Te Korowai o Waiheke

TOWARDS PREDATOR FREE WAIHEKE

Restoring our island song together

MUSTELID ERADICATION PLAN

ACKNOWLEDGEMENTS

This plan has been prepared by Jo Ritchie – Te Korowai o Waiheke Operations Manager. It has been made possible by the contributions and advice from many individuals and organisational representatives. They include some of New Zealand's most experienced mustelid researchers and field practitioners along with local Waiheke people who have been undertaken stoat control work on the island for a number of years. Te Korowai o Waiheke is immensely grateful for the generosity of time and invaluable information that has come from these sources

Ehara taku toa, i te toa
takitahi engari he toa takimano

My strength is not that of the strength of one
It is the strength of many

Figure 1: Stoat and Egg. Credit: Marty Taylor https://www.nzgeo.com/stories/the-menace-of-stoats/

DISCLAIMER

The Waiheke mustelid eradication project is a first round project funded by Predator Free 2050 (PF2050), Auckland Council and Foundation North. PF2050 funded projects are specifically directed at the eradication of possums, stoats and rats from New Zealand by 2050. Stoats are therefore the main species referenced in this plan and are the main species on Waiheke Island.

However, because all three species of mustelids (weasels, stoats and ferrets) may be present on the island and the removal of one species may lead to increases in the others, the eradication programme being undertaken by Te Korowai o Waiheke (Te Korowai) is directed at all three species.

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1. EXECUTIVE SUMMARY

Te Korowai o Waiheke is a charitable trust that was established by the Waiheke community in 2018 to deliver a community vision of a "Predator Free Waiheke". The first part of the Trust's work is to eradicate mustelids from Waiheke.

This mustelid eradication plan has been developed specifically for the Waiheke Island environment - both the natural environment and the people, who are integral to its success. It contains the methods, timing and stages of the eradication operation. Of the mustelid family present on Waiheke, stoats are common. Other species presence (ferrets and weasel's) has not been conclusively proven, however there is anecdotal reporting of ferrets on the island, so the eradication plan is for the broader mustelid family. Often when communicating, the Trust substitutes the word "mustelid", for "stoat", as it is more commonly understood.

Waiheke Island is 9,200ha in size and sits in the inner Hauraki Gulf in Auckland, New Zealand (Figure 2). It is the most populated island in New Zealand per land area, with approximately 9,500 permanent residents plus 3,500 part-time or holiday maker residents. The summer population swells to more than 50,000, and annually, the island receives more than 1.3 million tourists.

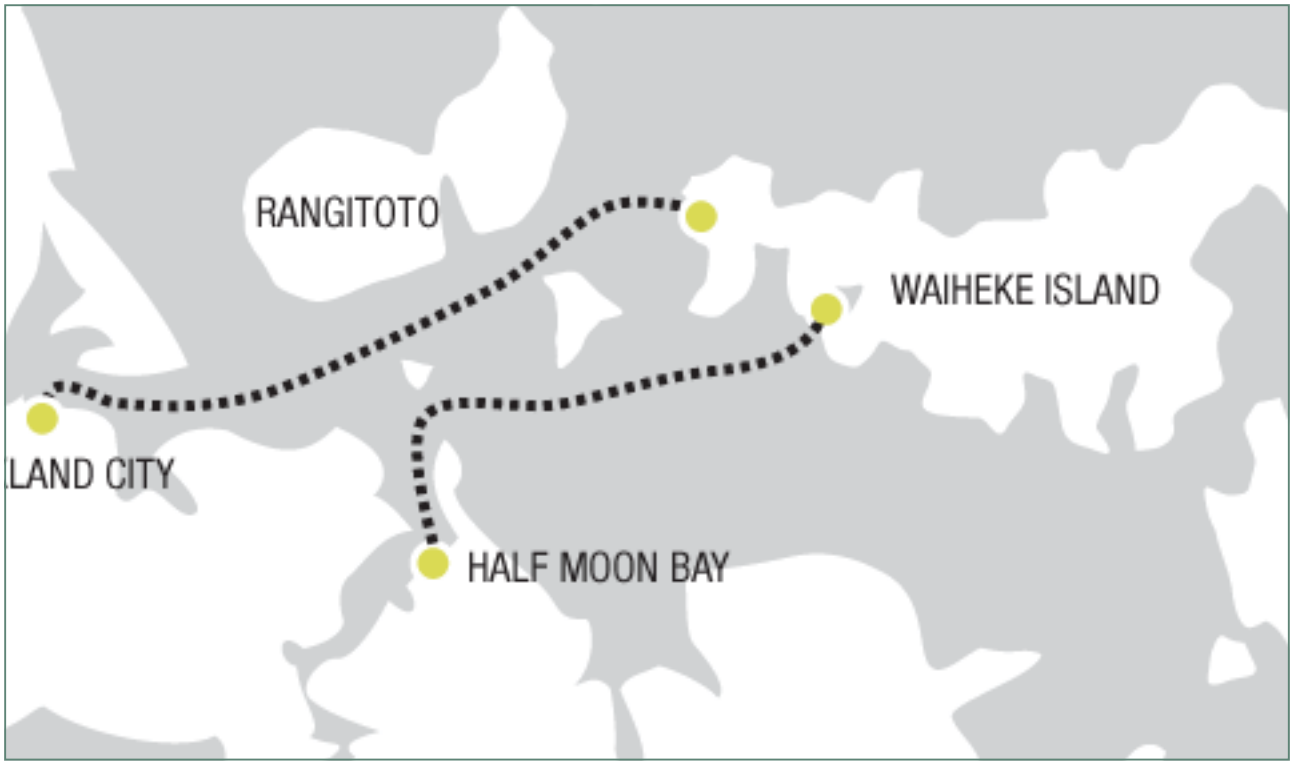

Figure 2: Waiheke Island main public access points being (Auckland City to Matiatia Wharf (passenger ferry) and Half Moon Bay to Kennedy Point (passenger and vehicle barges, barges also operate from Wynyard wharf in Auckland City to Kennedy Point
Source: https://www.waihekeislandwinetours.co.nz/book-now/getting-here/attachment/auckland-waiheke-map2/

The Te Korowai Trustees are all volunteers, and representatives of the broader Waiheke community including; elected community trustees, mana whenua representative trustees, as well as trustees that have been co-opted for skills. The Trust formed in 2018, and in 2019 employed project staff including a Project Director, Operations Manager, Engagement Manager and field team.

The eradication methodology outlined in this plan is based on best practice, experience from other mustelid eradication and research programmes around New Zealand, and local experience on Waiheke of those involved with existing stoat control programmes. It is supported by an operational plan, which details operational logistics, minimum requirements and quality control, and also health and safety.

The eradication uses more than 1,700 DOC series traps at an approximate network of one per six hectares across both private (87%) and public (13%) land. Lures will be a mix of fresh and salted rabbit (supplied locally), Trap lay out is based on lineal features including roads and habitat edges, and also ease of access and minimal impact on people's activities. Trap checks will be as many as four per month in summer and the breeding season, and drops to two per month or one per month the rest of the year. Operations will be delivered primarily by the Te Korowai field team, and also contractors in busy periods, all of whom are Waiheke locals. Other delivery will be done by community volunteers and/or staff of private landowners, who will be paired with a field team member for operational requirements and quality control.

Eradication delivery is supported by a comprehensive monitoring programme, including both biosecurity (trap check) data collection, outcome monitoring, and social monitoring. It also has wrap-around communications and engagement support, including; regular newsletters, press articles, events, videos, and intensive social media communications. Additionally, the programme is co-ordinated by an integrated data management system, that brings together 'customer' data, health and safety records and reporting, field team management (in-the-field tracking and timesheets), outcome monitoring, and biosecurity (trap check) data.

Biosecurity management is benefitted by Waiheke Island's location of more than 5km from mainland Auckland at the closest point. Waiheke is also largely surrounded by mammalian pest free islands, with the exception of Ponui Island. Biosecurity is already very active in the Hauraki Gulf through the Pest-Free Hauraki Gulf partnership programme run by Auckland Council and the Department of Conservation. Additional biosecurity to prevent reinvasion of mustelids is being co-ordinated in partnership with Pest-Free Hauraki Gulf.

The Te Korowai o Waiheke Trust is excited to begin the mustelid eradication programme. Together with the extraordinary support and encouragement of the Waiheke community, the Trust is ready for the challenge of permanently removing all mustelids from Waiheke, to allow native taonga species and the natural Waiheke environment, to flourish.

2. WHY ERADICATE MUSTELIDS FROM WAIHEKE?

Figure 3: Kākā in nest with chicks. Source: http://www.stuff.co.nz/dominion-post/news/8101434/Freed-pair-of-kākā_raising-chicks-in-town-belt

Waiheke people are passionate about where they live – their natural environment with its diverse landscapes and location in Tikapa Moana (the Hauraki Gulf) within easy commuting distance to Auckland makes it an attractive place to live work and play for many people. Waiheke's size (9200ha) and location also provides a diverse range of natural environments for native plants and animals, of which a number are rare and/or endangered. Waiheke people work hard to look after their natural environment.

But Waiheke's natural environment like much of the New Zealand mainland is under siege from animal and plant pests and despite significant, inspirational and enduring work by many in our communities – more needs to be done to reverse this trend. Animal pests have the greatest impacts on our native plants and animals through predation (e.g. a stoat raiding a kākānest) and competition (e.g. rats eating fruits and flowers – the staple diet of kereru).

The declines of arguably our most visible and well-known native species – birds - are a case in point. There are 168 different species of native birds in New Zealand. Of these 93 are especially precious because they are found in no other country. But they are far from safe. Only 20% - one in every five – is in good shape (Parliamentary Commissioner for the Environment 2017).

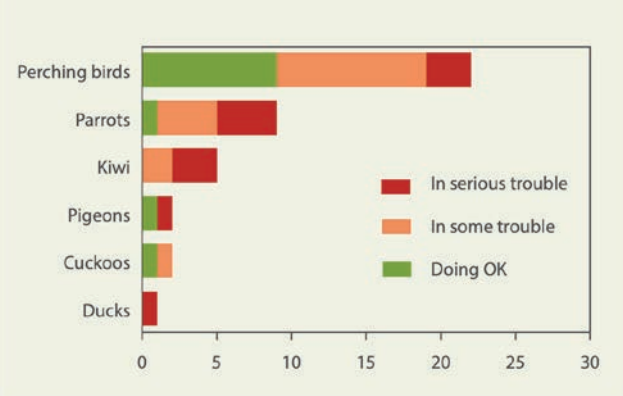

Figure 4: The conservation status of the six groups of forest birds. Source: Parliamentary Commissioner for the Environment 2017

The collective effects of mammalian predators (e.g. stoats, rodents, possums) and competitors (e.g. rabbits, possums, goats, deer) are a significant contributor to this decline. Since mammalian predators arrived in New Zealand many bird species have become extinct or reduced to small populations on predator-free islands (O'Donnell 1996; Towns et al. 1990; Merton 1992). The three greatest mammalian predators contributing to this decline are stoats, rats and possums. New Zealand's native species evolved largely free of predators and so have few attributes to be able to defend themselves.

Many native birds nest in holes or burrows, some are flightless and most of the larger species are long lived with low reproductive rates. Their vulnerability to introduced mammalian predators is shared by the other elements in our ecosystems they rely on. Many of our ecosystem engineers – insects and reptiles - are also flightless. They simply can't get away from mammalian predators. Native plants too evolved with only insects, reptiles and birds and a system of complimentary relationships where each provide the other with food supplies, pollination, movement of seed and the creation of new habitat. But all is not lost, and people are the key. Tikapa Moana (the Hauraki Gulf) abounds with predator free islands resounding with bird song and surrounded by clouds of seabirds. The work to make these largely uninhabited islands predator free was through innovation and hard work by people. Learning by doing and adaptive management has made New Zealand a world leader in the removal or eradication of mammalian free predators.

To maximise opportunities for native species (plants and animals) in Tikapa Moana it is necessary to take the next step – removing mammalian predators from islands where people are. Waiheke represents an unparalleled opportunity to do just this. The most populated island in the Hauraki Gulf surrounded by a network of predator free islands (Appendix 1). An island containing a rich array of natural habitats and native species (including some that are endangered - Figure 5), all threatened by the presence of stoats and rats. An island of people with a long history of caring for their environment.

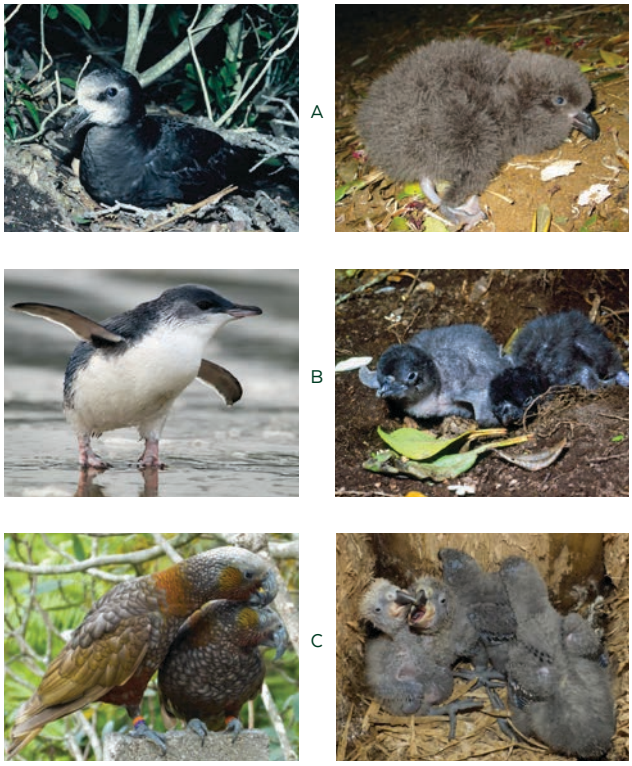

Figure 5: Examples of vulnerable biodiversity indicator species on Waiheke. A) oi (grey faced petrel) and chick, B) korora (Little blue penguin) and chick, C) kākā and chicks. Photo source: www.nzbirdsonline.org.nz

Te Korowai builds on this work. The community vision restoring our island song together, and removing mammalian predators from Waiheke provides the opportunity to both take advantage of the overflow from surrounding islands and their expanding native bird populations; and enable the recovery of Waiheke's remnant species and environments.

In time success can be celebrated in other ways. A predator free island the size of Waiheke provides opportunities for the release of some of New Zealand's most endangered species such as North Island brown kiwi, little spotted kiwi, kōkako and tuatara. It also provides a source of income for people to work on the project and establish or expand ecotourism businesses. A predator free Waiheke will transform the island environmentally and economically. However, the removal of key mammalian predators must be undertaken first. The examples below illustrate why:

- On average c. 94% of young brown kiwi die before reaching adulthood and predators, chiefly stoats, cause about half of these losses (McLennan et al 1996).

- the survival and nesting success of kākā are seriously affected by predation on eggs, chicks, and nesting females by stoats (Wilson et al 1998).

Waiheke is fortunate in many ways that it doesn't have many of the mammalian predator and competitor species that are on the mainland. Not having possums, goats or deer means its forests are in reasonably good condition but it does have stoats, rodents (rats and mice), rabbits, unowned cats and feral pigs.

Thanks to the enduring commitment of the Waiheke community both on and off island, Te Korowai was fortunate enough to become one of the first projects to be funded by Predator Free 2050 Limited (PF 2050) – a bold national initiative to assist communities with funding, technology and advice to eradicate stoats, rats and possums from New Zealand by 2050.

The Te Korowai project is a community initiative funded to remove stoats and undertake a pilot to determine what it will take to remove rodents. The project has until 2023 to achieve these two objectives. The removal or eradication of stoats and the other two members of the mustelid family (ferrets and weasels) is the first task at hand.

2.1 What are mustelids?

Stoats (Mustela erminea) are mustelids. Mustela are a genus of carnivorous mammals that include stoats, ferrets and weasels. Stoats were introduced to New Zealand towards the end of the nineteenth century to control rabbits (Gibb & Flux 1973). However, stoats are not an effective management tool (biocontrol) for rabbits due to rabbit population growth rates. Instead, the mustelids turned their attention to our more vulnerable native species with devastating results. The stoat is by far the most common of the three mustelid species occurring in New Zealand forests (King & Moody 1982). Stoats live in any habitat in which they can find prey, from beaches to remote high country, at any elevation up to and beyond the tree line; in any kind of forest, native or exotic; in scrub, dune lands, tussock grassland, and farm pastures. In open country they keep to cover as much as possible e.g. scrub filled gullies, ditches and piles of brush left after land clearing or patches of rank grass where mice are also more abundant (King Ed. 2005). Stoats are the most common mustelid on Waiheke and although they may not be in high numbers are present in sufficient numbers to be a serious ongoing threat to existing native wildlife on the island including northern NZ dotterel, Kākā, oi (grey-faced petrel) and korora (little blue penguin).

Ferrets are the largest of the mustelid family. They frequent areas where their primary prey – rabbits; are in good numbers. Ferrets are common in pastoral habitats, including fertile pasture, rough grassland, scrubland; in dune lands and swamps and river valleys, in forest especially at the margins along road edges, fence lines, grassy tracks, hedgerows and waterways (King Ed. 2005). Anecdotal reports are that at least one has been killed on Waiheke and others may be present in low numbers.

Figure 6: Ferrets are 'stoately' different to weasels. Source: http://halo.org.nz/mustelid-identification/

Weasels are the smallest of the three-mustelid species in New Zealand. They prefer thick ground cover, so they favour overgrown patches of any habitat from suburban gardens to agricultural land, in scrub and cutover native or exotic forest, or at the margins between these and open country King C.M. ed. 2005). Weasels have not been sighted on Waiheke but with an untrained eye it's often hard to differentiate between stoats and weasels. They are similar in size. However, stoats have a black tail tip, weasels do not (Figure 6). The Waiheke mustelid eradication programme will target all three species because if this is not done what's left may fill the void of what's been removed.

2.2 Why mustelids first

- **Because other mustelid eradications around New Zealand have proven it is possible.**

The experience and knowledge gained from mustelid eradications around New Zealand provides confidence that they can be eradicated on an island like Waiheke, but it requires methodical planning and implementation and a concurrent island wide programme.

The Waiheke methodology is based on an extensive review of available literature, research and field experience with mustelid control and eradications. It has also involved many discussions with several of New Zealand's most experienced field scientists and practitioners in this area of work as well as Waiheke people doing stoat control on the ground now. It's designed specifically for Waiheke conditions. There is a very real chance that mustelids can be eradicated from Waiheke. This is because it is surrounded by water, islands that are predator free (other than Ponui (1.3km distance) The normal swimming distance of a stoat is around 3km but distances of up to 5km have been recorded, e.g. Kapiti Island. There has been no evidence of stoats on Ponui since around 1990 (Veale, 2013) and none were detected there during trapping undertaken when Veale undertook his fieldwork for his thesis on the invasion ecology and molecular ecology of stoats on

New Zealand islands in the mid 2000's (his thesis was completed in 2013).

However, Veale identified a small number of events where stoats had been observed coming ashore at Ponui, so although it is likely that Ponui may not have a resident population, it is an island stoats are known to swim too (most likely Waiheke, from the direction of travel observed).

In theory, stoats could also island hop through Ponui from the mainland e.g. Waitawa or Kawakawa via Pakihi Island. An itinerant population is enough to be a threat (i.e. if there is stoat movement between Ponui and Waiheke then a temporary population could provide a source population for reinvasion), so Ponui is acknowledged as a potential source, as part of the planning for the Waiheke eradication.

Stoats are singled out here because they are known to reinvade islands by swimming, unlike ferrets and weasels, which have not been recorded doing so in New Zealand.

- Because a successful eradication is likely to encourage and galvanise the community to consider the same approach for other invasive species.

The programme builds on a considerable amount of work presently being undertaken by the local community on Waiheke to control mustelids (mainly stoats) but this work takes a lot of effort all the time – if mustelids can be eradicated permanently it's a "win-win". A win for our native species and a win for the people working on these programmes now who can celebrate their hard work and turn their attention to the eradication of other invasive species once mustelids are eradicated. A successful mustelid eradication is likely to result in increased support for other eradication programmes on Waiheke.

- Because devices are not required on every property and reduces the logistical cost and work.

Mustelids roam over large areas so traps are not required on every property. This reduces the volume of work required to get landowner support and manage the work on the ground. A stoat control pilot programme on Waiheke in 2016 between Whakanewha and Onetangi showed that landowners are highly supportive. Eradicating mustelids first requires a knowledge build about eradication, what information people need to support eradication, learn how to address concerns and expand the project community for the next stage – examining whether rodents can be eradicated from Waiheke.

- Because the potential benefits are huge for a wide range of native species and places on Waiheke but also for other islands.

Remnant populations of recovering/at risk native species are particularly vulnerable to mustelid predation. Examples include ground and hole nesting species and/or species that have small numbers of chicks and/or who breed infrequently. On Waiheke these includes oi (grey-faced petrel), korora (little blue penguin), kākā, kereru and NZ dotterel. North Island Brown Kiwi, a species many people would like to see on Waiheke – are particularly vulnerable to stoat and ferret predation. These species will not recover properly or ever be released on Waiheke if mustelids remain. Additionally, any translocations to Waiheke would need to be considered in a wider context, e.g. what other predator work is required prior, e.g. reductions in feral cats and rat numbers, eradication of feral pigs, sequencing of translocations to minimise any competition between species while they were establishing.

Figure 7: Stoat at entrance to a grey-faced petrel burrow between Enclosure and Hekerua Bays on Waiheke – August 2017 Source: Hue Ross.

As long as mustelids are on Waiheke, they also pose a threat to surrounding islands, which are all smaller than Waiheke – one swimming stoat because of their energetic nature, and their habit of killing independent of hunger, would quickly decimate taonga species on these islands.

Waiheke's location in relation to these other islands and their expanding numbers of mobile species means that in time it will benefit from the natural return of many species of seabirds, plus bellbirds, kākāriki, saddleback etc. Finally, Waiheke's size means that it can hold a diverse range of taonga species including kiwi BUT first every mustelid must be removed.

*"The eradication of stoats from Waiheke island would have significant benefits for a range of native bird species currently present and would allow the reintroduction of several species which are primarily limited by mustelid predation, but can survive in the presence of rodents; for example the North Island brown kiwi, North Island kākā**, North Island weka** and brown teal**" (Veale, 2013).*

*** These species are already present.*

2.3 Strategic Objectives

Every effective management programme requires guiding objectives. For Te Korowai these are contained in its Draft Strategic Plan 2019-2021 and are as follows:

- Eradicate mustelids and learn how to eradicate rats from Waiheke.
- Work collaboratively to build pride, ako (teach and learn) and connection.
- Secure funding and resources to deliver goals.
- Keep focus on a "healthy and thriving natural Waiheke environment".

3. HOW WILL THE ERADICATION METHODOLOGY WORK?

Figure 8: Hauraki Gulf Conservation Trust stoat pilot programme training 2017. Source: Jo Ritchie

3.1 People Power - expanding our project community

People are Te Korowai's greatest asset. Waiheke is a place where people live work and play. Te Korowai's establishment is a direct result of the dedication and commitment of the Waiheke community to protecting and enhancing its natural environment.

The mustelid eradication project is being undertaken first to provide confidence to the Waiheke community that eradication (permanent removal) of animal pest species is possible. The mustelid programme will illustrate by working on the ground what it takes to do and manage such a programme. The experience from other islands in New Zealand is that it is possible, but it takes methodical planning and implementation and a concurrent (every trap working at the same time) programme across the whole island.

Because mustelids roam over large areas and have large home ranges that can cover dozens of hectares in size, it is not necessary to place a trap on every property. Logistically this is a better way to start a mammalian predator eradication campaign on Waiheke (versus having to visit every single property as would be required for a rodent eradication) – 425 properties will be visited by the Te Korowai field team to get approval to place and run mustelid traps. An information kit has been developed for landowners that summarises the mustelid eradication programme (Appendix 2A and Appendix 2B).

Building confidence that the 'talk can be walked' is an essential part of any campaign that involves a community of people. The phrase "restoring our island song together" was developed by community representatives as a way of communicating the benefits of the Te Korowai programme for the wider community It also recognises that the removal of mammalian predators beginning with mustelids is a means to an end – an island full of bird song from the forest to the sea. If birds are thriving so is the rest of the environment, they depend on.

There is already have a groundswell of support from people doing restoration work on the island. However, to successfully achieve the mustelid eradication programme the imagination and support of those people who are not actively engaged and/or who have not been reached needs to be encouraged. Key to this is minimising the impact of the eradication work on everyday lives. People on Waiheke are already reporting stoat sightings and nests. Te Korowai will work with the community to expand this reporting to include other useful information such as a sprung or damaged trap.

Additionally, the considerable work undertaken by local conservation initiatives such as Ratbusters, Hauraki Islands Forest and Bird (Forest and Bird), Te Matuku Landcare and other groups on the island, will provide information on where rodents are in high numbers (which might determine where to locate double sets of traps, for example) as well as assist with selling the benefits of the mustelid programme in their neighbourhoods.

The Te Korowai project community is expansive and although its core focus is 'on island' will support is also needed from those people who stay seasonally along with tourists, visitors, trades people, suppliers and transport operators. People are genuinely interested and want to know more. Te Korowai wants to build on this enthusiasm and expand capacity to do this work. A fully invested community is central to the success of Te Korowai.

3.2 Learning from others – don't reinvent the wheel

Eradication programmes are based on methodical planning and common sense. Much of the information and confidence that the Waiheke mustelid eradication programme is feasible and is based on learning from other projects and people particularly those undertaking similar trapping based programmes. from other projects and people particularly those undertaking similar trapping based programmes. To date around 40 mustelid eradications have been attempted in New Zealand. Most have been successful; several have had periodic reinvasions. However, those that have had reinvasions are within swimming distance from the mainland, either directly or with 'stepping-stone' islands in between which make long swims for stoats that little bit easier. Waiheke is fortunate in that most islands within swimming distance are stoat free. Ponui (refer section 2.2) is the only possibility. However, it does have stepping -stone islands from the Auckland mainland at various points.

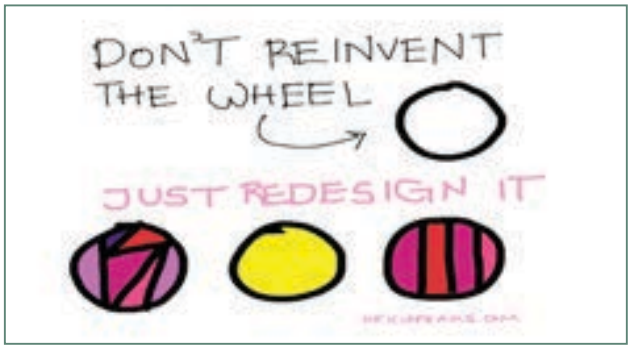

Figure 9: Smart adaptive management is learning from others and redesigning for local conditions. Source: https://ofilispeaks.com/dont-reinvent-the-wheel-redesign-it/

Key lessons from other eradication projects and research programmes

There are some key lessons for Waiheke from these projects and from mainland control and research programmes. These have been incorporated in the methodology and operational planning for the Waiheke mustelid eradication.

- Building and growing local capacity and knowledge.
- Communicating and engaging widely.
- All three species of mustelids found in New Zealand can cohabit – stoats are generally the most abundant and the most visible – plan for all three species to be present in every operation where potential habitat may exist.
- For projects reliant mainly on trapping, island size and the presence of rodents can influence eradication success. Eradication takes considerably longer for large islands (>1000ha) or medium-sized islands (100-1000ha) with mice present, than it does for small islands (<100 ha) or medium-sized islands without rodents.

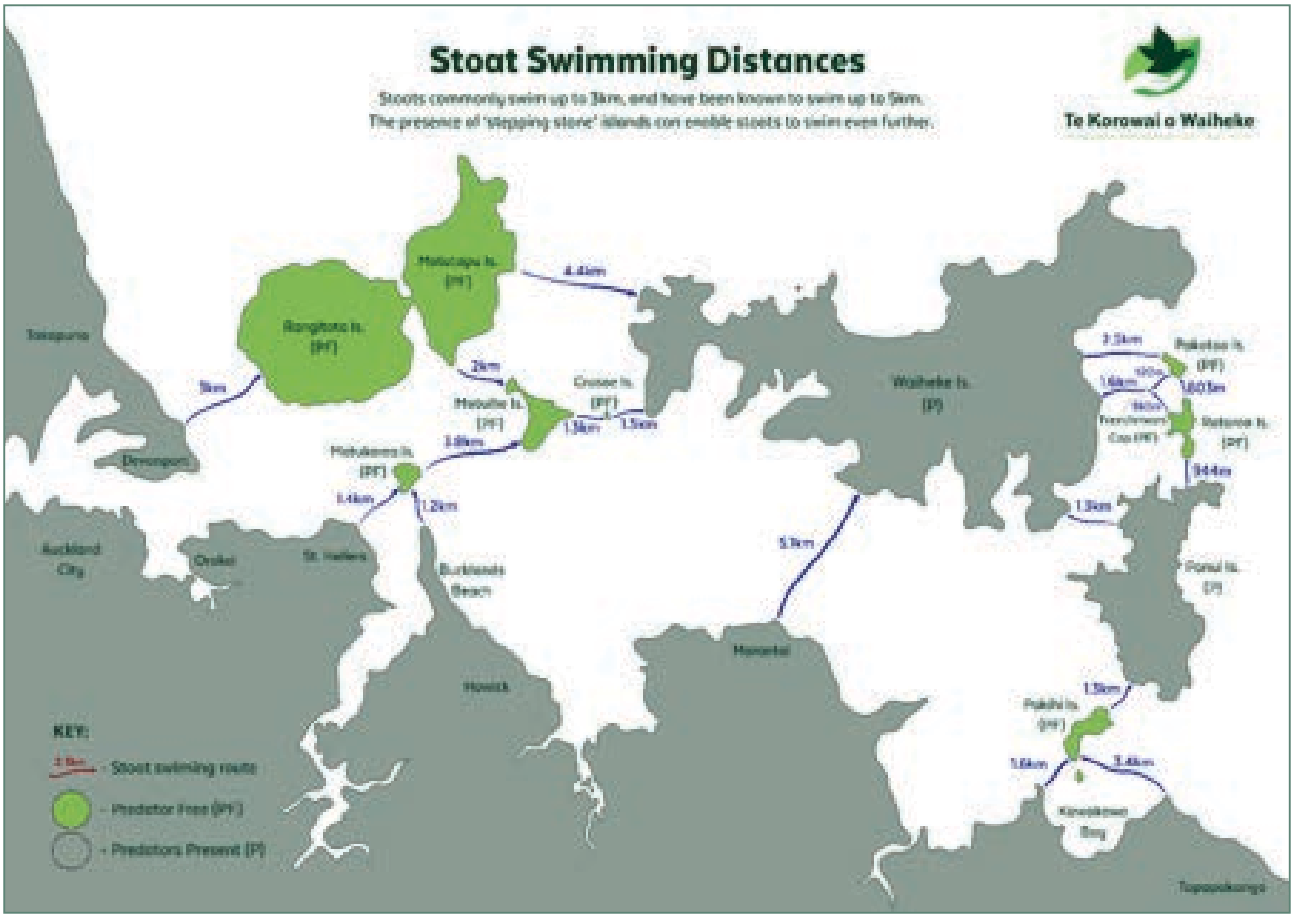

Figure 10: Stoat Swimming Distance. Source: Te Korowai o Waiheke

- Stoats are known to swim in both fresh and saltwater and could potentially reach offshore islands up to c. 5 km off the mainland coast if assisted by tides, currents or floating debris (Veale et al 2012).

- Trap spacings must be set to have multiple devices in home ranges to maximise chances of encounters.

- Double set DOC 200 traps are effective where there are high rodent numbers - rodent catches attract mustelids, one trap often remains working versus a single set.

- In any population there is likely to be animals that will not enter any control device (King et al 2003a) – this is pertinent for a number of species present on Waiheke - stoats, ferrets, weasels, rodents and hedgehogs.

- A variety of tools "toolbox" approach is the most effective means of achieving eradication. Toolboxes may include different trap boxes, lures (e.g. ferret bedding, taped bird calls), baits, other tools (such as different types of traps e.g. live capture and kill), predator dogs, cameras, vertebrate toxins. However, tools must be utilised in a planned manner and not all at once – the element of surprise and diversity is important.

- Pre-baiting increases the chances of a positive encounter.

- Diet analysis and knowledge of breeding and movements cycles are useful means of determining when to vary lures and baits and capture techniques.

- Females are harder to catch than males particularly when in dens with young.

- Females are fertilised soon after birth so can establish a new population without males' present – any means of dealing with them in dens before young emerge is highly advantageous.

It's likely that the founding female who produced at least 1 male and 1 female offspring that led to the c. $600,000 response on Kapiti Island may have gone undetected for up to 18 months (Brown 2011 & Prada 2014).

- Tracking tunnels are unreliable and will not necessarily detect stoats. Searching with a mustelid detection dog is the appropriate response (rather than tracking tunnels) when mustelid sightings are credible (Brown et al 2011, Alterio et al 1999, Alterio & Brown 1997).

- Remote cameras with quick shutter speeds are emerging as the most effective detection measure for indexing relative abundances of mustelids because they require no interaction with a device and can provide an accurate time stamp of when an animal was first detected (Smith & Weston 2017).

- Forensic DNA techniques are invaluable measures to differentiate between resident and reinvading mustelids.

- Detection at low densities is extremely challenging – trail cameras and predator dogs are essential tools here as is leaving detection tools out for extended periods (Pickerell et al 2011).

- Mustelids don't control rabbits or rodents, but their presence can influence where mustelids are.

- Projects must be able to detect and deal with invading animals before they disperse far (cost effectiveness) and breed.

A single undetected pregnant female stoat reaching an island would result in less than 10 stoats on the island for up to 31 months, after which numbers could rapidly rise (Elliott et al 2010).

- Planning must be methodical and to a consistently high standard but must also be flexible to respond to new knowledge and early adoption of new technology, testing of new methods etc.

- Clearly stated objectives and a continued focus on restoration goals are essential.

3.3 Mātauranga Māori

Waiheke is extremely fortunate that it has mana whenua who have been a supporter of the Te Korowai project from its genesis in the initial stoat pilot work done by the Hauraki Gulf Conservation Trust.

Ngāti Paoa's support is an essential part of the mustelid eradication project because it brings a wealth of opportunities to both grow an understanding of how traditional Māori knowledge (mātauranga Māori) can be incorporated into the project. There are also important project opportunities to involve and capacity build Ngāti Paoa people, especially youth in its implementation. Ngāti Paoa has a sizeable landholding in Waiheke Station at the eastern end of Waiheke and is therefore, a key player in the project.

Traditional Māori knowledge enabled mana whenua to live with the land. Their observations and practices, and their relationship with the natural and physical world can provide insights into how lunar cycles, forest and wetland patterns, movements of birds etc can inform or improve how the mustelid eradication programme is undertaken, both as it relates to removal of mustelids as well as native indicator species monitoring to determine its overall effectiveness.

Piritahi Marae is located in Te Huruhi Bay on Waiheke. It provides additional opportunities for learning and knowledge sharing. Te Korowai welcomes any advice mana whenua wish to share to assist with the mustelid eradication programme and will also ensure that any work undertaken around traditional sites has the prior approval of Ngāti Paoa and does not impact on these sites in any way and.

3.4 The Seven Golden Rules of Eradication

The following framework has been developed based on the experience of many eradications around the world in populated and unpopulated places and with a diverse range of species (animals and plants). The Golden Rules will be applied on Waiheke.
A brief explanation of each rule follows.

Rule 1: Social and economic conditions must be conducive to meeting the critical rules (2-4).

- Stoat as well as rat control work undertaken historically and presently on Waiheke and the increasing interest and support in the mustelid eradication programme evidences that the stoat eradication project is well on the way to conducive social conditions.

- A Community Engagement Plan has been drafted and uses a diverse variety of techniques and opportunities designed to reach as wide a cross section of the community as possible

- Te Korowai is committed to building knowledge and growing capacity locally on island to provide the people resource to both promote and undertake the eradication work and sustain it.

- This includes employing locally and the development of an ITO (Industry Training Organisation) based learning by doing training programme, which builds on the often-seasonal nature of fieldwork on the island by integrating horticulture, viticulture and ecological skill development.

- It is essential that resources must be sufficient to fund and manage the operation to its conclusion. Te Korowai is committed to the professional and transparent delivery of the eradication project. It has established clear lines of authority with its governance board and management team. It has budgeted for the eradication to the best of its abilities. This involved review with Auckland Council biosecurity and DOC eradication as well as other technical specialists during the PF2050 EOI and RFP process. As the project becomes operational actual costs are becoming more evident.

- Te Korowai has a methodical financial management system designed to capture all costs and signal shortfalls. It employs a financial administrator and has access to a

number of skilled business and fund raising specialists to assist with this process and raise additional funds should they be required.

- Animal pest eradication often involves the use of techniques that people may find objectionable because they may oppose the killing of animals on ethical grounds or have concerns about the use of some techniques – viewing them as inhumane and/or be opposed to the use of vertebrate pesticides.

- Te Korowai is respectful of all the above concerns. An attempt will be made to eradicate mustelids just by using traps but because some animals are likely to be trap shy – vertebrate pesticides are likely to be required in defined locations to remove untrappable animals/trap avoidance. Pesticides will be a last resort and will be applied in a safe manner including any specific label and industry best practice standards by trained and experienced personnel.

Untrappable animals/trap avoidance – this statement has been written in this way throughout the plan because this is a contentious issue amongst technical specialists and practitioners. It is common knowledge that some animals in every population are untrappable. However, untrappable may also often be trap avoidance. Trap avoidance can occur for a variety of reasons including – a bad experience with a trap (which can increase the chances of untrappable animals), abundant natural food sources, trap entrances obscured, or traps in the wrong places.

Rule 2: All target animals must be put at risk with the methods being applied.

- Eradication means that every animal in the target species must be removed permanently. Other mustelid eradications (mainly stoats on offshore islands) show the value of a toolbox approach is required. This helps deal with untrappability/trap avoidance or just not be interested in the devices that are to be used. A toolbox approach provides options and variety.
- A methodical and well-planned approach is also essential to achieve this rule. An operational plan will guide the field team in order to embed and consistently maintain the standards required to successfully implement the eradication methodology. It will contain a mustelid management manual, which sets out trapping standards, minimises the risk of trap shyness etc.
- Contractors, landowners who wish to look after their own traps and volunteers will be required to work to the Field Work Minimum Requirements (Appendix 3).

- All personnel (Te Korowai staff, contractors, landowners and volunteers) will be required to attend training prior to the eradication work starting to enable joint knowledge sharing and collective learning.

- A Register of Contractors will also be established from which suitably experienced people can be selected to undertake a variety of work.

- The Te Korowai field team and in time suitably experienced volunteers and contractors will also undertake regular quality checks on traps in the field as well as maintenance systems.

- This rule also includes knowing the factors that may risk the success of the operation and having strategies to mitigate them (refer Risk Management Plan in Appendix 4).

Rule 3: Target species must be killed at rates faster than their rate of increase at all densities.

- One of the greatest challenges and areas of learning for the Waiheke mustelid eradication project is being able to detect mustelids at low densities. This is relevant because ferrets have been sighted reliably on the island in recent years (refer Appendix 5). Several people have also seen weasels (D. Dromgoole. pers. comm.). In the presence of stoats, which tend to dominate, these two species (if present) will be in low numbers.

- Additionally, stoats need to be detected when they get down to very low levels. This is true for both the residual survivors of the existing population, and for new stoats that may swim back to the island. It is vital to be able to detect these animals as soon as possible before they disperse or reproduce to ensure cost effective responses and to minimise impacts to native species.

- The toolbox will help here as well as having a knowledgeable and responsive community, and robust reporting and response system.

- Pre-baiting will be used to speed up the initial knockdown at the start of the eradication stage in early 2020 as a means of trying to increase the attractiveness of the traps to stoats before they are activated in February 2020.

- The trail camera network (section 3.7.11) will also be used to monitor progress and detect survivors and reinvaders. The response to these 2 situations will include a variety of approaches:
  - Predator dogs to delimit where the target animal is, and whether more than one is present, and also whether other methods have successfully removed the target/s.
  - Live trapping, DOC 200's, Good Nature traps and other traps as agreed with TAG and other technical specialists.
  - Vertebrate toxins.

- One trap will be installed every six hectares (Figure 11) because it puts multiple traps in an average home range (refer section 3.9.2) and at least five traps in the smallest home known range of a denning female or juveniles. Female home ranges vary from about 70 to 114 hectares depending on food availability excluding the ones measured in seabird colonies that are minimal. ~90 hectares would be a reasonable size to work off (Veale A. pers. comm.). Te Korowai has taken a more conservative approach to maximise the chances of catching young stoats straight from a den while they are naïve (may have a much smaller home range) and used a 30 ha range.

- As part of the desktop planning exercise a 300m circle was placed around each trap to approximate that 30ha home range. There are at least five trap locations in any 30-hectare territory - a safety margin factor of almost five times is therefore built into the methodology. This is based on current knowledge of the smallest mustelid home range size (refer Figure 20) and an estimation of a female stoat home range when denning (C. Speedy pers. comm.).

- One trap per six hectares translates to a 245x245m grid. Advice from Andrew Veale, a Manaaki Whenua Landcare Research (Landcare Research) scientist specialising in stoat ecology is that this is good over-engineering because a 300x300m grid is viewed as optimal for an eradication.

- The network has been over engineered because of the home range factor identified above but also because there are known areas of high rat and hedgehog numbers so many traps will be working overtime.

- The trap network will be a concurrent one i.e. every trap on the island will be working at the same time.

- Any aspect of stoat behaviour that would enable females to be removed before they produce independent young would make control more effective and would determine both the timing of trapping and the area that an effective trapping operation needs to cover (Dilks & Lawrence 2011). Research work will be undertaken with predator dogs and a humane vertebrate pesticide to try and target females in dens.

Rule 4: The risk of recolonisation must be zero

- In reality the risk of recolonisation is rarely zero but the principle is that all practicable

means are employed to ensure this is as low as possible and manageable.

- This is all about preventing animals from coming back to Waiheke. Mustelids are not known to arrive with boats or freight in New Zealand, but it always pays to take a precautionary approach and ensure that biosecurity detection and prevention measures are in place to prevent this.
- Swimming is the most likely way mustelids could return, although due to the distance this is thought to be unlikely. However, effective planning is all about 'never say never', and driftwood, storms, storm debris, seasonal warm water and strong currents, as well as stepping-stone islands, can reduce these distances. Figure 10 shows how far the distances are.

Figure 11: Initial Desktop Trap network. Source: Cat Boyes & Jo Ritchie

- The Auckland Region is fortunate to have a growing island biosecurity programme "Pest Free Hauraki Gulf" – a joint initiative of Auckland Council and the Department of Conservation (DOC). This initiative includes detection devices at key mainland and island sites and rangers with predator dogs at departure points such as the Downtown Ferry Terminal, Wynyard Wharf and Half Moon Bay barge terminals.
- Part of this programme is the mandatory Pest Free Warrant initiative for all commercial vessels (boats – including vehicular and passenger ferries, planes or helicopters), which requires predator detection and control on every commercial vessel in the Hauraki Gulf. These measures along with an informed and observant community are the 'ambulance at the top of the cliff'.
- Te Korowai will continue to grow local capacity with some new initiatives including predator dogs on Waiheke managed by trained locals and continue to expand the community engagement programme.

- A biosecurity detection and response plan will be developed to support the mustelid eradication programme. The Community Engagement Plan will be expanded to support and implement this plan.

Rule 5: Where the benefits of management can be achieved without eradication, discounted future benefits should favour the one-off costs of eradication over the ongoing costs of sustained control.

- Prior to the establishment of Te Korowai, the largely volunteer based team who put together the successful application to PF 2050, canvassed advice from several technical experts from Auckland Council, DOC, scientists and researchers and practitioners working in mammalian predator management.

- PF2050 also obtained independent advice to evaluate the feasibility of mustelid eradication on Waiheke both in terms of cost effectiveness and whether the one-off costs of eradication stacked up against ongoing control.

Rule 6: Animals surviving the campaign should be detectable and dealt with before an increased population size becomes obvious.

- Detection of pests is a growing field in the management of invasive species internationally. Detection is both a technical problem (e.g. determining which devices are most suitable) and a statistical problem, because managers must put a probability on their belief that no pests are present when they cannot find any (Byrom & Parkes 2013).

- Detecting animals at low densities is the greatest challenge of most eradication programmes and particularly when it involves animals that are fast moving and secretive.

- In addition to the one trap/six hectares that puts multiple traps in home ranges, the toolbox contains 60 trail cameras paired with highly attractive lures (section 3.7.11) and predator dogs to help detect any surviving animals. Undertaking the operation continuously, at an island wide scale, over a period of 23 months (which includes two consecutive breeding seasons) provides a high degree of likelihood that Rule 6 will be met.

Rule 7: There must be no net adverse effects

- The method chosen to eradicate a pest must not affect valued species (unless the latter can be replaced) or permanently damage the environment (Byrom & Parkes 2013). It also must not lead to increases in another problem species as a result of removal of the target species.

- The Waiheke mustelid programme will seek to avoid adverse effects on valued species by using custom designed traps (all of which have baffles to minimise non targets, and over half have weka excluders for sites where native non targets or domestic cats may be at risk); and the limited use of vertebrate pesticides.

- Environmental damage will be minimised by establishing the trap network and access points to these by using road, tracks (farm and walking) and other established routes to minimise the need to cut new tracks. Walking into trap lines where practicable and efficient will be preferred to minimise the use of vehicles other than in the establishment phase when trap boxes need to be installed.

- Eradicating mustelids will not lead toincreases in rodents and rabbits. No evidence in the literature search or discussions had with technical specialists or field practitioners during the development of this eradication plan was found to counter this. Rather, it is rodents and rabbits that drive mustelid populations. Mustelid population size as well as preferred habitat is directly correlated to the availability and abundance of these food supplies.

- Rabbit spotlight counts using the McLean scale will be undertaken as part of the monitoring programme to assess any changes as well as the seeking of additional advice as to whether any relationships do exist.

3.5 A ground-based, island-wide concurrent network

Most mustelid eradication programmes have been undertaken using ground means e.g. traps and other tools. A few have been achieved using aerial baiting with vertebrate pesticides (mainly brodifacoum) and secondary poisoning through consumption of poisoned rodents.

The Waiheke programme will be undertaken by ground means alone. It will be the second largest island attempted and the first that is inhabited. Te Korowai is confident that sufficient funding is available, the people power and support and the technical knowledge, both from local experience as well as that gained from other eradications and research work. The toolbox combined with methodical planning and field implementation and to a consistently high standard is key. Being flexible, open minded and nimble enough to respond to new knowledge and early adoption of new technology, testing of new methods etc is also vital.

Best practice ground-based mustelid control is being demonstrated on Waiheke through the Auckland Council funded community-based stoat control project, along with similar work being undertaken by Forest and Bird., Te Matuku Landcare, several private landowners, and at Whakanewha Regional Park. As identified in Rule 3 above, the traps will be island wide and run concurrently to minimise gaps in home ranges and to maximise the chances of multiple encounters with traps at any one point in time. Experience with several other mustelid eradication programmes has shown the value of this approach. It's a significant logistical exercise but with landowner support, smart technology, proficient staff working methodically to the eradication plan there is a very high chance of success.

Figure 12: 420g Male 'Dog' Stoat caught at Awaawaroa Eco Village 4.11.19.

Source: Jo Ritchie

3.6 Think like a mustelid

It's no different to any other piece of work. The best people are those who immerse themselves in the task at hand and really get to know the key elements of the job they do. Thinking like a mustelid is just that – familiarising with their ecology – habitat, food, dispersal and behaviour, reproductive patterns and triggers, field sign. It's also about getting to know their habits locally as behaviours change according to variations in local habitat and food supplies. The eradication methodology reflects this knowledge both that gained locally on island and that from other eradication and research programmes.

New Zealand has the largest stoats in the world. 500g is the heaviest. The above male is estimated to be about 2 years old (D. Peters pers. comm.).

Local information can also be gained in the way conversations are had with people. It's apparent from initial conversations with several landowners that they have seen stoats or sign of stoats. Knowing how to ask the right questions through knowledge of mustelid ecology is invaluable as it can identify between species and hone down where animals are most likely to reside and be caught. It is also a great way of building relationships within the community. People see their information and observations as valuable and feel part of the project.

3.7 What's in the toolbox?

3.7.1 One trap per six hectares

The trap network of one trap per six hectares puts multiple traps in an average home range, and at least five traps in the smallest home range of a denning female or juveniles (which has been conservatively estimated for the purposes of this eradication at around 30ha – refer home range bullet point in section 3.4 under Rule 3).

"The most successful control operations will be the ones that place more than one trap per home range and are sustained over the long term. The practical management problem becomes one of keeping the traps or monitoring devices well maintained, always attractive and constantly ready to respond (King CM et al, 2003a)."

The trap lines this network is set on should ensure The trap lines this network is set on should ensure that every stoat on the island is likely to encounter a trap box during the pre-baiting and knock-down phase of the operation. No stoat will be further than 200m from a trap on the Island with the 245m x 245m layout.

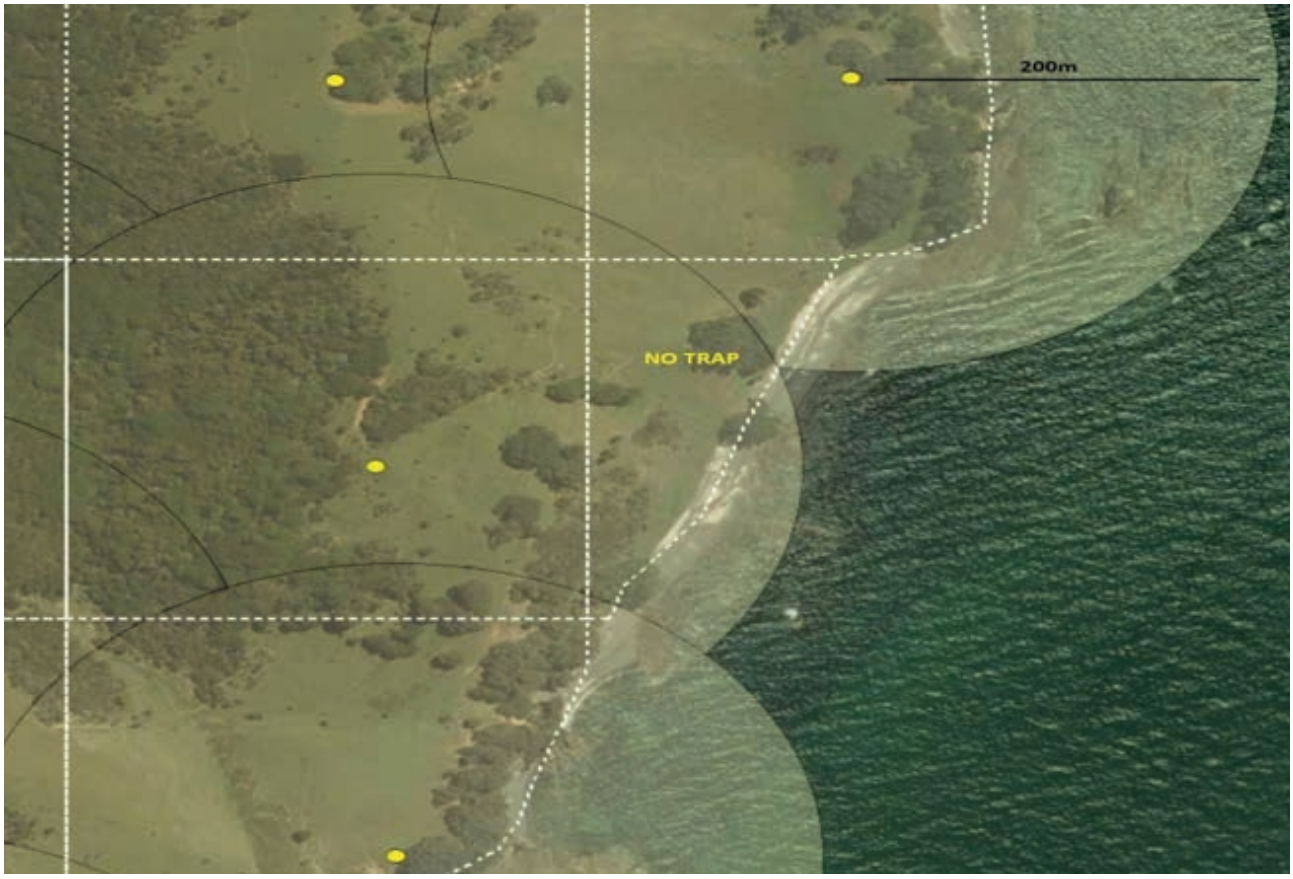

Figure 13: Coastline example of 200m buffer around all draft trap locations. At any point on the island no stoat would be further than 200m from a trap. Source: Cat Boyes, Auckland Council

3.7.2 Why the toolbox approach?

With traps at the above density there is a chance that eradication may be achieved just with these tools. However, eradication is not about chance, it's about maximising the likelihood of success. Some mustelids may appear to be untrappable ("trap shy") in this network. Trap shyness can come from a 'bad experience', which is minimised by maintaining a consistently high standard of trap management. Existing traps on the island that may not have been managed to eradication standard increase this risk. Trap shyness may also be innate (hard wired in), as experienced on Secretary Island in Fiordland, and in kiwi protection zones in Northland.

Employing a variety of tools (the toolbox) increases the probability of catching and killing such an animal. For this reason, the toolbox needs to have vertebrate pesticides, predator dogs and trail cameras. If pesticides are required, the decision will be when all trapping and other tool options have been exhausted. It will generally be at a small scale in specific sites as defined by predator dogs and trail cameras.

Getting to females, preferably in their dens is also key, because any aspect of stoat behaviour that can be manipulated to deal with females before they produce independent young would make eradication more effective (both time and cost).

A trial undertaken by the DOC in Trounson Kauri Park with predator dogs and Magtoxin (a rabbit fumigant) involved dogs finding dens, entrances being plugged and Magtoxin being released.

It was a trial and did have some measure of effectiveness but experienced a number of challenges principally around the inability to find all exits from all burrows and make them 'gas tight'. Some burrows were successfully sealed and all stoats inside killed. Te Korowai intends to investigate the possibility of a similar trial on Waiheke with denning females using predator dogs but using a more humane carbon monoxide like product registered for foxes in Australia that makes animals go to sleep quickly and then die. Neither of these toxins are registered for use on stoats – any use for this purpose would require regulatory permission for off label use under a very controlled environment. Te Korowai would only undertake this work in partnership with an experienced science research provider.

3.7.3 DOC series traps as core tool

The primary eradication tool will be tried and proven DOC series traps. The DOC series of traps are the most commonly used mustelid traps in New Zealand and are well proven. They are enclosed in a sturdy wooden or plastic box that requires a screwdriver to access traps. Most traps will be DOC 200's (stoats and weasels). DOC 200 traps have a sensitive trigger weight to maximise the chances of being set off when light animals walk over it. The weights have been specifically set for these species.

A very small proportion (section 3.7.5) will be DOC 250's to catch ferrets because they are significantly larger designed specifically for ferrets and because there is evidence that ferrets may be present in small numbers on the island. Large ferrets may not get into the entrances of DOC 200's may not be humanely killed.

Because DOC 250's can cause gaps in a stoat eradication network (lighter stoats and weasels may not trigger the heavier treadle plate) and because there have had no confirmed sightings of ferrets (although see below) for several years, DOC 250 traps will only be deployed if a sighting is confirmed by a reliable source (e.g. experienced person, trail or conventional camera/phone photo).

An experienced rabbit hunter did see an animal much like a ferret just east of Whakanewha Regional Park in October 2019, set ferret traps and trapped a similarly sized feral cat. Ferret traps are still deployed in this area to give the trapper confidence that it wasn't a ferret that he saw.

Other traps e.g. Good Nature A24, traps that can be buried, live capture traps may be used but only in limited situations (e.g. if the DOC series is not working) as they not as tried and true for eradication as the DOC series traps.

3.7.4 Trap boxes

All traps will be contained in boxes to minimise catch of non-target species. A variety of wooden based on the standard DOC series trap box design (Appendix 6A) or plastic trap boxes (Appendix 6B) will be used.

Figure 14: Double set DOC 200 traps in box (lid off) and DOC 200 single set with lid. Sources: https://www.gwct.org.uk/game/research/predation-control/tunnel-traps/doc-traps/ & https://predatorfreenz.org/resources/setting-up-your-trap/

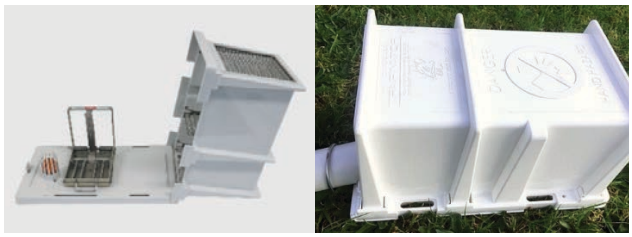

Figure 15: CMI Springs plastic DOC 200 trap box (weka excluder showing on 2nd photo). Source: CMI Springs.

A variety of box types will also be used because, although extensive research has been undertaken to determine the box type most stoats prefer (Burns, 2003; Butler, 2003, Brown 2001), it is possible that a few individual stoats will favour something different from the majority. This is an important consideration when aiming for eradication. The decision as to which type of box will be used where will be set out in the Operational Plan and will include factors such as:

- Presence of domestic cats or other native non target species known to access boxes e.g. banded rail. In these areas, DOC 250's won't be deployed, neither will run through DOC 200's, or DOC 200's with smaller baffles. Instead, longer boxes and/or weka excluders will be used.

- Abundance of other non-target species e.g. rats (double sets more likely to be used).

- Areas where camera's or other means detect stoats avoiding traps may mean the deployment of a wider variety of tunnel types in a set home range area.

Single and double set trap boxes

Both single (one trap in a box) and double (two traps) set traps will be used. Double set traps and/or run through boxes have been shown to be up to five times more effective in some locations around New Zealand (Beaudoin & Ducatillon 2012; Brown & Ward 2016; C. Speedy pers comm.), however, there has been insufficient comparative studies over time (both double sets and single set trials and testing the use of these against the recovery of a stoat sensitive native species) to conclusively prove this.

There are some obvious benefits of double set traps. If one trap is set off, the other one is often still working and the animal in the set off trap can attract mustelids. However, in some locations there was a very low double set capture rate such as on Secretary Island in Fiordland during initial knockdown and during subsequent trap checks which recorded no double captures (McMurtrie et al 2008). The most obvious benefits is that if one trap is set off the other will still likely be working and if one trap has caught an animal it can be more attractive to a stoat, attracted by smell and sight of a food source and in some cases (as has happened at the Awaawaroa Eco Village on Waiheke), the smell and sight of another stoat.

There can be issues with sympathetic firing (i.e. one trap going off triggers the other one) but this has largely been resolved with subtle design modifications that do not affect the efficacy of the traps. These include:

- taking the time to bed the traps in well (down to bare ground, removing rocks and roots, cutting a shelf into banks in some cases) so that there is minimal movement/rocking of the box prior to pegging them down.

- pegging the trap boxes down with a length of 10mm reinforcing steel re-bar at either end, the key is to have the trap box very well grounded so that the energy from a trap set off is transferred into the ground below and not along the trap box to the other trap.

- carefully weight testing each trap for both no firing at 50 but firing at 100g and sympathetic spring off.

- adjust the sears in some traps - mainly raising the sear slightly - so it is less sensitive but still firing at 100g.

Monitoring of the effectiveness of double and single sets is essential. They may also be moved around from time to time depending on rate of catch especially of non-target mammalian predators or native by-catch.

Trap box design

A variety of trap box design has been used on other island eradications (e.g. Secretary Island where wooden and wire mesh boxes were used (McMurtrie et al 2014), Maud Island where some had no floors (Crouchley 1994). Research has also been undertaken examining the behavioural response of stoats to trapping boxes (Brown 2001).

The variety aspect has not yet been clearly demonstrated by the results of recent stoat eradication operations (McMurtrie et al 2008). The Waiheke mustelid eradication programme offers a good opportunity to further test this based on the idea that there are some animals in every population that are fickle – a subtle difference in a trap box design could be the difference between catching a wary animal and not catching it.

A plastic box design (Figure 15) will be used for the majority of the single set DOC 200's because they are lighter and asier for the field team to carry – an important factor when there are over 1000 traps to get out in a short period of time.

Some concern has been expressed about the possible deterrent that the new petroleum smell, plastic texture as well as the colour of these boxes may generate. It has been suggested that masking could be done by placing bedding etc from chicken farms in trap boxes or placing familiar scent trails out around traps. However, advice from Darren Peters, an experienced DOC predator ecologist who designed the DOC 200 series traps has advised that this concern is unlikely to be an issue. Stoats experience new things in their environments all the time and are naturally inquisitive. Wooden boxes contain preservatives to protect the wood and have their own odour as well. The more important factors are correct placement and installation (making it as easy as possible for a stoat to enter), traps placed at the right density (the 1:6ha rule must be an unbreakable one) and checked at the right rate (refer Appendix 7).

It is worth noting that these trap boxes are deployed on the Auckland Council ecological contract (with no pre-treatment) on Waiheke and have caught at least 12 stoats in the last 3 years.

Trap boxes will be provided by the supplier as this is the most cost effective. However, a number of 'contingency' boxes are also required, e.g. if a box is damaged and needs to be replaced. These boxes will be built on Waiheke. Building the boxes on the island cuts down freight costs and provides another opportunity for community involvement.

Boxes will not need to be anchored to the ground unless they are in areas livestock may have access to and/or where there are pigs or where double sets are to be used. In these cases, they will be anchored with a length of 10mm reinforcing steel re-bar which will be contained inside a wire hoop screwed to either side of the box.

All traps will be secured inside boxes with screws and all lids that will be securely screwed down. Only stainless steel screws will be used. All trap boxes will be sequentially and individual numbered on a yellow Allflex tag screwed to the lid. All lids will have warning signage and Te Korowai identification on each lid. Some modifications to traps which arrive with boxes from the supplier may need to be made as there have been issues with traps hitting sides of the box and misfiring or not closing properly.

Where domestic cats, weka, or other potentially vulnerable ground bird species are present, weka excluders (Figure 15) will be used to mitigate the risk of by-catch. It should be noted that in the case of weka this will be an ongoing piece of work as the population is continuously expanding to new parts of the island.

3.7.5 Determining total trap numbers

Based on 9300ha, 1 trap per 6ha = 1533 traps for the eradication grid. However, refinements made during the desktop exercise reduced the total required to 1389, e.g. a number were at the end of peninsulas with the balance of the 6ha 'block being in the sea. There are also a number of existing traps that are more intensive networks than that of the eradication grid. These are to protect vulnerable native species. **Hence the end total of 1736 traps sets.**

- 1389 traps to still be placed inside their 6ha blocks in the eradication network

- 347 existing traps
  - 297 single set DOC 200's.
    - 43 CMI white plastic box version with no weka excluder so 600mm length.
    - 254 Haines wooden box version at 600mm long.
  - 50 double set DOC 200's wooden built on island, length unknown.
  - These traps are a mix of offset and run through baffle set ups.

Te Korowai has purchased 1390 trap sets (a small number were supplied by Auckland Council). All are stainless steel:

- 774 single set DOC 200's
  - 555 are CMI white plastic box version. with weka excluder so around 900mm long.
  - 119 are Haines wooden boxes at 600mm long.
  - 100 are Auckland Council wooden boxes at 900mm long.
  - All have offset baffles.

- 596 double set DOC 200's
  - All are in wooden boxes Haines wooden.
    - 546 are standard Haines boxes at 600mm long.
    - 50 are 900mm.

- 20 single set DOC 250's in wooden boxes at 400mm long.

Unused traps in good condition on the ground now will be repurposed as contingency traps.

The total trap number of 1736 trap sets translates into total trap set percentages as follows:

- DOC 200 single set = 61%.

- DOC 200 double set = 37%.

- DOC 250 single set = 2%.

Numbers are indicative only as there may be more traps on the ground that the Te Korowai field team is yet to find. Additionally, it may be advantageous to have more traps in areas where vulnerable species nest, or on long coastal peninsulas.

3.7.6 Stainless steel traps only

Only stainless steel versus zinc plated traps will be used for the following reasons:

- Problems have been encountered with zinc plated DOC traps. Oxidation around the trigger pin and plate caused traps to not spring-off as easily.

- Stainless steel traps will require significantly less trap maintenance and are therefore more cost effective in the long term on (McMurtrie et al 2008).

- Waiheke's salty and corrosive marine environment is unforgiving – stainless steel will have better longevity.

- The Te Korowai field team has been checking locations of closed existing traps the stainless steel traps are generally in working condition whereas the zinc ones are not, and are often not repairable.

3.7.7 NAWAC approved

The NZ National Animal Welfare Advisory Committee (NAWAC) 09 Guidelines test the welfare/humane performance of traps to restrain and kill the animal pest species they are designed for. In New Zealand, trap use is regulated by the Animal Welfare Act 1999. This Act permits any trap to be used for trapping

any species, but it also enables the Minister of Agriculture to recommend to the Governor General traps that should be prohibited because they cause unacceptable pain and suffering. To enable the welfare performance of traps to be assessed in a standardised way, NAWAC has developed a trap-testing guideline.

The Te Korowai project uses DOC series approved traps as the principal tools, which passed the NAWAC tests for all three mustelid species. The only exceptions would be trials of new traps or if a mustelid was detected that could not be caught with DOC series traps and technical advice was that a specific alternative trap type should be utilised. Trail cameras may pick this up, field sign such as fur in a trap or a sprung trap with no catch may also indicate evidence of this.

The decision to deploy any tools in the eradication that do not meet NAWAC guidelines, will be made by Te Korowai Trustees. It will be based on a recommendation by the Operations Manager in tandem with the field team and technical advisers (e.g. Te Korowai Technical Advisory Group) and other external technical specialists including trap suppliers. These exceptions would only be deployed in limited and controlled situations.

3.7.8 Baits and lures

Mustelids will be attracted to well-located traps set with attractive lures and baits in places mustelids are known to frequent or likely to live in. Baits are physical food items. For Waiheke it will be rabbit based and either fresh or long life dehydrated and egg (mainly fresh but plastic eggs may also be trialed).

Salted bait will not be used initially. Unlike fresh rabbit or dried rabbit (stoats are known to feed on old meat if fresh is not available), salted meat is not a natural food source and it is considered that replicating natural food sources is beneficial. Salted meat can also affect longevity of traps through the corrosive nature of salt (D. Peters pers. comm.). However salted rabbit may be revisited further through the eradication programme.

Fish based lures and baits will also not be used initially. Other than koura (freshwater crayfish) fish does not feature prominently in stoat diet studies from around New Zealand King & Moody 1982a & Gillies (undated). Salmon spray is used on some existing traps with rabbit on Waiheke. It is recommended that this cease when the eradication network opens in February 2020. It could be a tool that is used later on if additional variety is required, a stoat is frequenting coastal areas and is avoiding traps etc.

Lures are attractive smells – they may be food related, e.g. fish oil or spray or mayonnaise or they can be elements of odors that mustelids produce to mark territories.

Mustelid odors e.g. the ferret odors trialed and patented by Patrick Garvey at Landcare Research have been successfully used in a spray or in bedding (e.g., hay or grass) to catch animals on offshore islands they have swum too. A variety of lures (visual, audio, olfactory) will be used to create variety and retain interest in the traps.

In addition to attractive lures, “rodent nightclubs” may be used near some traps. A rodent nightclub is a field tool utilizing lures that attract rats like flour and fruit essence that encourage rodents to visit, and mark the area with urine and scent, which is an added attraction for mustelids.

Rats and mice are significant alternative sources of food for mustelids, especially when the chicks and eggs of native birds are not abundant. Good Nature A24 traps which target stoats and rats are an alternative form of a rodent nightclub and have the added benefit of killing a rodent before it enters a stoat trap – thereby reducing these traps being overwhelmed by a key non target species which is likely to be a disadvantage of a “rodent nightclub”. The scale of the trapping programme and providing consistently attractive bait in all traps over an extended period and throughout the intensive re-baiting programme from February 2020 to December 2021 on an island the size of Waiheke is a significant logistical exercise.

Pre baiting

It is essential to maximise the chances of mustelids who are naturally wary but often curious of new items in their environments. Pre-baiting or placing bait (e.g. rabbit) and/or lure e.g. ferret odor in unset

traps for a set period before opening them, allows traps and boxes to weather in, increases the chances of mustelids getting used to them by initially encountering them without getting caught.
This pre-baiting system will be done twice during January 2020. Fresh rabbit and egg will be placed inside the trap box to encourage stoats to become familiar with the boxes and traps and learn to associate them with food.

Pre-baiting will require the closure of all existing DOC series traps on the island during this period other than those protecting vulnerable native species that are nesting. The level and location of bait take will be measured and recorded through the data management system.

Pre-baiting has been used as a means of enticement on several other stoat eradications. For example, on Secretary Island baits were removed from 50% of all boxes during the pre-baiting (McMurtrie, 2014).

Baiting and luring traps once open

Fresh rabbit meat and egg will be used intensively when the traps are first opened in February 2020 because it is likely that the two previous pre-baiting (all traps closed) runs with fresh rabbit and egg will have created a lot of interest in the traps from mustelids (C. Speedy pers. comm.). Four runs 4-5 days apart will be undertaken. The short period in between reflects the often very hot and humid conditions on Waiheke at this time of the year. However, although Waiheke has a ready supply of rabbits and people who can provide them, fresh meat deteriorates rapidly particularly in warm, humid environments which are a consistent feature of Waiheke for extended periods. After the first few months Erayz blocks or a similarly long-life form of dehydrated rabbit will be used along with eggs most of the time. Salmon spray (or similar will be used occasionally to create variety.

Erayz blocks (Figure 16) are a non-toxic rabbit-based bait that has been oven dried to the same consistency of beef jerky, making it easier and cleaner to handle. They were specifically designed as a long-lasting mustelid integrated bait and lure. Erayz blocks also have the advantage of being long lasting (including the aroma) in the field (up to 4 months) and can be placed in a freezer for prolonged storage – an advantage that allows bulk buying.

Te Korowai is currently investigating whether there is local interest from rabbit hunters on Waiheke to undertake this work on island to both create another form of local income and utilise a readily available source of bait. Rabbits their numbers and the damage they do is a common frustration of many landowners. Even an additional small impact that local supply for traps could have will help reduce this and be a beneficial advocacy tool for Te Korowai.

Fresh rabbit will then be used again when mustelids are breeding and young are emerging.

Fresh rabbit may also be used if there are untrappable animals or animals avoiding traps as these situations will demand a more intensive programme involving shorter periods between bait changes, e.g. days and weeks versus a monthly change which will be the frequency for the main eradication programme trap checks and bait changes.

Indications from a trial in Northland are that mustelids caught with fresh bait were caught soon after re-baiting, suggesting that mustelids prefer fresh bait when it is freshest, but that freeze-dried bait will catch over a longer period (Miller 2003), i.e. in a situation such as Waiheke where most trap checks will be on a monthly basis.

Figure 16: Erayz blocks. Source: https://www.connovation.co.nz/erayz-blocks

Palatability trials undertaken in forest and coastal areas in Northland, which caught around 500 mustelids (mainly stoats) support the above (Miller 2003 & Pierce et al 2007):

- Fresh rabbit is more effective bait than freeze-dried rabbit meat but the difference in preference between fresh rabbit and salted rabbit was less clear and statistically not significant [however experience from other projects is that lasts a lot longer than fresh rabbit].

- Pilchards and eggs did not attract significant numbers but they should not be discounted because mustelids can have individual patterns of hunting and this, together with the occasional presence of bait-shy animals, means that the use of alternative baits (to rabbit) could be effective in catching some of these animals. Fish based baits may be more effective in coastal areas.

In addition to eggs other lures will also be used periodically. These include a variety of sounds (e.g. taped bird calls, squeakers to emulate bird or rabbit distress calls were used on Maud Island (Crouchley 1994)) but also sprays and oils with odors that are particularly attractive to mustelids. Ferret lure will also be used odor if enough is available.

Patrick Garvey, a leading researcher in this field from Landcare Research, has indicated that Waiheke would be an ideal location for the next round of his field odor trials. Ideally, ferret odor will be used ferret odor for the first baiting run. Wherever possible scent glands from female stoats caught will be removed prior to animals being sent off for DNA work.

Other materials such as oestrus bedding may also be trialed. This is the scent of captive female stoats in oestrus, a period of sexual receptivity and fertility. Research has been undertaken by filling tea strainer balls with a synthetic, cotton wool-like substance containing this material. A preliminary oestrus bedding trial in Abel Tasman National Park in 2014 found that it caught twice as many stoats compared to the traditional dehydrated rabbit bait, Erayz (Carson 2017). It has also been successfully used on Kapiti Island following an invasion event. A male stoat was captured within 10 days, following a 3-month period using traditional food-based lures (Duckworth 2013).

3.7.9 Vertebrate pesticides

Eradication is about maximising the likelihood of success. This means a toolbox approach and for most mammalian predators the need to include vertebrate pesticides, in the case of mustelids this is because some animals may be untrappable/avoiding traps.

Because there can be a strong negative reaction towards the use of vertebrate pesticides, and because it is essential that community support for Te Korowai's work is maximised and does not create challenges for other work being undertaken on Waiheke, vertebrate pesticides (toxins), will only be used as a last resort, when all other tools have been exhausted.

Ensuring the correct spacing, methodical and consistently high-quality management of the trap network will reduce the number of potentially trap shy animals but not completely remove it. The strategy for using toxins will be as follows:

I. Untrappable animal detected/animal avoiding trap/s.

II. Review camera footage, talk to field crew, landowners to determine length of trap avoidance.

III. Get a predator dog in to delimit range of individuals.

IV. Consider use of alternative traps and lures.

V. If it is determined IV will not be helpful or have been tried and didn't work use vertebrate toxins in area delimited by predator dog in combination with traps to remove animal.

VI. Continue III-IV response until individual caught or no longer detected on cameras in delimited area.

Para-aminopropiophenone (PAPP) is the only pesticide currently licensed for use on stoats directly. This pesticide results in animals becoming lethargic and sleepy before they die, hence is relatively humane with death occurring in around two hours from toxic effects to red blood cells.

A paste PredaSTOP for stoats containing 40% PAPP has been developed for use in meat baits in New Zealand. A toxic dose for stoats is achieved when pea-sized amounts of paste are syringed into 10–20 g meat baits, which are then placed into bait stations. Pre-feeding with similar nontoxic meatballs is required for 1-2 weeks prior (http://envirolink.govt.nz/assets/Envirolink/1294-NLRC160-Predator-control-and-PAPP-brochure.pdf).

Other pesticides can be used but not directly – e.g. brodifacoum can be placed in bait stations to attract rodents – stoats eat rodents and die through secondary poisoning. Use of secondary poisoning vectors may be considered with guidance from the Te Korowai Technical Advisory Group and other technical specialists, but it will be in defined situations in delimited areas as identified above. To be effective this would have to be done across a reasonably large area. Community rat control work on Waiheke currently uses brodifacoum and diphacinone, which may already be having a secondary poisoning influence on mustelids. However, neither of these toxins are registered for direct use on stoats.

Den-Co-Fume

Female mustelids are notoriously hard to catch particularly when they are denning with young. Getting to these animals in their dens is the golden goose and has been identified as a beneficial strategy in many research papers (mainly on stoats).

An initial trial undertaken by the Department of Conservation (DOC) in Trounson Kauri Park (Theobald & Coad 2002) on stoats with predator dogs and Magtoxin (a rabbit fumigant) involved dogs finding dens, entrances being plugged and Magtoxin being released. It was a trial with some encouraging results. However, it was challenged by the fact that some dens (stoats do not make their own dens, they use rabbit burrows and natural ground hollows, e.g. mulch piles, earth banks, hay bales, log piles, under tree roots etc) had multiple exits and/or were too porous (e.g. a mulch pile, tree roots) to ensure no fumes escaped. On the positive side the trial did show that the dogs could find dens and that Magtoxin did kill stoats.

Waiheke offers the opportunity to undertake further trials. In association with Landcare Research Te Korowai will work through the various permissions required from agencies such as the Ministry of Primary Industries to trial the use of a more humane carbon monoxide like product registered for foxes in Australia. Dens would be found with predator dogs, those that could be effectively sealed would then be treated with the product. Those that this did not work on would have cameras installed close by and use a variety of techniques such as predator dogs to flush them out, traps to catch etc.

3.7.10 Predator dogs

Predator detection dogs are another key tool in the knockdown toolbox. They will be used primarily on Waiheke to assist with the location of untrappable animals/animals avoiding traps, find denning females, checking trap lines and to confirm the eradication has been successful.

Situations where untrappable animals/animals avoiding traps and denning females are suspected - the dogs (potentially in combination with trail cameras) will both be used to detect and narrow down locations for a more intensive effort (which may include the use of additional trap types, live capture traps, vertebrate pesticides, confirm the presence of a den and then be used to confirm that the animal under management had been successfully removed (e.g. if it was not caught in a trap and to confirm whether all animals had been caught if for example a den was found or more than one animal was suspected).

The dogs will also be used periodically to see whether there are any mustelids living in between traps in the network. In this case either install more traps would be installed or pesticide used in a smaller area. Predator dogs and their handlers have also been widely proven as one of the best biosecurity tools available. They are a key tool in the “ambulance at the top of the cliff” approach, i.e. the prevention of mustelids coming back on boats and with freight.

Auckland Council is committed to the expansion of this programme to include a more comprehensive programme for checking people and commercial boats and aircraft.

Predator dogs are in high demand and as a result handlers and dogs are working nationally and need to be booked well in advance. Both Auckland Council and the Department of Conservation will assist us with this work, providing dogs and handlers and/or training dogs and handlers so an additional skill can be added into the Waiheke community – Waiheke based handlers and dogs.

Figure 17: Mustelid detection dogs.
Source: https://www.stuff.co.nz/environment/112101023/its-a-dogs-life-for-lifesaving-conservation-dogs

3.7.11 Trail cameras instead of tracking tunnels

Tracking tunnels one of the most commonly used means of tracking small mammals in New Zealand have been found to be an unreliable detection measure for stoats. There is growing concern that tracking tunnels are not always sensitive enough to conōrm presence of stoats, especially in situations where stoat density and probability of detection are low (Choquenot 2001) (as is likely the case at Waiheke). Choquenot's study that estimated the number of tracking tunnels that would be required to detect the presence of stoats in an area of 10 000 ha, where the average exclusive home range size was 50 ha.

The study took a cautionary approach (vital in eradication or reinvasion detection scenario's) and concluded that if realistic detection characteristics are assumed (e.g., 30% of stoats do not encounter tracking tunnels within their home range, or do not enter them if they are encountered), the number of tracking tunnels required to detect five or fewer stoats in 10 000 ha with 99% certainty exceeds 200 (Choquenot 2001). It should be noted this work was undertaken in beech forest, quite different to Waiheke's forest environments (Figure 25). However, the caution is worth noting, as the encounter rate is potentially similar.

Another study further illustrates the limitations of conventional tracking tools and emphasises the merit of using more than one technique to detect a species and recommends that detection devices are left open for at least 10 nights. This would need to be done at least 4x/annum and is particularly significant when animals are at low densities (Pickerell et al 2014).

On Waiheke a limitation common with many other areas where rodents are present is that many tunnels would be overrun with rodent prints (Figure 18) and make any mustelid prints extremely hard to detect. It would also be a considerable logistical exercise.

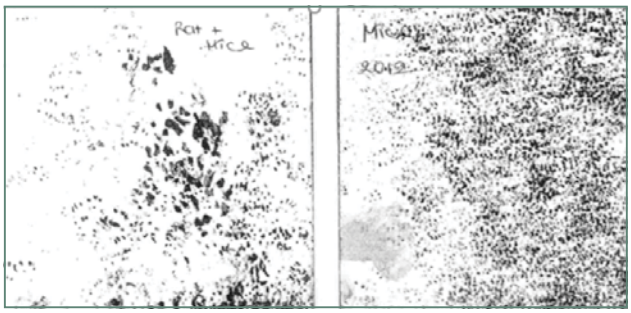

Figure 18: heavy rat and mouse tracking – Rotoroa Island 2013. Source: Jo Ritchie

Trail cameras are emerging as the most reliable way of indexing relative abundances and locations of mustelids. Remote cameras are emerging with a quick shutter speed are emerging as the most effective detection measure for indexing relative abundances of mustelids because they require no interaction with a device (lures often increase the chances) and can provide an accurate time stamp of when an animal was first detected (Smith & Weston 2017). Trail cameras can also be used for biodiversity monitoring.

Trail cameras will therefore be the primary way of indexing abundance and location of mustelids on Waiheke (refer section 3.7.11). Manaaki Whenua – Landcare Research personnel have advised on the characteristics camera's need to have as well as the most reliable brands. Manaaki Whenua is also working on an algorithm to enable computer identification of images, as the analysis is one of the most time-consuming features of this emerging tool.

Te Korowai views the use of trail cameras as having four key uses:

1. **Understanding mustelid population densities, habitat relationships and distribution on Waiheke and also nationally.** The more data we collect early in the programme will help inform early alterations, increase efficacy and efficiencies. There is little data for the vegetation/land use types on Waiheke and the associated likelihood of a stoat interacting with a camera. This is important in running both the Just Enough Surveillance Sensitivity (JESS) and Probability of Absence (POA) algorithms being developed by Landcare Research.

   Landcare Research has provided what little data there is in the literature pertaining to this function of stoat/camera interaction and detection which has been conducted primarily in Beech Forest and alpine environments. Any information we gather while conducting camera trapping prior to eradication (i.e. when we know stoats are present on the island, even at low densities) will inform the functions within the above mentioned algorithms but also of equal importance begin to provide data for North Island temperate environments.

2. **Possible detection of any ferrets.** There are anecdotal reports of ferrets, but this has never been conclusively proved. It is critical to try to determine presence/absence of ferrets as early on in the programme as possible.

3. **Understand any implications of eradication trap layout modifications due to the 'peopled environment' on the ability to detect and catch stoats.** How the traps are laid out on Waiheke is a function of trap density and key natural habitats, but also minimising impact on people's activities (e.g. minimal traps in grazed pasture, traps set well back from road edges).
4. **Community engagement.** Some people are incredulous that stoats are on Waiheke, they haven't seen any and are not involved in trapping. Camera's both provide powerful, conclusive visual imagery that can be used as an advocacy and education tool.

Waiheke will be split into four management units with a complete monitoring programme in each. 60 cameras will be deployed. The numbers are based on the DOC interim trail camera guide (Gillies 2018) and the suggested number of camera trap lines in relation to the size of the area to be surveyed. There are four traps on each line. In Waiheke's case - 9200 hectares / 15 lines with four cameras per line = 60 cameras.

The cameras will be moved between four management units at equal temporal scales e.g. two weeks each, so effective diverse island coverage is achieved. The placement of the cameras will incorporate all land, vegetation and habitat types. Each camera will also be paired with a trap to help with determining the sensitivity of both the cameras and the traps as control and monitoring devices.

Te Korowai will work with Landcare Research and establish a system for analysing data. Camera installation, management and analysis has been identified as an opportunity for local contractors and so also provides another local employment opportunity.

The camera programme is a work in progress. Te Korowai is hoping to install the cameras by early December 2020.

3.7.12 Dealing with untrappable animals/trap avoidance

This situation is one of the biggest challenges with the eradication programme, although it has been proven on several occasions both on Waiheke and on other eradication programmes that perseverance can catch

a number of these animals. It often requires some combination of the use of the same traps and different bait or lure combinations; different traps, baits and lures, predator dogs and vertebrate pesticides. Predator dogs will be used to detect locations of untrappable animals/animals avoiding traps which may be initially detected by field sign, sign in traps (e.g. hair or blood) or on trail cameras. Other trap types are often employed because sometimes the issue is simply a bad experience with the traps presently being used. Human scent can also be a deterrent – all trap checks that involve handling of the box and contents will be done with gloves on.

The decision-making process for using alternative trap types will be a function of available field information e.g. number of checks where a detected animal has been observed or avoided traps and their NAWAC status (section 3.7.7). Because mustelids can move large distances an island wide network of traps will be deployed and time allowed to determine that an individual is avoiding all traps. If after two of the planned trap checks an animal is still being detected and has not been caught the next step will be to look at which tool is best to deploy. (The two-trap checks figure is indicative only and will be informed by technical advisers and increasing knowledge of stoat behaviour on Waiheke.)

The only exception would be if an untrappable animal or trap avoidance was detected during the breeding times of vulnerable species. In these cases, immediate action would be taken – review current tools in the field, likely use a predator dog to narrow down where the animal's home range was and install additional tools. Consultation would also be undertaken with the Te Korowai Technical Advisory Group as well as field practitioners and other industry professionals.

3.7.13 Remote sensing technology

Remote sensing technology nodes will be installed on c. 50% of trap boxes. These nodes will send a signal to a phone when a trap goes off. This technology is already installed on some existing traps at Whakanewha Regional Park and in a few other locations on Waiheke. The percentage of traps with nodes relates both to funding availability and the proportion of traps that may be overwhelmed, and therefore need to be checked more often. Nodes may be moved between traps, e.g. if a trap has minimal catch, the node may be moved to one which has significant non-target animal pest catch.

The decision as to where to initially locate nodes will be influenced by several factors including:

- Where there is coverage.
- In remote/time limiting places, remoteness is a function of the time from where the trapper is and where they need to get too.
- Health and safety – e.g. coastline lone worker issues.
- In areas where stoats have been regularly caught.
- In areas where there are high populations of non-target species such as hedgehogs and rats that may spring traps on a regular basis.
- In areas of high biodiversity value, e.g. korora, oi, kākā nests/burrows.

Proposals will be requested from potential suppliers in November 2019. Proposals received will be assessed by looking at:

- Waiheke conditions
- A profile by Predator Free NZ (PFNZ) of the various features of products from a number of NZ companies in this market.
- Reliability and ease of maintenance.
- Cost (initial set up and ongoing data and maintenance costs.

3.8 How will traps be managed to minimise non-target catch?

- By how the traps are designed, which traps are used, where they are placed, and what lures are used.

By-catch of non-target species (possibilities include; rats, native birds, rabbits, cats and hedgehogs) is not ideal because once they set a trap off it becomes unavailable to a mustelid. A percentage of the total number of traps are double set DOC 200's, allowing for some by-catch, and maximizing the number of traps active in the network.

Every trap in the eradication network is enclosed in a custom designed box that has a series of wire mesh panels with entry holes cut in. For DOC 200's the entrance hole is 6cm x 6cm. For DOC 250's it is 8cm x 8cm. The entry hole on the internal panel is offset from the entrance panel hole to make it harder for non-target animals such as birds or cats to gain entry to the trap area.

Mitigating the risk of catching any domestic cats is significant, because there are many pet cats on the island and the catch of a domestic cat would have grave and potentially irreversible consequences for the project. The Te Korowai field team asks landowners whether they have cats, if they do, steps will be taken to locate traps and allocate trap box types to minimise the chance of encounter. The Operational Plan contains this information in more detail and has a procedure if a domestic cat is caught.
Non-target catch will be reduced by:

- If the location is in an area where banded rail are – the trap can be sighted as far away as possible from wetland edges.

- If the location is on a property where a domestic cat is resident – work with the landowner to determine the best location – some cats don't roam far.

- In both situations longer trap boxes (e.g. 900mm long versus 400mm), or boxes with weka excluders will be used.

- DOC 250's with wide entrance holes will not be used where domestic cats and/or banded rail are present.

- The baits and lures proposed in this programme are generally not attractive to birds.

3.9 The best places to put traps are where mustelids like to go and where they are easy to access

Final trap placement of the traps will vary slightly from the desktop planning exercise in Figure 11 due to a lack of detailed knowledge about all the lineal features on Waiheke and because of it is desirable to work with landowners about exact placement. Exact placement in each six hectare block will be undertaken by experienced trappers on the ground using their knowledge of stoat behaviour and habitat preference.

All lines and trap sites will be recorded with a Global Positioning System (GPS) location and property and other data collected as summarised in Appendix 6. This will be stored in a central database. This system is real time and provides desktop summaries as identified in Figure 19 below being progress with landowner permissions as of early November 2019. Progress checks and audits by the Te Korowai Operations Manager during the installation phase will also provide an early indication of whether the number of traps estimated for the project are adequate and therefore allow time to purchase/build extra boxes and traps if required.

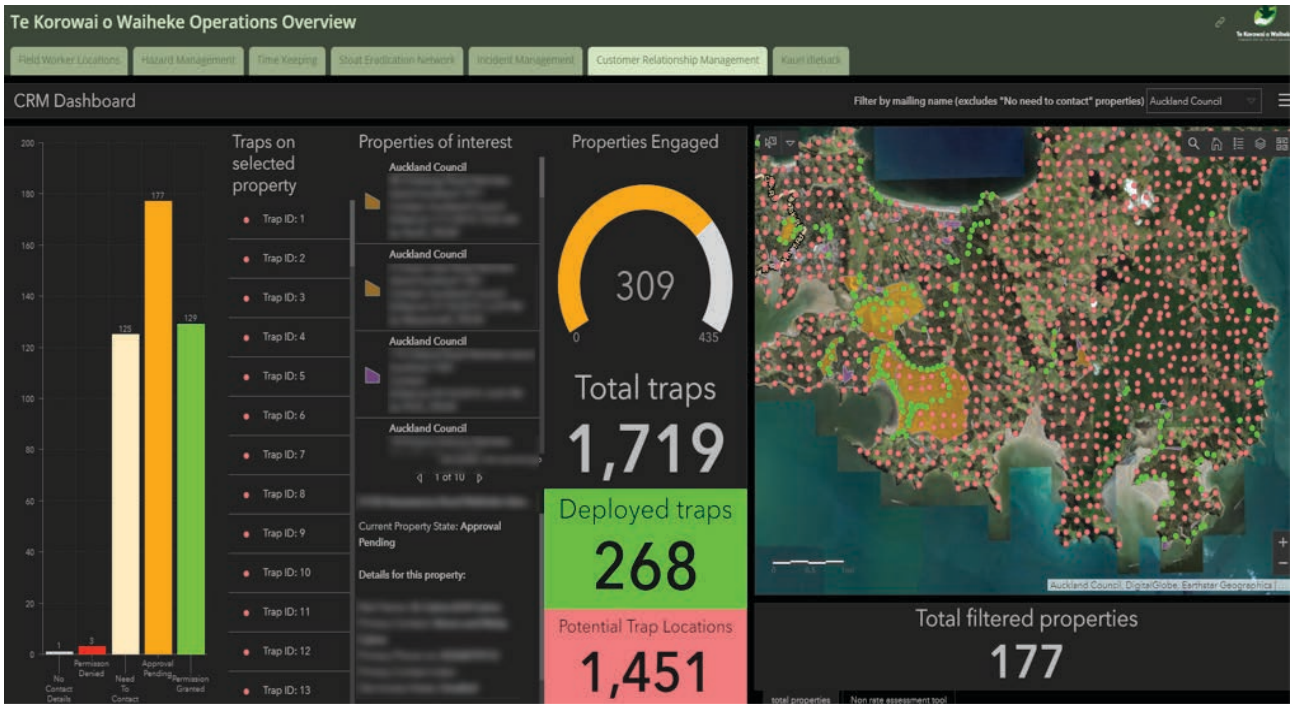

Figure 19: Te Korowai data management system overview page. Source: Te Korowai o Waiheke

3.9.1 Considering mustelid behaviour

It is clear from research and field observations of mustelid behaviour in the field that they follow linear features on the landscape, such as roads, tracks, ridgelines and habitat edges such as forest/pasture edge.

They also have preferences for certain habitat types – ferrets are close to areas where rabbits are in high numbers (e.g. pasture), while weasels and stoats prefer bush, wetland edges, forest and coast – pretty much anywhere where there is food and cover.

- Habitat boundaries e.g. pasture/bush; pasture/wetland; coastal margins, ridges, streams.
- Walking tracks, roads, property access tracks.
- Shelterbelts, fence lines, haybarns, sheds, mulch piles, garden edges.
- Areas where vulnerable species are known e.g. Kākā nests (these may also have additional traps, i.e. over and above the eradication network requirement – refer section 3.10).

3.9.2 Practicality of servicing

Practicality of servicing also comes into play, particularly given the size of the network and regularity of trap checks. New traps will therefore be located based on good habitat features located close to the following three factors in order of ease of servicing:

- Roads
- Tracks (vehicle first, then walking)
- Locations that need to be walked too.

3.9.3 Less attractive habitat areas

Home range (the area that an individual mustelid lives in) is important as well. Home ranges are rarely uniform and are affected by several variables including food availability (which often changes seasonally), reproduction and where the home ranges of other mustelids are. Males generally have bigger home ranges than females (Figure 20). Estimates for mustelids vary according to gender, season, and food availability (King and Powell, 2007).

Habitat type will also have a big influence on home range. Waiheke offers the opportunity to study this in

more detail across a diverse range of habitats from optimal (e.g. warm forest and wetland edges to less optimal e.g. open grazed farmland, residential areas. Field observations, the sightings database (Appendix 5) and trail camera's will also assist with this.

Species	Male (hectares)	Female (hectares)
Ferret	52-372, mean: 80-288	166-265 mean: 45-230
Stoat	65-107 but up to 200 has been recorded. As low as 16 recorded in a Hutton's Shearwater Colony	40-80. As low as 9.4 recorded in a Hutton's Shearwater Colon
Weasel (little work done in New Zealand)	59-150. In Pureora Forest 3 tracked between 66-150	59-150. In Pureora Forest 1 tracked over 59ha

Figure 20: Indicative home ranges of mustelids in New Zealand. Various sources: Cuthbert 2002; Gillies 2007; Haworth 2018; King 2005; Moller 1996; Moors 1981 and Morley 2002.

3.9.4 Less attractive habitat areas

Even though big gaps are not desirable, there is little point putting traps out in the middle of sports fields, large lawns, building sites and/or in areas of grazed pasture, because while mustelids may run across open spaces, if there is no shelter they won't stay.
There are always exceptions, and in an eradication, these are important to consider. For example, if there is a barn, implements shed, woodshed or similar they may, so if the GPS point for a trap falls in or near an open space that has some form of shelter, a trap may be located there. Some of these open areas may also have high rabbit numbers. Mustelids are often near these areas. In these cases, traps may be installed in open areas where rabbit impact is obvious.
Trail cameras will also be installed in some of these places to verify that mustelids are not resident in these places. Given the close trap spacing on average of 200m (other eradications are typically between 500-700m) any gaps in open ground will be minimized with the presence of other traps nearby in areas of more vegetation.

3.9.5 Favouring one site over another

The decision as to whether one site is better than another will be a decision that the Te Korowai Operations and Field Team manager make based on preferable habitats, sightings of mustelids, locations of vulnerable species and maintaining the 1:6ha rule for trap spacing.

3.9.6 Double or single set DOC 200 or a DOC 250

Double sets (two traps in a box) are useful in places where there are lots of non-target pests e.g. rats and hedgehogs (they can be more than 5-7 times more effective than a single set). Although the entry holes in the trap boxes are designed to minimize the entry of non-target animals, some non-target animals are the same size or smaller than mustelids and may be caught instead, rendering the trap inactive for mustelids until it is cleared. Double set traps go some way to alleviate this problem, because if something is caught in one trap the other will still be working.

A catch in one trap can also be attractive to a mustelid who comes to investigate and then never leaves. Double sets will be in places where rats and hedgehogs are likely to be in high numbers but also in places where vulnerable native species are, such as nesting Kākā.

The decision as to whether it's a double or single set DOC 200 will consider factors such as:

- Abundance of rodents and hedgehogs – based on local knowledge and habitat/environment characteristics, e.g. the rubbish transfer station, bush fingers in settlement areas.
- Presence of nests/burrows of vulnerable species.
- Remoteness and accessibility of trap location.

The decision as to whether it's a DOC 200 or DOC 250 will consider factors such as:

- Rabbit densities.
- Other habitat characteristics favored by ferrets.
- Reliable ferret sightings.

To avoid creating gaps in the network where lighter stoats and weasels may not trigger the trap, DOC 250's will only be deployed if a ferret sighting is confirmed (e.g. verbally from a reliable experienced source or visually as a result of a trail camera or personal camera photo).

3.9.7 Being efficient and minimising impact

The success of the mustelid trapping on Waiheke will rely on a network of trap lines that are well maintained and cover the whole island. Wherever possible these lines will be based on existing walking tracks, roads, property access tracks, habitat edges, shelterbelts, walls and fence lines etc. Using existing access points and features will also help minimize impact. Sightings of mustelids from the community will also influence trap location and may be intensified in places where there are sensitive species, e.g. around Kākā nests, oi and korora burrows. There are already stoat traps around many nests and burrows, which are currently being managed by the community.

Every attempt will be made to disguise entry points where these may attract public attention. Most trap locations will not be physically marked on the ground. This is to minimise visual evidence as many traps are on private land. The only exceptions will be on public land where this is required by the administering agency or road berms, so trap locations are visible to mechanical mowing as well as maintenance crews.

For road edge traps on sealed roads Te Korowai is investigating a stoat stencil on the road. This would act as a novel identifier and an advocacy tool. For unsealed roads the 'locator' will be a batten with a high visibility orange top. These solutions were suggested by Downer (the maintenance contractor) and Auckland Transport.

Lines and trap locations will be identified by way of sequential numbering, GPS points and routes. Sequential numbering is a simple means of checking whether a trap in a section has been missed or not. This system during pre-baiting will be tested during the pre-baiting phase in January 2020. If it is found to be too hard to find traps without physically marking, marking additions will be made on the baiting run when traps are first opened in February 2020.

To maximise efficiencies in trap checking, location will also consider where it's easier on the field team as well as landowners. Te Korowai wants to minimize impact on the land and people's properties by minimising the need to cut tracks, and not introducing new problems such as Myrtle rust or kauri dieback. Any tracks that do need to be cut will be with landowners' permission and just wide enough for safe field crew access.

Loops to avoid returning on the same line may be used, any areas of kauri will be avoided, and Te Korowai will work to the Auckland Council kauri dieback Standard Operating Protocols. It will also utilise as many of the existing traps out in the field now as possible and involve existing trapping volunteers.

Trap boxes will be placed on level ground alongside trap lines or in a position where the field crew can easily service them. They will be placed in the most accessible sheltered position which may mean placing the box a short distance off a track for example, especially on exposed ridgelines or in coastal locations or areas prone to flooding. Each trap site will be individually numbered, and a GPS location recorded. 10mm steel rebar pegs will be used to anchor any traps in exposed locations or where they are in stocked farmland.

3.10 Existing traps out on Waiheke

Using as many of the existing traps that are out on the island now means there will be some flexibility to put additional traps out in areas where mustelids have been sighted, as well as in areas where particularly vulnerable species e.g. kākā and oi (grey-faced petrel) are nesting.

Existing traps will all be checked by the field team to ensure that they are up to standard. There are at least 347 DOC 200 traps out on Waiheke at present. Most have been found by the Te Korowai field team. Many are being maintained by contractors and/or volunteers to high standards. Any not in use, stainless steel and in good condition will be repurposed into an eradication network location. Any damaged, faulty traps will be replaced.

To maintain community relationships all active traps will remain open in the establishment period August-December 31st, 2019). They will continue running until all remaining traps in the network are in place. At this point all existing traps, other than those required to protect endangered native species will be closed for the island wide pre-baiting runs.

It is likely that there will be some traps that will never be found. However, increasing knowledge of the Te Korowai project assisted by contractors, landowners and volunteers will over time identify most of these which will likely be removed if found once the eradication network is active.

3.11 Who will manage the traps?

The eradication programme requires a professional methodical, consistent and sustained approach, so traps all need to be managed in the same way. The programme will be delivered primarily by Te Korowai staff, along with volunteers, contractors, and several landowners who wish to the work on their land either itself and/or with their own personnel.
All traps will be installed and maintained in a way that always makes them attractive to mustelids. All the traps will be checked during each rebaiting period and the same level of information will be gathered for each trap.

Managing the traps in the same way means it is easier to make required changes when needed too -e.g. replacing damaged traps, changing to a different trap, bait or lure, dealing with a denning female, ensuring that attention to detail is never compromised with trap care and maintenance. There will also be a contingency of spare traps and boxes so that damaged traps can be changed in and out immediately and not create gaps in the network. Knowledge sharing and training sessions will be provided by Te Korowai for volunteers, contractors and its own field team. These will begin in November 2019. Regular get togethers to discuss progress and to throw ideas around will be held, as will occasional workshops with various technical specialists.

3.12 Some people may not want traps on their land – how will gaps be avoided?

Te Korowai is confident that there is a high level of support for the eradication programme, evident in the overwhelming support from landowners happy to participate in the programme to date.

Avoiding big gaps is essential. The process for dealing with this is laid out in the Operational Plan. Acquiring landowner permission goes hand in hand with the engagement programme. Community knowledge is key, and where suitable, community ambassadors may help broker a relationship with a recalcitrant landowner.

Blocks of the island will be allocated to each field team member (based on experience, existing relationships and personality) to help build working relationships with landowners and ensure consistency with regards to access and any other conditions that landowners may ask for. Te Korowai's requirements, together with any conditions landowners may have, are summarised in a landowner agreement with each property owner or manager (refer Appendix 2B).
If a landowner says no, the field team will do their best to find out why and find a solution so that traps can be installed. If it's a small property (6-30ha) and they still say no, a request will be made to run predator dogs through on a regular basis to flush out any mustelids.

An alternative is installing a trail camera. If this doesn't work, traps will be placed on adjacent properties within each 6-hectare block if these are properties that did not have a desktop trap located or alternatively intensified on adjoining properties where traps were planned.

As a last resort, the provisions of Auckland Council's Regional Pest Management Strategy and the Biosecurity Act can be used to install traps (process detailed in Operational Plan), but because positive and enduring relationships with all landowners is the goal, this option will only be employed if all other possible solutions have been exhausted.

Te Korowai will also ensure that it "sticks to its specific business". It is acknowledged that some properties may have activities being undertaken that they do not wish to have widely known. Te Korowai is only interested in its work. Te Korowai will not report on any activity other than its own, unless they pose a significant health and safety or environmental risk. In these cases, the field team will advise the Operations Manager and the Project Director will decide as to whether the matter is taken furthe

As a last resort, the provisions of Auckland Council's Regional Pest Management Strategy and the Biosecurity Act can be used to install traps (process detailed in Operational Plan), but because positive and enduring relationships with all landowners is the goal, this option will only be employed if all other possible solutions have been exhausted.

TKOW will also ensure that it sticks to its specific business. It is acknowledged that some properties may have unconsented dwellings and be undertaking other activities that may not always be legal. TKOW is only interested in its work. TKOW will not be reporting on any other activities other than its own unless they pose a significant health and safety or environmental risk. In these cases, the field team will advise the Operations Manager and the Project Director will make the call as to whether the matter is taken further.

3.13 How will it be known that all mustelids have been eradicated from Waiheke?

- When traps and other tools to be used stop catching and detecting them.
- When modeling algorithms in the toolbox provide a 95% or more degree of confidence.
- Two years or more with the above systems in place and no detections.

A toolbox approach

The toolbox for proof of eradication includes trap catch, field observations by people, trail cameras, predator dogs, DNA and related population relatedness work and the use of algorithms under development such as Just Enough Surveillance Sensitivity (JESS) and Probability of Absence (POA) by Landcare Research. There is no 100% certainty with eradication algorithms, hence the 95% above, which is why biosecurity prevention, detection and reinvasion management systems along with community buy-in are also essential tools in the box.

Research undertaken for this eradication plan provides confidence that the above combined with trap intensity combined with a methodical programme over two breeding seasons and a further two-year monitoring window will provide assurance that all mustelids have been removed from Waiheke.
One of the biggest challenges of an eradication programme is detecting animals when they are at very low densities. Mustelids are particularly challenging because they are very secretive, and one animal can travel big distances.

The toolbox approach and the 23 month + 2 years follow up timeframe provides a range of techniques and an extended timeframe to maximise the chances of a successful outcome. JESS and POA are also tackling this challenge and will build confidence with knowledge from each PF2050 project.

Time

For Waiheke the two-year monitoring window is indicative only. This may need to be extended to around 31 months (Figure 21 below). Summary research was undertaken as part of the development of this eradication methodology to confirm how long it's necessary to trap (and use other means) before it is possible to have the highest level of confidence that an island is stoat-free. This work indicates that a more conservative approach may be needed. It's all related to the extraordinary reproductive cycle of female stoats – testament to the tenacity of this species. Females mature at three-five weeks of age and are mated in the natal den. This means that for ten to eleven months of every year they carry three to 20 additional individuals either as developing zygotes (fertilized egg cells) for up to two weeks, blastocysts (a ball of cells containing the zygotes) in diapause (suspended development) for nine-ten months, or as embryos developing to full term within four weeks (King C.M. ed. 1990).

Modeling work has been done to determine how long it would take for a single undetected pregnant female stoat reaching an island, or surviving an eradication, to establish a founding population. The growth for three founder populations of different sizes and composition were modeled under two survival schedules as depicted in Figure 21.

The work deduced that it would result in less than 10 stoats on the island for up to 31 months, after which numbers could rapidly rise (Choquenot et al 2001).

Table 1. Months taken to attain three specified population levels for founder populations comprising different sizes and compositions, and two different survival schedules. Where the number of months required to attain successive population sizes is the same, the population reached the larger of the two population sizes within a single 12-month period.

Founder population		Annual survival		Months to attain specified population size (n)		
Females	Mature males	1-year-old females and immature males	>1-year-old females and mature males	$n = 10$	$n = 50$	$n = 100$
1	0	0.7	0.5	31	43	55
1	1	0.7	0.5	19	31	31
2	0	0.7	0.5	7	43	43
1	0	0.9	0.9	31	43	43
1	1	0.9	0.9	19	31	31
2	0	0.9	0.9	7	31	43

Figure 21: Stoat founder population modeling. Source: Choquenot D. et al 2001.

The study reasonably determined that failure to catch stoats for more than 31 months is a good indication of a lack of stoats on an island. This is supported by the fact that no stoats have been caught on Chalky and Anchor Islands in Fiordland post eradication (and post reinvasion events) for periods of much more than 31 months.

However, it is predicated on the fact that because the demographic data upon which the model was based came exclusively from beech forests, caution should be exercised in extending its results to the colonisation of other areas by stoats (Choquenot et al 2001).

What does this mean for Waiheke?

The programme takes a cautionary approach and will acquire much local knowledge as possible to inform how long a time is required post the eradication to confirm success. Planning for the D'Urville Island operation considered two breeding seasons due to female stoats being impregnated at a few weeks of age and then taking a year to mature (P. McMurtrie, pers. comm.) Based on the above discussion, a conservative approach will be taken for Waiheke hence the two-year monitoring window is indicative only, and may need to be extended to around 31 months.

The ideal scenario is that if there are no detections after the 2021/22 summer confidence that eradication has been achieved will be high. The two key timing windows for Waiheke and its intended indicative timeframe are:

- November 2020 – March 2021.
- November 2021 – March 2022.

It will be obvious if there a few females on the island as there would be a spike in captures in the November to March breeding/dispersal period – if there is only 1 female it wouldn't be as obvious but catching juveniles during this period would be a sure sign. A key tool that will continue to be deployed is the DNA analysis undertaken by Andrew Veale to

continuously build information on the Waiheke mustelid population, but principally to determine whether captured animals are residents/survivors or reinvaders. Waiheke is fortunate that stoat DNA from the island has been undertaken for several years prior to the eradication project.

Section 7 identifies how two forms of monitoring will be used to increase these levels of confidence that eradication has been achieved.

- **Results monitoring** is the direct monitoring of the eradication programme – camera's, trap catch, predator dog checks, sightings and field sign as well as monitoring of key triggers such lures and baits and finding that they fail to attract animals for consecutive extended periods, e.g. six months or more.

- **Outcome monitoring** is based largely based around biodiversity indicator species native species that are particularly vulnerable (e.g. korora, oi, Kākā) to mustelid predation. Every species cannot be monitored because of the sheer cost and time involved in doing so. As a result, indicator species are selected because the recovery of these species also represents recovery of a cascade of other species through food chains and ecosystems as indicated in Figure 22.

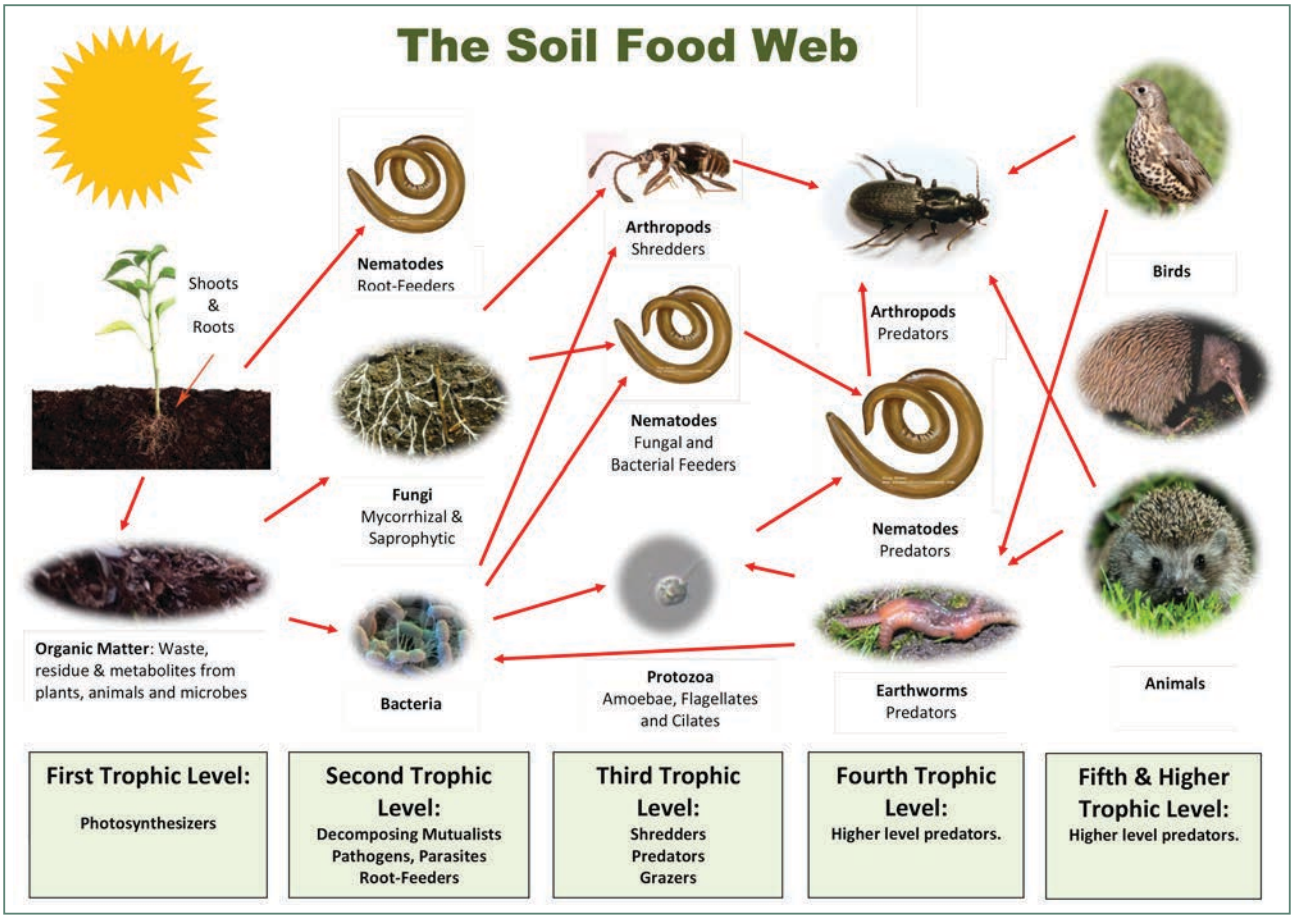

Figure 22: Soil food web in New Zealand. Source: http://www.soilfoodweb.co.nz/index.php/what-makes-a-healthy-soil-foodweb-web/

3.14 Stopping Rules

Andrew Gormley of Landcare Research suggested in a contract report for Predator Free Wellington (Gormley, 2019) to design a suitable surveillance network for proving pest eradication at Miramar Peninsula that: “the stopping target for declaring success should ideally be based on minimising the expected surveillance costs, the possibility of having to carry out further control in the event of an incorrect declaration, and the potential socio-political costs (e.g. loss of reputation) (Gormley, 2019)”.

This eradication plan has involved rigorous and methodical planning based on the DOC eradication best practice system and considerable background research into other eradication projects, mustelid ecology and the field experience of many practitioners in this field.

Challenges that may bring the project to a halt (for example, domestic cats being regularly caught in traps, funding ceasing, many stoats still being caught after December 2021, a fatal health and safety incident, a large landowner saying no to the project or stoats reinvading from the mainland) have been carefully considered, and mitigated or managed for. Many of these challenges and their solutions are listed in Figure 27 or in the overall Te Korowai Project Risk Register.

Regular auditing and peer review both by the Te Korowai team (primarily the Operations Manager and Project Director) but also its Technical Advisory Group (TAG), primary funders (PF2050, Auckland Council and Foundation North) and other external specialist advisors, is the primary tool that will be employed to ensure there is no need to stop the project.
In addition, is the local community itself, who established the Te Korowai o Waiheke Trust for the purpose of eradicating predators from Waiheke. The ever-watchful eye of the local community provides an informal, but intimately connected, important, and passionate judge of a stopping target.

4. SET UP PHASE – BUILDING CONFIDENCE, GETTING BUY-IN, GETTING SYSTEMS IN PLACE

Figure 23: Stoat and bird egg. Source: https://www.nzgeo.com/stories/the-menace-of-stoats/

4.1 Landowners and community partnerships

Landowners

Landowner and community partnerships are at the heart of Te Korowai o Waiheke. Te Korowai has a high level of support across a diverse cross section of the community, which was evident through its funding bid process with PF2050 Limited. Support for community-based stoat control work, the stoat pilot project, and a number of supportive conversations with landowners since Te Korowai was established, indicate that the majority of landowners are on board. Additionally, other landowners are establishing their own networks and requesting meetings with Te Korowai.

The indicative desktop exercise undertaken by Auckland Council Biosecurity GIS personnel indicates that there are 323 landowners on 425 properties, which will require agreements to place traps and manage traps on their land. Road reserves administered by Auckland Council are also being used as placing traps on these parcels where habitat is suitable further reduces the number of landowners that need to be contacted, and the partnership agreement and associated details are a key part of the Trust's initial work.

The field team will gather information as set out in Appendix 6. Agreements with landowners will be formalized in writing and are part of a Landowner Kit (Appendices 2A & 2B).

Several landowners already have traps on their properties as a result of their own or local community initiatives. Exact numbers of these and ones that can be incorporated into the eradication programme will be one of the top priorities for the field team in September 2019.

Animal pest management contractors' partnerships
Te Korowai is also in contact with contractors both on the island and off who are undertaking mustelid control (concentrated on stoats) on various private properties. The preferred option is to establish agreements with the landowner in these situations but if they delegate this to contractors, we will amend agreements to suit and expect contractors to attend an induction session.

Te Korowai will seek evidence from the landowner that this permission has been formally delegated to contractors. Te Korowai will also allocate one of its field team as a liaison person to work with these groups to ensure quality control and management to the Te Korowai eradication methodology, help with data collection, offer reminders when to do the various bits of work and undertake audits.

Community partnerships
Te Korowai will also build on the existing community group networks on the island. For example, the Auckland Council funded Ratbusters network already has indicated a willingness to use their networks to provide information and assist with making introductions for the field team. Forest and Bird are also assisting with their island networks, as are Auckland Council and many landowners and other community groups.

Other opportunities to assist include help with the biodiversity indicator species monitoring programme, the social survey, volunteer muck-in days, and reporting mustelid sightings or sprung or damaged traps to the 0800 BIRDSONG number.

Te Korowai is also establishing a Register of Contractors to assist with trap and trail camera installation and checking, biodiversity monitoring and the supply of rabbit meat. Other tasks may also be contracted, or assistance required with them as the project proceeds. Preference will be given to locally based people.

As identified in Rule 1 (section 3.4) Te Korowai will also work on ITO unit standard based training programme to build local capacity for field crew. A number of meetings have been held including with a training provider and assessor. There is significant support for this on Waiheke. On-island training opportunities leading to jobs are a core value for Te Korowai. This walk alongside learning by doing programme will commence in early 2020 once the Te Korowai field team has had time to get sufficient experience with running the eradication that they feel confident enough to train others.

4.2 A lean efficient machine - Project team structure and management

An efficient and cost-effective system is a key part of the mustelid eradication programme. Although Te Korowai will not compromise the operation by cutting costs, it will make use of any opportunities to reduce costs, e.g. utilising as many of the existing traps out on the ground now as possible, using existing tracks, road reserves and access ways to install the trap network, enlisting the help of volunteers such as sports clubs and others to work with the field crew to get traps out on the ground.

Te Korowai will also manage the programme in such a way that it has a clear and transparent process of recording costs, including overhead and establishment costs. In kind contributions such as sponsored vehicles and volunteer time are also often overlooked and in the case of volunteer time under-costed.
The project team consists of the following:

The project team consists of the following:

- 1x Project Director – oversight management including finances, partner relationships, project milestones, sponsorship and funding.
- 1x Engagement Manager – community relationships and managing project communications, including media and education.
- 1x Operations Manager – mustelid eradication planning and implementation, field staff employment, HSE, rodent pilot project development and implementation, operational project reporting, gear purchasing.
- 1**x Field Team Manager – establishing and managing mustelid programme on the

ground, landowner meetings and agreements, field team supervision, implementing rodent pilot, data management co-ordination, work programmes.

- 2** Field Crew – landowner meetings and agreements, logistics and gear management, all field work, implementation

** The field team manager and 2 field crew are fulltime time staff positions. Additional field crew will be required for various tasks including trap installation, management during hump periods (e.g. pre-baiting and months where there are 4 checks/month, installation and management of trail cameras). These people will be contractors to reduce Te Korowai overhead costs and provide more flexible working opportunities within the Waiheke community. They will be selected from the Register of Contractors on an as and when required basis.

Te Korowai is working closely with project partners such as Auckland Council, the Department of Conservation and Forest and Bird and will have Partnership Agreements or Memorandums of Understanding with each, to ensure that both parties aspirations are outlined, and that the Te Korowai eradication methodology is adhered too in relation to land parcels managed by these partners.

4.3 Data management

A data collection and management system is now in place based on the data summary in Appendix 6. It is a system custom designed for Te Korowai based on a system established by Scott Sambell of Ethos Environmental for managing a 230 hectare ecosanctuary on Aotea (Great Barrier Island). It uses ESRI ArcGIS Online through Eagle Technology. It is cloud based and provides a highly efficient, accurate and integrated management system (refer Figure 19 for a snapshot of the home screen).

The system is consistent with the intent of the PF2050 Predator Related Data Standard report. The system is compatible with TrapNZ, which is used by Auckland Council as well as Waiheke people involved in local stoat and rat control projects. In the interest of protecting landowner privacy and wishes some information such as landowner contact details, property access and any other sensitive information relating to properties is only be able to be accessed by Te Korowai personnel.

The system can produce graphic reports of progress integrating results and outcome monitoring. It will also be able to track trends and enable analysis of data relating to effectiveness of the various tools intended for use.

4.4 Maintaining consistently high standards

A consistently high standard of trapping and the use of other tools must always be maintained. In addition, good relationships with property owners must be upheld, based on open communication, respect for property rights and/or any landowner conditions.
The delivery team will consist of a mix of experienced people and people less experienced or new to this work. Those less experienced will be 'buddied up' with a more experienced person until there is confidence that this person is adequately skilled and reliable enough to maintain eradication standards. The majority will be staff, but some will also be volunteers, contractors and landowners.

Te Korowai will establish an induction programme for all personnel to both ensure understanding and support for the eradication methodology as well as for the health and safety principles. A summary of the key aspects of the project is contained in a Field Work Requirements document (Appendix 3).
A Mustelid Management Manual (MMM) is part of the Operational Plan. It builds on the trap guide and field sign manual established for the Hauraki Gulf Conservation Trust (HGCT) stoat pilot programme undertaken on Waiheke in 2017. This will be the guiding document to ensure the field team work to the Te Korowai eradication methodology and will form the basis of staff inductions and training programmes for all personnel.

Te Korowai also recognizes the considerable knowledge and experience of local people currently involved with stoat control work and the value this provides for learning for its field team as well as for the

wider project. With the support of these people, their experience will also be built into training programmes and the MMM.

The MMM will be a living document that will be updated using an adaptive management, learning by doing approach as the eradication project proceeds. This approach will allow innovation and research to be progressively incorporated and 'localise' how to work to best suit Waiheke conditions. Adaptations will need to be approved by the Te Korowai Operations Manager prior to being undertaken to ensure a consistent methodical approach and ensure all changes are captured in the data management system and communicated to all personnel and landowners where this is appropriate.

Te Korowai will also have weekly reviews with its field team to review and learn from problems or challenges experienced. The team will also have radios and cell phones so that those issues, which can be resolved in the field, are done so immediately to avoid the added cost of repeat visits. Regular team meetings, liaison with landowners and peer review by the Te Korowai management team will also be undertaken to ensure that consistently high standards are being met.
The Field Team Manager will establish a work programme for each week of work from a more comprehensive programme calendar. The weekly work programme is where the 'devil in the detail' will be – what bait, what lures, what problems to resolve etc.

4.5 Communications

Most of Waiheke has cell phone reception but there are areas where this is patchy or out of coverage. Cell phones will be the primary means of communication. A specific design of rugged phone has been purchased by Te Korowai for the field team which has a built in emergency system, GPS, and is also used to record all information for the data management system.

The Te Korowai field team will also have Personal Locator Beacons (PLB's) with them at all times. They will be required to log in and out with the Te Korowai office when they enter and leave each communication challenged location.

Initial field work undertaken by the field team during the set-up phase will identify areas where radio and cell phone coverage is incomplete or non-existent. This information will be included in the HSE plan and in inductions for staff, volunteers and contractors.

4.6 Transportation

Vehicles will generally be provided by Te Korowai for operational delivery work. The use of vehicles is outlined in the Te Korowai vehicle policy. In addition to having drivers' licences, staff and contractors may be required to have a suitable 4WD training certificate as required in the Te Korowai vehicle policy. The certificate must be current and have been obtained no more than 2 years prior to undertaking Te Korowai work. Other driving requirements such as driving with trailers, boat use, or ATV use are outlined in the Te Korowai vehicle policy.

4.7 Health and Safety

Te Korowai o Waiheke is committed to the health, safety and wellbeing of its all employees, volunteers and contractors. The Te Korowai Health, Safety and Environment (HSE) Plan is a detailed document covering all aspects of HSE relevant to the project work and is a field handbook for all personnel.
All people who are employed by, or volunteer for Te Korowai will be required to adhere to this plan. Te Korowai O Waiheke will also be engaging contractors for specific activities. All contractors without exception must either have their own HSE plan that is compatible with the Te Korowai Plan or agree to work to the Te Korowai Plan. Further information on HSE management is detailed in the Te Korowai HSE plan

Figure 24: Safety is everyone's business.
Source: https://www.natroad.co.nz/Category?Action=View&Category_id=149

5. TIMING OF THE ERADICATION STAGES

Figure 25: Waiheke coastal forest. Source: http://www.waihekegulfnews.co.nz/te-matuku-story-country-calendar/

(Please refer to Appendix 7: Operational planning calendar)

5.1 When will you start?

- Refer Appendix 7 Operational Planning Calendars.

This project has been in motion for several years – first as a community vision and then with the stoat pilot project by the Hauraki Gulf Conservation Trust in 2017. Following the formation of the Waiheke Collective, acquisition of funding, and establishment of the Te Korowai o Waiheke Trust in 2018, work has amplified in 2019 for an operational programme to start in early 2020.

- **Early 2019:** Establishing a project team, support systems (including financial, data management, office and plant, vehicles and equipment) as well as governance and project partner protocols and management. Ongoing community engagement and communications has been a key activity, as has reviewing all available information on mustelid control and eradication in New Zealand and the creation of a draft eradication plan.

- **September - December 2019:** Increased community engagement, and landowner permission to install and run traps on their land as well as trap installation. All existing DOC 200 traps checked, recorded and those in or close to (i.e. within 6ha block locations) incorporated into the eradication network. Trap installation from early November through to December 20th.

- **January 2020:** Two pre-baiting runs (with all traps inactive). Because maximising stoat encounters is desired, all traps will be pre-baited twice before they become active. This encourages mustelids to investigate traps and get used to them in their environment with no consequences other than beginning to associate them with food. It's been done on other eradications and helped maximise catch rates. Although there are reasonably regular food supplies for mustelids around all year round on Waiheke (e.g. rabbits, rodents, birds, coastal carrion) these natural food supplies are likely to be abundant when the eradication programme starts. In the Auckland Region, on average there is a 5x increase in the number of stoats (mostly young) caught in December-January than over winter months (Veale 2013a). There is often variation when these dispersal events happen and how long they go for. The Te Korowai trap opening is at the tail end of the 2019/20 season because of the time required to get all the systems and planning in place to manage and implement the project.

- **February 2020:** Traps will become active. The trapping programme will continue through at least two full breeding seasons with an indicative end date of December 20th. The end date for the eradication phase is indicative because it is dependent on proof of eradication monitoring results (section 3.13).

5.2 How often will traps be serviced?

More regularly at the start and during breeding seasons (Appendix 7). Pre-baiting runs in January will provide a clear indication of the time required to service all the traps on the island. The final trapping schedule will be confirmed after the first pre-baiting. The quality of the trapping effort during the initial knockdown will have a large influence on the success of the overall eradication operation.

Initially more checks (e.g. weekly for February 2020) will be undertaken so the team can make sure all the traps are working properly and to help the field team familiarize themselves with trap runs (allocating particular runs to each of the field team allows them to build detailed knowledge of particular areas and establish good relationships with landowners).

It's also the time that naïve juveniles are out and about so it's an ideal time to catch them. Fresh rabbit bait is the most effective. In summer months this needs to be changed regularly (a maximum of 4-5-day intervals between each re-bait) because it will not remain palatable in the hot, humid conditions.

5.3 How long will the eradication project run for?

The timing and length of the eradication period is designed to cover two breeding cycles to maximise getting all females and young. An extended, intensive island wide period of trapping maximises the chances of encounters with traps but it is imperative to keep traps well maintained so that stoats are killed on their first experience of triggering a trap encounter with a trap.

- August - December 2019: Five months of landowner liaison and trap installation, pre eradication monitoring.

- January 2020: One month pre baiting (traps closed).

- February 2020 - December 2021: 23 months eradication (traps open).

- January 2022 - January 2024: 24-31 months post eradication monitoring and biosecurity management*****.
  - ****If the monitoring programme (Section 7) provides a very high degree of confidence that mustelids have been eradicated earlier than 23 months and a robust biosecurity programme is in place, post eradication monitoring may start sooner.

Refer Appendix 7 for detailed calendar.

5.4 Reviewing effectiveness and timing

Throughout the programme several reviews will be undertaken by the Operations Manager and industry experienced external reviewers. As it relates to timing they will occur as follows:

- Early Dec 2019 - status of landowner approvals, traps installed, operational plan, personnel review (do we have enough) amendments if required.

- Mid-January 2020 – review of trap placement post first pre-bait, do some trap locations need to be physically marked on ground, condition of lure and bait in summer conditions, status of remote monitoring system.

- Mid-February 2020 – review of first two baitings, post trap opening.

- May 2020 – whole eradication review and then likely quarterly reviews through to December 2021.

6. MAINTENANCE AND BIOSECURITY PHASE

Figure 26: Waterborne stoat family. Source: Richard Steel photo in Veale 2013

6.1 Has the eradication been successful?

A maintenance and biosecurity phase follows the intense eradication period and is where a reduced intensity of work is done to determine whether all the target species has been removed. The focus changes from one of catching animals to one of monitoring to determine all animals have been removed and all practicable steps have been taken to prevent them from coming back.

The 24-month period (section 5.3) is based on the DOC system of waiting for two years post an eradication to determine success and is principally focused on rodents, so it needs to be treated with caution when applied to stoats. However, the fact that it is also linked to breeding and recovery patterns is relevant. The two-year period is specifically related to how long it takes for a species targeted for eradication to recover through a couple of breeding seasons and recognizes the challenges of detecting animals when they have been reduced to very low and potentially undetectable levels.

Timing needs to consider the scenario-modeling work undertaken by Choquenot et al. Although their work was based on recolonisation scenarios it equally applies to an undetected survivor and found that timing and gender are everything:

- A lone pregnant female will reproduce between <1 month (if she arrives in September or October), and 11 months (if she arrives in December). In the absence of a mature male to refertilise the colonising female or her female offspring, the population will remain at nine or less (assuming a maximum litter size of eight) from October/ November in the year of colonisation, until all surviving females are mated and give birth 2 years later. This suggests that an establishing population derived from a single colonising female will remain below 10 individuals for 25 to 35 months, depending on which month colonisation takes place.

- Once the establishing stoat population contains mature males as well as females, incremental increases in density would be more rapid, making detection of at least one individual easier. However, once the population goes into a phase of rapid growth, it is likely to prove more difficult to eliminate than when it is restricted to less than 9 individuals, particularly if dispersal of individuals is associated with rapid growth in numbers.

- If stoats are deliberately released into a previously unoccupied area, there is a greater chance that both females and males will be liberated. Under these conditions, colonising females and their female offspring can be mated in October/November of the year of colonisation, and rapid population growth is likely from year two on, assuming enough food resources. If a single male/female pair was released, the population would consist of those two individuals for <1 month if released in September or October, to 11 months if released in December.

- The population would then consist of 10 or fewer individuals until the subsequent October/November (13 months for a September/October release, to 23 months for a December release), before entering a phase of rapid population growth. Again, while detection during the initial establishment phase will be more difficult than it will be once the population begins to increase, elimination of the population during that phase will be more achievable.

Based on the above, the exact time when it can be declared that Waiheke is stoat free is therefore dependent on when the last individual has been found and confirmed and then on any reinvading animals. The two-year system on Waiheke will be used as the minimum time period.

6.2 What tools will be used to check that all mustelids are gone?

In addition to the minimum two-year period DNA genetic sampling will be utilised (to differentiate between Waiheke population and reinvading individuals), predator dogs, key areas of the trap network and camera's along with field observations to determine success.

Andrew Veale's landmark genetic work on Waiheke stoats identified that this population is genetically very isolated with extremely low connectivity to any other population. Of all islands in New Zealand with an extant (surviving) stoat population, Waiheke Island is likely to have the lowest reinvasion rate, given its distance offshore (Figure 10) and the migration estimates from this genetic study (Veale 2013a).

This is good news for Waiheke but when considerable investment has gone into an eradication programme and stoats have been recorded arriving on islands such as the Orkneys in Scotland in hay (Broome pers comm.), Te Korowai will still plan the potential for reinvasion events into its biosecurity programme.

There is some evidence that during other stoat eradications invasions have occurred, but individuals have not established because of the presence of an already well established population. Thus, it is worth being prepared for the worst on Waiheke (i.e. a higher rate of reinvasion than might be expected) at least initially and building this into the maintenance and biosecurity phase (section 6).

More work is still required to determine how many of the network traps will remain operational during the post eradication phase. Post eradication biosecurity maintenance networks on other large islands in the Hauraki Gulf such as Rangitoto/Motutapu Island will be reviewed to provide insights for Waiheke.

There are some key sites on Waiheke where network traps will become maintenance and biosecurity monitoring and reinvasion management devices. The outcome monitoring programme will be of assistance here – revealing which traps caught most stoats – these traps will remain in operation during the post eradication because there will be something special about these sites that are highly attractive - they will continue to catch reinvaders, too.

Swimming reinvaders are also more likely to get ashore on the eastern coast given the stepping-stone islands and proximity from the mainland. The biosecurity maintenance grid will retain productive traps on ridges within 500 – 1,000m of this shoreline. Other potential coastal sites include:

- Matiatia Wharf
- Orapiu Wharf
- Kennedy Point barge terminal and marina
- Man o War Bay wharf (likely to become an additional ferry wharf)
- Waiheke airfield
- Main beaches (also popular anchorages)
- Sealink freight depot
- Waste transfer station
- A representative range of habitats
- Any landing points where farms or other landowners/contractors (e.g. for development site ground protection/erosion/sediment management, any straw bale houses) may use barges or other means to bring hay and freight ashore.

This programme will be confirmed with assistance and potentially also physical checks from/by the Auckland Council island biosecurity team by early 2020 including the schedule of checks and predator dog runs. The budget for this phase of the project allows for three island wide dog checks as well as two reinvasion event dog checks based on a 900 hectare search each time.

6.3 Biosecurity

The key premise of biosecurity for this programme is the establishment of systems to prevent mustelids getting to Waiheke in tandem with building knowledge, understanding and capacity in the local community about the importance of biosecurity. Experience from many other eradication programmes is that biosecurity work must be part of a project from day one, so that when a successful eradication has been completed biosecurity is embedded into the whole community's way of doing things.

The mustelid biosecurity plan will be expanded on by mid-2020, following significant revision of biosecurity in the Hauraki Gulf by Auckland Council.
For the most part incursion prevention will be the responsibility of the Pest Free Hauraki Gulf programme, while detection and incursion response on Waiheke is the responsibility of Te Korowai:

- Parties will co-design a seamless biosecurity programme to protect the mustelid and future rat eradication on Waiheke, as one of the island specific plans that fit within that strategy. The programme will build on the current Auckland Council led programme of checking houses, high risk cargo etc for possums and add in stoats.
- Te Korowai will design a detection and incursion response plan and run detection and incursion response systems during the eradication programme. It is anticipated that these systems will shift to Pest Free Hauraki Gulf once eradication status has been achieved.

- Pest Free Hauraki Gulf will mitigate incursion risk (and advocacy to prevent incursion) from the mainland/other islands.

- Mitigating incursion risk (and advocacy to prevent incursion) through recreational boaties will be worked on in partnership by both entities, building on the Pest Free Hauraki Gulf biosecurity programme.

- Work that falls within the Hauraki Gulf Controlled Area Notice under the Auckland Council Regional Pest Management Plan will be carried out by Auckland Council.

6.3.1 How might stoats come back? - Reinvasion pathways

Figure 27 identifies the various reinvasion or incursion pathways to Waiheke. Swimming is the most likely means, but the potential is low. Stoats are the most likely mustelid swimmers. Stoats take to the water naturally without hesitation and can swim considerable distances when they do so. A common thread of the observations is that when stoats arrive on a beach after swimming (even considerable distances) they rapidly run up the beach and into cover (Veale 2013).

Experience from the Auckland Council & DOC Great Barrier Island stoat response in January 2019 also signals the value of extending potential source points beyond the Auckland Region. This investigation found that two barges had recently arrived from Coromandel (one with brewery supplies and one with hay) (Harrison M. pers. comm.) Education at key wharf locations is vital as is the identification of all barge operators likely to come to Waiheke and all operations and landowners likely to use barges so they can take proactive steps to prevent mustelids come with any high risk loads such as hay.

Figure 27: Reinvasion/incursion pathways and mitigation measures

Pathway	Risk	Pathway likelihood	Explanation	Mitigation measures
Swimming Includes direct swim, assisted (e.g. on storm debris), using stepping-stone islands, or a population establishes on Ponui as closest known island (1.3km away) that has had stoats but have not been recorded since mid-1990's - currently	Possible	Most likely	Swimming is the most common form of mustelid (stoats are the only ones recorded in NZ) incursions in NZ hence most likely ranking for Waiheke. 1-3km swims are common but 5km was the Kapiti distance so this cannot be discounted. App. 4 shows swimming distances to Waiheke. The closest direct mainland point is 5.1km. Other pathways are via stepping-stone islands. Because of the distance from the mainland, low possibility that stoats may be on Ponui & predator free status of closest islands risk is set as possible	Control devices are present on all stepping -stone islands and key mainland points & are maintained on a regular basis – add these locations to App 4 map Regular contact is maintained with Ponui landowners & kiwi researchers & TKOW to advise any stoat activity. TKOW prepared to assist Ponui if any occur Ask support from Ponui landowners to set up intensive surveillance (camera traps and detector dog checks) to help inform TKOW project. TKOW will fund this Majority of surrounding islands are predator free with annual predator dog check undertaken
Commercial ferry/barge/ water taxi Includes ferry into Orapiu, Matiatia or Man o War (Man o War not operational yet) or barge (including vehicles, freight, farm supplies) into Kennedy Point terminal, water taxi can go to any point (doesn't need a wharf).	Least likely	Least likely	Least likelihood risk & pathway for Waiheke because this is not a common form of recorded arrival, most gear on barges is securely packaged or enclosed in trucks. Ferry passengers' low risk as all walk on and cannot take heavy items. Potential vectors that stoats could hide in such as hay are rarely brought to Waiheke (generally made on island) and when it is will generally be on chartered barges versus public ones. Small amounts of hay could be brought on by small block owners in vehicles on barge.	Sealink, Fullers and Water taxi have Pest Free Warrants – biosecurity risks are managed by Pest Free Hauraki Gulf. Owners and operators will be provided with advocacy and biosecurity information about TKOW Advocacy programme by Pest Free Hauraki Gulf at points of departure including checks of all freight and vehicles with predator dogs in place by .... Permanent traps at departure and arrival points for Fullers and Sealink. On island maintained by TKOW, on mainland by Auckland Council

Risk and Likelihood keys: (i.e. the main potential pathways and level of risk a mustelid (primarily a stoat) could get to Waiheke. Least likely is based on the 'never say never' principle -In an eradication it always pays to plan for the unexpected.

Pathway	Risk	Pathway likelihood	Explanation	Mitigation measures
Barge other Barges are chartered for delivery 'straight to the door' – wharf construction & repair, house removal or arrival, farm machinery, supplies (e.g. hay, metal), heavy freight, livestock – can go to any point where there is a beach or boat ramp or wharf, barges also service mussel farms at Te Matuku and Man o War Bays. This includes Auckland based and out of Auckland based barges (barge movements are reasonably common from Coromandel)	Possible	Possible	Possible for both because more likelihood of freight coming from places where stoats could be resident, e.g. rural areas, old house relocated from mainland, mussel barges unlikely as open boats with minimal hiding places Hay brought to island for various uses – identify what these are, who brings them, when and where from .	All commercial barges are required to have Pest Free Warrants – biosecurity risks are managed by Pest Free Hauraki Gulf. Owners and operators will be provided with advocacy and biosecurity information about TKOW All farms, vineyards etc. will be provided with similar information. All above will be asked to have a predator dog check prior to the moving of any potentially risky items e.g. hay, old house relocations Work with landowners, commercial operators to inform of risk and provide advice on how to manage Get information on any landing points/sources/uses where farms or other landowners/contractors (e.g. for development site ground protection/erosion/sediment management, any straw bale houses) may use barges or other means to bring hay and freight ashore

Pathway	Risk	Pathway likelihood	Explanation	Mitigation measures
Aircraft (commercial or private) Small planes into Waiheke airfield, helicopters and seaplane can go to any point, top dressing generally done by helicopter	Least likely	Least likely	Least likely for both, airfield only takes light aircraft, helicopters are an unlikely vector	All commercial barges are required to have Pest Free Warrants – biosecurity risks are managed by Pest Free Hauraki Gulf. Owners and operators will be provided with advocacy and biosecurity information about TKOW Permanent traps will be maintained at the airfield. Airfield owner is Seaplane company which TKOW has a good working relationship with
Arrival by privately owned (recreational or locals') boat Can go to any point, spike in use from October to April with peak over Xmas period, Sealegs and amphibious style boats are popular with locals	Least likely	Least likely	Least likely for both as just not a known pathway, most private boats not used to carry risky freight. You'd probably known if there was a mustelid onboard	TKOW and Pest Free Hauraki Gulf will work in partnership to identify all risks and have various means to get message out and reinforce it especially over summer months
Deliberate release or 'pet' brought to island	Possible	Least likely	This has happened with ferrets being taken to a beach on Great Barrier. It's a possibility but a least likely pathway given that arrival by commercial means would be stopped by operators, private means is possible but remote	TKOW and Pest Free Hauraki Gulf will work in partnership to identify all risks and have various means to get message out and reinforce it Auckland Council RPMP 2019-2029 states that within the Hauraki Gulf Controlled Area "no person shall move or allow to be moved any mustelid to or within the Area

Ferrets do swim on occasion (Moors & Lavers 1981) but they have never established populations on any New Zealand offshore islands (King 2005). Weasels have not been recorded swimming in New Zealand.

Ponui is the closest island that stoats could swim from (Figure 10) but no mustelids (all occurrences have been of stoats) have been seen or trapped since the mid 1990's nor have any been detected during kiwi monitoring, or in Auckland Council trapping (Veale 2013). They have been caught on the island in the past and have been observed swimming ashore about 55 years ago. Mrs. George Chamberlain related the following story to members of her family:

"She was sitting on the veranda of the house looking out from north Ponui across to Waiheke Island. It was a flat calm day in summer with no waves. She saw some little wakes coming towards the island from some distance offshore. At first, she assumed that this was a large fish swimming at the surface, but as it came closer, she realised that it was in fact a stoat. It came from the direction of Waiheke Island (1.2 km away), and it was her assumption that this is where it originated. She saw it clearly in the water and when it arrived at the shore, it ran up the beach into the forest (Veale 2013)".

6.3.2 Estimating reinvasion rates

Estimating reinvasion rates has been the subject of considerable research in New Zealand but it's challenging. Improving the estimate for invasion rates on larger islands such as Waiheke is very difficult for several reasons:

- Individual stoats may not enter traps immediately (or ever). Detection probability for stoats changes according to prey density); therefore, when a stoat arrives on an island previously uninhabited by stoats, the high prey density decreases detection probability. There have been several cases where stoats have been known to be present on an island – through sightings, scat and footprints; however, they have avoided traps for several months – possibly years (as on Maud, Kapiti and Secretary Islands);
- Capturing multiple stoats on an island, even a year apart, may not necessarily indicate multiple incursions. Female stoats are impregnated before leaving the nest and so are always able to establish new populations.
- Regular comprehensive (and expensive) trapping over long periods would be required be catch all stoats that do arrive on an island (Veale 2012).

Veale's 2013 work on stoat population genetics found that the Waiheke population had minimal connectivity to all other [Auckland Region] populations and had a reduced genetic diversity due to founder effects.

Veale also suggests that based on the furthest recorded incursion of a stoat (5.2km to Kapiti Island) and the fact that only 1 stoat made this crossing, that direct invasion via swimming to Waiheke from the mainland is thus conceivable but will occur at extremely low rates, which is reflected by genetic data. Veale concludes that if stoats were eradicated from Waiheke Island, it is likely that the chance of reinvasion would be minimal. Notwithstan

6.3.3 Prevention

Advocacy and awareness – building partnerships for the future

Figure 27 also identifies mitigation measures to prevent reinvasions occurring. Te Korowai will begin the advocacy process to embed these measures before the end of 2019 both on and off the island. An integrated approach is essential with agencies such as Auckland Council and DOC as well as many other parties such as transport and tourism operators.

Embedding the importance of prevention and how it can be best managed by making it everyone's responsibility is a vital part of the Te Korowai community engagement programme. The Te Korowai programme is contingent on building a strong and enduring support base in the community both on and off island.

Statutory measures

There are also statutory measures to prevent the re-establishment of mustelids on Waiheke. In 1999 the then Auckland Regional Council declared the Hauraki

Gulf and all its islands a Controlled Area (refer map in Appendix) under the Biosecurity Act (Auckland Council 2013).

The Auckland Council Regional Pest Management Plan 2019-2029 has established three rules to support mustelid free islands within the Controlled Area:

- 7.1.2.7.1 No person shall move or allow to be moved any mustelid to or within the Hauraki Gulf Controlled Area. The purpose of rule 7.1.2.7.1 is to specify the circumstances in which the pest may be communicated, released, or otherwise spread.

- 7.1.2.7.2 All commercial transport operators moving goods or people to or among Hauraki Gulf Islands must attain and maintain Pest Free Warrant accreditation.

- 7.1.2.7.3 All persons intending to move a building to or among islands in the Hauraki Gulf Controlled Area must notify Auckland Council at least ten working days prior to movement, to arrange inspection and approval by Auckland Council. The purpose of rule 7.1.2.7.1 is to specify the circumstances in which the pest may be communicated, released, or otherwise spread Act (Auckland Council 2013).

Auckland Council also runs the Treasure Islands/ Pest Free Hauraki Gulf awareness and behaviour change programme in the Te Tikapa Moana/Hauraki Gulf in partnership with DOC, to encourage voluntary behaviour change by people living in or visiting the Hauraki Gulf.

As part of the Treasure Islands programme commercial transport operators can voluntarily apply for and attain a "Pest-Free Warrant" which certifies that steps have been taken by that operator to reduce the risk of accidentally transporting pests to islands. Over 40 operators have a Pest-Free Warrant and, combined with extensive networks of on-islands traps and other biosecurity devices, this programme has been remarkably successful at protecting the islands of the gulf (Auckland Council 2013).

Hauraki Gulf Controlled Area Pathway Management Plan

The Auckland Council Biosecurity Team is presently preparing a Hauraki Gulf Controlled Area Management Plan. This will refresh and replace the previous Hauraki Gulf Controlled Area Management Plan 2009.

This will outline and integrate the biosecurity and pest prevention undertaken for the Hauraki Gulf under the Biosecurity Act. Waiheke Island, as are all other Hauraki Gulf Islands, is protected under this Controlled Area Notice, with regard to the movement of specified pests to, from, on and between the islands of the Gulf.

6.3.4 Other biosecurity considerations

Te Korowai will lead by example. In addition to taking all practicable steps to prevent mustelids re-establishing Te Korowai will ensure that none of its actions present any other biosecurity risks. Waiheke is free of myrtle rust and more significant kauri dieback. Other biosecurity challenges such as plague skinks, Argentine and Darwin ants pose significant threats to native biodiversity if they become widely established.

The Te Korowai Biosecurity and Community Engagement Plans will support Auckland Council advocacy and biosecurity procedures to prevent the establishment and/or spread of these and any other identified species. Additionally, the field staff induction programme will contain biosecurity identification and management procedures that support this.

7. MONITORING AND PROGRAMME EVALUATION

Figure 28: Pair of Kākā. Source: http://www.artbythesea.co.nz/Craig%20Platt/Kākācommission.jpg

7.1 How will information required to measure progress and success be collected?

Various systems of data collection and monitoring will be used. The primary data collection system will be the database as depicted in Figure 19. The stoat eradication tab contains fields to collect trap data (refer Appendix 6). An outcome and biodiversity monitoring tab will be added to collect information as summarised in section 7.3. This outcome monitoring will be undertaken before during and after the project to provide baselines and grow knowledge over time.

Te Korowai will have a paperless data management system that allows the seamless transfer of information between the field and the Te Korowai office. These systems largely rely on GPS and cellular technology.

Te Korowai will also install remotely triggered wireless devices on at least 50% of traps. These will advise when traps have been triggered. The decision on which traps to install these on will be made on the basis of where there is high rodent and/or hedgehog activity. Some devices may also be installed where traps are in remote locations.

The final decision on where these devices will be installed will be made by the Te Korowai Operations Manager informed by the field team once they are more familiar with the network.

Te Korowai will present regular updates to its funders and the local community in the form of newsletters, Te Korowai website, on social media, in presentations, open days, meetings and events and in quarterly and annual reports.

7.2 Results monitoring

Results monitoring is directly related to analysis of the work being done to remove a target species to assess its effectiveness over time. Ideally it should (as will happen at Waiheke) start prior to any eradication operation.

It is planned (refer Appendix 7) that the eradication programme to be undertaken between January 2020-December 2021). Experience from other operations is that most mustelid captures occur in the first 6 or so months in areas that have not been trapped before. On Waiheke un-trapped areas covers around 70% of the island. Capture patterns will be influenced by seasonality, availability of natural food supplies and breeding as well as the quality of trap management.

Several indices will be used to determine the success or otherwise of the eradication programme and will include:

- The number of adult and juvenile mustelids trapped over time.
- The ratio of male-to-female mustelids.
- Analysis of which traps are consistently catching (it is likely that a small number of traps are likely to catch most mustelids - these sites will become important for monitoring because they are the places these animals likely favour the most.
- DNA analysis.
- Diet.
- Number and species of other animals (e.g. rodents, hedgehogs, rabbits) caught.
- Predator dog checks.
- Rabbit spotlight counts/McLean scale monitoring.
- Rodent indexing (opportunities for citizen science through RatBusters etc.).
- Trail cameras.

Due to the varying home ranges of male and female stoats the sex ratio of male to female captures should provide a good indication of whether the whole population on Waiheke is exposed to the trapping programme. Ideally at least 50% of all adult captures should be female. If the converse is true and more adult males are being caught than adult females, then it is likely that some female home ranges may not overlap with trap lines (McMurtrie 2008). The same should apply equally to ferrets and weasels. However, given the 200m spacing between traps and that there will be at least five traps in any 30-hectare area, this lack of overlap may not be an issue on Waiheke.

All mustelids captured will be bagged, tagged and frozen for DNA and diet work.

In the case of ferrets and weasels this will be new and therefore valuable information. For stoats, although Waiheke stoats are genetically distinct from both the pre-eradication Rangitoto/Motutapu Island's population [being the last known permanent population on an island close to Waiheke], and the mainland population (Veale 2013a); continuing to genetically describe Waiheke's stoats and gathering new information on ferrets and weasels is valuable for two reasons:

- to close kin mark recapture to assess the number of survivors.
- to identify if there are any invaders from elsewhere (Veale pers. comm. 2019).

Diet analysis will also be useful to provide information on what mustelids are eating and the specific impact they are having on Waiheke. It will also provide information to assist with timing of different baits and lures in traps.

Predator dog visits will occur at least three times over the trapping programme and as part of the Den-Co-Fume trial if this is approved. Searches will be

conducted on and off the stoat track network. All sign or indication of stoat presence while using dogs will be recorded using GPS, and the location will be checked again on subsequent trap checks. GPS records will also record all routes covered with a dog.

Te Korowai will also work with Auckland Council and the local community to undertake rabbit counts and rodent indexing (e.g. percentage residual trap indexes (RTI), chew cards, wax tags) pre during and after the mustelid programme so any changes in numbers of rabbits and rodents can be ascertained as a result of mustelid removal. Trail cameras will be used to index relative abundances and locations of mustelids.

7.3 Outcome monitoring

Outcome monitoring relates to the monitoring of species expected to benefit from an eradication programme. Outcome monitoring for stoat control and/or eradication has been undertaken for many species and a wealth of information is readily available documenting the negative impact stoats have on New Zealand's native fauna (King C.M. ed. 2005). Limited information is available for the impacts of weasels and ferrets on native species.

Outcome monitoring offers many opportunities to involve the community. Te Korowai is committed to building a strong element of citizen science into the biodiversity outcome monitoring programme. Waiheke is fortunate that historic data exists for several native indicator species as a result of work undertaken by Auckland Council and conservation groups. Reporting of penguin burrows and kākā nests to the Hauraki Islands Forest & Bird Branch and Waiheke Native Bird Rescue is an existing and ongoing project, and these organisations have developed capacity to respond and implement predator protection around nesting taonga species. Outcome monitoring will build on and align with this work, and provide baseline measurements, and measures over time, for each of these species.

Te Korowai has established and is beginning to socialize the use the eBird app and ten indicator bird species. These species are:

- Kākāriki.
- Kereru.
- Korora (little blue penguin).
- North Island kākā.
- Oi (grey-faced petrel).
- Piwakawaka (NZ fantail).
- Ruru (morepork).
- Puweto (spotless crake).
- Tui.
- Tūturiwhatu (northern NZ dotterel).

The indicator species have been selected for their sensitivity to mustelids, because they are species familiar to the public and/or because they may reintroduce themselves from neighbouring islands once mustelids have been removed. The public will be encouraged to report sightings of new bird species previously unknown from Waiheke. Although this is an informal monitoring measure, an annual review will be done of data collected, particularly of stoat sensitive species, to assess any changes over time. Annual monitoring and reporting on eBird records will measure presence/absence of species and any changes in records of species each year (e.g. any new species recorded on the island).
The more formal outcome monitoring programme below has been designed with assistance from Shona Myers, an experienced field ecologist who is developing a biodiversity strategy for Waiheke, funded by Auckland Council. An outcome monitoring framework is summarised in Appendix 9.

7.3.1 Five-minute bird counts

Te Korowai will establish up to 50 bird count stations (each at least 200m apart and set up on a randomised point basis, marked by GPS) across representative habitat types on the island. Count stations will be established in all representative habitat types (coastal forest, inland forest, shrubland – also freshwater wetlands) within each management unit on the island, avoiding roads and tracks. During each five-minute count, terrestrial birds seen or heard within 100 metres of the stationary observer will be recorded. Counts will be undertaken between September to December each year. Counts must be in the same month each year.

The five-minute bird count technique (Dawson & Bull 1975) will provide repeatable indices of abundance. Counts need to be made by experienced observers at the same time of the year in conditions of little or no wind or rain.

The counts will provide data on all species present and will allow comparisons between years and with other counts in similar habitats in the Auckland region and New Zealand. The five-minute bird count methodology is set out in the DOC Inventory and monitoring toolbox: birds (Hartley & Greene 2012).

NB: The number of count stations set up can depend on community resources. Research on the results of the five-minute bird count methodology recommends that due to the high variation in bird counts, a high sample number is required. The DOC toolbox recommends that more than 200 counts will be needed to detect a 25% change. The proposed number of count stations for Waiheke is based on Landcare Research methodology for bird counts in Hamilton City (a similar size to Waiheke Island).

7.3.2 Database of key stoat sensitive species

A number of native fauna species on Waiheke are particularly sensitive to stoat predation. They include hole-nesting birds such as kākā, and ground or burrow nesting birds such as oi (grey-faced petrel) and korora (little blue penguin). Other vulnerable species on Waiheke include pāteke (brown teal), bittern, and banded rail.

A considerable amount of work has been undertaken within the local community to protect and monitor these species particularly kākā, oi and korora. Additionally, surveys with a specialised handler and dog have been undertaken in the last few years for oi and korora supported by Auckland Council and Forest and Bird. Te Korowai will undertake an annual kākā count as a citizen science based initiative.
Te Korowai wishes to build on this work. Sightings of these species along with locations of nests and burrows will be shared with the existing databases held by Forest and Bird and Native Bird Rescue. This information will be reviewed annually to determine any changes that could be attributed to the stoat eradication programme and analysed against historic data.

Te Korowai will support the coastal bird surveys undertaken by Dabchick NZ who have undertaken previous surveys. Detailed and thorough maps and reports exist from these surveys, which can be used as a basis to evaluate change.

Monitoring of stoat sensitive fauna species will include measurement and annual reporting of the following:

- Sightings.
- Locations of nests and burrows.
- Records of nesting success.
- Fledging success.

Te Korowai is also investigating what useful monitoring information may come out of work being done by Brendon Dunphy and his University of Auckland students who are presently investigating foraging, breeding, and physiology of seabirds (petrels, shearwaters, penguins, shags) within Auckland and beyond.

8. REFERENCES

Figure 29: Weasel family. Source: https://braid.org.nz/ecology/threats/predators/weasel/weasel-2/

Agnew T. et al. 2019. Pen testing the animal welfare performance of the BT200 kill trap within a 'baffled' wooden tunnel to kill stoats ZIP www.zip.org.nz

Alterio N. Et al. 1999. Trappability and densities of stoats *(Mustela erminea)* and ship rats (Rattus rattus) in a South Island Nothofagus forest, New Zealand. New Zealand Journal of Ecology 23(1): 95-100

Alterio, N.; Brown, K.; Moller, H. 1997. Secondary poisoning of mustelids in a New Zealand Nothofagus forest. Journal of Zoology 243: 863-869.

Anderson D. et al. 2014. Eradication or control to zero density on near-shore islands? Kararehe Kino Issue 23. Manaaki Whenua – Landcare Research

Anton V. et al. 2018. Monitoring the mammalian fauna of urban areas using remote cameras and citizen science. Journal of Urban Ecology 1–9

Anton V. et al. 2017. Evaluation of remote cameras for monitoring multiple invasive mammals in New Zealand. New Zealand Journal of Ecology 42(1): 74-79

Auckland Council 2017. Proposed regional pest management plan.

Bassett I.E. 2016. Treasure Islands: biosecurity in the Hauraki Gulf Marine Park. New Zealand Journal of Ecology 40(2): 250-26

Beaudoin A. & Ducatillon L. 2012. Training period report – Trapping analysis in Te Urewera National Park - June to July 2012. Department of Conservation.

Blair D. 2002. Field guide to mustelid trapping. Yellow-Eyed Penguin Trust, Dunedin.

Blackwell G.L. et al. 2003. The role of predators in ship rat and house mouse population eruptions: drivers or passengers? Oikos Volume 100 Issue 3: 601-613

Broome K. 2007. Island biosecurity as a pest management tactic in New Zealand. USDA National Wildlife Research Centre Symposia managing vertebrate invasive species.

Brown K. & Ward W. 2016. Animal pest field trial report for the efficiency of un-baited run-through trap tunnels versus baited trap boxes for killing stoats. Internal Report, Department of Conservation

Brown, K.; Elliott, G.; Innes, J.; Kemp, J. 2015: Ship rat, stoat and possum control on mainland New Zealand: an overview of techniques, successes and challenges. Department of Conservation, Wellington.

Brown K et al 2011. Kapiti Stoat incursion response review. Internal Report, Department of Conservation

Brown S. 2001. The behavioural responses of stoats *(Mustela erminea)* to trapping tunnels. A thesis submitted in partial fulfilment of the requirements for the Degree of Master of Science at Lincoln University

Burns, R. 2003. Northern Te Urewera Ecosystem Restoration Project Annual Reference Report 2002-2003. Department of Conservation Unpublished Report, East Coast Hawkes Bay Conservancy.

Butler, D. 2003. Rotoiti Nature Recovery Project Triennial Report July 1998 - June 2001. Department of Conservation Unpublished Report, Nelson/ Marlborough Conservancy

Byrom A. & Parkes J. 2013. Applying the seven rules for eradication to pest-free New Zealand. Kararehe Kino – Vertebrate Pest Research 21. Manaaki Whenua – Landcare Research.

Carson J. 2017. Desire can be deadly: Sex scent snares stoats in Nelson Lakes trap trial. https://www.stuff.co.nz/environment/88529360/desire-can-be-deadly-sex-scent-snares-stoats-in-nelson-lakes-trap-trial

Choquenot D. et al. 2001. Colonisation of new areas by stoats: time to establishment and requirements for detection. New Zealand Journal of Ecology 25(1): 83-88

Christie J.E. et al. 2009. Environmental predictors of stoat (Mustela erminea) and ship rat *(Rattus rattus)* capture success DOC Research and Development Series 305. Department of Conservation

Christie J.E. et al. 2006. Measuring stoat (Mustela erminea) and ship rat (Rattus rattus) capture success against micro-habitat factors. New Zealand Journal of Ecology 30(1): 43-51

Clayton R. I. 2011. Density estimates and detection models inform stoat (Mustela erminea) eradication on Resolution Island, New Zealand Pages 413-417 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). 2011. Island Invasives: eradication and management. IUCN, Gland, Switzerland

Clout M.N. & Russell J.C. 2006. The eradication of mammals from New Zealand islands. In Koike, F., Clout, M.N., Kawamichi, M., De Poorter, M. and Iwatsuki, K. (eds.), Assessment and Control of Biological Invasion Risks. Shoukadoh Book Sellers, Kyoto, Japan and the World Conservation Union (IUCN), Gland, Switzerland,

Crouchley D. 1994. Stoat control on Maud Island 1982-1993. Ecological Management 2, Department of Conservation

Cuthbert R. & Sommer E. 2002. Home range, territorial behaviour and habitat use of stoats (Mustela erminea) in a colony of Hutton's shearwater (Puffinus huttoni), New Zealand. New Zealand Journal of Zoology, 29:2, 149-160

Dawson D.G. & Bull P.C. 1975. Counting Birds in New Zealand Forests. Notornis Volume 22:2

Department of Conservation. 2017a. Great Island A24 stoat elimination project update 01. Internal Document

Department of Conservation. 2017b. Conserving Fiordland's biodiversity 1987-2015.

Department of Conservation. 2011a. Stoat control - kill trapping DOCDM-29448

Department of Conservation. 2011a. Ferret control - kill trapping DOCDM-29433

Dilks P. & Lawrence D. 2000. The use of poison eggs for the control of stoats. New Zealand Journal of Zoology, 27:3, 173-182.

Dilks P. J. et al. 1996. The effect of bait type, tunnel design, and trap position on stoat control operations for conservation management. New Zealand Journal of Zoology, Vol. 23: 295-306

Dowding J.E., Elliott M.J. & Murphy E.C. 2015. Scats and den contents as indicators of the diet of stoats (Mustela erminea) in the Tasman Valley, South Canterbury, New Zealand. New Zealand Journal of Zoology, 42:4, 270-282

Dowding J.E. & Murphy E.C. 1996. Predation of Northern New Zealand Dotterels (Charadrius obscurus aquilonius) by stoats. Short Note in Notornis 43

Duckworth J. et al. 2013. Sex pheromone attractants to improve the trapping and monitoring of mammal pests at low densities Kararehe Kino - Vertebrate Pest Research, Issue 22 – Manaaki Whenua –Manaaki Whenua – Landcare Research.

Eason C.T. et al. 2017. Trends in the development of mammalian pest control technology in New Zealand. NZ Journal of Ecology, Vol. 44:267-304. New Zealand Journal of Ecology (2014) 38(2): 177-188.

Eason C.T. et al. 2014. Toxicology and ecotoxicology of para-amino propiophenone (PAPP) – a new predator control tool for stoats and feral cats in New Zealand. New Zealand Journal of Ecology 38(2):177- 188

Edge K. et al. 2013. Eradicating stoats from Resolution Island, Fiordland: progress made and what to do next. PowerPoint Presentation –Manaaki Whenua – Landcare Research.

Edge K. A. et al. 2011. Eradicating stoats (Mustela erminea) and red deer (Cervus elaphus) off islands in Fiordland. Pages 166-171 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). 2011. Island Invasives: eradication and management. IUCN, Gland, Switzerland.

Elliott G. et al. 2010. Stoat invasion, eradication and re-invasion of islands in Fiordland. New Zealand Journal of Zoology Vol. 37, No. 1, March 2010, 1-12

Fitzgerald N, Innes J, Bartlam S 2017. Hamilton City biennial bird counts: 2004–2016. Landcare Research Contract Report LC2800.
Fitzgerald G et al 2005. Social acceptability of stoats and stoat control methods. Science for Conservation 253. Department of Conservation.

Garvey P. M. et al 2016. Dominant predator odour triggers caution and eavesdropping behaviour in a mammalian mesopredator. Behavioural Ecology and Sociobiology: Volume 70:4: 481-492

Garvey P. M. 2016. Interspecific competition and olfactory communication between New Zealand's invasive predators. A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Biology Sciences (Animal behaviour and conservation), The University of Auckland.

Gibb, J. A; Flux, J. E. C. 1973: Mammals. In: Williams, G. R. ed. The natural history of New Zealand. Wellington, A. H. and A W. Reed. p. 334-371

Gigliotti F. et al. 2009. Performance and humaneness of chloropicrin, phosphine and carbon monoxide as rabbit-warren fumigants. Wildlife Research: 36, 333–341

Gillies C. 2018. Interim DOC trail camera guide v1.0.2: Using camera traps to monitor feral cats and mustelids. Version: 1.0.2 Department of Conservation

Gillies C. Controlling mustelids for kiwi protection – some things to consider. Department of Conservation PowerPoint presentation.

Gillies C. 2010. Home ranges of introduced mammalian carnivores at Trounson Kauri Park, Northland, New Zealand. New Zealand Journal of Zoology, 34:4, 317-333

Gillies C.A. 2003. Six years of intensive pest mammal control at Trounson Kauri Park, a Department of Conservation "mainland island", June 1996—July 2002. New Zealand Journal of Zoology, 30:4, 399-420

Golding C. et al. 2005. Secretary Island Operational Plan: Part A - Stoat Eradication. Department of Conservation

Gormley 2019. Designing a suitable surveillance network for proving pest eradication: Miramar Peninsula case study. Manaaki Whenua Landcare Research for Predator Free Wellington

Glen A.S. et al. 2014. Eradicating multiple invasive species on inhabited islands: the next big step in island restoration? Journal of Biological Invasions (2013) 15:2589-2603

Glen A. et al 2013a. Camera traps for monitoring cat, stoat and hedgehog populations. Kararehe Kino – Vertebrate Pest Research Issue 22

Glen A. et al 2013b. Optimising camera traps for monitoring small mammals. PLoS ONE 8: e67940

Griffiths R. et al. 2014. Successful eradication of invasive vertebrates on Rangitoto and Motutapu Islands, New Zealand. Biological Invasions Volume 16:11

Griffiths R. et al. 2012. Rangitoto and Motutapu – A Starting Point for Future Vertebrate Pest Eradications on Inhabited Islands. Proceedings 25thVertebrate Pest Conference University of California.

Hartley L. & Greene T. 2012. Birds: Incomplete counts – Five-minute bird counts: Version 1.0 Department of Conservation

Haworth D. 2018. Weasel *(Mustela nivalis)* dynamics in South Island beech forests of the Maruia Valley. Research and Developments Series 355 Department of Conservation. http://www.formak.co.nz/pdfs/05-bird-count/bird-count-planning-instruction.pdf

Innes J. et al. 2010. Predation and other factors currently limiting New Zealand forest birds. New Zealand Journal of Ecology (2010) 34(1): 86-114

Jones C. et al. 2011. Functional responses of an invasive top predator Mustela erminea to invasive meso-predators Rattus rattus and Mus Musculus, in New Zealand forests. Wildlife Research 38:131-140.

Kavermann M. et al. 2003. The Eradication of mammalian predators from Quail Island, Banks Peninsula, Canterbury, New Zealand. Prepared for Quail Island Ecological Restoration Trust and the Department of Conservation

King C.M. et al. 2013. Swimming capabilities of stoats and threats to inshore sanctuaries. Biological Invasions

King C.M. et al. 2008. *Why is eradication of invasive mustelids so difficult?* Biological Conservation 142:806-816

King C. M. & Powell R.A. 2007a. The natural history of stoats and weasels. 2nd edition Oxford University Press

King C.M. 2007b. The natural history of weasels and stoats. Oxford University Press.

King C.M. ed. 2005. The Handbook of New Zealand mammals. Oxford University Press

King C.M. & White P.C.L. 2004. Decline in capture rate of stoats at high mouse densities in New Zealand Nothofagus forests. New Zealand Journal of Ecology Volume 28:2.

King C.M. et al. 2003a. Capture probability and heterogeneity of trap response in stoats *(Mustela erminea)*. Journal of Wildlife Research 30:611-619.

King C.M. 2003b. Matching productivity to resource availability in a small predator, the stoat *(Mustela erminea)*. Canadian Journal of Zoology 81:4: 662-669

King C.M. 1994a. Monitoring and control of mustelids on conservation lands. Part 1: Planning and assessing an operation. Department of Conservation Technical Series No. 4

King C.M. et al. 1994b. Monitoring and control of mustelids on conservation lands. Part 2: Field and workshop guide. Department of Conservation Technical Series No. 4

King, C.M. 1990. Stoat. In: King, C.M. (Editor), The handbook of New Zealand mammals. Oxford University Press, Auckland, N.Z.
King C.M. 1984. Immigrant killers: introduced predators and the conservation of birds in New Zealand. Oxford University Press

King C. M. 1983. The relationships between beech (Nothofagus sp.) seed fall and populations of mice (Mus Musculus), and the demographic and dietary responses of stoats (Mustela erminea), in three New Zealand forests. Journal of Animal Ecology 52:141-166

King C. M. & J.E. Moody J. E. 1982a. The biology of the stoat (Mustela erminea) in the National Parks of New Zealand: I. General introduction. New Zealand Journal of Zoology, 1982, Vol. 9: 49-56

King C. M. & J.E. Moody J. E. 1982b. The biology of the stoat (Mustela erminea) in the National Parks of New Zealand II. Food habits. New Zealand Journal of Zoology, 9:1, 57-80

King C. M. & J.E. Moody J. E. 1982c. The biology of the stoat (Mustela erminea) in the National Parks of New Zealand III. Morphometric variation in relation to growth, geographical distribution, and colonisation. New Zealand Journal of Zoology, 9:1, 81-102.

King C. M. & J.E. Moody J. E. 1982d. The biology of the stoat ((Mustela erminea) in the National Parks of New Zealand IV. Reproduction. New Zealand Journal of Zoology, 9:1, 103-118

King C. M. 1980. Field experiments on the trapping of stoats *(Mustela erminea).* New Zealand Journal of Zoology, 7:2, 261-266

Landcare Research 2019. Use of trail cameras. Manaaki Whenua – Landcare Research — Standard Operating Procedure: NO.13 McLennan J.A. et al 1996. Role of predation in the decline of Kiwi, Apteryx spp., in New Zealand. New Zealand Journal of Ecology 20(1): 27-35

McMurtrie P. et al. 2014. Eradication of stoats (Mustela erminea) from Secretary Island, New Zealand. Pages 455-460 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). 2011. Island Invasives: eradication and management. IUCN, Gland, Switzerland

McMurtrie P. et al. 2008. Resolution Island Operational Plan Stoat Eradication Department of Conservation.

Merton, D. 1992: The legacy of "Old Blue". New Zealand Journal of Ecology 16: 65-68.

Miller N. 2003. Paired trial of fresh and long-life stoat baits in a warm, coastal environment. Internal Science Series 100. Department of Conservation.

Miskelly C.M. et al. 2017. Breeding petrels of Dusky Sound, Fiordland – survivors from a century of stoat invasions. 136 Notornis Vol. 64: 136-153

Moller H. et al. 1996. Ferrets as vectors of tuberculosis and threats to conservation. The Royal Society of New Zealand Miscellaneous Series 36

Moors P. J. & Lavers R. B. 1981. Movements and home range of ferrets (Mustela furo) at Pukepuke Lagoon, New Zealand. New Zealand Journal of Zoology, 8:3, 413-423

Morley C.G. 2002. Ferret (Mustela furo) abundance, survival and recruitment on farmland in North Canterbury, New Zealand New Zealand. New Zealand Journal of Zoology, 29:1, 23-31

Murphy E.C. et al. 2019. Conserving New Zealand's native fauna: a review of tools being developed for the Predator Free 2050 programme. Journal of Ornithology, Published online March 2019

Murphy E.C. et al. 2016. Flexibility of diet of stoats on Fiordland islands, New Zealand. New Zealand Journal of Ecology 40(1): 114-120

Murphy E.C. & Bradfield P. 2014. Change in diet of stoats following poisoning of rats in a New Zealand forest. New Zealand Journal of Ecology 16(2): 137-140.

Murphy E.C. et al. Development of re-setting toxin delivery devices for stoats and rats. Department of Conservation and Lincoln University PowerPoint presentation.

Murphy E.C. et al. 1998. Effects of ratōpoisoning operations on abundance and diet of mustelids in New Zealand podocarp forests. New Zealand Journal of Zoology, 25:4, 315-328

Murphy E. C. & Dowding J.E. 1995. Ecology of the stoat in Nothofagus forest: home range, habitat use and diet at different stages of the beech mast cycle. New Zealand Journal of Ecology 19:2: 97-109

Murphy E. C. & Dowding J.E. 1994. Range and diet of stoats (Mustela Erminea) in a New Zealand beech foresT. New Zealand Journal of Ecology 18 (1): 11-18

National Pest Control Agencies. 2015. Pest mustelids: monitoring and control.

Nichols M. et al. 2017. A comparison of horizontal versus vertical camera placement to detect feral cats and mustelids. New Zealand Journal of Ecology 41(1): 145-150

Norbury G. 1998. Space use and denning behaviour of wild ferrets (Mustela furo) and cats (*Felis catus*). New Zealand Journal of Ecology 22:2: 149-159

Norbury G. and Jones C. 2014. Pests controlling pests: does predator control lead to greater European rabbit abundance in Australasia? Mammal Review 45 (2015) 79–87

O'Donnell C.F.J. 1996. Predators and the decline of New Zealand forest birds: An introduction to the holeōnesting bird and predator programme. NZ Journal of Zoology Volume 23:213-219

Oppel S. et al.2010. Eradication of Invasive Mammals on Islands Inhabited by Humans and Domestic Animals. Conservation Biology 25:2:232-240

Parliamentary Commissioner for the Environment. 2017. Taonga of an island nation: saving New Zealand's birds. www.pce.parliament.nz.

Parker K.A. & Brunton D.H. 2004. Predation of banded rail (Rallus philippensis) nests in a saltmarsh habitat. Notornis, Vol. 51: 240-241

Parkes J. P. et al. 2017a. Eradicating mammals on New Zealand island reserves: what is left to do? New Zealand Journal of Ecology (2017) 41(2): 263-270

Parkes J.P. et al 2017b. Past, present and two potential futures for managing New Zealand's mammalian pests. New Zealand Journal of Ecology 41(1): 151-161

Pickerell G.A. et al. 2014. How can we detect introduced mammalian predators in non-forest habitats? A comparison of techniques? New Zealand Journal of Ecology 38(1): 86-102

Pierce R. J. et al. 2007. Field trials of fresh and long-life stoat baits in Northland, New Zealand. Department of Conservation Research and Development series 262. Department of Conservation

Pierce R. & Graham P. 1995. Ecology and breeding biology of Kukupa (Hemiphaga novaeseelandiae) in Northland. Science and Research Series No.91 Department of Conservation.

Powlesland R.G. et al. 2009. Breeding biology of the New Zealand Kākā (Nestor meridionalis) (Psittacidae, Nestorinae). Notornis, Vol. 56: 11-33

Prada D. et al. 2014. Unwelcome visitors: employing forensic methodologies to inform the stoat (Mustela erminea) incursion response plan on Kapiti Island. New Zealand Journal of Zoology, 41:1, 1-9.

Predator Free New Zealand 2019. Remote monitoring comparison table https://predatorfreenz.org/resources/recording-monitoring-options/remote-monitoring-traps/

Predator Free 2050 2019. Predator related data standard https://pf2050.co.nz/app/uploads/2019/10/Final-Predator-Related-Data-Standard-Review-71019.pdf

Ragg J. R. 1998. Intraspecific and seasonal differences in the diet of feral ferrets (Mustela furo) in a pastoral habitat, East Otago, New Zealand. New Zealand Journal of Ecology 22:2: 113-119

Robertson HA. et al 2016. Short pulse of 1080 improves the survival of brown kiwi chicks in an area subjected to long-term stoat trapping. New Zealand Journal of Zoology

Ruscoe W.A. et al 2011. Unexpected consequences of control: competitive vs. predator release in a four-species assemblage of invasive mammals. Ecological Letters. 14:1035–1042.

Russell J. C. et al. 2015. Predator - Free New Zealand: Conservation Country. Journal of Bioscience 65 No. 5.

Smith D.H.V. & Weston K. A. 2017. Capturing the cryptic: a comparison of detection methods for stoats (Mustela erminea) in alpine habitats. Journal of Wildlife Research 44:414-426

Smith D.H.V. et al. 2015. Using home-range data to optimise the control of invasive animals. New Zealand Journal of Ecology 39(2): 286-290

Taylor M. 2005. The menace of stoats. NZ Geographic Magazine Issue 74.

Taylor R.H. & Tilley J.A.V. 1984. Stoats (Mustela erminea) on Adele and Fisherman islands, Abel Tasman National Park, and other offshore islands in New Zealand. New Zealand Journal of Ecology 7: 139-145

Theobald S. & Coad N. Den control of stoats (Mustela erminea) in Trounson Kauri Park, Northland. Science Internal Series 90 Department of Conservation.

Towns D.R. & Daugherty C.H. & Atkinson I.A.E. (Eds) 1990. Ecological restoration of New Zealand islands. Conservation Sciences Publication No. Z Department of Conservation, Wellington.

Veale A.J. 2013a. The Invasion Ecology and Molecular Ecology of Stoats *(Mustela erminea)* on New Zealand's Islands. A thesis submitted in partial fulfilment of the requirements for the degree of PhD, The University of Auckland.

Veale A.J. 2013b. Observations of stoats (Mustela erminea) swimming. New Zealand Journal of Zoology, 40:2; 166-169.
Veale A.J. 2012. Modelling the distribution of stoats on New Zealand offshore islands. New Zealand Journal of Ecology 36(1): 38-47

Young J. B. 1998. Movement patterns of two New Zealand mustelids: Implications for predator pest management. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Applied Science at Lincoln University.

Watkins. A.F. et al 2010. Variable detectability in long-term population surveys of small mammals. European Journal of Wildlife Research Volume 56:3: 261-274

Wilson, P. R. et al. (1998). The role of introduced predators and competitors in the decline of kākā (Nestor meridionalis) populations in New Zealand. Biological Conservation, 83, 175-185.

Wittmer H.U. et al. 2007. Understanding contributions of cohort effects to growth rates of uctuating populations. Journal of Animal Ecology 76, 946-956

Zero Invasive Predators 2019a. Stoatally Detectable: Using trail cameras paired with automated lure dispensers to detect stoats when they are at low density. www.zip.org.nz

Zero Invasive Predators 2019b. *A surprising end to the ZIP200 project to develop an improved rat and stoat trap. http://zip.org.nz/findings/2019/7/the-zip200-project-to-develop-an-improved-rat-and-stoat-trap-comes-to-a-surprising-end*

9. APPENDICES

#	Title
1	Predator Free Islands
2A	Landowner Information Kit
2B	Landowner Agreement to Participate
3	Field Work Minimum Requirements
4	Eradication operational risks
5	Sighting and catch map
6	Data management summary
7	Operational planning calendar
8	Hauraki Gulf Controlled Area
9	Outcome Monitoring Framework

10. DOCUMENT CONTROL

Version	Summary of changes made	Date	Edited by
1	Final Eradication Plan	7.11.19	Jo Ritchie

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