-resetting traps to protect kea and weka (which would make these usable in roroa habitat that overlaps the ranges of these species) and a long-life lure for mustelids (see Appendix 1).
- Understand the effects of weka predation on roroa recruitment (see Appendix 2).

5. Growing and sustaining the kiwi conservation effort

5.1 Topic 15 – People and groups

Context

Existing roroa community projects are listed in Appendix 2. For many of these projects, the monitoring of transmittered kiwi has ended or is coming to an end but ground-based control will continue and expand in accessible areas (see section 2.1: Topic 1 – Pest control). There is also a role for community groups in implementing a roroa engagement strategy and making a case for the aerial use of toxins (see section 3.2: Topic 13 – Engagement and advocacy).

Objectives

Objective 15.1 To ensure that projects and organisations are healthy so that their roroa conservation work is sustainable in the long term.

Objective 15.2 To establish new roroa projects in target areas where they can meet priority needs for roroa.

Actions

ACTION		ACCOUNTABLE GROUP (SUPPORTING/ AFFECTED	PRIORITY
15.1	Support existing and new ground-based trapping or poisoning networks run by volunteers and community groups that protect accessible parts of high-priority sites in non-aerial-treatment years and/or are focused on reducing pest re-incursion from aerial treatment exclusion zones (e.g. around huts, rivers, roads and aerial treatment boundary areas) (see section 2.1: Topic 1 – Pest control).	Roroa Group	High
15.2	When funding opportunities become available, prioritise existing projects (where funding has not been available for completion) over starting new projects.	DOC Operations, SOIK, Tiakina Ngā Manu	High

5.2 Topic 16 – Funding

Context

Although DOC has had recent successes in gaining extra funding from Treasury for pest control (Tiakina Ngā Manu) and specifically for kiwi (SOIK), additional funding will be required to achieve all of the actions included in this species plan. While it is fortunate that roroa has a relatively large range, that range is fragmented, so there needs to be a strategic allocation of available resources/funding to the sites where the most gains will be achieved in the most cost-effective manner. In addition, work contributed by community groups needs to be consistent with their goals. Efforts to encourage philanthropic organisations, such as the NEXT foundation, to initiate new, very large-scale projects should continue, using roroa as a flagship beneficiary.

Objectives

Objective 16.1 To resource and provide sufficient support for all necessary kiwi conservation work.

Actions

ACTION		ACCOUNTABLE GROUP (LEAD/SUPPORTING)	PRIORITY
16.1	Develop a strategy to source the extra funding required, ensuring that this strategy works in with / sits under the national strategy to seek the extra funding required.	Species Lead, SOIK, K4K, Roroa Group	High
16.2	Prioritise funding and support for high-priority work/sites.	K4K, KRG, SOIK, DOC Operations	High
16.3	Ensure that any work that secures funding receives it on an ongoing basis (so that gains made are not lost).	K4K, SOIK, DOC Operations	High
16.4	Develop/support community groups so that they can sustain their work over the long term.	DOC Operations, K4K	High
16.5	Promote roroa conservation to philanthropic organisations such as the NEXT Foundation.	DOC Partnerships	High

6. Acknowledgements

This species plan was compiled by Robin and Sandy Toy, with the help of many other people (Appendix 4), largely during a 2-day hui organised by DOC Nelson Lakes staff in June 2017. The strong leadership from Robin and Sandy and the engagement and support from everyone is gratefully acknowledged. This plan is the result of many years' experience, investment and commitment from DOC, community groups, scientists and others. These collective efforts have provided the knowledge and opportunity to save roroa for future generations.

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Appendix 1

Supporting evidence – management of roroa (*Apteryx maxima*)

Options for increasing roroa populations

The major factor that is driving the decline in roroa (*Apteryx maxima*) that can be addressed is the predation of chicks/juveniles by mustelids. While it is also important to protect adults from dogs, vehicles and other hazards, the recovery plan goals will only be met if the issue of chick/juvenile predation is effectively addressed. Options to achieve this include:

- The use of toxins (aerial and ground application).
- Trapping.
- Operation Nest Egg (ONE), which involves rearing kiwi in captive and then releasing them into the wild once they have reached a safe weight to offset recruitment failure.
- Translocation/reintroduction, which aims to relocate kiwi from an area without predator control or that is at capacity to an area with good predator control and few or no kiwi. This has traditionally been widely used for kiwi management, and it is acknowledged that kiwi have previously been harvested from highly productive areas with minimal negative impacts (e.g. the Hawdon River valley).

The application of each of these options for roroa recovery is discussed below.

Toxins

Landscape-scale predator control is the most cost-effective recovery tool for roroa. It occurs on a large scale, maintains kiwi in natural ecosystems with natural genetic mixing, minimises the capture and handling of kiwi, and assists whole-ecosystem restoration goals (i.e. brings co-benefits for other taxa) (Innes et al. 2015). In addition, the aerial application of toxin and large-scale trapping may have genetic advantages by helping diverse individuals to breed, the dispersing offspring of whom will probably maintain natural genetic mixing and selection and adaptive learning in the surrounding landscape if they survive (Innes et al. 2015).

The aerial application of 1080 is currently the only tool available to control mustelids on the scale required to meet the recovery plan goals for roroa. Para-aminopropiophenone (PAPP) is the only toxin approved for mustelid control but is only approved for use in bait stations. Research is underway to develop safe aerial application methods, but this is not currently a viable management option.

A long-term study of kiwi recruitment at Tongariro has demonstrated that 1080 application every 3 years will enable a 2% per annum increase in the North Island brown kiwi (*A. mantelli*) population (H. Robertson, Department of Conservation (DOC), pers. comm.). However, it is not currently known whether these results are applicable to the forests and predator dynamics in the South Island. The naturally lower productivity of roroa will likely result in a more muted response to 1080 treatment. DOC initiated a study on roroa recruitment in a 1080 treatment area (Roaring Lion in Northwest Nelson) in 2016, which will provide evidence for the effect of mustelid control through secondary poisoning by aerial 1080 operations targeting rats on roroa recruitment.

DOC's Tiakina Ngā Manu response to large-scale beech mast events in 2014 and 2016 resulted in aerial 1080 applications for rat (*Rattus* spp.) control over some 300 000 ha of the roroa distribution covering most of north Northwest Nelson and c. 23 000 ha of the Arthur's Pass population range. Operational Solutions for Primary Industry (OSPRI) has also undertaken 1080 possum (*Trichosurus vulpecula*) control operations in areas occupied by roroa – for example, in the southern half of the Westport range in 2014 and the southwestern and northeastern part of the Paparoa Range in 2017 and 2018, respectively. Tiakina Ngā Manu operations are large scale, landscape predator control operations, undertaken in both mast and non-mast years, and are designed to maximise rat kill with consequent secondary poisoning of stoats (*Mustela erminea*). These operations are underpinned by extensive result (rodent and mustelid indices) and outcome monitoring to inform adaptive management, which is used to determine the optimum prescription for aerial 1080 pest control for a range of species, such as rock wren (*Xenicus gilviventris*), kea (*Nestor notabilis*) and orange-fronted parakeet (*Cyanoramphus malherbi*). Rat tracking of at least 10–30% is considered a reasonable operational trigger for aerial 1080 operations in the South Island (G. Elliott, DOC, pers. comm.), whereas rats usually track above that rate throughout the year in the North Island.

Historically, 1080 has been used primarily to control possums. However, a long-term territory mapping study on Gouland Downs showed that 1080 application for possum control approximately every 7 years is not sufficient to prevent a decline in the roroa population (Robertson et al. 2014).

Rodent index trigger thresholds and the optimal timing of aerial 1080 operations differ depending on the species being targeted for protection. Therefore, targeting the most sensitive species for protection when undertaking aerial 1080 operations is likely to benefit all species in an ecosystem. There is increasing collaboration and coordination between DOC and other agencies to maximise synergies in aerial 1080 management.

Due to the high reproductive capacity of rodents and mustelids, pest control is most effective when numbers are reduced to very low levels and the core/high-level area is located far from the treatment boundaries so that it takes a long time for re-invasion to occur. Small-sized operations also risk operational failure due to rapid reinvasion from operational boundaries by both rats and mustelids, which have large home ranges and dispersal distances. Rapid reinvasion has been observed (in the form of stoat trap catches) at the margins of 1080-treated areas in the Flora Stream catchment (hereafter 'Flora'). Minimising these reinvasion opportunities by treating large areas and undertaking trapping is likely to be beneficial.

Trapping

Trapping is a well-established control technique for stoats. Table A1.1 summarises the current trapping effort in the roroa range.

Best practice for stoat trapping is continually being developed, but the current standard is double-set DOC 150 or DOC 200 traps at 100-m spacing in a network of lines less than 1 km apart. Self-resetting traps (particularly those with effective long-life lures, such as Goodnature A24 traps) have the potential to revolutionise trapping in the remote, difficult terrain that roroa inhabit. One study demonstrated that self-resetting traps resulted in the same level of brown kiwi recruitment as a similar network of DOC series and Fenn traps, although all traps were checked at similar frequencies (every 3 weeks; Craig Gillies, DOC, pers. comm). The development of an effective long-life lure for stoats will help decrease the frequency at which the self-resetting traps would need to be rebaited.

Kiwi have been found to access the self-resetting Goodnature A24 traps when set at a height of 12–100 cm, resulting in bill injuries. An assessment of these interactions found that all kiwi that interacted with the traps were captive reared, although information from kiwi in the wild was limited. Therefore, it was considered that under *most* circumstances, A24s present no greater risk to kiwi than other tools that are regularly used for mustelid and/or rodent control, provided that they are used correctly (i.e. set at 12 cm above ground level and as vertical as possible). Further detail on the risk that A24 traps pose to kiwi can be found in a risk assessment report (Gorman 2020), which is available on request from Nic Gorman in the DOC Biodiversity Threats Team (ngorman@doc.govt.nz).

To minimise the risk to kiwi, the Kiwi Recovery Group and DOC's Trapping Technical Advisory Group recommend that A24 traps that are being used within roroa crèche sites are set at least 1 m above the ground or used in conjunction with an effective kiwi-excluding device. In all other roroa habitat, A24s can be used provided that they are set at 12 cm above ground level and as

Table A1.1. Trapping projects in or adjacent to the current roroa (*Apteryx maxima*) range (as at June 2020).

LOCATION	REGION	AREA (Ha)*	No. TRAP STATIONS	TRAP TYPE	NETWORK/ LINEAR	YEAR INITIATED/ EXPANDED	PROGRAMME
Flora Stream catchment	Northwest Nelson	9536	1192	Single/double set	Network	2001	Friends of Flora
Cobb River valley	Northwest Nelson	3200	400	Single set	Network	2006	Friends of Cobb
Wangapeka River / Fyfe River	Northwest Nelson	8432	1054	Double set	Linear	2009/2014	Department of Conservation (DOC) / Whio Recovery
Gouland Downs	Northwest Nelson	6500	813	Single-set A24s	Network	2017	DOC / Air New Zealand
Ōpārara	Northwest Nelson	5600	700	Double set	Linear	2002/2007	DOC / Whio Recovery
Ōpārara kiwi sanctuary	Northwest Nelson	7200	900	Single/double set	Network	2016	Bathurst Mining Ltd compensation project (John McLennan)
Ugly River	Northwest Nelson	2160	270	Double set	Linear	2007	DOC / Whio Recovery
Huia River / Kākāpō River / Cuckoo Creek	Northwest Nelson	2720	340	Double set	Linear	2011/12 2016/17	DOC / Whio Recovery
Little Wanganui River	Northwest Nelson	1360	170	Double set	Linear	2011/12	DOC / Whio Recovery
Old Ghost Road	Westport	2568	321	Single set	Linear (small network at Lyell)	2015	Mokihinui-Lyell Backcountry Trust
Western Paparoa Range	Paparoa	13 000	200 (additional 260 traps proposed)	Double set	Linear	2020	DOC / Air New Zealand
Southern Paparoa Range	Paparoa	10 288	1286	Single/double set	Network	2014	Paparoa Wildlife Trust
Motukiekie	Paparoa	12 (780 proposed)	8	Single set (proposed expansion A24)		2016	Motukiekie Shakedown (Leon Dalziel)
Pike Stream	Paparoa	1480	185	Single/double set	Linear		DOC / Whio Forever
Arthur's Pass	Arthur's Pass–Hurunui	6192	774		Linear	2005	Arthur's Pass Wildlife Trust / Alpine Bird Sanctuary / Bealey Spur Residents Association

Continued

Table A1.1 continued

LOCATION	REGION	AREA (Ha)*	No. TRAP STATIONS	TRAP TYPE	NETWORK/ LINEAR	YEAR INITIATED/ EXPANDED	PROGRAMME
Hawdon River valley, Andrews Stream, Poulter River, Hurunui River South Branch	Arthur's Pass–Hurunui	16 000† (expanding to c. 26 000)	4300 trap stations over 200 km (expanding to 300–350 km)	Single-/double-set A24s (programme to be upgraded and expanded)	Linear shifting to network	1995, 2003 (1st expansion), 2017 (2nd expansion)	DOC
Nina River valley	Arthur's Pass–Hurunui	1600, 240, 240	200 George Moran and New Zealand Deer Stalkers Association (NZDSA) lines, each 3 km		Linear	2009	Hurunui College Nina Valley Restoration Group / George Moran line / NZDSA
Rotoiti	Rotoiti	7216	902	Single set	Network	1998	DOC (Friends of Rotoiti run additional buffer lines)
Total		**66256**					

* The area trapped was calculated on the basis of a 400-m-wide protection area either side of a trap line (no. traps × 8 if traps @100-m spacings or km of traps x 80; DOC 2013). This is likely to be an overestimate in situations where traps run either side of a river or adjacent to a wide river where the protected area may be as little as half the estimated area.

† The Hawdon, Andrews, Poulter and Hurunui South Branch area has a higher than normal density of traps, so the length of the trap line has been used to calculate the area covered rather than the number of traps. This is likely to be an overestimate given that the trap lines are only 200 m apart and/or run along rivers in places.

vertical as possible. We do not currently know whether these new measures will affect the efficacy of catching stoats or alter the non-target risk profile of other bird species. Therefore, DOC is conducting work to test excluder devices with kiwi and determine if the traps can be mounted at a height of <1 m. This advice is based on information available to date (January 2020) and will be reviewed and potentially revised over time.

Suitable mitigation measures to reduce the risk of self-resetting traps to kea and weka have not yet been developed, and a risk–benefit analysis of using self-resetting traps in kea and weka habitat still needs to be undertaken. Therefore, since kea and weka share much of the roroa habitat, the use of self-resetting traps should be undertaken with caution and reviewed once more information is available.

It is impractical to undertake trapping across the full range of roroa habitat. However, in areas where it is being used, the efficacy of the trapping regime in achieving roroa recruitment is an important consideration. Many of the trapping programmes shown in Table A1.1 use linear trapping, either because they are designed to protect whio/blue duck (*Hymenolaimus malacorhynchos*) nesting along waterways or because the nature of the terrain makes a network impractical. Linear trapping has been sufficient for roroa recruitment in the Arthur's Pass area, possibly because the topography of the Southern Alps/Kā Tiritiri o te Moana, where the valleys occupied by kiwi are separated by mountain ranges rising to more than 1700 m, results in limited stoat re-invasion. Trap catches at Flora from more than a decade of trapping demonstrate that a large-scale network is achieving sufficient control for roroa chick survival in this part of Kahurangi, where constant mustelid reinvasion has been demonstrated. No project to date has investigated the effectiveness of linear trapping in lower altitude habitat, such as that initiated for whio protection.

In summary, effective trapping networks for roroa may vary with topography, altitude and ecosystem type. The current minimum recommendations are to follow best practice where the terrain allows, to maximise the management area and to plan for a toxin operation at least every 3 years to poison any untrappable stoats. If possible, possums should also be managed. It is difficult for any project (by DOC or the community) to control predators over large areas through trapping. However, large operational areas can be achieved where multiple projects work strategically together.

Operation Nest Egg (ONE)

The ONE process and associated issues are summarised in Wildlands (2013). ONE was initially trialled in 2008 by the Paparoa Wildlife Trust (PWT) and DOC to test its applicability as a tool for roroa. This work was supported by the New Zealand Conservation Trust and Willowbank, who incubated and hatched the eggs. The results were disappointing in the first few years but improved as incubation, creching and release management techniques were refined.

A limited number of studies following ONE-hatched roroa have shown that these birds will breed but the age at first breeding is 4 years at the earliest. There have been no longitudinal studies of wild-born roroa to compare the onset of breeding and recruitment success, although one wild-born chick in Arthur's Pass started to breed at 3 years. Therefore, the long-term success of ONE is still uncertain. ONE birds have successfully hatched chicks in the Paparoa Range and the Nina River valley, one of which in the Paparoa Range was raised to a safe weight. However, the cost of ONE is high for roroa compared with brown kiwi due to there being a low density of birds in remote terrain and relatively little increase in population growth (see section 2.9: Topic 9 – Operation Nest Egg). In addition, there are genetic and disease risks associated with captive management and, since the technique does not address the causes of the decline, it will provide only a short-term benefit. ONE can add value in emergency conservation situations, however, such as when managing birds in areas where predator control is not possible, developing mitigation methods, etc.

Translocation

Translocations have been used to re-establish or boost remnant roroa populations at three sites (Table A1.2), and successful techniques have been developed through these programmes. However, translocations are expensive and there are genetic risks associated with small founder populations.

Table A1.2. ROROA (*Apteryx maxima*) TRANSLOCATIONS.

PARAMETER	RECEIVING SITE				
	FLORA STREAM CATCHMENT (2010–2016)	ROTOITI (2004–2016)	NINA RIVER VALLEY (2011–2015)	HAWDON RIVER VALLEY (2009–2010)	TE HAUTURU-O-TOI / LITTLE BARRIER ISLAND (1915)
Number of translocated kiwi	42 adults and 2 subadults	16 wild adults and 1 wild subadult 13 ONE subadults	8 wild adults 10 ONE subadults	4 ONE subadults	19 adults
Number of different source sites	4	2	1	1	1
Wild sourced or Operation Nest Egg (ONE) sourced	Wild	Wild and ONE	Wild & ONE	ONE	Wild
Number of transmittered monitoring years to 2017	135	133	48	4.7	0

Appendices

DOC (Department of Conservation) 2013: Stoat – kill trapping. Unpublished report (DOCDM 29448). Department of Conservation. 2 p.

Innes, J.; Eppink, F.; Robertson, H. 2015: Saving a national icon: preliminary estimation of the additional cost of achieving kiwi population stability or 2% growth. Landcare Research Contract Report LC2136. Prepared for Kiwis for kiwi – The Kiwi Trust. Landcare Research Manaaki Whenua, Lincoln. 45 p.

Robertson, H.A.; Colbourne, R.; Ogle, M. 2014: Status of Great Spotted Kiwi (*Apteryx haastii*) near Saxon Hut, Kahurangi National Park, in 2014. Department of Conservation (unpublished report).

Wildlands 2013: Operation Nest Egg situation analysis. Contract Report No. 2999. Prepared for Kiwis for kiwi – The Kiwi Trust. Wildland Consultants Ltd, Rotorua. 43 p.

Gorman, N. 2020: Trap Risk Assessment: Kiwi and Goodnature A24 (DOC-6098733). Department of Conservation (unpublished report).

Appendix 2

Supporting evidence – the biology of roroa (*Apteryx maxima*)

The information in this appendix was compiled up to October 2017, with the exception of Figures A2.2–A2.4, which were updated in October 2019.

Whakapapa and taxonomy

When Māori arrived in Aotearoa, kiwi were among the many bird species that were present. The classification of kiwi began when different iwi settled or travelled through the regions, and the whakapapa or genealogy of kiwi is explained and understood in different ways and can be specific to each iwi – for example, great spotted kiwi (*Apteryx maxima*), has two Māori names – roroa and roa (Germano et al. 2018). Very little is documented on the mātauranga or knowledge that whānau, hapū and iwi hold for kiwi.

Recent genetic analysis has led to the change in scientific name for roroa from *Apteryx haastii* Potts, 1872 to *A. maxima* Sclater and Hochstetter, 1861 (Sheperd et al. 2021). The study reviewing hybridisation revealed that the syntype specimens collected near Okarito in the early 1870s, which displayed unusual morphologies, were hybrid specimens of rowi (*Apteryx rowi*) and little spotted kiwi (*Apteryx owenii*). Analysis of the *A. maxima* neotype specimen revealed a genotype aligned with roroa, resulting in the resurrection of the scientific name, *A. maxima*.

Historically, roroa were thought to comprise three distinct populations: Northwest Nelson, Paparoa Range and Arthur's Pass–Hurunui (McLennan & McCann 2002). More recent genetic analysis has revealed substantial genetic variation within this species, with geographical structuring of the populations due to isolation by distance or barrier, likely as a result of limited dispersal since kiwi cannot fly (McLennan & McCann 2002). The genetic data available suggest that all roroa on the West Coast of the South Island (from north Northwest Nelson to south Paparoa Range) formed a continuous population until relatively recently. Birds in north Northwest Nelson, Westport and the Paparoa Range are all quite genetically distinct when viewed as discrete populations but show a clear signal of isolation by distance when viewed as a whole – i.e. there is a continuum of genetic differentiation stretching from one end of the west coast range to the other. By contrast, the Arthur's Pass population seems to have been isolated from the west coast roroa for a relatively long time. Thus, birds in the Arthur's Pass–Hurunui region form one discrete population that exhibits isolation by distance within it but is genetically distinct from all other roroa populations.

Maintaining the genetic diversity within a species is crucial to maximising its adaptive potential and will make it more resilient to challenges (such as disease and climate change) over the long term. Thus, if a population or species exhibits a pattern of isolation by distance, it is important to maintain this pattern when managing it (Germano et al. 2018). Therefore, to maintain the current genetic structure of roroa, birds should not be moved from one end of their population range to the other or between the west coast and Arthur's Pass–Hurunui, but rather should be moved within realistic 'neighbourhood' distances that individual roroa would naturally be able to navigate themselves. As an indication of suitable distances, an individual roroa in the Flora River valley (hereafter 'Flora') that was fitted with a radio tag travelled a straight-line distance of 13 km and returned (R. Toy and S. Toy pers. comm.), and a subadult dispersed 20 km from the Hawdon River valley to Arthur's Pass. It should be noted that the kiwi populations that were reintroduced at Nelson Lakes and Flora all comprise individuals that were translocated from different areas prior to the recent genetic analyses being undertaken.

The important number for a population is how many birds contribute to population growth rather than the absolute number that are present (H. Taylor, University of Otago, pers. comm.), and there is concern that many roroa are old and may be past breeding age. To address this, it would be possible to monitor the effective population size (i.e. the number of actual breeding birds) using genetic data obtained from pin feathers.

Manaaki Whenua – Landcare Research is coordinating work to combine genetic, morphological, behavioural and acoustic information to publish a definitive taxonomy for all kiwi species (J. Innes, Landcare Research, pers. comm.).

Ecology

McLennan & McCann (1991) were the first to investigate and summarise the ecology of roroa at two sites in Northwest Nelson. Subsequently, projects have been undertaken at several sites using transmittered kiwi, which have greatly expanded our knowledge and understanding of this species. The following summary of key aspects of roroa ecology that are of relevance to roroa management has been compiled from the collective experience of practitioners involved in these studies, the locations of which are shown in Fig. A2.1.[2]

Home range and dispersal

A number of studies have assessed the home range size of roroa. Keye et al. (2011) estimated that the mean (± standard error) minimum home range size of 10 transmittered kiwi in North Hurunui was 29.3 ± 1.6 ha (range = 19.6–35.4 ha), while Jahn et al. (2013) found that the mean home range size of roroa at Rotoiti was 34.4 ± 9.4 ha for adults and 17.4 ± 5.7 ha for subadults, with a 78–99% overlap between adults and subadults. At Gouland Downs, the home range size has increased from an average of 23 ha (11 territories in 250 ha) in 1987 to 32 ha (14 territories in 450 ha) in 2014 (Robertson et al. 2014). Finally, the low-density, recently translocated population at Flora have larger home ranges – for example, day-time roost sites in some areas with established kiwi cover exceed 50 ha (Toy & Toy 2020).

Habitat quality and/or population density are thought to determine the home range size. Roroa sometimes exhibit seasonal and inter-annual variation in their home ranges (e.g. at Flora and Stockton), and such variation was also recorded by McLennan & McCann (1991). In addition, some habitat may be used by more than one pair (e.g. areas above the bushline at Paparoa Range and Hurunui). Kiwi can wander relatively large distances – for example, an unpaired male at Flora was located 13 km from its normal range and subsequently returned, and even individuals in established pairs have occasionally been found several kilometres from their established home range at Flora (Toy & Toy pers. comm.). Furthermore, a subadult dispersed 20 km in Arthur's Pass, and two-sub adults have been recorded dispersing over a 1700-m-high (snow bound) mountain range (G. Graeme Kates, Arthur's Pass Wildlife Trust pers. comm. 2017).

Breeding biology

Roroa lay a single egg but can make up to three breeding attempts in a season if nest failure occurs (Paparoa Range, Flora). Fecundity is variable, and some pairs do not breed every year or at all, which may be related to old age (Flora, Paparoa Range). The age at first breeding in wild-hatched roroa ranges from 3 years 10 months (Arthur's Pass) to 8 years (Paparoa Range) and averages 4 years in Operation Nest Egg (ONE)-raised birds (Paparoa Range, Nina).

Roroa lay and incubate their eggs from July through to February. Males generally incubate during the day, while females share incubation during the night. Offspring from previous years have also sometimes been seen entering nest burrows at night (Flora, Arthur's Pass, Hawdon) and roosting in the nest during the day (Flora). The full-term incubation period averages 83 days in Arthur's Pass (n = 22) but only 77 days at Flora (n = 19).

Family bonds are long-lasting, with young birds being found with their parents for up to 27 months in Arthur's Pass and up to 3.5 years at Rotoiti (Jahn et al. 2013). Chicks do not emerge from their nests for 7–10 days after hatch (Hawdon, Hurunui, Flora, Arthur's Pass), and parents

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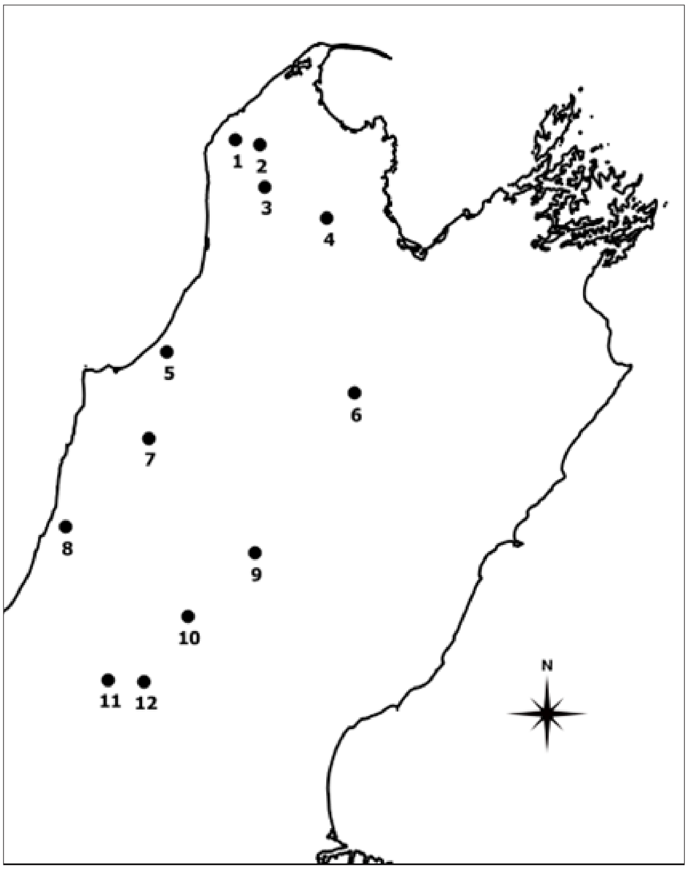
[2] Note that the site names provided in Fig. A2.1 are abbreviated in the following text.



SITE		ORGANISATION	PROJECT	PEST CONTROL	DATES
1	Saxon	Department of Conservation (DOC)	Territory mapping	1080, A24 trapping starting	1987–present
2	Gouland Downs	DOC	Operation Nest Egg (ONE) source monitoring	1080, A24 trapping starting	2009–2012
3	Roaring Lion River valley	DOC	Population monitoring	1080	2016–present
4	Flora Stream catchment	Friends of Flora	Translocation monitoring	1080 and trapping	2010–2018
5	Stockton	Stockton Mine	Mitigation monitoring		2010–2015
6	Rotoiti	DOC	Translocation monitoring	1080 and trapping	2004–present
7	Te Wharau	DOC	Population monitoring	1080 since 2018	2016–present
8	Paparoa	Paparoa Wildlife Trust	ONE and population monitoring	Trapping initiated	2007–present
9	Nina River valley	Nina Valley Restoration Group	Translocation monitoring	Trapping	2013–2017
10	North Hurunui	DOC	ONE and population monitoring	None; 1080 planned for 2019	2007–2015
11	Arthur's Pass	Arthur's Pass Wildlife Trust	Population monitoring	Trapping	2008–2013
12	Hawdon River valley	DOC	ONE and population monitoring	1080 and trapping	2008–2015

Figure A2.1. Locations of transmittered roroa (*Apteryx maxima*) study populations.

remain close to the nest while foraging for at least the first month after hatch (Flora). Chicks in Arthur's Pass reach a safe weight (1.2 kg) between 260 and 385 days, with this occurring faster in chicks that hatch earlier in the breeding season, although predation has rarely been seen after 6 months of age. Across all sites, an average of 9.4% of adults change partners from one breeding season to the next.

Behaviour

Roroa are notorious for their flighty nature. Some individuals rarely roost underground, which makes them extremely difficult to catch for transmitter fitting, a prerequisite for life-table studies. For example, five out of seven kiwi at Nina could not be caught for a transmitter change. Night capture and handling have been used to overcome this problem at Roaring Lion, but this is only possible in areas with reasonable terrain and individuals may become less responsive to taped calls over time (James Fraser, Dog contractor, pers. comm.).

Habitat

Roroa inhabitat areas ranging from sea level on the West Coast of the South Island to subalpine habitats up to 1200 m above sea level and have been reported crossing 1700-m-high mountain ranges in Arthur's Pass. Habitats include dense, mixed beech–podocarp forest in the west, open beech forest, subalpine scrub and open tussock basins. Roroa have also occasionally been encountered in secondary scrub adjacent to more climax habitat at Flora and New Creek.

Status

Classification

Roroa is currently classified as Nationally Vulnerable under the New Zealand Threat Classification System (Robertson et al. 2017). However, a decline of 2% per annum (p.a.) (see below) would amount to a >70% decline over 60 years. Therefore, if the generation time (mean age of breeding females) is >20 years, this species should be classified as Nationally Critical.

Population dynamics based on call rates and territory mapping

Over the 20-year period from 1993 to 2013, call rates obtained during the national long-term call count monitoring scheme declined at an average rate of 2% p.a. in three unmanaged areas (Stockton, Taramakau and North Hurunui) and increased at an average rate of 0.4% p.a. in three areas where predators were trapped and/or poisoned in 1080 operations (Gouland Downs, Heaphy and South Hurunui) (Hugh Robertson, DOC, unpubl. data). It is noted that the 0.4% increase in managed areas is an average of 11 listening stations, which individually exhibited call rate changes of −4% to +6.1% p.a. A long-term territory mapping study on the Gouland Downs revealed a population decline of 1% p.a. despite 1080 operations aimed at possum (*Trichosurus vulpecula*) control being undertaken at approximately 7-year intervals (Robertson et al. 2014). However, call rates at two stations in the same area indicated changes of −4% and −1.8% p.a. The relationship between the call rate and population density on the ground will vary for a number of reasons, especially at individual listening stations. Therefore, more long-term work is needed to determine whether changes in call rates (from a much greater number of listening stations covering far more individuals) can be used to determine overall population trends (Hugh Robertson, pers. comm.).

Population dynamics based on life-table analysis

The survival and productivity of transmittered birds can be used to populate life-table models that estimate population numbers. Video monitoring using trail cameras placed near the entrances of nest burrows can be used to monitor the survival of chicks in the first weeks after hatching before they leave the nest. To assist this, guidelines have been developed for the interpretation of roroa nest videos (see Appendix 5).

The survival of transmittered roroa chicks and subadults has been calculated by Kaplan-Meier analysis using the method described by Robertson & Westbrooke (2005), who also provided the following 'rough rules' for determining the number of data needed to run adult survival analyses using the Mayfield technique:

- The total tracking years of the study should be at least 10× the average life expectancy of the study animal; or
- The product of the number of deaths recorded and the number of tracking years should exceed 500 (e.g. 50 deaths in 10 tracking years' data, 10 deaths in 50 years' tracking data or 2 deaths in 250 tracking years' data).
- There are insufficient data to run such analyses for individual roroa projects, so data from projects in areas with similar management (see Table A2.1) have been combined based on the following rationales:
- The survival of adult roroa (birds > 4 years old or < 4 years old that have bred) is very high across all sites, irrespective of whether pest control is in operation. During 1006 years of adult roroa monitoring, only 20 adult birds have died and only 3 of these deaths were due to predation – two by dogs and one by an unidentified predator. Therefore, all adult data have been combined to derive a single survival figure. Both of Robertson & Westbrooke's (2005) 'rough rules' are clearly met by this dataset.
- The survival of wild, subadult roroa (birds from 6 months old to the age at first breeding or 4 years old) has been monitored for 14 birds at sites without pest control and 24 birds at sites with pest control. However, only one subadult has died. Therefore, the survival figures from all wild subadults have been combined.
- The survival of 64 subadults derived from ONE programmes has been monitored. Although 18 of these birds have died, predation has only been identified as the cause of death in one instance, which is as expected since ONE programmes aim to get birds to a stoat (*Mustela erminea*)-proof weight before release. Therefore, all ONE subadult survival data have been combined irrespective of whether the birds were released into areas with or without pest control.

TABLE A2.1. PERCENTAGE SURVIVAL OF DIFFERENT LIFE STAGES OF ROROA (*Apteryx maxima*) AT SITES WITH DIFFERENT LEVELS OF MANAGEMENT ESTIMATED USING KAPLAN-MEIER ANALYSES OF DATA OBTAINED FROM TRANSMITTERED ROROA WITH SUPPLEMENTARY INFORMATION FROM NEST CAMS.

LIFE STAGE	MANAGEMENT	No. KIWI	No. MONITORING YEARS	No. DEATHS	% SURVIVAL* (95% C.I.)
Adult	All sites (pest control, no pest control and Operation Nest Egg (ONE))	376	1006	20	98.2† (96–99.2)
Subadult	Pest control and no pest control	43	64	1	99
	ONE	64	125	18	90 (79.4–95.5)
Chick/juvenile	Pest control	58	11.6	24	53.6 (37.4–67.4)
	ONE	96	38	24	74.5 (64.4–82.1)

* % survival is annual for adults and subadults and up to 180 days for chicks.

† Gives an adult life expectancy of 57 years.

Notes on Table A2.1:

- The data do not delineate the effects of pest control and no pest control at sites but rather indicate the % survival for each life stage, differentiating between wild and ONE (captive-reared) roroa in the subadult and chick stages.
- The survival of chicks in North Hurunui (unmanaged site) was surprisingly high and sufficient to sustain the population, which was likely a product of the small sample size (Hugh Robertson, pers. comm. 2019).
- The sample size is recorded in bird-years (e.g. 10 birds monitored for 3 years, 12 for 2 years and 6 for 1 year would give 30 + 24 + 6 = 60 bird-years).

- A total of 14 of 20 wild chick deaths with a known cause of death were due to predation. Therefore, the survival of chicks has not been combined from areas with and without pest control. To date, only 17 chicks from areas without pest control have been monitored, whereas data are available for 58 chicks from areas with pest control and the product of the number of deaths recorded and the number of tracking years is 278.
- Data are available for 96 ONE-reared chicks, and the product of the number of deaths recorded and the number of tracking years is 912.

Life-table modelling also requires knowledge of fecundity. Since roroa do not breed every year and may re-lay if an egg is lost, the total number of eggs laid cannot be used for such analysis. Instead, the relevant input to the models is the proportion of adult kiwi producing a chick each year. The productivity of roroa has been determined for 468 pair-years, 263 of which are in sites that are not subject to ONE (194 with pest control, 69 without pest control) and 205 of which are in sites that are subject to ONE. Over this period, 210 single adult bird-years have also been monitored: 109 from sites with pest control, 21 from sites without pest control and 80 from ONE sites.

The survival (Table A2.1) and productivity (Table A2.2) data were run through two Leslie matrices: one for areas subject to pest control at which ONE was not practised and one for areas in which ONE was practised. These analyses showed that:

- **Roroa populations increase at 5.6% p.a. in areas that are subject to pest control.**
- **Chicks are most vulnerable to predation and appear to be safe from stoat predation once they reach the subadult stage. In any one year, 52% of adults in areas subject to pest control are breeding but only 18% of pairs produce a chick that reaches the subadult stage.**

When interpreting these findings, the following caveats should be noted:

- Although large amounts of data are available for wild subadults and chicks in areas subject to pest control, they do not meet Robertson & Westbrooke's (2005) 'rough rules', suggesting that the Mayfield method may be more suitable for analysing this sample.
- Translocated birds have been included in this analysis, which will lead to productivity being underestimated as, in some cases, it has taken birds >1 year to settle into pairs and

TABLE A2.2. PRODUCTIVITY DATA FOR ROROA (*Apteryx maxima*) THAT WERE USED TO INFORM THE LIFE-TABLE ANALYSES, AS COLLATED IN DOC-3189966.

MANAGEMENT REGIME	PROPORTION OF ADULTS BREEDING	PROPORTION OF BREEDING ADULTS HATCHING A CHICK	PROPORTION OF PAIRS HATCHING A CHICK	PRODUCTIVITY (CHICKS HATCHED/ADULT/ YEAR)
Wild with pest control	0.52	0.66	0.34	0.17
Wild without pest control	0.55	0.57	0.31	0.16
Operation Nest Egg (ONE)	0.66	0.74*	0.49	0.24

* Adjusted for the proportion of ONE eggs that hatched.

Notes on Table A2.2:

- To understand the full context of the data presented in Table A2.2, and because the data include non-independent observations, it is necessary to consider the number of sites included in each management regime, number of monitored individuals (sample size), number of years over which monitoring was conducted and standard error. This information can be obtained from the dataset provided in the DOC spreadsheet Kiwi – GSK Life Cycle Analysis, Survivorship and Breeding Master – All sites (DOC-3189966; see DOC 2019 in references).
- This table presently shows very little difference in productivity between different pest control regimes, which may be due to the small sample size within and between management regimes. Therefore, before inferences are drawn about the impacts of predator control on kiwi productivity, the data should be considered in light of additional information, as mentioned above.
- This table shows that 66% of adults would hatch a chick, while only 34% of pairs would hatch a chick, indicating that a large proportion of adults could hatch a chick without being in a pair. However, this is considered unlikely based on our knowledge of the life-history traits of roroa.
- The sample size is recorded in bird-years (e.g. 10 birds monitored for 3 years, 12 for 2 years and 6 for 1 year would give 30 + 24 + 6 = 60 bird-years).

territories. This may also have been associated with higher adult mortality as birds get to know the new area.

- Pest control encompasses a range of management methods and intensities, including trapping and aerial 1080. In addition, data have been collected at varying times after 1080 applications. The analysis does not show which type of management is sufficient to achieve population growth.
- All ONE data were included but ONE techniques have developed over time, so the 'gain' from ONE is probably underestimated.
- Adult mortality was estimated at 1.8% p.a., which is similar to the 2% decline seen in call-count studies at unmanaged sites once 95% confidence intervals (0.8–4.0% adult mortality per annum) are taken into account. Furthermore, although there were insufficient data to undertake a life-table analysis for unmanaged sites, some recruitment was observed at North Hurunui. This discrepancy is likely due to the size of the datasets used in the life-table analysis or the difficulty in interpreting call-count data.

All of the survival and productivity data and the analyses performed are stored in a DOC spreadsheet DOC-3189966, see DOC 2019 in References.

Distribution

Roroa are thought to be distributed across 800 000 ha of land, excluding areas in which they are extremely sparse and the population is considered inviable (Innes et al. 2015). However, it is difficult to establish an accurate picture of roroa distribution due to the remote and extensive nature of the species' range. The deployment of acoustic recorders in the backcountry provides both presence/absence information and call rates, but there is significant variation in roroa call rates (Colbourne & Digby 2016), meaning that large numbers of samples are needed to map

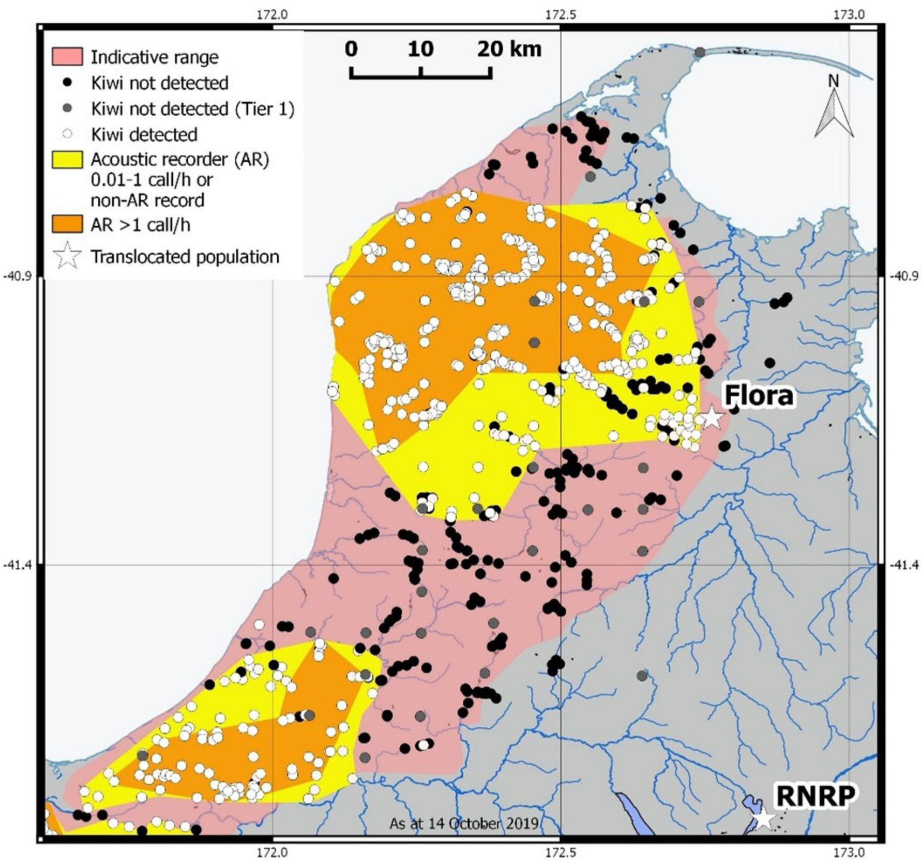


Figure A2.2. Call rates and distribution of roroa (*Apteryx maxima*) in Northwest Nelson and Westport (as at October 2019).

call-rate contours. However, a clear picture of the distribution and call rate is emerging for the Northwest Nelson and Westport populations (Fig. A2.2; R. Toy & S. Toy unpubl. data). This shows that roroa occupy core areas of c. 140 000 ha in Northwest Nelson and 48 000 ha in Westport in which the acoustic recorder call rates exceed 1 call/h and fringe areas of 120 000 ha in Northwest Nelson and 41 000 ha in Westport in which the call rates range from 0.01 to 1 calls/h. The maximum call rate in the core areas was 13.8 calls/h, and there were many sites with call rates > 5 calls/h. There also appears to be a c. 30-km gap in the distribution between the Karamea and Mōkihinui rivers. There were a few records of roroa in this area in the 1980s and 1990s (McLennan & McCann 2002), but little information is available for these records and some may have been misidentifications, possibly even with little spotted kiwi (*A. owenii*). Given the genetic differences between roroa in Northwest Nelson and Westport, the species may have disappeared from this area a long time ago.

Studies on the distribution of roroa in the Arthur's Pass–Hurunui region are less advanced, but the picture emerging indicates that there is a core area of 82 000 ha in which acoustic recorder call rates exceed 1 call/h with a maximum rate of 3.4 calls/h and a fringe area of 89 000 ha in which call rates range from 0.01 to 1 calls/h (Fig. A2.3). The main differences between the current distribution and historic records in the Kiwi Call Scheme (R. Colbourne, DOC, pers. comm.) are that roroa have disappeared from the Doubtful and Hope river valleys. However, new records have appeared in a band from the Crooked River to the mid-reaches of the Trent River and roroa appear to be more widespread in the Taipo River than was previously thought.

An acoustic recorder study undertaken in the Paparoa Range during 2016–2018 mainly covered the western slopes of the range, with limited data available for the east. Consequently, although some additional roroa distributional records are available from the national Kiwi Call Scheme, Tier 1 monitoring and the NZ Bird Atlas Scheme by Birds New Zealand, the core and fringe roroa distribution areas shown for the Paparoa Range in Fig. A2.4 are indicative only.

There are also small numbers of kiwi in two isolated translocated populations: one at Nina and one to the east of Lake Rotoiti.

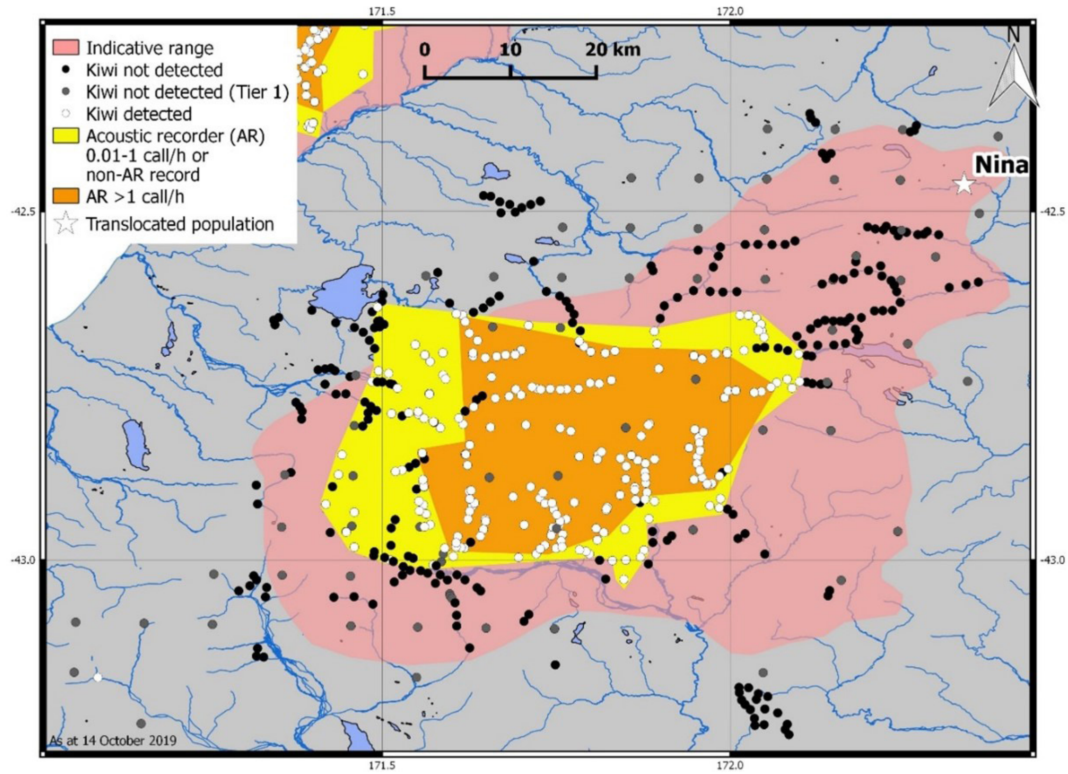


Figure A2.3. Call rates and distribution of roroa (*Apteryx maxima*) in the Arthur's Pass–Hurunui region (as at October 2019).

Population

Innes et al. (2015) estimated that there are c. 14 800 roroa, while the most recent kiwi recovery plan estimated a total of 14 000 birds (Germano et al. 2018). The 2015 roroa population estimate of 14 800 birds (range = 10 360–19 240) was derived from the best guess published by Holzapfel et al. (2008) and calculating how this population would have changed over the following 7 years

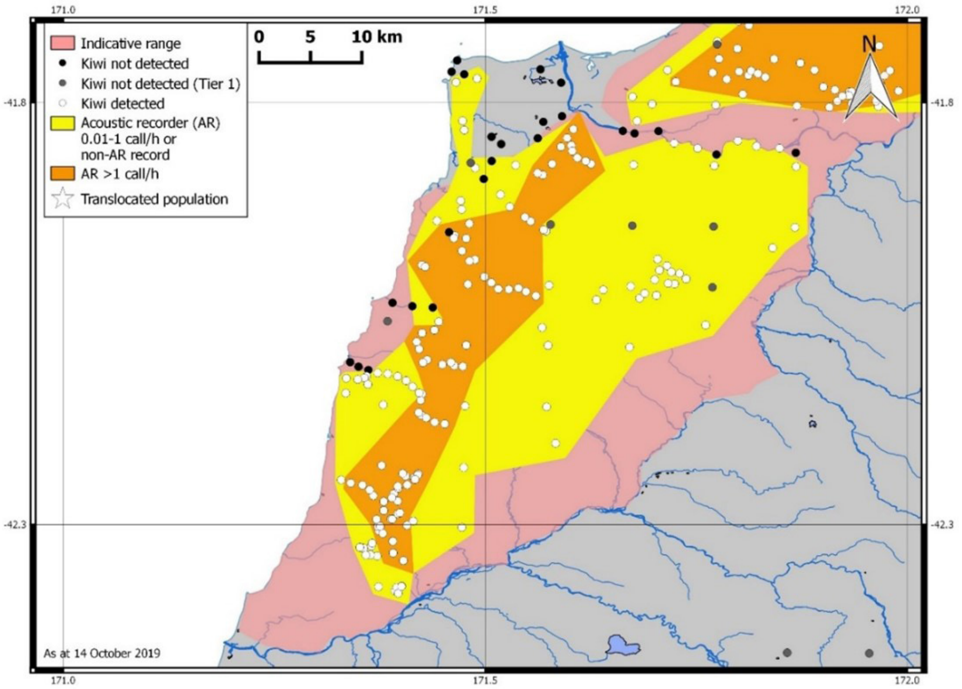


Figure A2.4. Call rates and distribution of roroa (*Apteryx maxima*) in the Paparoa Range (as at October 2019).

by allocating the 2008 birds to either managed or unmanaged regimes, which were assumed to result in growth rates of +0.3–2% and −2%, respectively. To acknowledge uncertainty, maximum and minimum error sizes of 30% were suggested (Innes et al. 2015).

If call rates are correlated with kiwi density, the population could be estimated from the distribution of call rates. However, call rates may not be directly proportional to density since kiwi at a low density may call less (no neighbours to warn off) or more (searching for mates) than those at a high density. Therefore, analyses of call rates in areas with known kiwi densities are needed to resolve this.

Threats

Roroa have low adult mortality and consequently a high life expectancy of 57 years, estimated as the inverse of the annual mortality rate calculated by Kaplan-Meier analysis of transmittered adult kiwi. Established causes of adult death include old age (Flora); drowning, lodging under tree roots and other ‘accidents’ not related to human intervention (Paparoa Range, Flora, Rotoiti), road kill (Arthur’s Pass, Nina, Buller); and predation – likely by dogs (Rotoiti, Stockton). Although there have been no reports of roroa being predated by feral cats (*Felis catus*) or ferrets (*Mustela putorius furo*), they are likely to be a threat, particularly in areas close to habitation or farmland, such as Rotoiti.

The main cause of chick mortality is stoat predation (Arthur’s Pass, North Hurunui, Flora, Rotoiti), but kārearea / New Zealand falcon (*Falco novaeseelandiae*) predation and drowning have also been recorded in Arthur’s Pass.

Weka (*Gallirallus australis*) have caused incubation failure at Flora and Roaring Lion. For example, at Roaring Lion, 3 nests out of 12, 5 nests out of 11 and 2 nests out of 6 failed due to weka in the 2018/19, 2017/18 and 2016/17 seasons, respectively. It appears that repeated harassment of the adult kiwi on the nest by weka can result in a broken egg. In addition, the disturbance of nests by kea (*Nestor notabilis*) and possums has occurred in the Hurunui.

The significance of other possible agents of decline in the wild, such as competition with rodents for food, habitat modification by ungulates and the effects of disease or parasites, is unknown but these may be collectively important.

Roroa chicks may be more vulnerable to stoat predation than the chicks of other kiwi species. Although the parents will defend a chick, they can only do so when they are with it. Since incubation lasts c. 78–83 days and roroa chicks can roost in the nest for at least 3 months, the nest is often occupied for 6 months, which must provide ample opportunity for stoats to discover it. At Flora, stoats have been captured on nest cameras 'staking out' nests and returning with increased frequency towards egg hatch.

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Appendix 3

Ngā mātāpono – Recovery principles for kiwi

The following guiding principles are essential for successful kiwi recovery (Germano et al. 2018):

Kāore he korehāhā – No extinction
The highest priority for recovery management is to ensure that all kiwi species survive.

Whakaoranga kaha – Strong recovery
Survival alone is not enough; all kiwi species will grow by at least 2% per annum.

Rerenga ā-ira – Genetic diversity
The genetic diversity and distribution of each species or subspecies will be maintained or enhanced as much as is feasible within the core areas of its distribution.

Whakanui ake i ngā hua pūnaha hauropi – Maximisation of ecosystem benefits
Kiwi recovery will, wherever possible, focus on gaining maximum benefits for the wider ecosystem.

Whakahaere ki ngā nohoanga tūturu – In situ management
Kiwi will be managed within their natural range or, if outside this range, with the overall aim of restoring them to their natural range in the wild.

Oranga kararehe – Animal welfare
The welfare of the birds will be a primary consideration in all aspects of kiwi recovery.

Whanaungatanga – Relationships
The new and existing relationships between the Department of Conservation, tangata whenua, organisations, communities and the public will continue to be respected and nurtured as we work together in the recovery of kiwi for present and future generations.

Mātauranga and tohungatanga – Knowledge and expertise
Knowledge and ideas will be pursued that will strengthen and grow our kiwi populations and all those involved with their recovery. This puna mātauranga or pool of knowledge will be shared amongst kiwi practitioners for the betterment of all kiwi and people involved.

Rangatiratanga – Leadership
A high degree of personal and organisational integrity, professionalism and ethical behaviour will be maintained in all actions and decisions involving the protection and enhancement of kiwi.

Kaitiakitanga – Guardianship
Collectively, work will be undertaken to protect the environment, knowledge and resources required to reverse the decline of kiwi populations. If kiwi and their ecosystems are healthy, all New Zealanders benefit.

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Appendix 4

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Appendix 5

Guidelines for interpreting roroa (*Apteryx maxima*) nest camera video information to obtain chick survival data for life-table analysis

These guidelines were developed from discussion between Hugh Robertson, Sandy Yong, Robin Toy and Sandy Toy on 3 August 2017 using case studies from the Hawdon River valley and the Flora Stream catchment area.

1. Since nest camera monitoring is imperfect and interpretation is required, the basis for decisions should be recorded to enable future re-interpretation if necessary.
2. Video output should be analysed during the incubation period (as well as post-hatch) to obtain an indication of how regularly the adults are captured on video. This will provide an indication of the adequacy of camera coverage necessary to interpret activity videoed post-hatch. Some nests cannot be covered adequately by cameras, so chick survival cannot be estimated by video at these nests.
3. It is necessary to monitor the transmitter outputs to determine the hatch date, as it may not be obvious from the video footage.
4. The number of days after hatch that the adults abandon the nest should be used to determine the 'best estimate' for chicks, rather than the date the chick was last seen. This is because chicks are more likely to be missed on camera than adults as they move faster. A proviso here is that the adults are seen regularly on camera throughout the incubation and post-hatch periods so that there is confidence that they have really abandoned the nest on this date.
5. If the chick is found after the nest has been abandoned (e.g. with its parents at transmitter change time), the date of abandonment should remain the 'best estimate' to avoid biasing the data (a dead chick would never be found away from the nest). Using this rule, chick survival may be slightly underestimated, which is better than overestimating the value.
6. The timing of nest abandonment is usually clear cut. However, where there is uncertainty, the censored date should be used as a 'best estimate', as it would if the chick was transmittered and disappeared. Censoring is carried out following Robertson & Westbrooke (2005) – i.e. if the period between when the adults were last seen at the nest and when the nest was definitely abandoned exceeds 14 days, the censored date is 40% of this period, whereas if this period is less than 14 days, the censored date is half of this period.
7. Making a decision between 'fate unknown' and 'chick death' can be tricky. The following evidence may suggest chick death:
   - Unusual adult behaviour at the nest captured on video.
   - Parents suddenly roosting a long distance from the nest (determined from regular daytime roost triangulation).
   - Presence of a predator captured on video at the nest. Note: a stoat may kill a chick and revisit the nest several days later to eat it.
   - Nest abandonment relatively soon after hatch. 'Soon' cannot be quantified but a rough guide could be within 2 months.

If a nest is abandoned because of human interference (e.g. transmitter fitting), 'fate unknown' should be recorded.

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