



Manaaki Whenua
Landcare Research

Sanctuary Mountain Maungatautari Restoration Plan 2019–2029

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Sanctuary Mountain Maungatautari Restoration Plan 2019–2029

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Every gift calls for a return gift, and so, by placing the gift back in the forest, the priests treat the birds as a gift of nature. We now understand this to be ecological. Ecology as a science began at the end of the nineteenth century, an offshoot of the rising interest in evolution. Originally, the study of how animals survive in their environments, one of ecology's first lessons was that, beneath all the change in nature, there are steady states characterised by cycles. Every participant in the cycle literally lives off the others, with the ultimate energy source, the sun being transcendent. Widening the study of ecology to include man means to look at ourselves as a part of nature again, not its lord. When we see that we are actors in natural cycles, we understand that what nature gives to us is influenced by what we give to nature. So the circle is a sign of an ecological insight as much as of gift exchange. We come to see ourselves as one part of a self-regulating system. The return gift, the '*nourishing hau*' is literally feedback, as they say in cybernetics. Without it, that is to say, with exercise of any greed or arrogance of will, the cycle is broken. We all know that it isn't 'really' the *mauri* placed in the forest that 'causes' the birds to become abundant, and yet now on a different level it is: the circle of gifts enters the cycles of nature and, in so doing, manages not to interrupt them and not to put man on the outside. The forest's abundance is in fact a consequence of man's treating its wealth as a gift.

Lewis Hyde. *The Gift: Imagination and the Erotic Life of Property*. Vintage Books, 1983

Tukua mai kia piri Tukua mai kia tata
Tukua mai ki a Ranginui,
ki a Papatūānuku
ki Maungatautari
hei korowai
hei whakaruruhau
ki ngā uri a Tāne Mahuta
Tūturu ka whakamaui kia tina.
Tina, haumi ē, hui ē, tāiki ē!

Let us come together, let us draw near,
Let us come closer to Father Sky
and Mother Earth
To our mountain, Maungatautari,
to provide a korowai,
to protect these children of
Tāne Mahuta.
We are committed to this purpose.
It will be done!

Summary

Project and Client

- Maungatautari (3,239 ha inside the pest fence) is a native forest-covered andesitic volcanic cone (797 m asl) surrounded by grazed farmland in the Waikato. It has seen at least seven centuries of sustained occupation and usage by mana whenua.
- In 1912, it was proposed that Maungatautari be 'set aside as a reserve due to its value for climatic and water conservation purposes'; it became a Scenic Reserve in 1927.
- In 2001, the private, non-profit making Maungatautari Ecological Island Trust (MEIT), comprising landowners, local iwi, and local residents, was formed to 'Remove, forever, introduced mammalian pests and predators from Maungatautari, and to restore to the forest a healthy diversity of indigenous plants and animals not seen in our lifetime'.
- In 2004, MEIT eradicated all introduced mammals from two small exclosures on Maungatautari and then (exception for mice) from the entire maunga in 2006. Translocations of threatened native taxa, such as North Island brown kiwi, tuatara, and giant wētā, to Maungatautari followed mammal removal.
- In 2016, MEIT forged a new long-term vision to 'share the mauri (life force) and mana of Maungatautari'. The concept of mauri is inherently highly ecological.
- Building on the founding 2004 restoration plan, this restoration plan provides a new strategic framework from which the MEIT can plan and implement the restoration of Maungatautari and sharing of its mauri and mana between 2019 and 2029.
- This report, prepared by Manaaki Whenua – Landcare Research with assistance from members of the Maungatautari Scientific and Technical Advisory Panel, was funded by Maungatautari Ecological Island Trust and Strategic Science Investment leverage funding of the Ministry of Business, Innovation and Employment.

Plan goals

The long-term goals of the Plan are to

- 'increase indigenous dominance and species occupancy on Maungatautari by the sustained removal of introduced species and by translocations, so that the original and natural character of ecosystems is as far as possible restored' and
- 'increase the number of people who treasure the Sanctuary Mountain Maungatautari project and are involved with its operation'.

Recommended key actions for MEIT in the Plan period 2019–29

The Plan suggests 45 actions relating to nurturing and monitoring biodiversity on Maungatautari, and a further 22 actions concerning additional monitoring, research, education, climate change responses and social/cultural achievements. The following actions are priorities in different parts of the Maungatautari restoration project. This Plan is for Maungatautari Ecological Island Trust (MEIT), but who is responsible for each action is not generally stipulated.

Maintain the pest-proof fence, and detect and remove invader pests

- Follow recommendations outlined in the Maungatautari Ecological Island Biosecurity Plan 2015–2020 (Maungatautari Ecological Island Trust 2015) to maintain the fence, detect pest invasions and subsequently remove them.
- While it is, as of April 2019, unaffordable to eradicate mice from the whole maunga, it is important to continue monitoring mice densities and minimising their impact on native biota on Maungatautari.

Monitor biodiversity to track progress to restoration

- In 2024, remeasure vegetation in the 35 permanent plots established in 2004–06 and first remeasured in 2014, to assess vegetation responses between 10 and 20 years after removal of all pest mammals except mice
- Monitor abundance and wellbeing of all translocated taxa, and sustain strong relationships with relevant species Recovery Groups, iwi and other stakeholders such as Kiwis for Kiwi
- Continue MWLR triennial bird counts (due 2020, 2023, 2026, 2029) and other regular counts that methodically document bird distribution and abundance on the maunga, to study bird species and community changes after pest mammal removal and translocations
- Establish a more formal monitoring system to look for, record and curate data of lizard tracks on tracking cards set for pest mammals at Maungatautari, and consider other possible maunga-wide monitoring systems for lizards
- Continue formal, episodic monitoring of Hochstetter's frog abundance and distribution on the maunga
- Repeat pitfall sampling as previously undertaken by MWLR at decade intervals to monitor ongoing terrestrial invertebrate responses to pest mammal removal
- MEIT Scientific and Technical Advisory Panel further consider which species and ecological *processes* should be monitored and assist MEIT to prepare a biodiversity monitoring plan.

Translocate threatened, iconic, missing animal and plant species

- Continue to translocate taxa that would have been present on Maungatautari and will contribute to restoring the ecological integrity of the maunga, pending results of surveys.
- Undertake 'population reinforcement' translocations of species already translocated to the maunga whose genetic founders were probably too few to ensure long-term retention of rare alleles (NI kākā, NI tīeke, NI kōkako).
- Translocate kākāpō to the main maunga outside NE and SE after undertaking trials demonstrating that they will be unlikely to climb out over the pest-fence.
- Translocate NI rifleman, little spotted kiwi, brown teal and at least one other kākāriki (*Cyanoramphus* spp.) species, to the maunga.
- Encourage, listen to and, if possible, accommodate iwi requests regarding translocation to, or harvest of, species from Maungatautari that are significant to them.

Survey to see which species are present

- Undertake targeted survey for plants known to be present historically but not known recently (e.g. *Tupeia antarctica*, *Ileostylus micranthus*, *Beilschmiedia tarairi*, *Botrychium australe*, *Daucus glochidiatus*).
- Undertake targeted survey for plants not currently known to be present, despite the maunga apparently being suitable habitat (e.g. *Dactylanthus taylorii*, *Pittosporum kirki*).
- Undertake further surveys for long- and short-tailed bats on the maunga.
- Undertake targeted survey for possible or known extant lizard species (striped skink, speckled skink, Whirinaki skink, Duvaucel's gecko, striped gecko) on the maunga, as a necessary prelude to considering translocations.
- Undertake targeted survey for Archey's frog on the maunga.
- Re-survey Tautari Wetland, and the bridge pool and teal pond in the southern enclosure, to determine if previous translocations of banded and giant kokopu to these sites have been successful.
- Undertake targeted surveys for invertebrate species of interest for possible future translocations (Forest ringlet butterfly, giraffe weevil, stag beetle, large land snail, and large stick insect species, *Argosarcus* spp. and *Peripatus* spp., Table 5).
- Undertake maunga-wide, primary surveys for, for example, fungi, bryophytes, algae, and lichens to further document Maungatautari biodiversity.

Control unwanted weeds, and establish desired native plants

- Follow actions outlined in the Maungatautari Ecological Island Biosecurity Plan 2015–2020 (MEIT 2015) regarding control and surveillance of weeds and diseases.
- Restore indigenous dominance by establishing native plants at sites where natural processes are unlikely to result in natural colonisation in a reasonable timeframe and to disrupt and prevent weed reinvasion where any clearance has occurred.

Connect the maunga to the surrounding landscape

- Participate in regional biodiversity planning processes with Waikato Regional Council and Waipa District Council to establish biodiversity corridors and stepping stones from Maungatautari to other significant natural areas in the central Waikato.
- Encourage adjacent landowners to establish biodiversity corridors, stepping stones and wetlands, remove any barriers to fish passage, and monitor outcomes.

Encourage kaitiakitanga, whakawhanungatanga and wairuatanga of mana whenua

- Engage with mana whenua regarding their use of Maungatautari species for whakairo (carving), raranga (weaving), rongoā (medicinal) and kai (food).

Measure the path to restoration

- Monitor the number of pest mammals, other than mice, detected and trapped inside the pest-fence, and the number of mice detected and trapped inside the NE, SE, Garland Block and Tautari wetland.
- Monitor the area (hectares) in the reserve dominated by adventive plant species.
- Monitor the number of pest plant species in the reserve
- Monitor the proportion of species present as self-sustaining populations relative to a hypothetically fully-occupied ecosystem
- Monitor the number of species translocated into the reserve and the number of these species that have achieved self-sustaining populations.

Monitor and plan for social/cultural outcomes

- Monitor the number of visitors to the maunga annually in ways that enable valid comparisons between years
- Monitor the number of volunteers engaged with the SMM project in ways that enable valid comparisons between years
- Monitor the number of students that visit the maunga for educational purposes
- Complete obtaining legal access agreements with all 21 landowners whose properties abut the pest fence
- Assist key agencies such as Waikato Regional Council, Waipa District Council, and the Department of Conservation by punctually fulfilling legal and permit obligations, by participating in regional biodiversity planning, and by openly communicating about matters of common interest.
- Ensure that any Tourism Plan prepared by SMM realises tourist growth and development opportunities in such a way as to safeguard key natural values of the maunga (as described in Bamford & van der Scheer 2016).
- MEIT to discuss with tangata whenua whether they find current biodiversity monitoring on the maunga adequate. Alternative indigenous community-based measures have been proposed by Lyver et al. (2017) and could be used as a model for a similar system at Maungatautari.

Encourage uptake of unique research opportunities

- Encourage universities, Crown Research Institutes, and other research providers to undertake, publish, and communicate research about the maunga, its natural and human history, and about outcomes of the SMM project
- Facilitate and execute effective and timely procedures for receiving, assessing, and making decisions on proposals for new research on the maunga, with due regard to key stakeholders

Network about climate change

- MEIT should maintain strong science networking about climate change to keep up to date on best adaptive practice, and to consider opportunities to contribute to national research and management agendas.

Value the special smaller exclosures

- MEIT should maintain the mouse-free status of all the smaller fenced exclosures so that they are available for mouse-sensitive taxa such as invertebrates and lizards, and for research projects in which being entirely pest-mammal free is important

Support, promote and expand education

- Continue to grow the education programme as a centre for place-based education; engage with local schools to encourage recurring visits, and participative restoration activities.
- Establish a system where researchers applying to conduct research in Maungatautari are required to return for an outreach event once research is complete.

Glossary

Māori word	Meaning
ahi kā roa	literally 'long fire'; refers to long-term occupancy of land
hapū	subtribe
hau	vital essence, vitality
iwi	tribe
kai	food
kāinga	home, household, village
kaitiaki	trustee, guardian or steward
kaitiakitanga	guardianship, stewardship, protection and enhancement of all things on and within the environs of whenua (land) and moana (sea)
korowai	cloak
mana	power, prestige, status
mana whenua	territorial rights, power associated with possession and occupation of tribal land; refers to indigenous people at a place
manu	winged creature, usually a bird
mātauranga	knowledge, wisdom, understanding
maunga	mountain
mauri	life force, vitality of a being or entity
pākehā	people of non-Māori or non-Polynesian descent
raranga	to weave, plait
raupatu	literally 'disrupt' or 'conquer'; refers to land unfairly confiscated by the colonial government after the 'New Zealand land wars', mainly in the Waikato and in Taranaki
rongoā	plant material used for medical purposes
toi	art, knowledge
wairuatanga	spirituality, genealogy
whakairo	to carve, carving
whakapapa	lineage, descent
whakawhanaungatanga	a relationship through shared experiences and working together which provides people with a sense of belonging
whānau	extended family or group

Acronym	Meaning
DOC	Department of Conservation. The national government agency that administers the Conservation, Reserves and National Parks Acts.
MEIT	Maungatautari Ecological Island Trust. The private, non-profit-making registered charitable Trust established in 2001 to restore and sustain Maungatautari mountain.
MWLR	Manaaki Whenua – Landcare Research. Crown Research Institute (like NIWA) that addresses terrestrial ecosystems and biodiversity, greenhouse gases and sustainable environments.
NKK	Ngāti Koroki Kahukura. One of three iwi entities (including Ngati Hauā, Raukawa) that together have mana whenua at Maungatautari.
NIWA	National Institute of Water and Atmospheric Research. Crown Research Institute (like MWLR) that addresses aquatic resources and environments, plus weather and climate.
SMM	Sanctuary Mountain Maungatautari. The project being undertaken by MEIT and others to restore Maungatautari mountain..
WDC	Waipa District Council. Local territorial authority based in Te Awamutu; administers the Maungatautari Scenic Reserve Management Plan.
WRC	Waikato Regional Council. Regional territorial authority of which WDC is part

1 Introduction

Maungatautari (3,239 ha inside the pest fence) is a native forest-covered andesitic volcanic cone (797 m asl) surrounded by farmland in the Waikato and is a visually dominant landscape feature. It has seen (at least) 7 centuries of sustained occupation and usage, first by Ngāti Kahupungapunga and then by various tribes descended from the Tainui waka. Ngāti Koroki Kahukura, along with Ngāti Hauā and Raukawa ki Wharepuhunga, currently maintain mana whenua there. In 1912, it was proposed that Maungatautari be 'set aside as a reserve due to its value for climatic and water conservation purposes', but it was not until 1927 that it became a Scenic Reserve under the Scenery Preservation Act 1903 (Waipa District Council 2005). In 2001, the private, non-profit making Maungatautari Ecological Island Trust (MEIT), comprising landowners, local iwi and local residents, was formed 'to restore and protect the unique ecosystems on Maungatautari'. Led by local farmer, David Wallace, the Trust raised resources to pest-fence two small parts of the maunga in 2004. Introduced mammals were eradicated from these cells. Funds were found to fence and eradicate mammals from the entire maunga in 2006 (Campbell-Hunt & Campbell-Hunt 2013).

Sanctuary Mountain Maungatautari (SMM) project is nationally and internationally significant – extraordinarily ambitious and valuable – by its sheer size, and its largely intact, old-growth native forest. At the time of writing of this plan (April 2019), the mammal-free (except for mice) estate at Maungatautari is more than twice the area of all other New Zealand ring-fenced sanctuaries combined (MWLR, unpubl. data). Monitoring in the 12–14 years since the eradications has revealed many ecological changes, and nine birds, two freshwater fish, tuatara and Mahoenui giant wētā have been reintroduced by translocation.

The project is also significant because it is co-governed by community, landowners, and mana whenua, putting the Treaty of Waitangi into practice. It attracts numerous paying visitors, volunteers and students seeking natural history inspiration and education. It has a visitor centre, workshop, nursery, 12 full-time staff, and several contractors.

In 2004, a comprehensive ecological restoration plan (McQueen 2004) was produced as a working document to guide restoration. Fourteen years on, a review of achievements and refreshed contexts and recommendations for restoration objectives and actions is useful and necessary. This document provides a strategic framework from which the MEIT can plan and implement the restoration of Maungatautari for the next decade.

1.1 Vision and nurturing of the project

The original vision of the project was 'To remove, forever, introduced mammalian pests and predators from Maungatautari, and to restore to the forest a healthy diversity of indigenous plants and animals not seen in our lifetime' (Waipa District Council 2005). This was replaced in 2015–16 with the vision to 'share the mauri (life force) and mana of Maungatautari' (MEIT 2016a), to better recognise cultural values of the maunga and to reflect longer-term (post-eradication) outcomes.

In this document, we present fresh ecological and social/cultural vision statements (section 7.2) that more precisely serve the purposes of this Plan and are compatible with the 2016 and 2005 visions.

Legally, the project must have regard for the ca 2,497 hectares of the maunga (being 77% of the fenced area) that is set aside under the Reserves Act 1977 as a Scenic Reserve (Fig. 1). The current (adopted but not yet approved, at November 2018) Maungatautari Scenic Reserve Management Plan describes values, linked plans, objectives and policies for the maunga (Waipa District Council 2005).

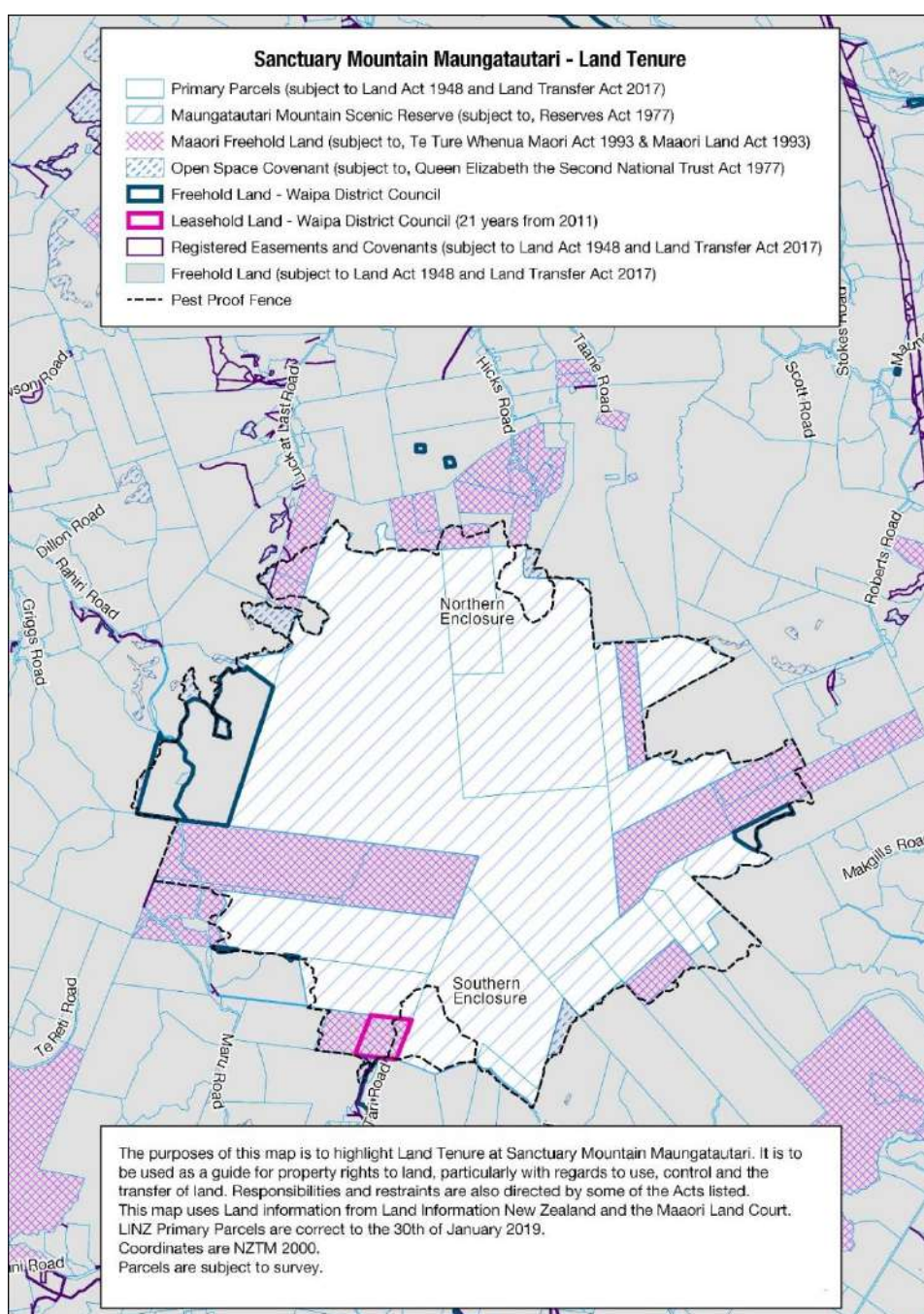


Figure 1. Land tenure at Maungatautari, showing scenic reserve land (2497 ha), Te Ture Whenua (Māori freehold land, 580 ha inside the pest fence) and freehold non-Māori land (162 ha inside the pest fence). Also shows the Pest Fence and the Northern and Southern Enclosures. (Map by Aaron Barnsdall).

The primary purposes of Scenic Reserves are defined in the Reserves Act under Section 19 (1) (a) as:

...protecting and preserving in perpetuity for their intrinsic worth and for the benefit, enjoyment and use of the public suitable areas possessing such qualities of scenic interest, beauty, or natural features or landscape that their protection and preservation are desirable in the public interest

and under Section 19 (2) (a) as:

Except where the Minister otherwise determines, the indigenous flora and fauna, ecological associations, and natural environment and beauty shall as far as possible be preserved, and for this purpose, except where the Minister otherwise determines, exotic flora and fauna shall as far as possible be exterminated.

Ownership of the Scenic Reserve as fee simple estate is now vested in 'Te Hapori o Maungatautari – The Maungatautari community comprising iwi with customary interests in Maungatautari and members of the wider community connected with Maungatautari' (Ngāti Koroki Kahukura Deed of Settlement 2012). However, administration and management of the Reserve is vested with the Waipa District Council, which is in turn required to meet relevant provisions of the Reserves Act and thus to seek approvals of the Department of Conservation. MEIT manages the Reserve and Sanctuary on behalf of Waipa District Council. Given that further to this, there are parcels of Te Ture Whenua and private land inside the fence, administration of the site is complex.

Both the Reserves Act and the current MEIT vision link the revitalisation of the maunga with its use and appreciation by people, Māori and pākehā alike, and furthermore there are ca 580 ha of private Māori land and 162 ha of private non-Māori land inside the pest-fence (Fig. 1).

For Ngāti Koroki Kahukura (NKK):

Maungatautari and the Waikato River continue to provide spiritual and physical sustenance to Ngāti Koroki Kahukura and are inextricably linked to the identity of Ngāti Koroki Kahukura. Maungatautari and Waikato (river) are inseparable and indivisible. (Ngāti Koroki Kahukura Deed of Settlement 2012)

1.2 Purpose of the Plan

The purpose of this Plan is to:

- present actions that should be taken in the next decade that support achieving the project vision outcomes of maintaining and restoring indigenous species and ecosystems, and sharing mana and mauri of the maunga, while having regard to other relevant plans
- link ecological restoration objectives with cultural and social objectives
- present survey, research, monitoring and education priorities towards achieving the project vision, and
- communicate, through the above, to project staff, stakeholders, volunteers, funders, and other collaborators what SMM is about.

1.3 Plan period

The period of this plan is for 10 years – from 2019 to 2029.

1.4 Links to other plans and documents

This Restoration Plan has important links to other plans and documents (Fig. 2). Three plans relate clearly and definitively to what happens at Maungatautari: the Waikato-Tainui Environmental Plan (2013), the Waikato-Tainui cultural materials plan (2017), and the Raukawa Environmental Management Plan (2015). Within the SMM, actions must be consistent with this restoration plan.

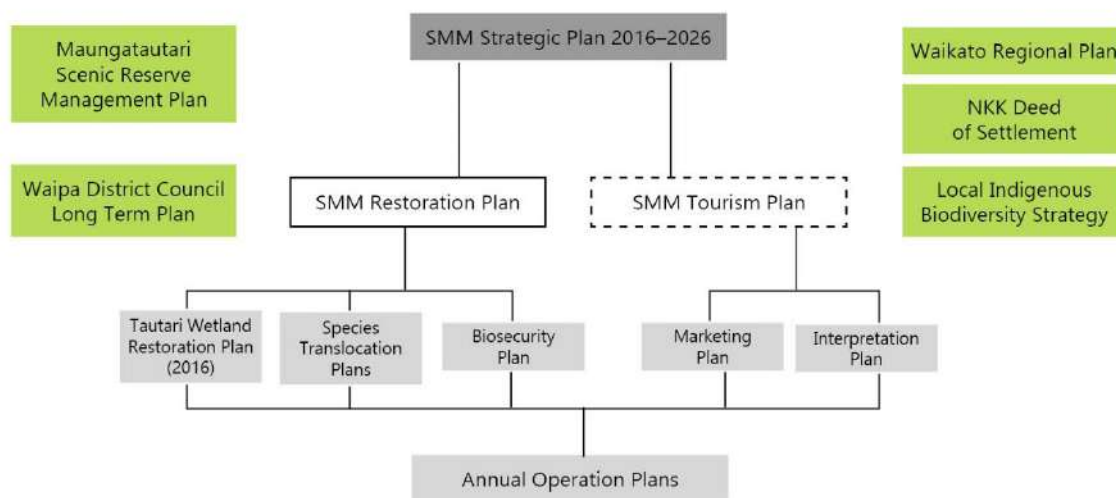


Figure 2. Links between this Restoration Plan and other existing (solid lines) or likely (dashed lines) plans and documents relevant to the SMM project. In general, this Plan will not repeat material found in other existing or imminent plans.

The Vision ('share the mauri and mana of the maunga') and Purpose ('protect and enhance the mauri of Maungatautari') statements in the current SMM Strategic Plan are implicitly but not explicitly ecological. Plans in Strategic Objective 1 ('Sanctuary Mountain Maungatautari is widely recognised as a world class conservation project') are consistent with this Plan, with the probable exception of naming snipe as a taxon to be re-established by 2026.

Objectives and policies of the Maungatautari Scenic Reserve Management Plan – including regarding management of flora and fauna (Sections 6.3, 6.4) – are entirely consistent with this Plan.

Without good planning, there is tension between tourism and maintaining a natural environment, but this important matter is not addressed in this Plan. Rather, a detailed Tourism Plan should be written for the maunga that concerns both the SMM Strategic Plan and this Restoration Plan (as shown in Fig. 2).

1.5 What the plan is not

This document does not:

- provide an operational plan describing what management should be carried out by whom, in what sequence, at what cost, and by when. Instead, we identify target outcomes and major management actions, such as what species could be established and why
- discuss details of the communications, relationships, advocacy, regulation, and compliance actions required to guarantee effective management
- repeat other management plans and agreements (e.g. Biosecurity Plan) or documents (e.g. NKK Deed of Settlement)
- provide a detailed account of ecological history and ecology or cultural history of Maungatautari.

2 History of Māori connection and relationship

Ko te mana o Maungatautari hei ārahi mō tātou
Let the mana of Maungatautari guide us.

This brief account is derived primarily from the NKK Deed of Settlement (2012), and from Robyn Nightingale, Poto Davies and Aaron Barnsdall.

With the abundance of natural resources, it is not surprising that Ngāti Kahupungapunga, who pre-dated the Tainui waka, took up early occupation within the Maungatautari district. The forests on and below the maunga, and their associated wetlands, provided many resources for Māori forest birds; plants for clothing, such as kiekie (*Freycinetia banksii*), harakeke (*Phormium tenax*, flax); edible vegetation, such as tī kouka (*Cordyline australis*, cabbage tree), water cress (*Nasturtium microphyllum*), and, pikopiko (fern shoots); fish, crustaceans and molluscs, tuna (*Anguilla* sp., freshwater eel), koura (*Paranephrops planifrons*, freshwater crayfish); and kāeo fresh water mussels (Robyn Nightingale, MEIT, pers. comm. 2018).

From popular writing and oral history, the arrival of the Tainui waka in Kawhia over 700 years ago led to steady infiltration of inland areas by Waikato hapu; by 1600, Ngāti Kahupungapunga were expelled from the Maungatautari area by Raukawa, by right of conquest.

Between 1810 and 1830, the introduction of muskets to tribal warfare saw Ngāti Maru (Hauraki region) pursued and displaced. Ngāti Hauā and Ngāti Koroki offered them shelter in the Cambridge and Maungatautari areas. In the early 1820s, in response to calls for support from Te Rauparaha to join armed conflict, many Ngāti Raukawa moved from Maungatautari to Horowhenua and surrounding districts and remained there, at the invitation of Ngāti Toarangatira. Many settled there permanently, notwithstanding requests in 1862 from King Tawhiao and Rewi Maniapoto to return to Maungatautari.

By the 1830s tension between mana whenua (Ngāti Hauā and Ngāti Koroki) and Ngāti Maru culminated in the battle of Taumatawīwī, which cemented Ngāti Hauā and Ngāti Koroki as mana whenua in the Maungatautari and Karāpiro region. Ngāti Hauā returned to their homes in Peria (Matamata) and left Ngāti Koroki to hold the mana.

In the early years of European settlement (1840s and 1850s), Ngāti Koroki had many kainga (villages) in the area and flourished by growing wheat, potatoes, cattle, pigs, and harakeke for trade and export to Australia and England. Below the southern and western slopes of Maungatautari, pockets of Ngāti Hauā, Raukawa, and Ngāti Hourua engaged in similar commercial activities. As well as providing resources for food, buildings, and traditional clothing, the maunga continued to be a font of cultural and spiritual well-being. Despite the large Māori population who resided in the area, there is little evidence of bush clearance by them on Maungatautari, with possible exceptions on some of the higher rocky outcrops (Clarkson 2002).

The establishment of the Settler Government and the New Zealand Land Company saw the increasing loss of land from hapū ownership and through dubious land sales and growing tensions between Māori and Pākehā settlers. The resulting conflicts throughout Taranaki and Waikato gave rise to the establishment of the Māori King Movement in 1858.

Waikato Māori enjoyed undisturbed occupation and mana over Maungatautari maunga until 1864–66. Ongoing land disputes between the Crown and Waikato iwi resulted in the confiscation (the raupatu) of 2,563 hectares of hapu land on Maungatautari that later become Scenic Reserve. From the 1870s to the 1880s, the remaining land was partitioned through Māori Land Court sittings, where ownership was divested in successful Māori applicants and their representatives. Today, the maunga comprises 2,497 ha Scenic Reserve land, 580 ha freehold Māori land, and 162 freehold non-Māori land (Fig. 1).

The Ngāti Koroki Kahukura Treaty Claim 2012 sought in part the return of the confiscated land on Maungatautari, which became the Scenic Reserve. This land was to be placed under Te Wherowhero title, thereby guaranteeing an inalienable title. While this part of the claim was not successful, NKK secured the co-governance of the Scenic Reserve with Waipa District Council. Also, in recognition of the great significance of Maungatautari to iwi and the community, ownership over the maunga has been vested in an umbrella entity, Te Haapori o Maungatautari, which comprises Waikato Tainui, NKK, Ngāti Hauā, Raukawa, and Waipa District Council.

Despite many adversities, ahi kā roa has been maintained to the present day by NKK (Pōhara and Maungatautari marae), Ngāti Hauā (Te Iti o Hauā, Raungaiti, Rukumoana, Kai-a-te-mata and Waimakariri marae), and Raukawa ki Wharepuhunga (Pārawera, Whakamarama, Rawhitiroa, and Aotearoa marae).

Mana whenua continue to practice their wairuatanga, their spiritual connection to their maunga, through karakia, whakapapa, and the acknowledgement of Maungatautari as their tupuna maunga. As kaitiaki or guardians of Maungatautari, mana whenua bring a depth of knowledge to the SMM project while using their ability to actively exercise their kaitiakitanga over all living things found on the lands they own, both inside and outside the main fence. They continue to be critically important to the project, in their ability to

exercise whakawhanaungatanga (relationships) thereby establishing and maintaining the iwi-iwi relationships that underpin all species translocations.

Maungatautari Maunga is a sacred source of spiritual pride and prestige for Waikato Māori. The dignity and mana of Maungatautari is a legacy that ensures linkage between Waikato's past, present and future generations. He (the Maunga) is revered by all for his significance to the tribal roots and rich diversities that confirm eternal bonds between Waikato and other Iwi within Aotearoa. (Waipa District Council 2005)

3 European arrival and influence

In the late 1800s, settlers began to develop farms around Maungatautari on land once covered in forest and scrub (Moon 2018). The current forest margins on the lower slopes of Maungatautari have changed little since the time of European arrival. The edges (mainly on the western side) that were fern and scrub in the late 1800s, have now reverted to forest dominated by mangeao (*Litsea calicaris*), pigeonwood (*Hedycarya arborea*), and mahoe (*Melicytus ramiflorus*), while edges that are dominated by tawa (*Beilschmiedia tawa*) were cleared by early European farmers (Bill Garland, pers. comm., 2019).

On the lower elevations of Maungatautari, selective logging of tawa and some rimu (*Dacrydium cupressinum*) occurred on privately owned land up until the 1970s (Garland, pers. comm.). There was also some harvesting of tōtara (*Podocarpus totara* var. *totara*) for fence posts from the margins of the forest by farmers who had adjoining farms.

Emergent northern rātā (*Metrosideros robusta*) trees in the canopy of Maungatautari (particularly on the north-western and eastern slopes of the maunga), began to die and were visible as large skeletons in the 1970s (Garland, pers. comm.). Their decline has been attributed to impacts of possum browsing and possibly the old age (>1000 years) of the trees (Waipa District Council 2005).

The boundaries between privately-owned farm land and Maungatautari Scenic Reserve have changed over the years, including after the pest proof fence was built, to exchange mature forest for areas near the forest margins that were scrub or pasture (Garland, pers. comm.). Before the 1970s, farmers had a grazing arrangement with the Crown to allow cattle into the Scenic Reserve. The cattle grazed through the forest and in clearings dominated by grass, blackberry (*Rubus fruticosus*), gorse (*Ulex europaeus*), and bracken fern (*Pteridium esculentum*), which were likely to be old Māori cultivation sites. Cattle were in the forest until the 1970s, when Matamata Council surveyed the forest margins and incentivised fences to exclude stock (Garland, pers. comm.). The majority of the forest clearings have now regenerated into forest, but some old fence lines still remain inside the forest (Kate Richardson, pers. comm., 2019).

4 Project history

4.1 Pest-fence project conception and implementation

The 47-km fence that now encircles and protects Maungatautari deals explicitly with one of the two key causes of species decline on the New Zealand mainland – introduced pest mammals. Removing and excluding the high diversity of pest mammals – from large, trampling and browsing ungulates such as cattle to small arboreal omnivores (possums and rats) and predators such as stoats and cats confers diverse benefits to forest ecosystems (King 2005). The fence does not, however, substantially address the other key decline factor – habitat loss and fragmentation.

The evolution of conservation approaches to limiting impacts of pest mammals in New Zealand – from island eradications to unfenced ‘mainland islands’ to fenced sanctuaries – is well documented (Saunders & Norton 2001; Pech & Maitland 2016; Parkes et al. 2017).

The first trials of contemporary pest fences that can exclude all pest mammals were started in Wellington in 1994 and led to Zealandia, the first mainland pest-fenced sanctuary (Hitchmough 1994). Additional trials by David Wallace and Tim Day in the Waikato led directly to the formation of Xcluder™ pest-fencing company, one of whose first major jobs was building the fence around Maungatautari. This is still by far the largest pest-fenced sanctuary in New Zealand (Day & MacGibbon 2007). The idea of building the fence at this site was that of local farmer and entrepreneur David Wallace, the first Trust Chair. The fence cost \$9.75 million (in 2006), funded primarily by the NZ Government’s Significant Community-based Projects Fund, the Scottwood Trust, the Lion Foundation, the Lottery Grants Board, the Waipa District Council, and Waikato Regional Council.

Initially, two pest-proof fenced exclosures were established on the northern (36 ha) and southern (61 ha) sides of Maungatautari (Speedy et al. 2007; Fig. 3). During September–October 2004, mammals were eradicated from these exclosures as a trial for the entire mountain. In the southern exclosure, four ship rats and five mice were detected and removed by trapping between November 2004 and May 2006 (Speedy et al. 2007). Between January 2007 and February 2013, there were no confirmed mammal incursions into the southern exclosure (Geoff Churchill, Sanctuary Mountain Maungatautari, pers. comm. 2019). To eradicate mammals from the entire mountain, a prolonged mammal eradication operation started in November 2006 at a cost of \$1.3 to \$1.4 million (Speedy et al. 2007, Campbell-Hunt & Campbell-Hunt 2013). All mammals became scarce, but mice were probably never eradicated from the entire reserve and, since February 2012, no further control has been attempted and they have become increasingly abundant (Wilson et al. 2018).

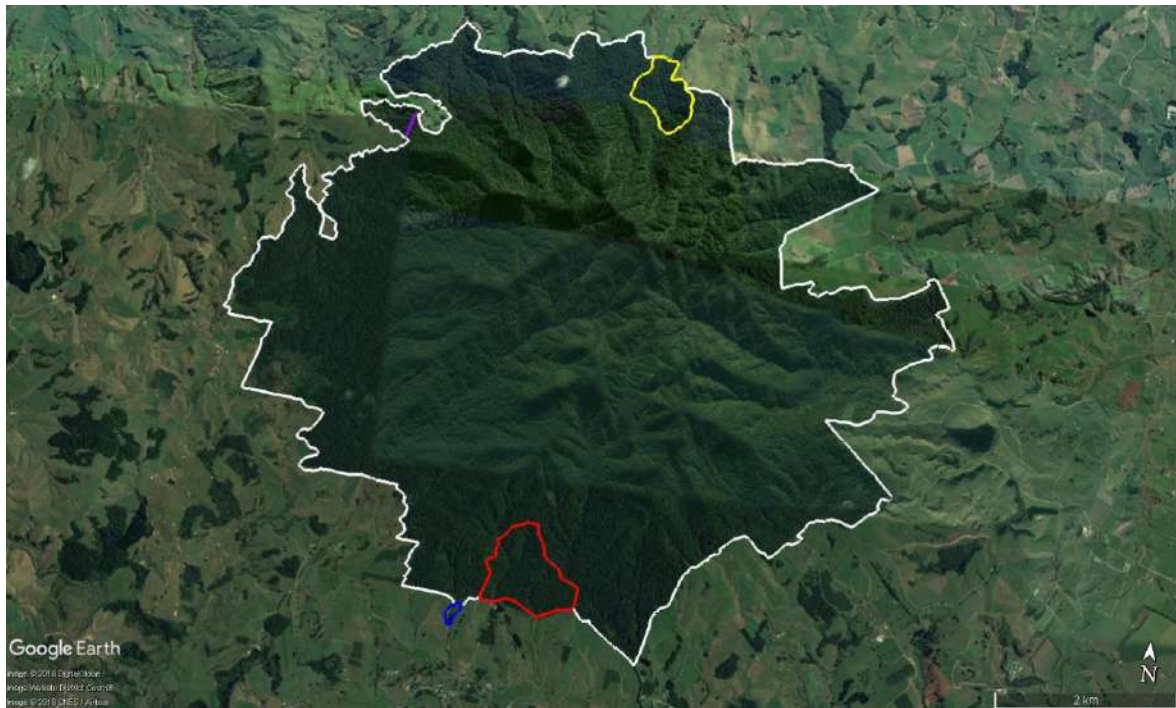


Figure 3. Sanctuary Mountain Maungatautari. The white line indicates the predator-proof fence surrounding the entire mountain, the red line indicates the southern enclosure (65 ha), the yellow line (top right of fenced area) indicates the northern enclosure (35 ha), the blue line (bottom) indicates the Tautari Wetland (3 ha) and the purple line (top left) indicates the QEII block (17 ha) owned by the Garlands.

In addition, there are two other small fenced blocks on SMM. The first is Tautari wetland, gifted to MEIT by the Tauroa family in 2005 (MEIT 2016b). It is a small (2.2 ha), steep-sided marshy gully located on the southern side of SMM (Fig. 3). The vegetation is dominated by exotic pasture grasses with a small bush remnant. MEIT has developed the wetland area and reintroduced takahe and tuatara.

The second enclosure is a 15.5-ha steep-sided forested gully block on the northwest edge of Maungatautari (Fig. 3). It is owned by Bill and Sue Garland, covenanted to the Queen Elizabeth II National Trust, and separated from the main Maungatautari reserve by a vehicle track. Mammals were eradicated from this block starting in 2006 but mice apparently reinvaded and had become abundant again by 2011. Since August 2013, when MEIT eradicated mice from Q block, they have been absent (Wilson et al. 2018).

Provided that they are maintained, modern pest-fences '...keep out most mammals most of the time' (Elton Smith, Orokonui Ecosanctuary, pers. comm. 2018). During 2013–2017 inclusive, 21 mice, 42 rats, 14 weasels, and 3 hedgehogs were trapped at SMM (Churchill, pers. comm.). One cat was detected in the reserve but apparently climbed out by itself, as ship rats are also known to have done (Innes et al. 2011). Before 2013, a '...smaller number of rats and two stoats' were also trapped (Richardson, pers. comm.).

4.2 MEIT governance, infrastructure, adjacent landowners, staff and visitors

Four years after establishment in 2001, MEIT evolved to a Trust Board of 17 members, comprising five representatives each from mana whenua, landowners, and community, plus a representative from Waipa District Council and from DOC; the chairperson was appointed annually from the members. In 2011, the Trust was downsized to ten members, five from each mana whenua and landowners/community, and with one mana whenua chair and one non-iwi chair. This revised structure closely reflects the original (2001) Trust Deed of having two main stakeholder groups; it puts the Treaty of Waitangi into action in a local project. A detailed analysis of the roles of sociocultural difference and biculturalism in the SMM project is available in Harms (2015, 2018).

It is unsurprising – with 21 landowners plus multiple pieces of iwi-owned and other private land adjacent to or inside the fence – that the governance change, and other matters, have triggered some disagreements among stakeholders. Some landowners who host fence sections have yet (January 2019) to sign final legal access agreements with SMM.

The MEIT administration HQ was based in Cambridge, central Waikato, from instigation (2001) until 2012, when it moved to the main visitor centre at Tari Road end, Pukeatua, on the slopes of the maunga. The operations base occurred at various sites in Pukeatua and Cambridge and is now split between Gillies St Cambridge and Tari Rd end, Pukeatua.

In 2017/2018, 15,719 people visited Maungatautari, an increase of 2.8% from the previous year (MEIT 2018). Over the same period, the education programme hosted 4,509 people (mainly students) in conservation education. There were 377 volunteer members, contributing 16,521 hours in 2018 (MEIT 2018). In 2018, the Trust had 12 fulltime staff and 3 contractors.

5 Restoration frameworks

The restoration of Maungatautari is 'biocultural' (Lyver et al. 2015a, 2016; Harms 2015, 2018) in that it has both ecological and social/cultural components. These are reflected in the original ('To remove, forever, introduced mammalian pests and predators from Maungatautari, and to restore to the forest a healthy diversity of indigenous plants and animals not seen in our lifetime') and current ('To share the mauri and mana of Maungatautari') visions of the project. Under these visions, the scientific aspirations of ecological restoration at Maungatautari are likely to be broad and diverse, focus on improving ecological integrity towards selected, more original, ecological states (Lee et al. 2005; MacDonald et al. 2016; Towns et al. 2018; Sinclair et al. 2018). In contrast, the cultural (Lyver et al. 2015a; Harms 2018), policy (Baker & Eckerberg 2016) and personal (Campbell-Hunt & Campbell-Hunt 2013) motivations of the project's stakeholders are diverse.

Major tenets of this plan are that humans are part of the nature of Maungatautari, not separate from it; that shared grounds and passion for conservation between the diverse stakeholder individuals and agencies make a single guiding restoration plan

possible; and that restoration is an endless journey rather than a destination. Also, the project operates at multiple scales and sites that include the small fenced areas within and outside the main reserve, the main reserve itself, and the surrounding pastoral and urban landscapes. It also provides local, regional, national, and international inspiration and learning from having the largest pest-free area on the NZ mainland.

In this plan, manipulation of *species* (Section 6) is the main tool of ecological restoration, and the main way to track restoration progress. This is true both for limiting abundance of unwanted species and for introducing or enhancing desired species. We expect *ecosystems* (Section 7) to change as a result, but a lesson from New Zealand island restoration is that outcomes of ecological responses are complex and therefore often unexpected (Towns et al. 2018). Knowledge shortfalls about species can be improved by survey (Section 8), and progress toward target endpoints can be tracked by monitoring (Sections 9 and 10). Research (Section 11) is required to better document how species and ecosystems function and interact in the absence of most pest mammals, and to improve understanding of ecological baselines relevant to time-scales larger than human lifetimes (Balaguer et al. 2014; Soga & Gaston 2018).

5.1 Ecological restoration, ecological integrity, and desired future ecological states

The International Society for Ecological Restoration defines Ecological Restoration as ‘...the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed’ (McDonald et al. 2016).

In the New Zealand setting, Ian Atkinson (1994) defined it as ‘...management that aims to restore particular biotic communities to a condition more like that of a selected time period in the past’. In practice, restoration can never be full and complete because:

- we do not usually know in detail the composition and structure of original communities (especially for invertebrates)
- some original species are extinct (e.g. moa) or non-harvestable for transfer from extant populations elsewhere
- many exotic species are now present that cannot be eradicated, particularly invertebrates, but also mice and non-native birds
- environmental conditions have changed through climate change, global industrialisation, and surrounding land-use change
- ‘conservation triage’ may demand translocation of critically endangered species to Maungatautari that never occurred there naturally (Miskelly 1999; Brown et al. 2016).

Furthermore, Atkinson (1994) noted that all ecosystems are constantly changing their structure and composition, therefore ‘The aim is not to establish communities of narrowly defined composition as static glimpses of the past. It is to re-activate the major successional processes likely to have operated during the selected time-periods and within

the physical conditions (site factors and climate) specified for each restoration programme’.

In the biodiversity monitoring framework suggested by Lee et al. (2005), the ecological goal of pest mammal eradication or control of exotic species is to restore ecological integrity, which includes indigenous dominance (i.e. indigenous taxa dominate composition, biomass and key ecological processes), and species occupancy (i.e. the full complement of species that should naturally occur at Maungatautari are present; Lee et al. 2005). Indigenous dominance and community occupancy are increased by pest control and native translocations respectively – these are the two most frequent activities undertaken by sanctuary managers.

The objective of indigenous dominance clarifies that it is neither desirable nor achievable to stop, for example, predation or herbivory *per se*; rather, predation should be by indigenous predators such as ruru (*Ninox novaeseelandiae*) and kārearea (*Falco novaeseelandiae*) rather than stoats and rats, and herbivory should be by, e.g. kererū (*Hemiphysalis novaeseelandiae*) or kōkako (*Callaeas wilsoni*), not possums. The historical extinctions of entire guilds such as moa and numerous other species of bird, lizard, and invertebrate mean that complete restoration to an ecological state before human arrival in New Zealand is now impossible (Atkinson & Milliner 1991; Scofield et al. 2011).

This powerful framework is useful for managers when assessing success of restoration in their biodiversity sanctuary. Progress towards species and ecosystem endpoints can be tracked by ‘restoration indices’ (Sinclair et al. 2018), once the key endpoints are chosen (Section 9).

5.1.1 Society for Ecological Restoration guidelines

McDonald et al. (2016) use International Standards for the Practice of Ecological Restoration (2016) to evaluate the progress of restoration over time. We have evaluated SMM’s progress as of 2018 in terms of recovery of the ecosystem attributes suggested by McDonald et al. (2016) and these are depicted and tabulated in Figure 4.

The guidelines are valuable for placing the SMM project into an accepted international framework. They identify six major and 18 component attributes that together give a broad assessment of where further effort could be focused. The recovery wheel illustrates that eight of 18 attributes already have a five-star rating, showing that by international standards Maungatautari is already in many regards restored. This is because the original forest vegetation cover is largely intact and because there was substantial mammal pest control before the SMM project. Maungatautari was treated with aerially applied 1080 (sodium fluoroacetate) in June 1997 and July–August 2002. These aerial operations primarily targeted possums but non-target mammalian pests would also have been killed, including many ship rats, feral cats, and stoats.

The lowest scoring attributes are within the category ‘External Exchanges’, for example Gene flow, which is related to the fence providing a barrier to poor-dispersing taxa.

However, the guidelines are too broad to clarify details of best next restoration steps, such as which species should be considered for future translocation.

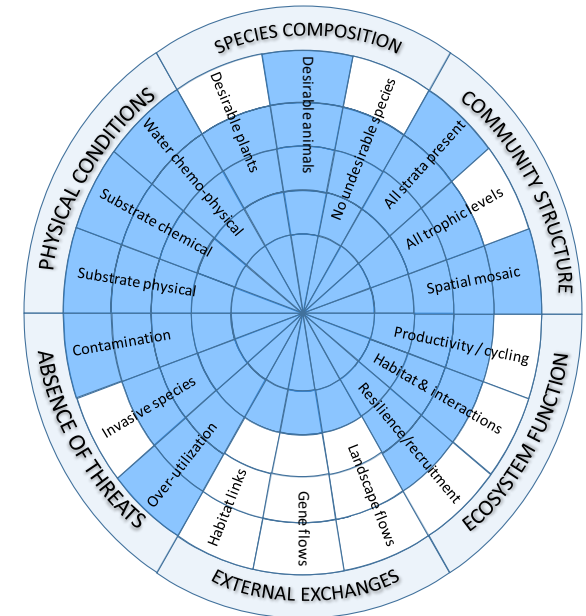
EVALUATION OF ECOSYSTEM RECOVERY - ECOLOGICAL RESTORATION STANDARDS

ASSESSOR: Corinne Watts and John Innes (Manaaki Whenua - Landcare Research)

SITE: Sanctuary Mountain Maungatautari

DATE: November 2018

ATTRIBUTE CATEGORY	RECOVERY LEVEL (1-5)	EVIDENCE FOR RECOVERY LEVEL
ATTRIBUTE 1. Absence of threats		
Over-utilization	5	Clearing and grazing entirely ceased. Site dedicated to conservation.
Invasive species (external)	4	Eradication of invasive mammals; ongoing management of weeds and invasive invertebrates (eg wasps) when required (?).
Contamination	5	None detected.
ATTRIBUTE 2. Physical conditions		
Substrate physical	5	Soil structure unchanged from pre-existing ecosystem state.
Substrate chemical	5	Not tested but soil likely to be healthy with diverse micro/macro-fauna.
Water chemo-physical	5	Not tested but site operating in natural state.
ATTRIBUTE 3. Species composition		
Desirable plants	4	Site dominated by native forest from rimu-tawa to montane tawari-kamahi (Clarkson 2002). High diversity of native plants of all classes (Burns et al. unpubl data).
Desirable animals	5	Diverse native bird fauna (Fitzgerald et al. unpubl data). Threatened taxa (eg kokako, giant weta) are establishing after translocation.
No undesirable species	4	Mice (?); Occasional introduced mammal incursion; Few weed species present (?);
ATTRIBUTE 4. Community structure		
All strata present	5	All strata present, including a good cover and diversity of canopy (including epiphytes), sub canopy, understorey and ground cover (e.g. ferns) plants (Burns et al. unpubl data).
All trophic levels	4	All trophic structure levels are present, with complex webs of interaction linking decomposer, producers and consumers. Good faunal representation including invertebrates (detritivores, predators, herbivores), reptiles, amphibians, and birds (insectivores, nectarivores, frugivores).
Spatial mosaic	5	Self-organisation and complexity present.
ATTRIBUTE 5. Ecosystem function		
Productivity, cycling etc	4	Good depth and diversity of leaf litter and diversity; Evidence of decomposition.
Habitat & plant-animal interactions	4	Fauna species utilising habitats on site, including flowering of native plants, woody debris and
Resilience, recruitment etc	4	Fauna species breeding including threatened taxa establishing. Seedlings/saplings present.
ATTRIBUTE 6. External exchanges		
Landscape flows	2	Some integration with natural areas (eg fragments) on adjacent farmland.
Gene flows	2	There is some opportunity for gene flow of mobile species such as birds and wind pollinated plants due to the proximity of remnant native vegetation. However, surrounding farmland presents a barrier to terrestrial fauna species and poor-dispersing native insect pollinators.
Habitat links	2	There are some habitat links to other natural areas (eg gullies, fragments) on surrounding farmland.



Source: McDonald T, Gann GD, Jonson J, and Dixon KW (2016) International standards for the practice of ecological restoration – including principles and key concepts. Society for Ecological Restoration, Washington, D.C. [After McDonald T., Jonson J. and Dixon K.W. (eds) (2016) National Standards for the Practice of Ecological Restoration in Australia. Restoration Ecology S1: 1-340.]

Artwork: Little Gecko Media. Excell file formulated by Simone Pedrini.

Figure 4. Evaluation (by Corinne Watts and John Innes, Manaaki Whenua – Landcare Research in 2018) of recovery level at Sanctuary Mountain Maungatautari using MacDonald et al. (2016) International Standards for the Practice of Ecological Restoration

5.2 Restoration visions and objectives

Restoration at Maungatautari is primarily - but not just – about ecology. It is also about the supply of resources to – and mental and spiritual well-being of – the people who cherish or depend on that ecology. The project should meet aspirations of its diverse stakeholders, including those of mana whenua on their own terms.

Ecological restoration objectives should arise logically from consideration of present species and ecosystems in an ecological integrity framework; they should practicably guide sanctuary management as well as survey and monitoring requirements, and they should be consistent with other documents such as the Maungatautari Scenic Reserve Management Plan.

5.2.1 Ecological

Vision: ‘To share the mauri and mana of Maungatautari’ (from MEIT 2016a). Note that mauri is implicitly a very ecological concept.

Long-term goal: To increase indigenous dominance and species occupancy (Lee et al. 2005) on Maungatautari by the sustained removal of introduced species and by translocations, so that the original and natural character of ecosystems is as far as possible restored.

Plan-period goals (2019–2029):

- a Indigenous species
 - protect indigenous species that have a natural range that includes Maungatautari, particularly threatened species, local species (those found or protected nowhere else), and species at the limits of their current distribution
 - translocate ecologically and biogeographically appropriate indigenous species into the reserve
 - by the above, maintain or reinitiate evolutionary processes
 - use the pest-free sites at Maungatautari to protect other threatened taxa that were not or may not have been naturally present there, if stakeholders agree
- b Ecosystems
 - maintain and restore ecosystem composition, structure and successional processes by as far as possible removing threats, and by increasing indigenous dominance and species occupancy
- c Pests
 - ‘Eliminate or mitigate where possible the risks of pests and diseases impacting on the Maungatautari ecological island operation’ (Maungatautari Ecological Island Biosecurity Plan; MEIT 2015)

5.2.2 Social/cultural

Vision: ‘To share the mauri (life force) and mana of Maungatautari’ (from MEIT 2016a).

Long-term goal: To increase the number of people who treasure the SMM project and are involved with its operation.

Plan-period goals (2019–2029):

- a Mana whenua
 - enable mana whenua to sustain or enhance kaitiakitanga (guardianship), whakawhanaungatanga (relationships) and wairuatanga (spiritual connection) on the maunga
 - improve the possibilities for mana whenua to hand down taonga species to future generations and to gift taonga species to recipient iwi by translocation
 - sustain or enhance the ability of mana whenua to harvest kai, rongoa, and other valued resources
- b Other individual stakeholders
 - enable adjacent landowners, volunteers, and other interested public to appreciate the natural history of the maunga, to participate in its restoration, and to obtain the mental and spiritual wellbeing of these participations, as they desire.
- c Agencies
 - assist key agencies such as Waikato Regional Council, Waipa District Council, and DOC by punctually fulfilling legal and permit obligations, by participating in regional biodiversity planning, and by openly communicating about matters of common interest.
- d Tourism
 - Ensure that any Tourism Plan prepared by SMM realises tourist growth and development opportunities in such a way as to safeguard key natural values of the maunga (as described in Bamford & van der Scheer 2016).

5.3 Connectivity between Maungatautari and surrounding landscapes

Being embedded in a largely pastoral landscape is both a threat and an opportunity for MEIT. The farmed landscape around the fenced and forested SMM project is a source of unnatural nutrients, agri-chemicals (e.g. fertilizer drift, herbicides, pesticides) and other perturbations (Deakin 2013). The surrounding landscape contains invader pests, including plants, animals, and diseases (Connolly et al. 2009). Also, the fence limits dispersal of some taxa such as brown kiwi (Burns et al. 2012). Some streams sourced on the mountain have physical or chemical blocks to fish passage that restrict their migration, e.g. hanging culverts on smaller streams and hydro-dams on the Waikato River.

However, a major opportunity for Maungatautari is to facilitate restoration *outside* the fence as well as inside. This has undoubtedly already occurred to some extent (e.g. tui) but could be greatly facilitated by planning and establishing vegetated terrestrial and riparian corridors from the maunga to other significant natural areas in the central Waikato (Fig. 5). Achieving this will require participation by MEIT in selected regional biodiversity planning processes, which will strengthen the relationship between MEIT and Waikato Regional Council and Waipa District Council, the two local authorities undertaking this planning.

Establishing substantial corridors on what is mostly privately owned land will inevitably be a long-term process. However, there is a strengthening interest in and demand for such work, particularly through the National Policy Statement for Freshwater Management 2014 (amended 2017¹) and Farm Environmental Plans applying the Good Farming Practice Action Plan for Water Quality (2018).² These are beginning to explicitly include management that benefits native biodiversity, such as excluding stock from wetlands and riparian areas to benefit water quality. NES-Plantation Forestry (2018³) is seeing highly erodible and riparian plantations reverted to alternative uses post-harvest, and this includes native forests. The increase in lifestyle blocks to the east of MEIT is both an opportunity for revegetation, and a risk (primarily from new weed species that are planted).

¹ <http://www.mfe.govt.nz/publications/fresh-water/national-policy-statement-freshwater-management-2014-amended-2017>

² http://www.fedfarm.org.nz/FFPublic/Policy2/National/Good_Farming_Practice-Action_Plan_for_Water_Quality_2018.aspx

³ <http://www.mfe.govt.nz/land/proposed-nes-plantation-forestry>

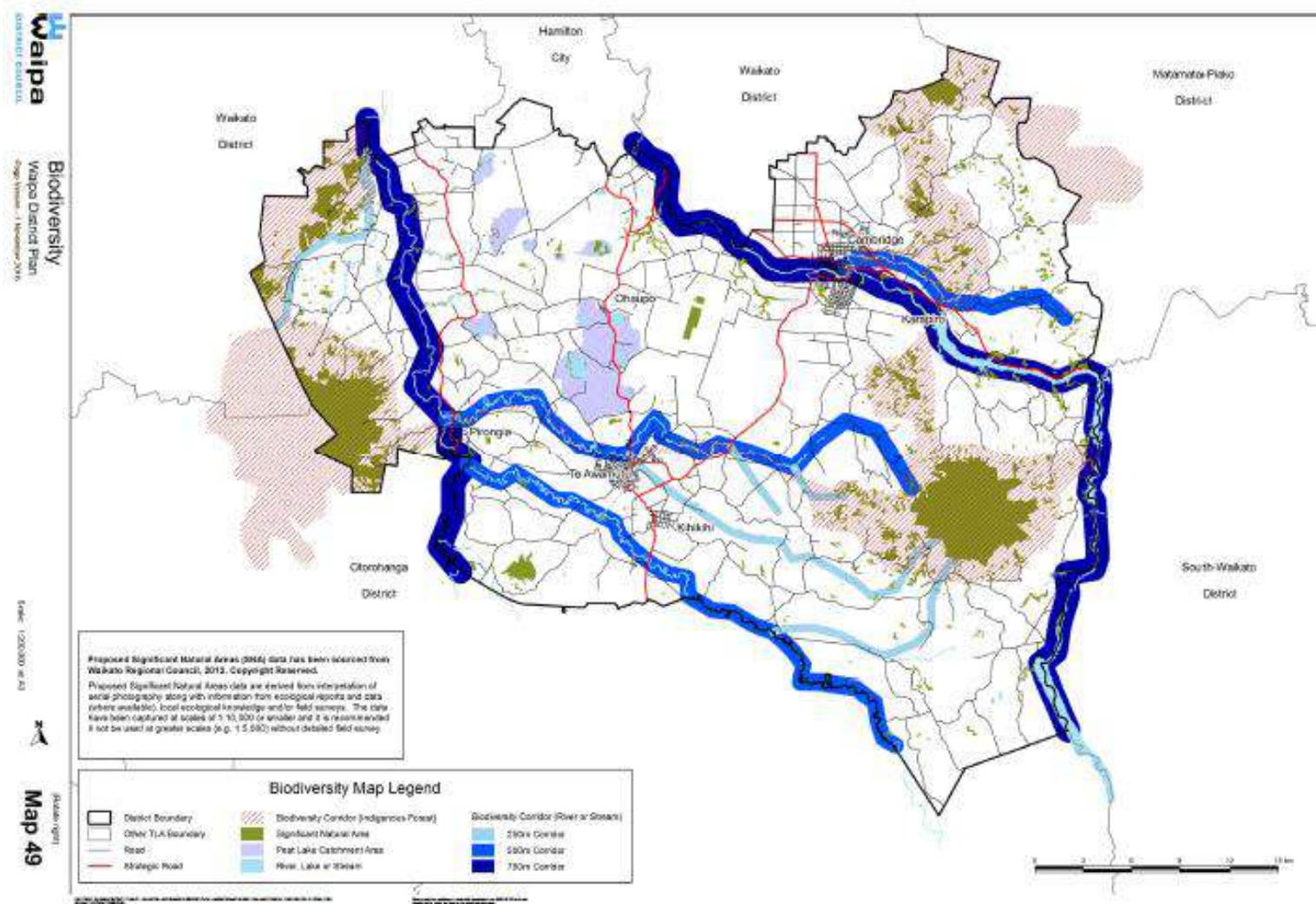


Figure 5. Planned areas of 'targeted encouragement' of landowners to establish biodiversity movement corridors across Waipa District (reproduced from Waipa District Plan (2016) with kind permission of Waipa District Council).

5.3.1 Wildlife movement outside the sanctuary

The pest fence at Maungatautari blocks movement of some native fauna (e.g. kiwi that are flightless) but not others (taxa that can fly or climb). For example, the average maximum number of tūi seen by landowners 5–10 km from the maunga increased 6-fold from 2006 to 2014 (N. Fitzgerald, J. Innes, unpubl. data). Movement of other forest birds is also likely, although birds vary greatly in their ability and willingness to cross pasture gaps (Burge et al. 2017). Placing the maunga in a landscape context reinforces that Maungatautari is a remnant, upland environment (300–800 m asl) and it is likely that many forest birds originally ranged widely to find seasonal foods into lowland environments that are now mostly cleared. This may explain why kererū, in particular, have been slow to recover inside the SMM project (N. Fitzgerald, J. Innes, unpubl. data).

The largest scale of avian connection would be for seabirds – if these can be successfully translocated – that may in future nest on the maunga but feed at sea, and for shining and long-tailed cuckoos that annually migrate to remote Pacific islands such as Fiji and the Solomon Islands.

However, aquatic species also move across landscape scales, tuna (eels) migrate to the Pacific Ocean to spawn, and some whitebait (galaxiids) also migrate to the ocean. Invertebrates such as windblown spiders and aphids may also disperse very large distances to and from the maunga, while other spiders are very localised (tunnel-web spiders). Many terrestrial invertebrates are obligate forest dwellers.

Therefore, wildlife movement outside the sanctuary assists ecological processes such as seed dispersal (Tanentzap & Lloyd 2017) and is also a necessary component of life cycles for some taxa, such as tuna and cuckoos.

5.3.2 Regional planning

Waikato Regional Council and District Councils have legal roles under the Resource Management Act 1991 to maintain indigenous biodiversity, their habitats, and intrinsic values of ecosystems on broad scales. This requires action (by partnership) in Significant Natural Areas and other private land across Waikato landscapes. Guided by the Regional Policy Statement, Waikato Regional Council has produced a Local Indigenous Biodiversity Strategy Programme as a process to assist such partnerships. Pilot projects to plan possible biodiversity restoration actions have been undertaken in the Waihou-Piako catchment (Vare 2016), and in Hamilton City (M. Vare, pers. comm. 2018).

Waipa District Council (2016, Section 24 – Indigenous Biodiversity⁴) notes that there are poor ecological links between key remaining forests, lakes and rivers in the Waipa District, and plans to encourage private landowners to support the establishment of strong corridors in the future (Fig. 5).

⁴ [https://www.waipadc.govt.nz/our-council/Waipad2050/wdc-part-operative/Pages/Waipad2050District20Plan20\(part20Operative\).aspx](https://www.waipadc.govt.nz/our-council/Waipad2050/wdc-part-operative/Pages/Waipad2050District20Plan20(part20Operative).aspx)

Regional planning for Predator Free NZ by the Department of Conservation or by Predator Free NZ 2050 Ltd⁵ is likely to involve MEIT in the future, but it is not currently clear when or how that will unfold.

5.3.3 Plan period (2019–29) connectivity actions

- 1 Participate in regional biodiversity planning processes with Waikato Regional Council and Waipa District Council to encourage and facilitate the establishment of biodiversity corridors from Maungatautari to other significant natural areas in the central Waikato.
- 2 Encourage adjacent landowners to establish biodiversity corridors.

6 Maungatautari species

6.1 Plants

A total of 257 indigenous vascular plants have been recorded on Maungatautari (Appendix 1). This list was compiled by Bruce Clarkson (University of Waikato) based on visits between 1979 and 2002 and was updated in December 2018 by Catherine Kirby (University of Waikato) with updated names and the list cross-checked against Fisher (1961), Gudex (1963), Brown et al. (2006), and Clarkson & Boase (1986). The list also includes plant species recorded by Manaaki Whenua – Landcare Research and University of Waikato in 20×20-m permanent plots established on Maungatautari in 2004/2006 and remeasured in 2014 (Bruce Burns, University of Auckland, unpubl. data). No lists of bryophytes, algae or lichens present on Maungatautari are currently available.

Maungatautari supports highly diverse old-growth native forest. At a plot scale (alpha-diversity), there was a mean of 47 vascular plant species per 400-m² plot recorded in 2014 ($n = 31$ plots), which is high in comparison with other such measures in New Zealand (Burns 1995). Clarkson (1981) and Clarkson & Boase (1986), however, described the maunga as being floristically poorer overall (gamma diversity) than other mountains of the Waikato basin, with the notable absences, for example, of the tree dracophyllums (*Dracophyllum traversii* and *Dracophyllum latifolium*), as well as *Coprosma colensoi* and *Raukaua simplex*.

Fifteen plant species found on Maungatautari are currently listed as threatened (de Lange et al. 2017) (Table 1). Seven of these are from the family Myrtaceae and the threat status of these species has been elevated in this 2017 update of the threatened species list because of the recent arrival (2017) of myrtle rust (*Austropuccinia psidii*) to New Zealand. *Corybas rivularis* is considered *At risk – naturally uncommon* but needs further taxonomic consideration to determine which of the several forms distinguished occurs on Maungatautari (Irwin 1994, 1996).

⁵ <https://pf2050.co.nz/project/>

We do not currently know of lists of non-vascular plant species (e.g. bryophytes, algae, lichens) that occur on Maungatautari.

Table 1. Vascular plant species observed at Maungatautari that are listed as ‘threatened’ in de Lange et al. (2017)

Conservation status	Species
Nationally vulnerable	<i>Brachyglottis kirkii</i> var. <i>kirkii</i> <i>Kunzea robusta</i> <i>Metrosideros carminea</i> <i>Metrosideros diffusa</i> <i>Metrosideros fulgens</i> <i>Metrosideros perforata</i> <i>Metrosideros robusta</i>
At risk – declining	<i>Daucus glochidiatus</i> <i>Leptospermum scoparium</i> <i>Mida salicifolia</i> <i>Ptisana salicina</i> <i>Tupeia antarctica</i>
At risk – naturally uncommon	<i>Botrychium australe</i> <i>Corybas rivularis</i> <i>Thismia rodwayi</i>

A study of vegetation change on Maungatautari over the first 10 years since the pest fence was established showed that the cover abundance of nine species (including four major canopy tree species) increased significantly over all plots, but not stand mean basal area or tree density (B. Burns, unpubl. data). Mean sapling and seedling densities were relatively high at both measurements, and no significant increases occurred (B. Burns, unpubl. data). These results suggest that the forests on Maungatautari were not as strongly degraded by introduced mammals as similar forests elsewhere in New Zealand at the time of fencing, so the response of pest mammal removal has been modest so far.

It is possible that the white mistletoe or tāpia, *Tupeia antarctica*, was historically present on Maungatautari as it was listed by Gudex (1963) but has not been seen since. This may also be true for *Botrychium australe* and *Daucus glochidiatus*, also both listed by Gudex (1963) (Bruce Burns, University of Auckland, pers. comm., 2018). The green mistletoe or pirita, *Ileostylus micranthus*, occurs on Bill Garland's property very close to Maungatautari, but has not been seen inside the fence (Burns, pers. comm.). These plant taxa require targeted surveys and if they are not found on the maunga, they could be considered as potential species for future translocation to Maungatautari.

Weed species are present on Maungatautari, e.g. Barberry *Berberis glaucocarpa* in the Tautari Wetland, buttercup *Ranunculus repens* in the Tuatarium and gorse *Ulex europaeus* on the main maunga. Their control is discussed in the Biosecurity Plan (MEIT 2015). The threat of new weed species establishing on Maungatautari is also discussed in the Maungatautari Ecological Island Biosecurity Plan 2015–2020 (MEIT 2015). The main vectors

of new plant weeds are bird-dispersal (by tūī, blackbird and kerurū) from gardens (cherry etc.) and weedy hedgerows (barberry, privet, hawthorn); and wind-blown/mower-spread weeds along road corridors (e.g. pampas).

6.1.1 Plan period (2019–29) plant actions in approximate priority order

- 1 In 2024, remeasure vegetation in the 35 permanent plots established in 2004–06 and first remeasured in 2014, to assess vegetation responses between 10 and 20 years after removal of all mammals except mice.
- 2 Undertake targeted survey for plants recorded as present historically but not observed recently (*Tupeia antarctica*, *Ileostylus micranthus*, *Beilschmiedia tarairi*, *Botrychium australe*, *Daucus glochidiatus*).
- 3 Undertake targeted survey for plants not currently known to be present, despite the maunga apparently being suitable habitat (*Dactylanthus taylorii*, *Pittosporum kirkii*).
- 4 Undertake surveys for and monitor threatened plant species (*Brachyglottis kirkii* var. *kirkii*, *Kunzea robusta*, *Metrosideros carminea*, *M. diffusa*, *M. fulgens*, *M. perforata*, *M. robusta*, *Daucus glochidiatus*, *Leptospermum scoparium*, *Misa salicifolia*, *Ptisana salicina*, *Tupeia antarctica*, *Corybas rivularis*, *Thismia rodwayi*, Table 1).
- 5 Monitor highly localised species (e.g. *Celmisia gracilentia*) that are likely to be overwhelmed by vegetation recovery after browsing mammal removal.
- 6 Undertake maunga-wide, primary surveys for bryophytes, algae, and lichens to further document Maungatautari biodiversity.
- 7 Restore indigenous dominance by creating conditions to favour native plants at sites where natural processes are unlikely to result in natural colonisation in a reasonable timeframe; prioritising methods that leverage natural regeneration, and avoid/minimise planting of nursery-raised seedlings.
- 8 Pending outcomes of 6.1.1 (3), explore translocation of *Dactylanthus taylorii* to the maunga to provide a known food supply for short-tailed bats, kākāpō and other fauna and mistletoes to provide food supply for tūī, etc.
- 9 Follow actions outlined in the Maungatautari Ecological Island Biosecurity Plan 2015–2020 (MEIT 2015) regarding control and surveillance of weeds and diseases.
- 10 Train staff to watch for symptoms of myrtle rust appearing at the maunga, and to stay in touch with relevant management and science agencies that are working on this species.

6.2 Birds

Thirty-five bird species have been observed at Maungatautari during 2002–2017; 23 native/endemic and 12 introduced (Appendix 2; Smuts-Kennedy & Parker 2013). Indices of abundance of diurnal (daytime) birds were counted triennially during 2002–2014 to determine their responses to fencing, pest removal and translocation (Fitzgerald, Innes, unpubl. data), and biannually during 2007–2011 by EcoQuest Education Foundation (Sinclair & Brejaart 2001). Also, an American researcher Sara Bombaci measured absolute

bird densities inside and outside the maunga during 2016 and 2017 (Bombaci et al. 2018) and compared these with differences in seed dispersal (S. Bombaci, Colorado State University, USA, unpubl. data).

These studies agree that in general, populations of endemic forest bird species (including translocated species) have increased after pest removal in 2004–2006, while introduced and native species that self-established relatively recently (e.g. grey warbler, fantail) have been stable or even declined. Endemic birds seem to be particularly vulnerable to introduced mammalian predators but may outcompete other birds as avian communities re-sort themselves after pest removal (Innes et al. 2010; Miskelly 2018).

Bird increases at Maungatautari have resulted in improved pollination and seed dispersal for species such as tree fuchsia (*Fuchsia excorticata*) that rely on birds for these ecological services (Iles & Kelly 2014; Sara Bombaci et al., unpubl. data).

The closest site to Maungatautari with an account of the pre-human avifauna that may provide a reference site for bird restoration in SMM is Waitomo, in western Waikato, where bones of subfossil birds accumulated in caves (Atkinson & Milliner 1991). At Waitomo, the whole guild of ground-herbivores (seven species of moa) is now extinct, as are snipe-rail, stout-legged wren, Travers' wren, piopio, hūia, and bush wren (Atkinson & Milliner 1991). However, many other taxa, including red- and yellow-crowned kākāriki, NI kākā, kākāpō, NI kōkako, NI brown kiwi, little spotted kiwi, NI robin, NI tīeke/saddleback, hihi/stitchbird, whitehead, and rifleman eventually disappeared from Waitomo, and presumably Maungatautari, but can be translocated back again because populations remain elsewhere. Some North Island taxa such as NI takahē *Porphyrio mantelli* and NI snipe *Coenocorypha barrierensis* are extinct, but SI takahē *Porphyrio hochstetteri* and Chatham Is. snipe *Coenocorypha pusilla* could be respective substitutes (Seddon & Soorae 1999). Furthermore, some marine-feeding, tubenose petrels, such as black petrel *Procellaria parkinsoni* and Cook's petrel *Pterodroma cookii*, formerly nested on inland mountain tops on the North Island mainland, until eradicated by mammalian predation (Bell 2013; Taylor & Rayner 2017), and could also be translocated to Maungatautari.

Nine bird species have already been translocated back to the maunga (Smuts-Kennedy & Parker 2013, Table 2). Smuts-Kennedy & Parker (2013) suggested 18 bird species that could be translocated to the maunga from that timepoint, with the first introductions of two of these completed (Table 3).

We agree that this sets a suitable preliminary agenda for avian translocations, and note that:

- 40 NI kokako were translocated to Maungatautari in 2015–2016; however, population reinforcement will be needed to safeguard long-term genetic diversity
- A MOU concerning the intention to translocate kakapo to Maungatautari is completed and awaits sign-off by DOC and MEIT (April 2019)
- NI saddleback have already been translocated but top-ups for genetic reasons are also desirable (Kevin Parker, pers. comm., 2018)
- Recent palaeoecological studies of brown teal diet using stable isotope analyses suggest that brown teal should be released into fenced forested areas such as

Maungatautari to '...test whether modern birds can survive in habitats once occupied by now-extirpated populations' (Holdaway et al. 2013)

- The national charity Kiwis for Kiwi is using Maungatautari as a kohanga (breeding nursery) for western brown kiwi, rapidly accelerating the Maungatautari brown kiwi population towards carrying capacity in the next 5 years; establishing little spotted kiwi may slow brown kiwi population growth rates
- Omnivorous NI weka are charismatic and important seed dispersers (Carpenter et al. 2018) and were once widespread; we suggest that it would be valuable to trial if NI weka also may control mice in one of the fenced areas at Maungatautari
- So far, few attempts have been made in New Zealand to re-establish burrow-nesting seabirds at inland sites. Seabirds are vulnerable to attraction to land-based artificial lights (Rodríguez et al. 2017) and it is possible that this could undermine such restoration efforts at Maungatautari. Also, they are very vulnerable to incursion by even a single stoat (Colin Miskelly, Te Papa, pers. comm., 2018)
- A now expired 2003–2013 snipe (*Coenocorypha* spp.) Recovery Plan (Roberts & Miskelly, undated) advocated for Snares Island snipe to be returned to islands around the South Island and Chatham Island snipe to be returned to islands around the North Island. Colin Miskelly (pers. comm.) considers that North Island islands (Hauturu, Mana, Tiritiri Matangi) should be first-receiver sites (before mainland sanctuaries) because snipe are extremely vulnerable to pest mammal predation
- Spotless crane have been seen and heard on several occasions in the Tautari wetland enclosure in the last three years (J. Ward pers. comm. May 2019). Fernbird, banded rail and spotless crane may self-establish from nearest remnant populations. The latter two species self-colonised Hauturu/Little Barrier Island so are clearly strong dispersers. Fernbird could be a priority target of efforts to link nearest source areas to the mountain via pest control, corridors and stepping-stones of wetlands.
- Rifleman have been seen and heard in at least four parts of the maunga between 2009 and 2019 (J. Ward pers. comm. May 2019). Whether the ongoing presence of rifleman at Maungatautari should put paid to consideration of a mooted rifleman translocation from elsewhere requires discussion with experts, including geneticists.

Table 2. Translocations of nine bird species, tuatara, two fish and one insect to SMM between 2005 and 2018 (compiled by J Ward, MEIT, February 2019 and Kate Richardson, WRC)

Year	Species	DOC threat status, 2016	Source population	Current (February 2019) population at Maungatautari	Notes
2005–2017	North Island brown kiwi (<i>Apteryx mantelli</i>) western taxon (WBK)	'At Risk – Declining'	Various wild and captive sites with WBK, e.g. Tongaririo, Waimarino, Taranaki	88 released on the main mountain. 2 in NE, 20 in SE and 1+ (suspected) in QEII block. This does not count any kiwi bred on the mountain or in SE that are not tagged.	2 chicks in the S.E. (crèche) 2018. Kiwis for Kiwi plan – 500 over next 5 years.
2006–2017	South Island takahē (<i>Porphyrio hochstetteri</i>)	'Threatened - Nationally Vulnerable'	MEIT has received 10 adult birds from 4 breeding sites in the past 10 years.	2 adults, 1 subadult + 2 chicks: (Wetlands) 2 adults, 1 subadult and 1 chick: (Coopers')	MEIT has exported 8 chicks to various sites. 100 breeding pairs in total population now countrywide.
2007–2010, 2013–2014	North Island kākā (<i>Nestor meridionalis septentrionalis</i>)	'At Risk – Recovering'	21 juvenile kākā (10M and 11F from three captive breeding pairs) were released from the on-site aviary. Five more from Mt. Bruce, Auckland Zoo and Cape Sanctuary released in 2013-2014.	~30 Kaka (according to 2016/2017 annual report).	First wild breeding on Maungatautari was recorded in 2009/10 season.
2009	Whitehead Pōpokatea (<i>Mohoua albicilla</i>)	'At Risk – Declining'	60 from Little Barrier Island.	Unknown, but can be heard in small flocks throughout the SE and on main maunga.	Unbanded birds now rarely seen.
2009-2011	Stitchbird Hihi (<i>Notiomystis cincta</i>)	'Threatened – Nationally Vulnerable'	155 over 3 translocations (135 from Tiritiri Matangi Island and 20 from Little Barrier Island).	Survey completed annually. Minimum adult population 47 in 2018/19.	Hihi feeding stations now distributed more widely across maunga.
2010-2011	Yellow-crowned parakeet Kākāriki (<i>Cyanoramphus auriceps</i>)	'Not threatened'	12 captive-bred (9M, 3F).	Unknown.	No confirmed sightings since 2012.

Year	Species	DOC threat status, 2016	Source population	Current (February 2019) population at Maungatautari	Notes
2011-2012	North Island Robin Pītoitoi (<i>Petroica longipes</i>)	'At Risk – Declining'	40 in 2011 and 40 in 2012 from Pureora Forest.	Widespread – sightings now are mostly of mountain-bred birds (unbanded).	One of the most commonly seen/heard across most of the maunga.
2013	North Island Saddleback Tieke (<i>Philesturnus rufusater</i>)	'At Risk – Recovering'	40 from Tiritiri Matangi Island (20M and 20F).	Widespread throughout southern half of maunga.	Territory mapping in 2013/14 and mark-recapture survey in 2014/15.
2015-2016	North Island Kōkako (<i>Callaeas wilsoni</i>)	'At Risk – Recovering'	40 from Pureora Forest.	2018 census: 19 territorial pair, 1 unconfirmed territorial pair, 6 single territorials = total 44 territorial.	Further translocation recommended.
2007	Giant kōkopu (<i>Galaxias argenteus</i>)	'At Risk – Declining'	Released into streams in the S.E. and Tautari Wetland.	Monitoring between 2010 and 2011 found fish in the Tautari wetland and southern enclosure. Surveys in 2012 found fish in the Tautari wetland but no fish in the bridge pool and teal pond in the southern enclosure. No more monitoring has been undertaken since 2012.	Seen in streams in the S.E. on night tours and in the wetland pond in 2011/2012.
2007	Banded kōkopu (<i>Galaxias fasciatus</i>)	'At Risk – Declining'	Released into streams in the S.E. and Tautari Wetland.	As for giant kokopu	Seen in streams in the S.E. on night tours and in the wetland pond in 2011/12.
2012	Tuatara (<i>Sphenodon punctatus</i>)	'At Risk – Relict'	50 from Stephens Island Takapourewa.	20 adults in Tuatarium (12M and 8F). 8 sightings of juveniles have been observed since 2013. Regularly seeing juveniles and eggs.	Extinct on mainland since late 1700s. Now occupy <10% of former range.
2012	Mahoenui giant wētā (<i>Deinacrida mahoenui</i>)	'At Risk – Recovering'	Mahoenui giant weta scientific reserve (King Country).	Occasional sightings near release site in SE.	Tracking tunnels are set up in selected trees for monitoring in 2013 and 2014.

Table 3. Potential future avian translocations from 2013 to Maungatautari, presented verbatim (with abbreviations) from Smuts-Kennedy & Parker (2013). References to support the selection of species are in Smuts-Kennedy & Parker (2013)

Species	Potential source site	Notes
NI kokako <i>Callaeas wilsoni</i>	Waikato/King Country sites, & Little Barrier Island	Research-based translocation desirable
Kākāpo <i>Strigops habroptilus</i>	Codfish I Anchor I, Pearl I, Chalky I & Little Barrier I.	Initial trial translocation desirable to assess Maungatautari as breeding site, using males surplus to breeding programme; barrier required to prevent birds climbing over fence; prototype already designed and tested by MEIT
NI saddleback <i>Philesturnus rufusater</i>	Multi-source	Multi-source translocation desirable to maximise genetic and behavioural diversity of founders
NI rifleman <i>Acanthisitta chloris granti</i>	Pureora and Pirongia	Translocation protocols established; impact of mice unknown
Cook's petrel <i>Pterodroma cookii</i>	Little Barrier I	Long-term translocation programme required; translocation protocols established; impact of mice unknown
Black petrel <i>Procellaria parkinsoni</i>	Great Barrier I	Long-term translocation programme required; translocation protocols being developed/refined; impact of mice unknown
Red-crowned parakeet <i>Cyanoramphus n. novaezelandiae</i>	Wild and/or captive stock	Preferably translocate before yellow-crowned parakeets reach high density, to reduce risk of hybridisation
Orange-fronted parakeet <i>C. malherbi</i>	Likely captive bred.	To be investigated
Chatham I snipe <i>Coenocorypha pusilla</i>	Chatham I	Analogue species to replace extinct North Island snipe (<i>C. barrierensis</i>); impact of mice unknown
Blue duck <i>Hymenolaimus malacorhynchos</i>	Wild and/or captive birds	Unlikely at present time due to paucity of 'classic' habitat; any translocation should assess habitat plasticity of the species
Brown teal <i>Anas chlorotis</i>	Captive birds	As for blue duck, but a few small ponds are included within the pest fence
Rock wren <i>Xenicus gilviventris</i>	South I	As for blue duck; known from Holocene fossils from North I, but may be misidentified; potential analogue species to replace extinct North Island bush wren; impact of mice unknown

Little spotted kiwi <i>Apteryx owenii</i>	Kapiti I	Potential conflict with brown kiwi
NI weka <i>Gallirallus australis greyi</i>		Probable conflict with other species; any translocation should assess impact on other species
Long-tailed cuckoo <i>Eudynamys taitensis</i>		Possible self-introduction, but translocation might be required – protocols to be developed
NI fernbird <i>Bowdleria punctata vealeae</i>		Possible self-introduction, but translocation protocols exist
Banded rail <i>Rallus philippensis assimilis</i>		Possible self-introduction, but translocation protocols exist
Spotless crane <i>Porzana t. tabuensis</i>		Possible self-introduction

6.2.1 Plan period (2019–29) bird actions in approximate priority order

- 1 Monitor abundance and wellbeing of all translocated taxa (Table 2), and sustain strong relationships with relevant species Recovery Groups, iwi, and other stakeholders such as Kiwis for Kiwi.
- 2 Continue MWLR triennial bird counts (due 2020, 2023, 2026, 2029) and other regular counts that methodically document bird distribution and abundance on the maunga, to study bird species and community changes after mammal removal and translocations.
- 3 Undertake 'population reinforcement' translocations of species already translocated to the maunga whose genetic founders are probably too few to ensure long-term retention of rare alleles (NI kākā, NI tīeke, NI kōkako).
- 4 Translocate some kākāpō to the main maunga outside NE and SE after undertaking trials demonstrating that they are very unlikely to climb out over the pest-fence.
- 5 Translocate NI rifleman, little spotted kiwi, brown teal and at least one kākārīki (*Cyanoramphus* spp.) species, to the maunga, pending discussion of likely remnant rifleman on the maunga.
- 6 Engage with species experts, relevant iwi and other stakeholders to further explore whether Cooks petrel, Black petrel, and Chatham Island snipe should or could be translocated to Maungatautari.
- 7 Undertake 5-yearly targeted survey for NI fernbird, banded rail, and spotless crane that may self-colonise but remain undetectable in the usual forest bird counts (6.4.2) and work with WDC and landowners to increase connectivity and populations. Consider translocation of these taxa if they have not self-colonised by 2029.
- 8 Introduce NI weka to the Garland QE II block in a trial to see if they would control mouse numbers, as part of a discussion about restoring them to the main maunga. (This would require discussion with the Garlands, and the reintroduction of mice).
- 9 Continue to seek and formally collate records of long-tailed cuckoo on the maunga, to add to the three existing observations during 2016–19 (J. Ward, pers. comm., May 2019).

6.3 Bats

In December 2008/January 2009, Chris Smuts-Kennedy *et al.* detected long-tailed (*Chalinolobus tuberculatus*) but not short-tailed bats (*Mystacina tuberculata*) on Maungatautari by placing remote digital recorders out for 22 days on high saddles on the maunga in mid-summer when tāwari (*Ixerba brexioides*) and kāmahī (*Weinmannia racemosa*) were flowering. Long-tails were also detected in a previous survey with older style 'bat-boxes' (Chris Smuts-Kennedy, pers. comm., 2017). Long-tailed bats have also been sighted at dusk around the forest edge and over the Tautari Wetland.

6.3.1 Plan period (2019–29) bat actions in priority order

- 1 Undertake further surveys for long- and short-tailed bats on and in landscapes surrounding the maunga
- 2 Pending results of the above, consider translocating short-tailed bats to the maunga

6.4 Tuatara, geckos and skinks

Fifty tuatara (*Sphenodon punctatus*) were translocated to Maungatautari in 2012 (Table 1). Twenty tuatara live in the Tuatarium, a 40×40-m enclosure within the Tautari Wetland (MEIT 2016b). Juveniles have been sighted since 2013. The other 30 tuatara live in an undisclosed location not accessible by the public. Since their introduction, there have been several tuatara surveys and health checks completed by Victoria University of Wellington. Sixty-one percent of individuals relocated and checked after translocation to Maungatautari had improved in condition. ‘Decades’ of monitoring is required to confirm the establishment of a viable, self-sustaining population at the maunga because tuatara are so long-lived (Price 2016).

No formal surveys for native lizards (skinks and geckos) have been undertaken (Andrew Styche, DOC, pers. comm., 2019), aside from targeted surveys for Duvaucel’s gecko. The following information regarding lizards is a summary of comments from experts, reported sightings from DOC’s Amphibian and Reptile Distribution Scheme Card (<https://www.doc.govt.nz/our-work/reptiles-and-frogs-distribution/atlas/species-sightings-and-data-management/report-a-sighting/>), and publications. Two skink species, copper skink (*Oligosoma aeneum*, ‘Not Threatened’ in Hitchmough et al. 2016) and ornate skink (*O. ornatum*, ‘At Risk – Declining’) have been recorded. Both species inhabit dense leaf litter or rank grass in forest and scrubland habitats (Chapple et al. 2008). The elegant gecko (*Naultinus elegans*, ‘At Risk – Declining’), forest gecko (*Mokopirirakau granulatus*, ‘At Risk – Declining’), pacific gecko (*Dactylocnemis pacificus*, ‘At Risk – Relic’), and Duvaucel’s gecko (*Hoplodactylus duvaucelii*, ‘At Risk – Relic’) have all been observed in forest or shrubland at Maungatautari. The record of Duvaucel’s gecko was a single specimen caught in a mouse trap in 2010, and genetic analysis indicates that it represents a naturally occurring North Island population that is likely to be at very low densities (Morgan-Richards et al. 2016). Duvaucel’s gecko, although once present on the mainland, currently inhabit offshore islands around the north-eastern North Island and Cook Strait (Morgan-Richards et al. 2016). Clearly, regard will need to be given to genetics of any remaining Maungatautari Duvaucel’s geckos if translocations are planned.

Six species of skinks and two geckos were likely to have been historically present on Maungatautari (Table 4). Of these, two skinks (striped skink and speckled skink) and both gecko species (Duvaucel’s gecko and striped gecko) are priorities for translocation (Table 4) after surveys are completed and assuming no individuals are found.

Mice may be predators of lizards at Maungatautari (Norbury et al. 2014), on the ground and up trees (Innes et al. 2018), but if the smaller fenced exclosures including NE and SE can be kept mouse-free, the sites that are entirely pest-mammal free may be available to receive translocated lizards.

Plague skinks (*Lampropholis delicata*) have not been confirmed at Maungatautari but are potentially a biosecurity threat for Maungatautari. This species is discussed in the Maungatautari Ecological Island Biosecurity Plan 2015–2020 (MEIT 2015).

6.4.1 Plan period (2019–29) reptile actions in priority order

- 1 Continue to monitor abundance and individual health of translocated tuatara at both Maungatautari locations at 5-year intervals as recommended by Price (2016)
- 2 Establish a more formal monitoring system to look for, record and curate data of lizard tracks on tracking cards set for mammals at Maungatautari, and consider other possible maunga-wide monitoring systems
- 3 Undertake targeted survey for possible or known extant lizard species (striped skink, speckled skink, Whirinaki skink, Duvaucel's gecko, striped gecko) on the maunga, as a necessary prelude to considering translocations
- 4 Discuss further with experts and relevant stakeholders if there are other reptiles (such as robust skink, McGregor's skink, Whitaker's skink) that should be considered for translocation to the maunga
- 5 Pending results of all the above, plan translocation of selected reptiles to the maunga – perhaps to mouse-free smaller fenced exclosures such as NE and SE. This could include habitat enhancement.

Table 4. Lizard species that were likely historically present but currently not recorded from Maungatautari and some are possible species for translocation. Compiled by Kelly Hare, Rod Hitchmough, Dylan van Winkel, and Andrew Styche. NZTC =New Zealand Threat Classification

Species (NZTC)	Habitat preference	Notes	Priority candidates for translocation
SKINKS			
Striped skink <i>Oligosoma striatum</i> (‘At Risk – Declining’)	In epiphytes and rotten wood in primary forest (especially tawa).	Range extends from southern Taranaki northwards to Kaipara and east to East Cape (including a recent record from Motu). Maungatautari falls within the known current range of this species.	AFTER 5–10 years mammal-free coupled with a survey to confirm they are not already present.
Speckled skink <i>Oligosoma infrapunctatum</i> (‘At Risk – Declining’)	Occurs in forest and scrubland.	The taxon likely to be/have been present is the crenulate skink (<i>Oligosoma</i> aff. <i>infrapunctatum</i> “crenulate”). It is generally rare across its range but is relatively common around Pureora. It should occur at or to have occurred at Maungatautari. NB <i>O. nfrapunctatum</i> is currently a species complex but Chapple et al. (in review) will split it into 4-5 species.	AFTER 5–10 years mammal-free coupled with a survey to confirm they are not already present.
Whirinaki skink <i>Oligosoma whirinaki</i> (‘Nationally Critical’)	Open forest.	This taxon has been recorded from Whirinaki forest and Bream Head (Northland). The genetic relationship between these two disjunct populations is unknown. They look identical so their historic distribution may extend from Whirinaki to Whangarei and therefore could still be/may have been present in Maungatautari.	
Robust skink <i>Oligosoma alani</i> (‘Recovering’)	Low coastal forest.	North Island only. Currently restricted to Mercury Island and Castle Island off Coromandel Peninsula. Subfossil bones found in Waikato.	Needs to be resolved whether translocating coastal species to Maungatautari is appropriate. Source populations maybe limiting. Mouse densities need to be very low.
McGregor’s skink <i>Oligosoma macgregori</i> (‘Recovering’)	Leaf litter, logs under coastal forest and scrub.	North Island only. Currently restricted to offshore islands in Northland, Hauraki Gulf and Mana Island. Subfossil bones found in Waikato.	Needs to be resolved whether translocating coastal species to Maungatautari is appropriate. Source populations maybe limiting. Mouse densities need to be very low.
Whitaker’s skink <i>Oligosoma whitakeri</i> (‘Vulnerable’)	Leaf litter and seabird burrows in coastal forest and scrub.	North Island only. Currently restricted to Middle Island (Mercury Islands), Castle Island (Coromandel), and possibly Pukerua Bay (Wellington). Subfossil bones found in Waitomo.	Needs to be resolved whether translocating coastal species to Maungatautari is appropriate. Source populations maybe limiting. Mouse densities need to be very low.

Species (NZTC)	Habitat preference	Notes	Priority candidates for translocation
GECKOS			
Duvaucel's gecko <i>Hoplodactylus duvaucelii</i> (‘At Risk – Relict’)	Forest and scrubland.	Duvaucel's gecko might be present based on the single animal found. These animals can live for decades and may be present at very low densities.	AFTER 5-10 years mammal-free coupled with a thorough survey to confirm they are not already present. Many previous successful translocations so methods well established.
Striped gecko <i>Toropuku stephensi</i> (‘Nationally Vulnerable’)	Coastal forest and shrubland.	The taxon likely to be/have been present is the <i>Toropuku</i> “Coromandel” (the Coromandel striped gecko). It is extremely rare and has only been recorded from Stephens Island and Maud Island in the Marlborough Sounds and on the Coromandel. Perhaps similarly for <i>W. chrysosireticus</i> ?	AFTER 5-10 years mammal-free coupled with a survey to confirm they are not already present. How far beyond current known range should they be translocated?

6.5 Frogs

In November 2004, a population of Hochstetter's frog (*Leiopelma hochstetteri*) was found in two catchments (> 120 ha) on the south and southeast of Maungatautari (Baber et al. 2006). Surveys conducted in 2005 found that encounter rates and relative abundances were similar to other populations in Northland and to the non-pest control area in the Hunua Ranges but were lower than most other populations (Baber et al. 2006). Surveys after the mammal eradication (excluding mice) on the maunga found that numbers of Hochstetter's frog had increased four-fold from 2009 to 2012 and that the population was spreading from an initial limited distribution (Longson et al. 2017). Latest monitoring in November 2018, found no statistically significant change in frog numbers since 2012 (EcoQuest Education Foundation, pers. comm., 2019). EcoQuest Education Foundation continues to monitor this population in April and November every 3 years (EcoQuest Education Foundation, pers. comm.).

It is also possible that Archey's frog (*Leiopelma archeyi*) inhabit Maungatautari but have not been discovered yet. The Native Frog Recovery Group has recognised Maungatautari as a possible translocation site for Archey's Frog but surveys looking for this species, plus habitat and weather/climate assessments, need to be completed (Amanda Haigh, DOC, pers. comm. 2019).

6.5.1 Plan period (2019–29) frog actions in priority order

- 1 Continue formal, episodic monitoring of Hochstetter's frog abundance and distribution on the maunga
- 2 Undertake targeted survey for Archey's frog on the maunga
- 3 Pending results of 6.5.1 (2), liaise with the Native Frog Recovery Group regarding possible translocation of Archey's frog to the maunga, perhaps to mouse-free SE and NE if suitable habitat is available, and with due regard to biosecurity risks.

6.6 Fish

NIWA carried out one fish survey in a tributary draining the north side of Maungatautari in the early 2000s. The only diadromous fish species found in the NIWA survey were eels and in addition, non-migratory bullies were also captured that were likely Cran's bullies *Gobiomorphus basalis* (Cindy Baker, NIWA, pers. comm., 2019). No introduced fish species were found. Further survey work is required.

In April 2007, approximately 60 young giant kōkopu (*Galaxias argenteus*) and 20 young banded kōkopu (*Galaxias fasciatus*) were released into the Tautari Wetland and approximately 115 banded kōkopu were also released into the first stream inside the southern enclosure (under the bridge) and into the 'teal pond' on the Rata Track in the southern enclosure (Table 1; MEIT 2016b). Monitoring in 2010 and 2011 found fish in the Tautari wetland and southern enclosure. Surveys in 2012 found fish in the Tautari wetland but no fish in the bridge pool and teal pond in the southern enclosure (Churchill pers. comm.). Overgrown vegetation in the bridge pool and changes (water level, lack of

vegetation around pool edges and construction work) to the teal pond could be reasons why no fish were found. No more monitoring has been undertaken since 2012 (Churchill, pers. comm.).

There is potential for a further translocation of banded kokopu into the stream on the northern enclosure to occur.

Other taxa for translocation could be considered after further survey work has occurred.

6.6.1 Plan period (2019–29) fish actions in priority order

- 1 Re-survey Tautari Wetland, and the bridge pool and teal pond in the southern enclosure, to determine if previous translocations of banded and giant kōkopu to there have been successful
- 2 Undertake further surveys of freshwater fish fauna at Maungatautari
- 3 Pending results of the above, discuss with experts and stakeholders whether and where any further translocations of these species, or of other species, should occur
- 4 Consider whether any management can be undertaken to improve the connectedness of freshwater fish in the fenced reserve to larger rivers and the sea, outside the sanctuary. With agreement of landowners, walk all streams entering and leaving the maunga to identify fish passage issues and opportunities to reinstate connectivity and resilience (e.g. deep pools and overhead cover).

6.7 Aquatic invertebrates

Kōura (*Paranephrops planifrons*) are common in the streams on Maungatautari (Churchill, pers. comm.). To date there have been no aquatic invertebrate surveys carried at Maungatautari and these would need to occur before any translocations (e.g. the large dragonfly (*Uropetala*) which may be present) could be considered.

6.7.1 Plan period (2019–29) aquatic invertebrate actions in priority order

- 1 Undertake targeted survey of aquatic invertebrates in representative streams across the maunga
- 2 Pending results of the above, discuss with experts and stakeholders whether and where any translocations of aquatic invertebrates should occur

6.8 Terrestrial invertebrates

Invertebrate sampling on Maungatautari has included:

- a Monitoring ground-dwelling invertebrates (focusing on beetles and wētā in pitfall traps) in the southern enclosure and on main Maungatautari during 2004–2013 to determine their responses to mammal removal (C. Watts, Manaaki Whenua – Landcare Research, unpubl. data);

- b Wētā monitoring in tracking tunnels in the southern enclosure during 2004–2006 to determine their responses to mammal removal (Watts et al. 2011);
- c Monitoring the impacts of mice on ground-dwelling invertebrates (sampled by pitfall traps, litter sampling, tracking tunnels and earthworm surveys) in the QEII block and main Maungatautari between 2011 to 2015 (Appendix 3; Watts et al 2017).

Species listed in Appendix 3 also include 33 records of taxa lodged in the Auckland War Memorial Museum Entomological Collection. EcoQuest have also carried out invertebrate sampling on Maungatautari but these have only been identified to Order and/or Family level so have not been included in the Appendix 3.

The invertebrate communities observed at Maungatautari are typical of communities inhabiting native forests of the northern North Island. All trophic groups, such as detritivores, predators and herbivores, are found at Maungatautari, with some Orders containing the full range (e.g. beetles; Watts, unpubl. data). The presence of a diverse forest vegetation community provides numerous habitats for invertebrates especially herbivores. In addition, the deep and varied leaf litter with the presence of deadwood allows for a variety of habitats for decomposers, such as pill millipedes (*Procyliosoma* species), resulting in a rich soil invertebrate community (e.g. earthworms).

With the removal of mammals, beetle species richness and abundance increased within two summers over the eight-year study in the still-mouse-free southern enclosure on Maungatautari, (Watts, unpubl. data). In other areas on the maunga, predation by mice alone adversely affected invertebrate communities (especially beetles, spiders, caterpillars and earthworms) by reducing abundance and selectively removing larger individuals (Watts et al. 2017).

Large-bodied invertebrates, such as wētā, also responded to mammal removal. Watts et al. (2011) reported a dramatic increase in wētā abundance, both adult Auckland tree wētā (*Hemideina thoracia*) and other wētā, within 2 years of mammal eradication on Maungatautari. Additional data collected between 2010 and 2013 showed that wētā abundances inside and outside the southern enclosure were similar when most pest mammals had been eradicated but mice were controlled. However, both adult Auckland tree wētā and other wētā declined in the following 2 years outside the southern enclosure when mouse abundance increased, and mouse control ceased in February 2012. Also on Maungatautari, Watts et al. (2017) found strong evidence that the tracking rates of adult Auckland tree wētā and other wētā were inversely related to mouse tracking rates when they examined the impact of mice 'alone' on wētā.

In 2012 and 2013, 200 Mahoenui giant wētā (*Deincrida mahoenui*; MGW) were translocated from the MGW Scientific Reserve in the King Country to the southern enclosure (Table 1). To date, monitoring in the tall tawa-dominant forest of the southern enclosure has been difficult and no MGW have been detected using tracking tunnels or by searching (Watts, unpubl. data). However, at night there are increasing observations of MGW by visitors. The development of a new tracking tunnel device for detecting MGW in forest canopies is currently being trialled by Manaaki Whenua – Landcare Research (Watts, pers. comm.).

We have identified five potential invertebrates for translocation to Maungatautari (Table 5). Before these translocations can occur, survey work is needed to attempt to detect these species within Maungatautari. In addition, the translocation decision for each invertebrate will need input from experts with knowledge for the species/group.

Table 5. Possible future invertebrate translocations to Maungatautari (Compiled by Corinne Watts, Ian Stringer, and Chris Green)

Species	Habitat preference	Notes
Forest Ringlet <i>Dodonidia helmsii</i> (‘At Risk – Relict’)	Larvae feed on <i>Gahnia pauciflora</i> and <i>G. setifolia</i> (both present on Maungatautari – see Appendix 1) on edges of forest clearings.	Once widespread from Lewis Pass northwards but has become increasingly rare over the past 50 years. Causes of decline need to be determined, but habitat loss, over-collection, predation by introduced birds, rodents and wasps, parasitic wasps, as well as impacts of feral pigs on host plant abundance are likely factors. Captive rearing, understanding of habitat requirements and survey of <i>Gahnia</i> plants for distinctive caterpillar feeding sign are required.
Giraffe weevil <i>Lasioryhynchus barbicornis</i> (‘Not threatened’)	Trunks and logs in native forest.	Probably present, so need thorough surveys before considering translocation.
Stag beetle <i>Geodorcus auriculatus</i> (‘At Risk – Relict’)	Moist logs and under stones in native forest.	From Manaia to Mt Te Aroha. Need surveys to check it or a similar species is not there.
Large stick insect <i>Argosarcus</i> species	Native forest and scrub.	Probably present. Survey for eggs using leaf fall traps before considering translocation.
<i>Peripatus</i> species	Moist leaf litter and rotten logs in forest	Probably present, so need thorough surveys before considering translocation.

Some invasive invertebrates that are known to be present at Maungatautari (e.g. German wasp (*Vespula germanica*)) or that may arrive (e.g. Argentine ant *Linepithema humile*) are discussed in the Maungatautari Ecological Island Biosecurity Plan 2015–2020 (MEIT 2015).

6.8.1 Plan period (2019–29) terrestrial invertebrate actions in priority order

- 1 Determine best standard methods for monitoring translocated Mahoenui giant wētā in the SE and use these to monitor this species’ abundance throughout the Plan period.
- 2 Repeat pitfall sampling as previously undertaken by MWLR at decade intervals to monitor ongoing invertebrate responses to pest mammal removal.
- 3 Undertake targeted surveys for the species of interest for possible future translocations (Forest ringlet butterfly, giraffe weevil, stag beetle, large land snail, and large stick insect species, *Argosarcus* spp. and *Peripatus* spp., Table 5).
- 4 Pending results of 6.8.1 (3), discuss with experts and stakeholders whether and where any translocations of terrestrial invertebrates should occur.
- 5 Undertake general surveys of terrestrial and underground invertebrates as opportunities arise, to learn more about the current biodiversity of Maungatautari.

6.9 Fungi

Only 28 species of fungi are known from Maungatautari, most collected in a survey targeting fungi associated with kareao *Ripogonum scandens* (Appendix 4). The low diversity collected from the maunga is a result of there being few fungal surveys conducted there (Peter Johnston, MWLR, pers. comm., 2019).

It is impossible to determine which taxa were historically present on or are now missing from Maungatautari but species that occur in other northern North Island forests may be present. Further surveys are required including searching for threatened taxa. For example, the very rare large bracket fungus, *Ganoderma* sp. "Awaroa" ('Nationally Critical'), is known only from three specimens collected on pukatea (*Laurelia novae-zelandiae*) in the vicinity of Mt Pirongia prior to 1975. There have been no sightings since, despite several surveys but it is possibly also on Maungatautari (Peter Buchanan, MWLR, pers. comm., 2019). Fungi (including leaf spot pathogens, leaf endophytes/saprobies and root inhabiting fungi) that are host specific to plant species that are proposed for translocation to Maungatautari could also be options for translocation. Some fungi were food resources for Māori (<https://www.curiousminds.nz/stories/nga-hekaheka-fungi-with-a-maori-lens/>) and harvest of them may still be of interest to tangata whenua.

6.9.1 Plan period (2019–29) fungi actions in priority order

- 1 Undertake targeted surveys of Maungatautari fungi, to learn more about the fungal biodiversity of the site, and as a necessary prelude to consideration of possible translocations.
- 2 Pending results of the above, discuss with experts and stakeholders whether and where (and how) any translocations of fungi should occur.

6.10 Significant species for iwi

Mana whenua have particular interests in numerous Maungatautari species as taonga for diverse purposes, both practical and spiritual. Many of these relationships are based on harvesting. Native plants, for example, were used for construction, dyes, fibre for weaving, food, medicines, adornment, and scent. There is much traditional knowledge (matauranga) about harvesting guidelines and processes that is known or could be revived⁶.

Legal and cultural restraints to harvest vary in known ways between lands of different tenure inside the pest-fence. Harvesting is potentially allowable in the Maungatautari Scenic Reserve Management Plan. Under Section 6.6 (Protection of historic and cultural values), there are policies 'To allow tangata whenua to take or kill birds from the Maungatautari Scenic Reserve where this does not contravene the Wildlife Act' and 'To allow tangata whenua to collect, with the appropriate consents, fallen trees or logs for cultural and spiritual purposes from the Maungatautari Scenic Reserve'. Further, Section 42 of the Reserves Act (1977) states that '...trees or bush shall not be cut or destroyed except in accordance with the express consent of the Minister of Conservation. Terms and conditions may be set for the method of cutting, extraction and restoration', and Section

⁶ <https://www.landcareresearch.co.nz/resources/data/nga-tipu-whakaoranga-maori-plant-use-database>

46 '...allows the Minister of Conservation to grant Maori the right to take or kill birds or bury their dead in any ancestral burial grounds within any reserve which, immediately before the making of the reserve, was Maori land'.

6.10.1 Whakairo species (carving)

Māori carvers require timber for carving, and may pull out fallen trees from their own or other private land for this purpose. They may also browse for timber, adopting a pruning-type practice, to preserve living trees, looking for worthy branches and recording them for later collection. Species of interest are maire (*Nestegis* sp.), matai (*Prumnopitys taxifolia*), miro (*Prumnopitys ferruginea*), northern rātā (*Metrosideros robusta*), rimu (*Dacrydium cupressinum*), tawa (*Beilschmiedia tawa*), tītoki (*Alectryon excelsus*), and tōtara (*Podocarpus totara*).

6.10.2 Raranga species (weaving)

Weaving with natural fibres was a vital component of all aspects of Māori life for centuries, for clothes, ropes, fishing lines, snares and decoration of houses and marae. While the mainstay resource was harakeke (flax; *Phormium tenax*), other important species at Maungatautari were houhere (lacebark, *Hoheria* sp.), kiekie (*Freycinetia banksia*), tī kōuka (*Cordyline australis* and tōi *Cordyline indivisa*). In addition, kareao (supplejack, *Ripogonum scandens*) and akaaka (climbing rata *Metrosideros* sp. or *Passiflora tetrandra*?) were also used to make hinaki to catch tuna (eels).

6.10.3 Rongoa (medicinal) and kai (food) plants

The Manaaki Whenua Landcare Research Māori plant use database lists 218 plants that were used (nationally) as medicines by Māori, including harakeke, kawakawa (*Piper excelsum*), northern rata, koromiko (*Veronica stricta*), kowhai, kumarahou (*Pomaderris kumarahou*), manuka (*Leptospermum scoparium*), and rimu, and 254 plants, including fungi, that were used (nationally) for food.^{7, 6}

6.10.4 Manu (birds)

Forest bird species such as kererū, which traditionally were most cherished as food by Māori, cannot currently be legally harvested, but this may change in the future. Harvesting is an excellent goal for wildlife management and restoration, because it requires that populations and species are abundant enough to sustain harvest, as we do (with regulations) with say snapper (*Pagrus auratus*) or Paradise shelducks. In the interim, iwi value feathers of dead, moulting or handled birds for korowai (traditional Māori cloak), and for toi (art works).

⁷ <https://www.landcareresearch.co.nz/resources/data/nga-tipu-whakaoranga-maori-plant-use-database>

⁶ <https://www.curiousminds.nz/stories/nga-hekaheka-fungi-with-a-maori-lens/>

6.10.5 Plan period (2019–29) action regarding species of particular interest to iwi

- 1 Encourage, listen to and, if possible, accommodate iwi requests regarding translocation or harvest of species that are significant to them, to or from Maungatautari.

7 Maungatautari ecosystems

7.1 Defining ‘ecosystems’

Ecosystems are biological communities of interacting organisms and their physical environment. Ecosystem-level processes include interactions with disturbance regimes, and flows of energy, nutrients and non-living materials. Since these processes can occur at diverse scales of time and space, there is no single optimal scale at which to apply the ecosystem concept.

Numerous classifications of plant communities or ecosystems at different scales have been produced in New Zealand, including NZ Forest Service forest type and class maps (McKelvey 1963, Nicholls 1963), ‘vegetation mapping units’ (Atkinson 1985), ‘forest and shrubland communities’ (Wiser et al. 2011) and ‘terrestrial ecosystems’ (Singers & Rogers 2014).

For the purposes of this plan, we suggest that NZ Forest Service vegetation types (Nicholls 1963) are satisfactory surrogates for major ecosystems, but acknowledge that there are also many other small ecosystems at Maungatautari such as streams and cliffs, although none of these are nationally significant ‘historically rare ecosystems’ (Williams et al. 2007).

7.2 Historical/past ecosystems

Examining the palaeoecological records of pre-human settlement ecology gives an insight into past communities to sharpen restoration objectives for mainland sanctuaries and provides information for assessing biodiversity. However, there have been no fossil bones found or pollen records analysed from Maungatautari (Janet Wilmshurst, MWLR, pers. comm., 2018). In 1840, forest covered 54% of the Waikato Region with rimu-tawa forest being dominant including the forest on Maungatautari (Fig. 6). In addition, there was a smaller area of montane conifer-broadleaved forest on the higher slopes of Maungatautari (Fig. 6). Connectivity of the present forest to surrounding vegetation was increasingly lost after 1880 with European farming, but forest inside the SMM project has always been continuous.

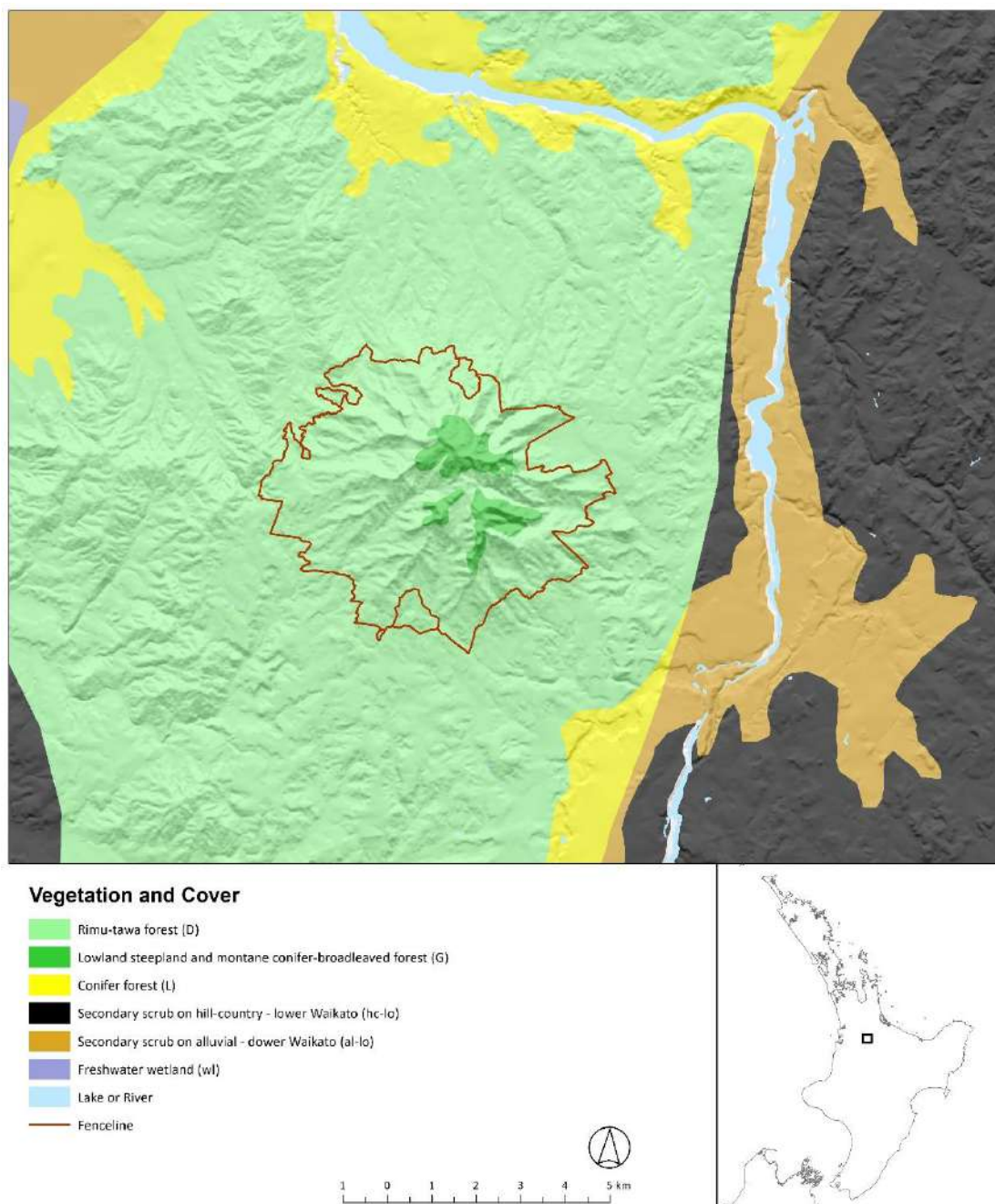


Figure 6. 1840 vegetation on and near Maungatautari (data from Nicholls 1979 and Leathwick et al. 1995). The Waikato River was not dammed at Arapuni and Karapiro in 1840 but has been shown in this map to allow for comparison with Figure 7.

7.3 Current ecosystems

By the late 1800s, large areas of the Waikato Region had been converted to grazed, non-native pasture (Leathwick et al. 1995). Maungatautari was, and has remained, surrounded by an agricultural landscape. It represents nearly half the remaining forest within the Maungatautari Ecological District (Kelly & Park 1986; Fig. 7).

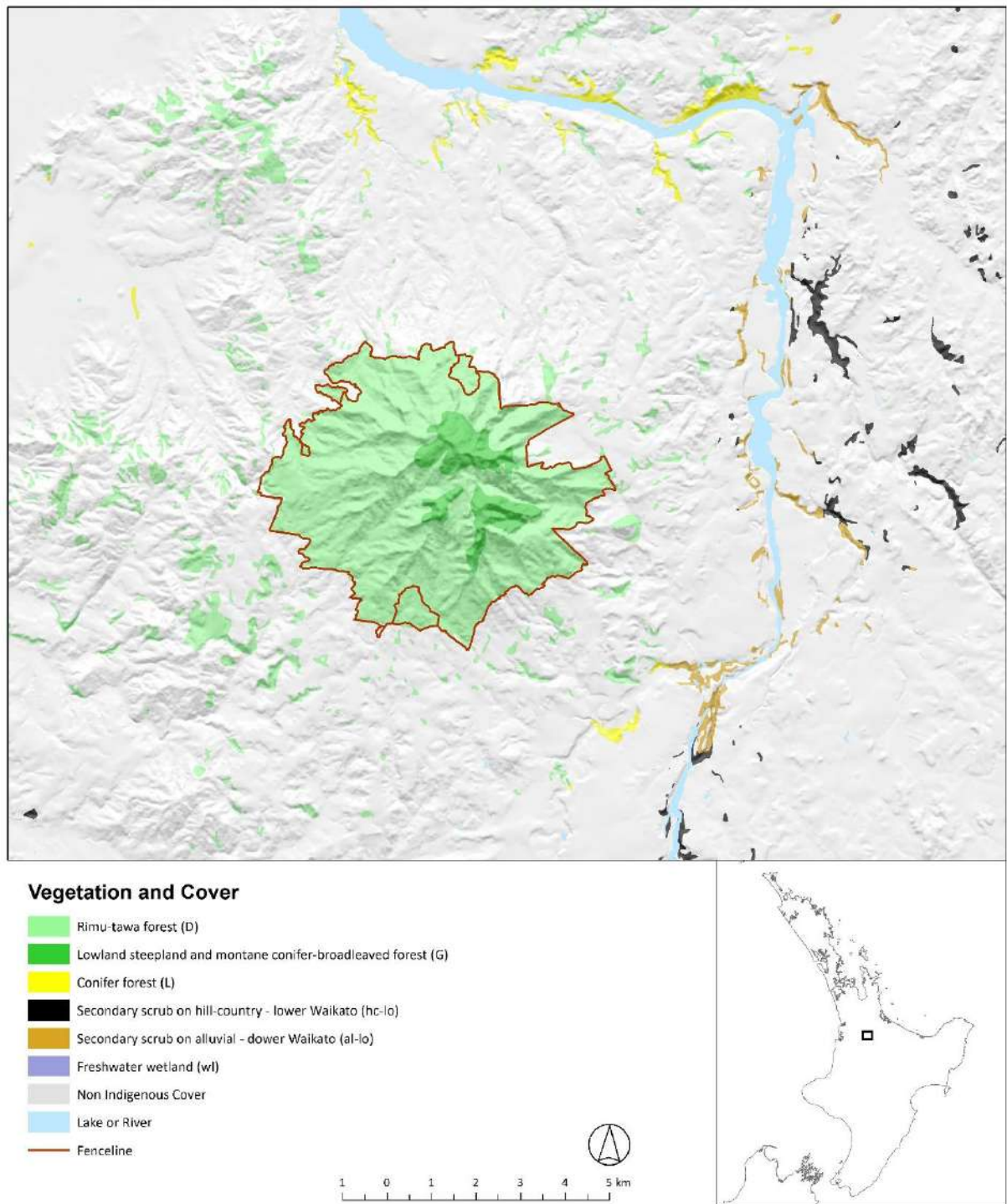


Figure 7. Current vegetation on and near Maungatautari (data from Nicholls 1979 and Leathwick et al. 1995).

Eight vegetation types have been recorded on Maungatautari (Fig. 8). They are predominantly associated with abundant tawa with occasional rimu (Nicholls 1979). Vegetation types around the perimeter are often considered logged variants of the type further in. That is, rata/tawa-rewarewa is similar to rimu-rata/tawa-rewarewa with the rimu cut out. Also, some of the areas recorded as mānuka-kānuka in the 1950s when surveys were undertaken have probably moved further along secondary succession since then (Burns, pers. comm.). Upland forest (miro/tawa-kāmahi-tāwari and thin-barked-totara-kāmahi-tāwari) occurs above 600 m asl on Maungatautari (Clarkson 2002).

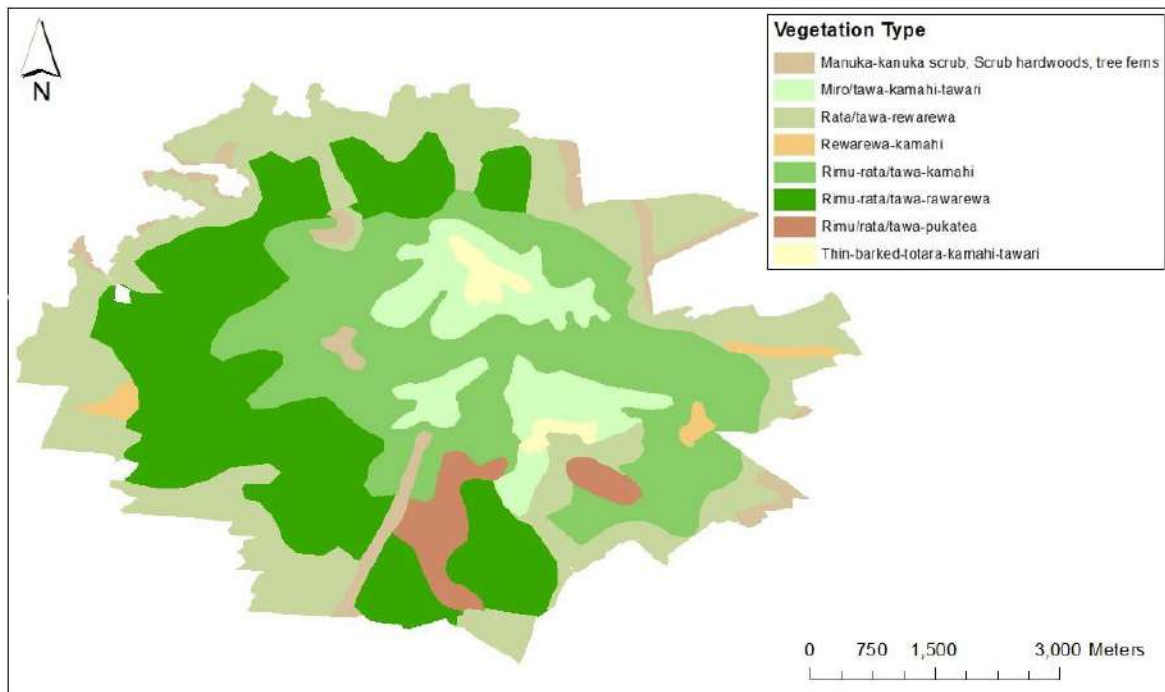


Figure 8. Vegetation types on Maungatautari recorded by the New Zealand Forest Service (McKelvey 1963; Nicholls 1963).

8 Survey

In this document, 'survey' refers to initial, sometimes one-off, searches for a taxon or taxa, while 'monitoring' (below) is formal, repeated measurement of an attribute for a purpose. In certain contexts, both may be seen as 'research' (section 9).

Survey for animals and plants in New Zealand has, with few exceptions, been sporadic in both time and location. The Wildlife Service of the Department of Internal Affairs (absorbed by DOC in 1987) had a Fauna Survey Unit that undertook large-scale field surveys during 1973–1986; there were two national bird distribution surveys with field work in 1969–1979 and 1999–2004 respectively, and DOC now undertakes brief but standardised surveys for pest mammals, plants and birds at Tier 1 sites on DOC estate across NZ. Regional Councils are planning to partner with this project by surveying sites off the conservation estate (Alan Saunders, WRC, pers. comm., 2018).

However, at local-site level, undertaking surveys and adequately storing information have always been serendipitous and uneven. It is frequently determined by the enthusiasm of local amateurs and agency staff. Also, many plants (such as mistletoes and dactylanthus) and animals (such as lizards, bats, and invertebrates) are cryptic, so practical searches can never entirely rule out that a few individuals may remain. This report recommends new surveys at Maungatautari for plants (6.2.2, 6.2.3, 6.2.6), birds (6.4.7), long- and short-tailed bats (6.6.1), lizards (6.8.3), Archey's frogs (6.10.2), freshwater fish (6.12.2), aquatic invertebrates (6.14.1), terrestrial invertebrates (6.16.3, 6.16.5) and fungi and lichen (6.18.1).

8.1 Data collation

A parallel requirement is the collation, curation and analysis of survey and monitoring data. While there are national databases for reptiles and frogs (<https://www.doc.govt.nz/our-work/reptiles-and-frogs-distribution/atlas/>), freshwater fish (<https://www.niwa.co.nz/information-services/nz-freshwater-fish-database>), birds (<https://ebird.org/newzealand/home>), and diverse biodiversity (<https://inaturalist.org/>), it would be highly desirable for MEIT and partner agencies to consider a mechanism by which valuable biodiversity data from the maunga project can be sustainably curated.

8.1.1 Plan period (2019–29) action regarding curating survey and monitoring data from the Maungatautari site

- 1 MEIT and relevant parties that hold or will obtain biodiversity data from the site will develop a Maungatautari biodiversity database, and resolve curation protocols and responsibilities for this database. This should consider where specimen collections should be held.

8.2 Palaeoecological survey

There would be substantial stakeholder interest in further palaeoecological surveys on the maunga that may reveal details of past vegetation change or on-site evidence of lost vertebrate species.

8.2.1 Plan period (2019–29) action regarding palaeoecological survey at the Maungatautari site

- 1 MEIT should get advice about the likely scientific value and potential from a) pollen and charcoal analyses of short soil cores at different elevations, and b) searches for ancient bones or coprolites (fossilised faeces) on high elevation rock outcrops. In particular, this may provide evidence of former occupancy by nesting seabirds, that would greatly sharpen enthusiasm for reintroducing them.

9 Biodiversity monitoring

Main purposes of biodiversity monitoring at Maungatautari are to:

- determine population trends of indigenous taxa and to measure ecological processes, that in the first instance may be interpreted as being a response to mammal pest removal. This interpretation is typically difficult since ecology is complex, so would be greatly assisted by scientific design, such as having comparable non-treatment (no or less mammal removal) sites, and by using other national data to facilitate interpretation of the Maungatautari results
- fulfil contractual and cultural obligations to key stakeholders, especially DOC and iwi in relation to translocated species. Note that iwi may prefer different monitoring measures that are more culturally relevant and that at least one such framework (for Tuawhenua, Urewera) has been published for forest (Lyver et al.

2017), and others for freshwaters and wetlands (<http://knowledgeauckland.org.nz/publication/?mid=2758>)

- track progress toward agreed restoration goals
- contribute to national understanding of responses of the biota to the removal of all pest mammals in a large mainland environment.

The first three purposes are respectively examples of curiosity-driven, mandated, and question-driven monitoring (Lindenmayer & Likens 2010). Lindenmayer and Likens (2010) list numerous characteristics of effective and ineffective monitoring programmes. Effective long-term monitoring has strong (and evolving) main questions, an underlying conceptual model, reasoned selection of best measures, good design, long-term funding and maintenance of data integrity once they are collected. Ineffective programmes lack strong underlying questions; have poor experimental design; collect ‘...a blizzard of ecological details’; have disengagement between policymakers, scientists and landowners/managers; curate data poorly; and lack long-term funding (Lindenmayer & Likens 2010).

As by far the largest mammal-free area on the New Zealand mainland, Maungatautari is uniquely positioned to contribute outcome data that – when analysed in relation to other national data – help national understanding about the roles of pest mammals in determining species, community and ecosystem outcomes. National databases such as NIVS (National Vegetation Survey⁸) and the DOC Tier 1 monitoring system provide frameworks within which data taken *with standard methods* at Maungatautari are most valuable. A key requirement of national monitoring is for longitudinal data from a range of sites and management regimes. Strong design at the outset is required to enable data taken at Maungatautari to be analysed in such frameworks.

9.1 Biodiversity monitoring to date

Several agencies have carried out biodiversity monitoring on Maungatautari (Table 6), but it lacks a framework. The purpose of monitoring has been principally to investigate the responses of biota to the removal of introduced mammals, and monitoring has been funded by partner agencies rather than by MEIT. There is therefore no coordinated biodiversity monitoring plan for the SMM project. MEIT has prudently used its limited resources to monitor fence integrity and mammal incursions, as well as abundance of translocated taxa, which are all key requirements for project success.

Biodiversity monitoring undertaken so far has been valuable to demonstrate to all SMM stakeholders progress towards the long-term goal ‘To increase indigenous dominance and species occupancy on Maungatautari by the sustained removal of introduced species and by translocations, so that the original and natural character of ecosystems is as far as possible restored. However, ongoing monitoring is vulnerable to changes in funding or personnel in partner agencies.

⁸ <https://www.landcareresearch.co.nz/resources/data/national-vegetation-survey-nvs>

Table 6. Biodiversity (excluding pest mammals) monitoring carried out on Maungatautari

Attribute	Measurement method	Years	Ongoing?	Curation agency	Contact Person/Agency
Birds	5-minute bird counts, 3-yearly	2002-	Yes	MWLR	Neil Fitzgerald
	Kiwi, hihi, etc. surveys, intermittent	2005	Yes	MEIT	Janelle Ward
Vegetation	20 x 20 m permanent plots, 10-yearly	2004-	Yes	MWLR/Akld University	Neil Fitzgerald/Bruce Burns
Invertebrates (mainly beetles and wētā)	Pitfall traps; tracking tunnels, intermittent	2004-	Possibly	MWLR	Corinne Watts
Frogs	Search transects, 3-yearly (see Longson et al. 2017)	2009-	Yes	EcoQuest Education Foundation	Shelley Langton-Myers

9.2 Recommended biodiversity monitoring

We recommend that, if possible, partner agencies sustain current monitoring, and expand and increase monitoring as resources of MEIT and the agencies allow. We do not think there is any current monitoring that is inappropriate and should therefore be stopped.

The following sections discuss this in the framework of the four main purposes of biodiversity monitoring presented above.

To determine population and process trends after pest mammal removal

Monitoring of birds, vegetation, invertebrates, and frogs in the decade after pest mammal removal has addressed a key, preliminary ecological question of the SMM project: How has pest mammal removal changed taxon abundance and community composition? This question is preliminary to more ecosystem-oriented questions, especially: How have taxon abundance and community composition changes affected ecological processes (such as pollination, seed dispersal, decomposition and regeneration)? All these processes can also be monitored in routine, repeated ways, although both measurement techniques and outcome interpretations require science advice. One-off research projects (e.g. Iles & Kelly 2014; Bombaci et al. unpubl. data) can therefore greatly help support monitoring programmes.

Plan-period monitoring actions are described in Section 6 for plant communities and regeneration (6.2.1), threatened plants (6.2.4), pest plants (6.2.9), myrtle rust (6.2.10), bird abundance and communities (6.4.2), lizard tracks in tracking tunnels (6.8.2), Hochstetter's frogs (6.10.1), and litter invertebrate communities (6.16.2).

9.2.1 Additional plan period (2019–29) biodiversity process monitoring action

- 1 MEIT Scientific and Technical Advisory Panel to further consider which taxa and ecological processes should be monitored, and assist MEIT to prepare a biodiversity monitoring plan. For example, there could be monitoring of regeneration of significant plant species, such as long-lived conifers, that have been severely depleted through logging or pest damage but may be necessary to bolster food sources for birds (e.g. rimu for kākāpō).

To fulfil contractual and cultural obligations to key stakeholders

Monitoring is a routine, contractual requirement in species translocation proposals for DOC, and clearly MEIT staff and contractors must meet these requirements. Stakeholders are also keenly interested in translocation outcomes, particularly mana whenua who exercise kaitiakitanga for the translocated taonga species in their rohe, and the iwi that 'gave' the animals. Plan-period actions for monitoring translocated taxa were presented previously for birds (6.4.1), tuatara (6.8.1), freshwater fish (6.12.1), and Mahoenui giant wētā (6.16.1).

9.2.2 Additional plan period (2019–29) contractual and cultural monitoring action

- 1 With iwi assistance, MEIT staff prepare and maintain a monitoring plan that meets legal and cultural obligations of translocations. Updates to the plan should consider which species and processes mana whenua think should be monitored, and with what assessment tools. Mana whenua may wish to consider for use an iwi (Tuhoe)-based monitoring system for assessing forest health presented by Lyver et al. (2017). Lyver et al. (2017) based this system on nine wide-ranging, Tuhoe-relevant themes including food procurement, nature of the water, spirituality and mental health.

To track progress toward agreed restoration goals

Key monitoring is that which tracks progress to meet the long-term and Plan-period goals in 5.3.1. The main requirements are to measure species richness (number of species present) and abundance of each, for selected taxa groups in defined areas, and measuring these at a frequency that enables natural variation to be assessed, given the impact of 'mast' seasons on many NZ ecosystems. Note that restoring original taxa may *reduce* the abundance of others, as for example endemic birds outcompete exotics and biogeographically recent natives (Miskelly 2018). The key outcome is maximising ecological integrity; details of the resultant ecosystem(s) are hard to predict.

9.2.3 Additional plan period (2019–29) restoration goal monitoring actions in priority order

- 1 Monitor the number of pest mammals, other than mice, detected and trapped inside the pest-fence, and the number of mice detected and trapped inside the NE, SE, Garland Block, and Tautari wetland.

- 2 Monitor the area (hectares) in the reserve dominated by adventive plant species cover in any 'layer', e.g. *Tradescantia* below trees, or gorse as a canopy.
- 3 Monitor the number of pest plant species and their locations in the reserve.
- 4 Monitor the proportion of species present as self-sustaining populations (defined as persisting in the absence of management other than ongoing mammal removal) relative to a target, fully occupied community of those species.
- 5 Monitor the number of species translocated into the reserve and the number of these species that have achieved self-sustaining populations.

To contribute to national understanding of responses of biota to the removal of all pest mammals in a large mainland environment

9.2.4 Additional plan period (2019–29) national monitoring integration action

- 1 Encourage integration of Maungatautari monitoring data and their analyses into national frameworks, by allowing scientists requesting such data to use it, provided that the research activities meet other acceptability criteria (see Research below) and acknowledge MEIT.

10 Social/cultural monitoring

Monitoring is required to ensure that the project is meeting the long-term goal 'To increase the number of people who treasure the SMM project and are involved with its operation' (5.3.2). Many of the previously stated actions support plan-period goals in 5.3.2.

10.1.1 Additional plan period (2019–29) social/cultural monitoring actions in rough priority order

- 1 Monitor the number of visitors to the maunga in ways that enable valid comparisons between years.
- 2 Monitor the number of volunteers engaged with the SMM project in ways that enable valid comparisons between years.
- 3 Monitor the number of students and their institution that visit the maunga for educational purposes.
- 4 Complete obtaining legal access agreements with all 21 landowners whose properties abut the pest fence.
- 5 Assist key agencies such as Waikato Regional Council, Waipa District Council and Department of Conservation by punctually fulfilling legal and permit obligations, by participating in regional biodiversity planning, and by openly communicating about matters of common interest.

- 6 Ensure that any Tourism Plan prepared by SMM [MEIT] realises tourist growth and development opportunities in such a way as to safeguard key natural values of the maunga (as described in Bamford & van der Scheer 2016).
- 7 MEIT should discuss with tangata whenua the adequacy of current biodiversity monitoring on the maunga. Alternative indigenous community-based measures proposed by Lyver et al. (2017), could be used as a model for Maungatautari.

11 Research

There are agreed policies and processes for undertaking research on the maunga. Research objectives must be consistent with the vision and goals of SMM and proposals must be submitted in the approved template form to the MEIT before commencement. Proposals are considered by Waipa District Council and by mana whenua, who may consult with others such as members of the Scientific and Technical Advisory Panel. Researchers will often require other approvals also, such as animal ethics or Permission to Handle Wildlife from the Department of Conservation.

11.1 Research completed

Sixty-one scientific reports, including published papers, submitted papers, MSc and PhD theses and unpublished reports, about or relevant to Maungatautari are listed in Appendix 5. Most concern birds (15), vegetation (13) and small mammals (11). Three significant papers describe the animal-fence trials that resulted in the Xcluder[®] pest fence design (Day & MacGibbon 2007), the world-leading, multi-species eradication once the fence was built (Speedy et al. 2007), and in situ, experimental reinvasion trials on the fence (Connolly et al. 2008). Eight papers or reports describe ecological outcomes of a range of biota after eradication. Two of these (Iles & Kelly 2014; Bombaci et al. submitted) describe second-order outcomes (i.e. bird increases leading to better pollination and seed dispersal). Two describe the significant fauna finds (Hochstetter's frogs, Baber et al. 2006; Duvaucel's gecko, Morgan-Richards et al. 2016) after the fence was built and eradications completed. These demonstrate further survey of the maunga for cryptic fauna is justified. There are studies of three translocated bird species (takahē, hihi and brown kiwi) and seven reports about mouse abundance, behaviour and impacts.

Mana whenua roles in the growing project were studied by Harms (2015, 2018), and Roche & Rolley (2011) studied the connection between ecological restoration and workplace happiness.

In aggregate, this body of work cements Maungatautari as a nationally significant site of restoration learning, although much remains to be done.

11.2 Possible future research

February 2019 marked 15–13 years after pest mammal eradications in the small (northern and southern) exclosures and the main reserve respectively. It is therefore too late to take before-and-after measures to document changes due to the eradications, unless suitable 'pre-eradication' data were collected. It is, however, possible to measure a snapshot of an aspect of ecology on Maungatautari and on other estates that have had a different pest control history (e.g. Bombaci et al. 2018).

Excluding survey and monitoring (section 8), we see the following possibilities for research that would have benefits for SMM and for national learning about mainland ecological restoration (order does not imply priority):

- 1 Projects examining ecological community reassembly and function at large (1,000+ ha) scale. These capture Maungatautari's unique contribution to NZ restoration – the largest substantially pest-free site on the NZ mainland. Example projects are:
 - A study of regeneration within treefall gaps on Maungatautari (could be very different to similar processes where mammalian pests are present) and outside the fence to measure spillover conservation benefits. This would be relevant to rimu and miro regeneration. A restoration approach might be to try and influence the outcome of treefall gap regeneration by establishing and/or advantaging (releasing) conifer seedlings within natural treefall gap sites on the maunga.
 - Avian community assembly as new species are added. Recent research suggests that competition strongly influences abundance of forest birds when mammalian predators and competitors are removed.
 - A study regeneration outside the fence to measure spillover conservation benefits to the broader landscape.
- 2 Methods and outcomes of species translocations. Translocations are inherently experimental and can be managed to maximise learning (Seddon et al. 2007, papers in Armstrong et al. 2015). Again, the large area of intact, pest-free forest on Maungatautari offers unique mainland opportunities for natural expression of intrinsically large-scale behaviours, such as post-translocation and natal dispersal (Richardson et al. 2015, 2017).
- 3 Abundance, behaviour, control and impacts of mice as the only pest mammal present. It is currently unaffordable, if not impossible, to eradicate mice from all Maungatautari, although MEIT generally manages to keep all smaller exclosures mouse-free. However, mice alone are also widespread in other fenced sanctuaries and on offshore islands such as Resolution (Fiordland), and this is a likely future outcome of current Predator Free NZ ventures. Maungatautari has sites with and without mice that have already been exploited as research opportunities (Watts et al. 2017; Wilson et al. 2018), and much more is possible.
- 4 Durability, effectiveness and cost of maintaining the predator-resistant fence. Substantial current research about non-fence approaches to limiting reinvasion has produced no tool yet that is remotely as effective as a fence. It is likely that pest-fences will greatly diversify in the future, to be cheaper and more widely used.

Learning more about the efficacy of the Xcluder[®] fence at Maungatautari would help other restorationists.

- 5 Co-governed integration of cultural harvest for kai, rongoā, whakairo, raranga, and toi on iwi land inside the fence with no harvest on adjacent Scenic Reserve land. The extent of broad stakeholder acceptance of increased access for mana whenua to their own resources could be explored and documented as some kind of template for other mainland reserves (following work of Harms 2015, 2018).
- 6 Determine what biodiversity and ecological opportunities would be provided for adjacent Waikato landscapes by enhancing beneficial conservation spillover by, for example increasing the area of lowland forest and wetland contiguous to the maunga and/or developing a forested lowland corridor with ecological stepping stones and no barriers to native fish passage from Maungatautari to the banks of the Waikato River.
- 7 Well-being outcomes of SMM, and the potential contributions of the project to regional mental health, through participation, visitation and education (following work of Roche & Rolley 2011).

11.2.1 Plan period (2019–29) research actions

- 1 Encourage universities, Crown Research Institutes, and other research providers to undertake, publish, and communicate research about the maunga, its natural and human history, and about outcomes of the SMM project.
- 2 Facilitate and execute effective and timely procedures for receiving, assessing and making decisions about allowing new research on the maunga, with due regard to key stakeholders.

12 Climate change

Potential effects of climate change on New Zealand's terrestrial biodiversity, and policy recommendations for mitigation, adaptation and research are described by McGlone & Walker (2011) and Christie (2014). Direct outcomes of climate change are likely to include southwards (latitude) and upwards (elevation) shifts in species distributions, and changes in the annual timing of phenological events such as flowering and fruiting. Sea-level rise and storm surges may occur but will mainly affect the coastline; however, increased inland storms would make maintaining pest-fence integrity more difficult. Indirectly, climate warming may increase the range of animal and plant pest threats, such as wilding pines (*Pinus contorta*) and heather (*Calluna vulgaris*), and increase the risk of fire. Finally, climate change mitigation actions taken by land management sectors (e.g. agriculture, forestry, power generation) such as tree-planting for carbon storage, windfarms, biofuel production and increased irrigation may in turn affect biodiversity (McGlone & Walker 2011; Christie 2014).

Maungatautari may one day be requested to undertake assisted colonisation (translocation of species beyond their natural range to protect them from human-induced threats such as climate change; Seddon et al. 2012). Detailed monitoring of species

distributions would be required to identify elevation increases or new arrivals due to climate change.

12.1.1 Plan period (2019–29) climate change action

- 1 MEIT should maintain strong science networking about climate change, to keep up to date on best adaptive practice, and to consider opportunities to contribute to national research and management agendas.

13 Using the smaller exclosures for optimum conservation gain

There are three smaller fenced areas within the SMM project (the 61-ha southern exclosure, the 36-ha northern exclosure, and the 2.2-ha Tautari wetland) and a fourth privately owned 15.5-ha block on Bill and Sue Garland's property that is separated from the main reserve fence by the width of a road. More fenced areas may be developed in future as MEIT area attracts people who may invest in such actions.

The small areas of these four exclosures means they can practicably be kept mouse-free most of the time, so that they are truly pest mammal-free, while the task of removing mice from the remaining 3,142 ha of the reserve is currently unaffordable. Being mouse-free means these sites are extremely valuable for hosting or translocating mouse-sensitive taxa such as tuatara, giant wētā, and lizards; the small size of the sites is not problematic for these small-bodied taxa.

They are also very valuable for research to study ecological processes on the New Zealand mainland in the absence of all pest mammals, although pest invertebrates such as German wasps *Vespula germanica* and potentially non-native earthworms and slugs will still be present.

The Garland block has already demonstrated its value for research; MWLR has especially used this block to determine mouse impacts on biodiversity during 2011–2016 (Watts et al. 2017; Wilson et al. 2018). Garland's is potentially a valuable block for further research if resources and the landowners allow. An example project is to determine if weka *Gallirallus australis* would limit the abundance of mice. This would require the reintroduction and then later removal of the mice, or a new exclosure.

13.1.1 Plan period (2019–29) small exclosure action

- 1 MEIT should maintain the mouse-free status of all the smaller fenced exclosures so that they are available for mouse-sensitive taxa such as invertebrates and lizards, and for research projects in which being entirely pest-mammal free is important.

14 Education

14.1 Students

Just as the fence gave the maunga a new lifeforce, the restoration process delivers a lifeforce to visitors. People are a vital component of restoration. Knowledge and connecting messages increase caring and openness to conservation, which in turn increases the likelihood of people engaging in conservation behaviours (Weinstein et al. 2015). Maungatautari is a restoration success that provides knowledge about Aotearoa NZ's natural history, effective pest control, and kaitiakitanga. Maungatautari offers all visitors the opportunity to engage in positive conservation messages and inspire visitors to protect the environment of their own back yard as well as precious environments across the globe. Individual visitors will engage with conservation messages at the various levels. SMM is provided with a prime opportunity for promoting restoration when education is the primary reason for visiting.

The aim of the SMM education programme is to 'influence our tamariki/children to be aware of their kaitiaki role in conservation and ecological restoration' (MEIT 2016a). Children visiting SMM as a part of their education are engaging in place-based learning. Place-based learning differs from environmental education that frequently focuses on messages of fear (rainforest destruction, plastic pollution, ozone depletion, etc.). Place-based education is broader, incorporating natural and built environments that include history, culture, economics and the environment (Hart 1997; Sobel 2004). As students visit Maungatautari, there is an opportunity for SMM to fully engage them in place-based learning.

Place-based learning is most successful when students directly participate in beneficial activities (Hart 1997). When students become players in a community ecosystem, they can act back on the system and improve the restoration process. If students can come to a place where their actions matter, they are rooted within the system, as opposed to being observers looking in. Maungatautari is an excellent resource for students; the SMM education programme has an opportunity to shape its system so that the students are a resource for the maunga. Ultimately this teaches students they can make a difference, here and now. Education monitoring and restoration activities can cater to all ages. Young children can check wētā hotels, while older students may monitor a tracking tunnel line, taking the data back to the classroom, and analysing results. Coordination between dedicated teachers and experts helps deliver detailed monitoring that is valuable to the students and to MEIT. 'Curious Minds' programmes are a valuable source of resources that may be used at Maungatautari education visits, for example, recent moth and fungi projects.⁹

⁹ <https://www.curiousminds.nz/projects/maori-knowledge-and-uses-of-fungi/>,
<https://www.curiousminds.nz/events/moths-and-me/>

14.2 Outreach

The goal of education outreach is to provide information to local people who normally do not have access to such information. Outreach is an important responsibility for researchers. When researchers are provided with a privileged opportunity to study our natural taonga, there is a great benefit when the knowledge gained is shared beyond the scientific community. Outreach improves communication, which clearly benefits both scientists and the public (Clark et al. 2016). Reported benefits researchers gain from participating in outreach include improved communication skills (Clark et al. 2016), research respite that is energizing and refreshing (Harrison et al. 2010), an enjoyable opportunity to contribute (Andrews, 2000), and a chance to meet with people outside science (Harrison et al. 2010). Benefits to the public include increased awareness and enthusiasm for nature, a chance to learn new things, and a better understanding of sense of place (Clark et al. 2016; Harrison et al. 2010). Outreach potentially can improve how the public values scientific research.

Education and knowledge connect people and the environment. This plan requires researchers proposing work at Maungatautari to report their findings in a (Maungatautari) community setting. This expectation can be communicated to the researcher during the researcher's application process. Community settings for presentations can include the SMM visitor centre, Pohara marae, or a local conservation focused group. A further conduit for communication is the annual Sanctuaries of NZ workshop. SMM should facilitate these processes.

14.2.1 Plan period (2019–29) education actions

- 1 Continue to grow the education programme as a centre for place-based education; engage with local schools to encourage recurring visits, and plan restoration activities that students can participate in, including using resources of 'Curious Minds' projects.
- 2 Establish a system where researchers applying to conduct research in Maungatautari are required to return once research is complete for an outreach event.

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Appendix 1. Indigenous vascular plants recorded at Maungatautari

List compiled by Bruce Clarkson (University of Waikato) based on visits between 1979 and 2002. Updated Dec 2018 by Catherine Kirby (University of Waikato) with updated names, cross-checked list with Fisher (1961), Gudex (1963), Brown et al. (2006) and Clarkson & Boase (1986), and includes *Adiantum cunninghamii* and *Arthropodium candidum* (observations contributed by Bruce Burns (University of Auckland)).

Scientific Name	Common name	Family	Life form
LYCOPHYTES (4)			
<i>Lycopodium deuterodensum</i>	Puakarimu	Lycopodiaceae	Ground cover
<i>Lycopodium scariosum</i>		Lycopodiaceae	Ground cover
<i>Lycopodium volubile</i>	Waewaekoukou	Lycopodiaceae	Ground cover
<i>Phlegmariurus varius</i>	Iwituna	Lycopodiaceae	Epiphyte
FERNS (75)			
<i>Adiantum cunninghamii</i>	Maidenhair fern	Pteridaceae	Ground cover
<i>Adiantum fulvum</i>	Maidenhair fern	Pteridaceae	Ground cover
<i>Asplenium bulbiferum</i>	Hen and chicken fern	Aspleniaceae	Ground cover
<i>Asplenium flaccidum</i>	Hanging spleenwort	Aspleniaceae	Epiphyte
<i>Asplenium gracillimum</i>		Aspleniaceae	Ground cover
<i>Asplenium lamprophyllum</i>		Aspleniaceae	Ground cover
<i>Asplenium oblongifolium</i>	Shining spleenwort	Aspleniaceae	Ground cover
<i>Asplenium polyodon</i>	Sickle spleenwort	Aspleniaceae	Epiphyte
<i>Austroblechnum colensoi</i>		Blechnaceae	Ground cover
<i>Austroblechnum lanceolatum</i>		Blechnaceae	Ground cover
<i>Austroblechnum membranaceum</i>		Blechnaceae	Ground cover
<i>Botrychium australe</i> (Gudex 1963)	Parsley fern	Ophioglossaceae	Ground cover
<i>Cranfillia fluviatilis</i>	Kiwakiwa	Blechnaceae	Ground cover
<i>Cranfillia nigra</i>		Blechnaceae	Ground cover
<i>Cranfillia vulcanica</i>		Blechnaceae	Ground cover
<i>Cyathea cunninghamii</i>	Gully treefern	Cyatheaceae	Treefern
<i>Cyathea dealbata</i>	Silver fern; kaponga	Cyatheaceae	Treefern
<i>Cyathea medullaris</i>	Mamaku	Cyatheaceae	Treefern
<i>Cyathea smithii</i>	Soft tree fern	Cyatheaceae	Treefern
<i>Dicksonia fibrosa</i>	Wheki-ponga	Dicksoniaceae	Treefern
<i>Dicksonia lanata</i>		Dicksoniaceae	Treefern
<i>Dicksonia squarrosa</i>	Wheki	Dicksoniaceae	Treefern
<i>Diplazium australe</i>		Athyriaceae	Ground cover
<i>Doodia australis</i>		Blechnaceae	Ground cover
<i>Gleichenia dicarpa</i>	Tangle fern	Gleicheniaceae	Ground cover
<i>Histiopteris incisa</i>	Water fern	Dennstaedtiaceae	Ground cover
<i>Hiya distans</i>		Dennstaedtiaceae	Ground cover

Scientific Name	Common name	Family	Life form
<i>Hymenophyllum bivalve</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum demissum</i>	Filmy fern	Hymenophyllaceae	Climber
<i>Hymenophyllum dilatatum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum flabellatum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum flexuosum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum frankliniae</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum multifidum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum nephrophyllum</i>	Kidney fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum rarum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum revolutum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum sanguinolentum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hymenophyllum scabrum</i>	Filmy fern	Hymenophyllaceae	Epiphyte
<i>Hypolepis ambigua</i>		Dennstaedtiaceae	Ground cover
<i>Hypolepis rufobarbata</i>		Dennstaedtiaceae	Ground cover
<i>Icarus filiformis</i>		Blechnaceae	Climber
<i>Lastreopsis hispida</i>		Dryopteridaceae	Ground cover
<i>Leptopteris hymenophylloides</i>		Osmundaceae	Ground cover
<i>Leptopteris superba</i>	Heruheru, Prince of Wales fern	Osmundaceae	Ground cover
<i>Lindsaea trichomanoides</i>		Lindsaeaceae	Ground cover
<i>Lomaria discolor</i>	Crown fern	Blechnaceae	Ground cover
<i>Loxogramme dictyopteris</i>		Polypodiaceae	Epiphyte
<i>Loxsoma cunninghamii</i> (Brownsey & Perrie 2015)		Loxsomataceae	Ground cover
<i>Lygodium articulatum</i>	Mangemange	Lygodiaceae	Climber
<i>Microsorium novae-zealandiae</i>		Polypodiaceae	Climber
<i>Microsorium pustulatum</i> subsp. <i>pustulatum</i>	Hound's tongue fern	Polypodiaceae	Climber
<i>Microsorium scandens</i>		Polypodiaceae	Climber
<i>Notogrammitis angustifolia</i> subsp. <i>nothofageti</i>	Strap fern	Polypodiaceae	Epiphyte
<i>Notogrammitis billardiarei</i>	Strap fern	Polypodiaceae	Epiphyte
<i>Notogrammitis ciliata</i>	Strap fern	Polypodiaceae	Epiphyte
<i>Notogrammitis heterophylla</i>		Polypodiaceae	Ground cover
<i>Notogrammitis pseudociliata</i>	Strap fern	Polypodiaceae	Epiphyte
<i>Paesia scaberula</i>	Ring fern	Dennstaedtiaceae	Ground cover
<i>Parablechnum novae-zelandiae</i>	Kiokio	Blechnaceae	Ground cover
<i>Parablechnum procerum</i>		Blechnaceae	Ground cover
<i>Parapolystichum glabellum</i>		Dryopteridaceae	Ground cover
<i>Pellaea rotundifolia</i>		Pteridaceae	Ground cover
<i>Pneumatopteris pennigera</i>		Thelypteridaceae	Ground cover

Scientific Name	Common name	Family	Life form
<i>Polystichum neozelandicum</i> subsp. <i>neozelandicum</i>		Dryopteridaceae	Ground cover
<i>Polystichum silvaticum</i>		Dryopteridaceae	Ground cover
<i>Pteridium esculentum</i>	Bracken; aruhe	Dennstaedtiaceae	Ground cover
<i>Pteris macilenta</i>		Pteridaceae	Ground cover
<i>Pteris tremula</i>		Pteridaceae	Ground cover
<i>Ptisana salicina</i>	Para, King fern	Marrattiaceae	Ground cover
<i>Pyrrosia eleagnifolia</i>	Leather-leaf fern	Polypodiaceae	Climber
<i>Rumohra adiantiformis</i>		Dryopteridaceae	Climber
<i>Sticherus cunninghamii</i>	Umbrella fern	Gleicheniaceae	Ground cover
<i>Trichomanes endlicherianum</i>		Hymenophyllaceae	Epiphyte
<i>Trichomanes venosum</i>		Hymenophyllaceae	Epiphyte
<i>Tmesipteris elongata</i>	Fork fern	Psilotaceae	Epiphyte
<i>Tmesipteris tannensis</i>	Fork fern	Psilotaceae	Epiphyte
GYMNOSPERMS (6)			
<i>Dacrycarpus dacrydioides</i>	Kahikatea	Podocarpaceae	Large tree
<i>Dacrydium cupressinum</i>	Rimu	Podocarpaceae	Large tree
<i>Podocarpus laetus</i>	Hall's totara	Podocarpaceae	Large tree
<i>Podocarpus totara</i> var. <i>totara</i>	Totara	Podocarpaceae	Large tree
<i>Prumnopitys ferruginea</i>	Miro	Podocarpaceae	Large tree
<i>Prumnopitys taxifolia</i>	Matai	Podocarpaceae	Large tree
MONOCOT TREES & SHRUBS (4)			
<i>Cordyline australis</i>	Cabbage tree; ti-kouka	Asparagaceae	Tuft tree
<i>Cordyline banksii</i>	Ti-ngahere	Asparagaceae	Tuft tree
<i>Cordyline indivisa</i>	Toi	Asparagaceae	Tuft tree
<i>Rhopalostylis sapida</i>	Nikau	Arecaceae	Palm tree
LIANES & SCRAMBLERS (16)			
<i>Calystegia sepium</i> subsp. <i>roseata</i>	Pohuehue	Convolvulaceae	Liane
<i>Clematis forsteri</i>	Clematis	Ranunculaceae	Liane
<i>Clematis paniculata</i>	Puawhananga; clematis	Ranunculaceae	Liane
<i>Freycinetia banksii</i>	Kiekie	Pandanaceae	Scrambler
<i>Metrosideros carminea</i>	Carmine rata	Myrtaceae	Liane
<i>Metrosideros diffusa</i>	Climbing rata	Myrtaceae	Liane
<i>Metrosideros fulgens</i>	Climbing rata	Myrtaceae	Liane
<i>Metrosideros perforata</i>	Climbing rata	Myrtaceae	Liane
<i>Muehlenbeckia australis</i>	Pohuehue	Polygonaceae	Liane
<i>Parsonsia capsularis</i>	Akakiore; N.Z. jasmine	Apocynaceae	Liane
<i>Parsonsia heterophylla</i>	Akakiore; N.Z. jasmine	Apocynaceae	Liane
<i>Passiflora tetrandra</i>	Kohia	Passifloraceae	Liane
<i>Ripogonum scandens</i>	Supplejack; kareao	Ripogonaceae	Liane
<i>Rubus australis</i>	Lawyer; tataramoa	Rosaceae	Liane

Scientific Name	Common name	Family	Life form
<i>Rubus cissoides</i>	Lawyer; tataramoa	Rosaceae	Liane
<i>Rubus schmidelioides</i>	Lawyer; tataramoa	Rosaceae	Liane
DICOT TREES (39)			
<i>Alectryon excelsus</i> subsp. <i>excelsus</i>	Titoki	Sapindaceae	Large tree
<i>Aristotelia serrata</i>	Wineberry	Elaeocarpaceae	Small tree
<i>Beilschmiedia tarairi</i> (Fisher 1961)	Taraire	Lauraceae	Large tree
<i>Beilschmiedia tawa</i>	Tawa	Lauraceae	Large tree
<i>Carpodetus serratus</i>	Marbleleaf; putaputaweta	Rousseaceae	Small tree
<i>Corynocarpus laevigatus</i>	Karaka	Corynocarpaceae	Large tree
<i>Dysoxylum spectabile</i>	Kohehohe	Meliaceae	Large tree
<i>Elaeocarpus dentatus</i> var. <i>dentatus</i>	Hinau	Elaeocarpaceae	Large tree
<i>Fuchsia excorticata</i>	Kotukutuku	Onagraceae	Small tree
<i>Griselinia littoralis</i>	Broadleaf	Griselinaceae	Large tree
<i>Hedycarya arborea</i>	Pigeonwood	Monimiaceae	Small tree
<i>Hoheria sexstylosa</i>	Lacebark; houhere	Malvaceae	Small tree
<i>Ixerba brexioides</i>	Tawari	Strasburgeriaceae	Large tree
<i>Knightia excelsa</i>	Rewarewa	Proteaceae	Large tree
<i>Kunzea robusta</i>	Kanuka	Myrtaceae	Small tree
<i>Laurelia novae-zelandiae</i>	Pukatea	Atherospermataceae	Large tree
<i>Litsea calicaris</i>	Mangeao	Lauraceae	Large tree
<i>Lophozonia menziesii</i>	Silver Beech	Nothofagaceae	Large tree
<i>Melicytus lanceolatus</i>	Narrow-leaved mahoe	Violaceae	Small tree
<i>Melicytus ramiflorus</i>	Mahoe	Violaceae	Small tree
<i>Metrosideros robusta</i>	Northern rata	Myrtaceae	Large tree
<i>Mida salicifolia</i>	Sandalwood	Nanodeaceae	Small tree
<i>Myrsine australis</i>	Matipo	Primulaceae	Small tree
<i>Myrsine salicina</i>	Toro	Primulaceae	Small tree
<i>Nestegis cunninghamii</i>	Black maire	Oleaceae	Large tree
<i>Nestegis lanceolata</i>	White maire	Oleaceae	Large tree
<i>Olearia rani</i>	Heketara	Asteraceae	Small tree
<i>Pennantia corymbosa</i>	Kaikomako	Pennantiaceae	Small tree
<i>Pittosporum colensoi</i>	Kohuhu	Pittosporaceae	Small tree
<i>Pittosporum eugeniioides</i>	Tarata	Pittosporaceae	Large tree
<i>Pittosporum tenuifolium</i>	Kohuhu	Pittosporaceae	Small tree
<i>Pseudopanax arboreus</i>	Fivefinger	Araliaceae	Small tree
<i>Pseudopanax colensoi</i>	Mountain fivefinger	Araliaceae	Small tree
<i>Pseudopanax crassifolius</i>	Lancewood; horoeka	Araliaceae	Small tree
<i>Quintinia serrata</i>	Tawheowheo	Paracryphiaceae	Large tree
<i>Raukawa edgerleyi</i>	Raukawa	Araliaceae	Small tree
<i>Schefflera digitata</i>	Pate; sevenfinger	Araliaceae	Small tree

Scientific Name	Common name	Family	Life form
<i>Streblus heterophyllus</i>	Turepo	Moraceae	Small tree
<i>Weinmannia racemosa</i>	Kamahi	Cunoniaceae	Large tree
DICOT SHRUBS (29)			
<i>Alseuosmia macrophylla</i>	Toropapa	Alseuosmiaceae	Small shrub
<i>Alseuosmia quercifolia</i>		Alseuosmiaceae	Small shrub
<i>Brachyglottis kirkii</i> var. <i>kirkii</i>	Kohurangi	Asteraceae	Epiphyte
<i>Brachyglottis repanda</i>	Rangiora	Asteraceae	Large shrub
<i>Coprosma areolata</i>		Rubiaceae	Large shrub
<i>Coprosma foetidissima</i>	Hupiro	Rubiaceae	Large shrub
<i>Coprosma grandifolia</i>	Kanono	Rubiaceae	Large shrub
<i>Coprosma lucida</i>		Rubiaceae	Small shrub
<i>Coprosma propinqua</i>	Mingimingi	Rubiaceae	Divaricate
<i>Coprosma propinqua</i> X <i>C. robusta</i>		Rubiaceae	Semi-divaricate
<i>Coprosma robusta</i>	Karamu	Rubiaceae	Large shrub
<i>Coriaria arborea</i> var. <i>arborea</i>	Tutu	Coriariaceae	Large shrub
<i>Gaultheria antipoda</i>	Snowberry	Ericaceae	Small shrub
<i>Gaultheria antipoda</i> X <i>G. paniculata</i>		Ericaceae	Small shrub
<i>Gaultheria oppositifolia</i>	Niniwa	Ericaceae	Small shrub
<i>Gaultheria paniculata</i>		Ericaceae	Small shrub
<i>Geniostoma ligustrifolium</i>	Hangehange	Loganiaceae	Large shrub
<i>Griselinia lucida</i>	Puka	Griselinaceae	Epiphyte
<i>Leptospermum scoparium</i>	Manuka	Myrtaceae	Large shrub
<i>Leucopogon fasciculatus</i>	Mingimingi	Ericaceae	Small shrub
<i>Piper excelsum</i>	Kawakawa	Piperaceae	Large shrub
<i>Pittosporum cornifolium</i>	Tawhirikaro	Pittosporaceae	Epiphyte
<i>Pomaderris amoena</i>	Tauhinu	Rhamnaceae	Small shrub
<i>Pseudowintera axillaris</i>	Lowland horopito	Winteraceae	Large shrub
<i>Pseudowintera colorata</i>	Upland horopito	Winteraceae	Large shrub
<i>Solanum aviculare</i>	Poroporo	Solanaceae	Large shrub
<i>Tupeia antarctica</i> (Fisher 1961, Gudex 1963)	Mistletoe	Loranthaceae	Hemi-parasite
<i>Urtica ferox</i>	Nettle	Urticaceae	Large shrub
<i>Veronica stricta</i>	Koromiko	Plantaginaceae	Large shrub
GRASSES (8)			
<i>Austroderia fulvida</i>	Toetoe	Poaceae	Tussock
<i>Deyeuxia avenoides</i>		Poaceae	Ground cover
<i>Dichelachne crinita</i>	Plume grass	Poaceae	Ground cover
<i>Microlaena avenacea</i>	Bush rice grass	Poaceae	Ground cover
<i>Microlaena stipoides</i>		Poaceae	Ground cover
<i>Oplismenus hirtellus</i> subsp. <i>imbecillis</i>	Bamboo grass	Poaceae	Ground cover
<i>Poa anceps</i>		Poaceae	Ground cover

Scientific Name	Common name	Family	Life form
<i>Rytidosperma gracile</i>		Poaceae	Ground cover
ORCHIDS (18)			
<i>Acianthus sinclairii</i>		Orchidaceae	Ground cover
<i>Bulbophyllum pygmaeum</i>	Bulb-leaved orchid	Orchidaceae	Epiphyte
<i>Chiloglottis cornuta</i>		Orchidaceae	Ground cover
<i>Corybas macranthus</i>	Helmet orchid	Orchidaceae	Ground cover
<i>Corybas oblongus</i>	Helmet orchid	Orchidaceae	Ground cover
<i>Corybas rivularis</i>	Helmet orchid	Orchidaceae	Ground cover
<i>Corybas trilobus</i>	Helmet orchid	Orchidaceae	Ground cover
<i>Dendrobium cunninghamii</i>	Winika; bamboo orchid	Orchidaceae	Epiphyte
<i>Drymoanthus adversus</i>		Orchidaceae	Epiphyte
<i>Earina autumnalis</i>		Orchidaceae	Epiphyte
<i>Earina mucronata</i>		Orchidaceae	Epiphyte
<i>Gastrodia cunninghamii</i>	Black orchid	Orchidaceae	Ground cover
<i>Microtis unifolia</i>		Orchidaceae	Ground cover
<i>Orthoceras novae-zeelandiae</i>		Orchidaceae	Ground cover
<i>Pterostylis banksii</i>	Greenhood orchid	Orchidaceae	Ground cover
<i>Pterostylis trullifolia</i>	Trowel-leaved orchid	Orchidaceae	Ground cover
<i>Thelymitra longifolia</i>		Orchidaceae	Ground cover
<i>Thelymitra</i> sp.		Orchidaceae	Ground cover
RUSHES (3)			
<i>Juncus australis</i> (Gudex 1963)		Juncaceae	Reed
<i>Juncus edgariae</i>		Juncaceae	Reed
<i>Juncus prismatocarpus</i> (Gudex 1963)		Juncaceae	Reed
SEDGES (14)			
<i>Carex banksiana</i>	Hook-seeded sedge	Cyperaceae	Ground cover
<i>Carex dissita</i>		Cyperaceae	Tussock
<i>Carex geminata</i>		Cyperaceae	Tussock
<i>Carex imbecilla</i>	Hook-seeded sedge	Cyperaceae	Ground cover
<i>Carex uncinata</i>	Hook-seeded sedge	Cyperaceae	Ground cover
<i>Carex virgata</i>		Cyperaceae	Tussock
<i>Carex zotovii</i>	Hook-seeded sedge	Cyperaceae	Ground cover
<i>Cyperus ustulatus</i>		Cyperaceae	Tussock
<i>Gahnia pauciflora</i>		Cyperaceae	Tussock
<i>Gahnia setifolia</i>		Cyperaceae	Tussock
<i>Gahnia xanthocarpa</i>		Cyperaceae	Tussock
<i>Isolepis inundata</i> (Gudex 1963)		Cyperaceae	Ground cover
<i>Luzula decipiens</i>		Juncaceae	Ground cover
<i>Morelotia affinis</i>		Cyperaceae	Tussock

Scientific Name	Common name	Family	Life form
MONOCOT HERBS (11)			
<i>Arthropodium candidum</i>	Small renga lily	Asparagaceae	Ground cover
<i>Astelia fragrans</i>		Asteliaceae	Ground cover
<i>Astelia hastata</i>	Kahakaha	Asteliaceae	Epiphyte
<i>Astelia microsperma</i>	Kahakaha	Asteliaceae	Epiphyte
<i>Astelia solandri</i>	Kowharawhara	Asteliaceae	Epiphyte
<i>Astelia trinervia</i>	Kauri grass	Asteliaceae	Ground cover
<i>Dianella nigra</i>	Turutu	Xanthorrhoeaceae	Ground cover
<i>Libertia micrantha</i>		Iridaceae	Ground cover
<i>Phormium tenax</i>	Harakeke	Xanthorrhoeaceae	Tussock
<i>Thismia rodwayi</i>		Thismiaceae	Ground cover
<i>Typha orientalis</i>	Raupo	Typhaceae	Reed
DICOT HERBS (28)			
<i>Acaena anserinifolia</i>	Bidibidi	Rosaceae	Ground cover
<i>Cardamine dolichostyla</i>	Native cress	Brassicaceae	Ground cover
<i>Celmisia gracilentia</i>	Mountain daisy	Asteraceae	Ground cover
<i>Daucus glochidiatus</i> (Gudex 1963)		Apiaceae	Ground cover
<i>Dichondra repens</i>		Convolvulaceae	Ground cover
<i>Drosera auriculata</i>		Droseraceae	Ground cover
<i>Elatostema rugosum</i>	Parataniwha	Urticaceae	Ground cover
<i>Epilobium nerteroides</i>		Onagraceae	Ground cover
<i>Epilobium pubens</i>		Onagraceae	Ground cover
<i>Epilobium rotundifolium</i>		Onagraceae	Ground cover
<i>Euchiton audax</i>		Asteraceae	Ground cover
<i>Euchiton limosus</i>		Asteraceae	Ground cover
<i>Geranium microphyllum</i>		Geraniaceae	Ground cover
<i>Gonocarpus</i> sp. (cf. <i>incanus</i> & <i>montanus</i>)		Haloragaceae	Ground cover
<i>Haloragis erecta</i> subsp. <i>erecta</i>		Haloragaceae	Ground cover
<i>Hydrocotyle dissecta</i>		Araliaceae	Ground cover
<i>Hydrocotyle heteromeria</i>		Araliaceae	Ground cover
<i>Lagenophora pumila</i>		Asteraceae	Ground cover
<i>Lobelia angulata</i>	Panakenake	Campanulaceae	Ground cover
<i>Nertera depressa</i>		Rubiaceae	Ground cover
<i>Nertera dichondrifolia</i>		Rubiaceae	Ground cover
<i>Oxalis exilis</i>		Oxalidaceae	Ground cover
<i>Pseudognaphalium luteoalbum</i>		Asteraceae	Ground cover
<i>Ranunculus reflexus</i>		Ranunculaceae	Ground cover
<i>Senecio minimus</i>		Asteraceae	Ground cover
<i>Solanum americanum</i>		Solanaceae	Ground cover
<i>Stellaria parviflora</i>		Caryophyllaceae	Ground cover
<i>Wahlenbergia</i> sp.		Campanulaceae	Ground cover

Appendix 2. Birds observed on Maungatautari during 2002 to 2017

Birds observed on Maungatautari during 2002 to 2017 (Sinclair & Brejaart 2011; Smuts-Kennedy & Parker 2013; N. Fitzgerald, J. Innes unpubl. data), listed in alphabetical order by common name. All species listed are resident year-round except for shining cuckoo (migratory), longtailed cuckoo (migratory and vagrant) and paradise shelduck (nesting area only). Species with an asterisk were translocated.

Common name	Māori name	Scientific name	Native/exotic
Harrier	Kāhu	<i>Circus approximans</i>	native
Bellbird	Korimako	<i>Anthornis melanura</i>	native
Blackbird		<i>Turdus merula</i>	exotic
Chaffinch		<i>Fringilla coelebs</i>	exotic
Hedgesparrow		<i>Prunella modularis</i>	exotic
Eastern rosella		<i>Platycercus eximius</i>	exotic
Falcon	Kārearea	<i>Falco novaeseelandiae</i>	native
Fantail	Piwakawaka	<i>Rhipidura fuliginosa</i>	native
Goldfinch		<i>Carduelis carduelis</i>	exotic
Greenfinch		<i>Carduelis chloris</i>	exotic
Grey warbler	Riroriro	<i>Gerygone igata</i>	native
Hihi/stitchbird*	Hihi	<i>Notiomystis cincta</i>	native
Kaka*	Kākā	<i>Nestor meridionalis</i>	native
Kereru/pigeon	Kereru	<i>Hemiphaga novaeseelandiae</i>	native
Kingfisher	Kotare	<i>Todiramphus sanctus</i>	native
Long-tailed cuckoo	Koekoeā	<i>Eudynamys taitensis</i>	native
Magpie		<i>Gymnorhina tibicen</i>	exotic
Morepork	Ruru	<i>Ninox novaeseelandiae</i>	native
Myna		<i>Acridotheres tristis</i>	exotic
Brown kiwi*	Kiwi	<i>Apteryx mantelli</i>	native
Kokako*	Kokako	<i>Callaeas wilsoni</i>	native
Paradise shelduck	Putangitangi	<i>Tadorna variegata</i>	native
Robin*	Pitoitoi	<i>Petroica longipes</i>	native
Saddleback*	Tieke	<i>Philesturnus rufusater</i>	native
Shining cuckoo	Pipiwaharuroa	<i>Chrysococcyx lucidus</i>	native
Silvereye	Tauhou	<i>Zosterops lateralis</i>	native
Songthrush		<i>Turdus philomelos</i>	exotic
Starling		<i>Sturnus vulgaris</i>	exotic
Takahe*	Takahe	<i>Porphyrio hochstetteri</i>	native
Tomtit	Miromiro	<i>Petroica macrocephala</i>	native
Tui	Tui	<i>Prothemadera novaeseelandiae</i>	native
Welcome swallow		<i>Hirundo neoxena</i>	native
Whitehead*	Popokatea	<i>Mohoua albicilla</i>	native
Yellow-crown parakeet	Kākāriki	<i>Cyanoramphus auriceps</i>	native
Yellowhammer		<i>Emberiza citrinella</i>	exotic

Appendix 3. Invertebrates recorded at Maungatautari

Invertebrate sampling on Maungatautari includes: monitoring ground-dwelling invertebrates (focusing on beetles and wētā in pitfall traps) in the southern enclosure and on main Maungatautari during 2004 to 2013 to determine their responses to mammal removal (C Watts, Manaaki Whenua – Landcare Research, unpubl. data), weta monitoring in tracking tunnels in the southern enclosure during 2004 to 2006 to determine their responses to mammal removal (Watts et al. 2011), and monitoring the impacts of mice on ground-dwelling invertebrates (sampled by pitfall traps, litter sampling, tracking tunnels and earthworm surveys) in the QEII block and main Maungatautari between 2011 to 2015. The 33 records of taxa lodged in the Auckland War Memorial Museum Entomological Collection are also included.

Family	Species	Status
Coleoptera (Beetles)		
Anobiidae	<i>Sphinditeles</i> sp(p.)	Native
Anthicidae	<i>Cotes crispi</i>	Native
Anthicidae	<i>Cotes optima</i>	Native
Anthicidae	<i>Cotes</i> sp(p.)	Native
Anthribidae	<i>Micranthribus atomus</i>	Native
Brentidae	<i>Lasioryhynchus barbicornis</i>	Native
Buprestidae	<i>Maoraxia eremita</i>	Native
Byrrhidae	Byrrhidae sp(p.)	Native
Byrrhidae	<i>Synorthus</i> sp(p.)	Native
Cantharidae	<i>Asilis</i> sp(p.)	Native
Carabidae	<i>Allocinopus smithi</i>	Native
Carabidae	<i>Amarotypus edwardsi</i>	Native
Carabidae	<i>Aulacopodus calathoides</i>	Native
Carabidae	<i>Ctenognathus adamsi</i>	Native
Carabidae	<i>Ctenognathus sulcitaris</i>	Native
Carabidae	<i>Dicrochile cephalotes</i>	Native
Carabidae	<i>Dicrochile</i> sp(p.)	Native
Carabidae	<i>Holcaspis mordax</i>	Native
Carabidae	<i>Holcaspis</i> sp(p.)	Native
Carabidae	<i>Mecodema crenaticolle</i>	Native
Carabidae	<i>Mecodema curvidens</i>	Native
Carabidae	<i>Mecodema jacinda</i>	Native
Carabidae	<i>Molopsida polita</i>	Native
Carabidae	<i>Neocicindela spilleri</i>	Native
Carabidae	<i>Parabaris atratus</i>	Native
Carabidae	<i>Pentagonica vittipennis</i>	Native
Carabidae	<i>Prosphodrus waltoni</i>	Native
Carabidae	<i>Selenochilus omalleyi</i>	Native
Cerambycidae	<i>Blosyropus spinosus</i>	Native
Cerambycidae	<i>Microlamia pygmaea</i>	Native

Family	Species	Status
Cerambycidae	<i>Nodulosoma angustum</i>	Native
Cerambycidae	<i>Oemona hirta</i>	Native
Cerambycidae	<i>Ptinosa sp(p.)</i>	Native
Cerambycidae	<i>Somatidia antarctica</i>	Native
Cerambycidae	<i>Stenellipsis bimaculata</i>	Native
Cerambycidae	<i>Stenellipsis sp(p.)</i>	Native
Cerambycidae	<i>Tenebrosoma sp(p.)</i>	Native
Cerambycidae	<i>Xylotoles sp(p.)</i>	Native
Cerylonidae	<i>Hypodacnella rubripes</i>	Native
Chrysomelidae	<i>Adoxia sp(p.)</i>	Native
Chrysomelidae	<i>Caccommolpus sp(p.)</i>	Native
Chrysomelidae	<i>Eucolaspis sp(p.)</i>	Native
Chrysomelidae	<i>Peniticus sp(p.)</i>	Native
Ciidae	<i>Ciidae sp(p.)</i>	Native
Clamidae	<i>Clambus pluto</i>	Native
Clamidae	<i>Clambus sp(p.)</i>	Native
Cleridae	<i>Phymatophaea sp(p.)</i>	Native
Coccinellidae	<i>Adoxellus sp(p.)</i>	Native
Coccinellidae	<i>Coccinella undecimpunctata</i>	Introduced
Coccinellidae	<i>Halmus chalybeus</i>	Introduced
Coccinellidae	<i>Rhyzobius fagus</i>	Introduced
Corylophidae	<i>Arthrolips sp(p.)</i>	Native
Corylophidae	<i>Holopsis sp(p.)</i>	Native
Corylophidae	<i>Micrambina sp(p.)</i>	Native
Corylophidae	<i>Sericoderus sp(p.)</i>	Introduced
Corylophidae	<i>Stanus sp(p.)</i>	Native
Cryptophagidae	<i>Paratomaria sp(p.)</i>	Native
Cryptophagidae	<i>Picrotus thoracicus</i>	Native
Cryptophagidae	<i>Thortus sp(p.)</i>	Native
Curculionidae	<i>Agacalles sp(p.)</i>	Native
Curculionidae	<i>Allanalcis sp(p.)</i>	Native
Curculionidae	<i>Allaorus sp(p.)</i>	Native
Curculionidae	<i>Arecophaga varia</i>	Native
Curculionidae	<i>Asynonychus cervinus</i>	Introduced
Curculionidae	<i>Bantiades sp(p.)</i>	Native
Curculionidae	<i>Brachyolus punctatus</i>	Native
Curculionidae	<i>Catoptes binodis</i>	Native
Curculionidae	<i>Clypeolus sp(p.)</i>	Native
Curculionidae	<i>Cossoninae sp(p.)</i>	Native
Curculionidae	<i>Crisius binotatus</i>	Native
Curculionidae	<i>Crisius sp(p.)</i>	Native
Curculionidae	<i>Crisius variegatus</i>	Native
Curculionidae	<i>Crooktacalles certus</i>	Native

Family	Species	Status
Curculionidae	Crytorhynchinae sp(p.)	Native
Curculionidae	<i>Cuneopterus conicus</i>	Native
Curculionidae	<i>Dermothrius</i> sp(p.)	Native
Curculionidae	<i>Ectopsis ferrugalis</i>	Native
Curculionidae	<i>Ectopsis</i> sp(p.)	Native
Curculionidae	<i>Epitimetes</i> sp(p.)	Native
Curculionidae	<i>Etheophanus</i> sp(p.)	Native
Curculionidae	<i>Exomesites optimus</i>	Native
Curculionidae	<i>Geochus</i> sp(p.)	Native
Curculionidae	<i>Gerynassa</i> sp(p.)	Introduced
Curculionidae	<i>Gromilus setosus</i>	Native
Curculionidae	<i>Gromilus</i> sp(p.)	Native
Curculionidae	<i>Gromilus variegatus</i>	Native
Curculionidae	<i>Hiiracalles</i> sp(p.)	Native
Curculionidae	<i>Hygrochus</i> sp(p.)	Native
Curculionidae	<i>Hygrochus/Epitimetes</i> sp(p.)	Native
Curculionidae	<i>Hypocryphalus asper</i>	Native
Curculionidae	<i>Indecentia nubila</i>	Native
Curculionidae	<i>Inosomus rufopiceus</i>	Native
Curculionidae	<i>Lithocia</i> sp(p.)	Native
Curculionidae	<i>Lyperobates</i> sp(p.)	Native
Curculionidae	<i>Metacalles</i> sp(p.)	Native
Curculionidae	<i>Nestrius</i> sp(p.)	Native
Curculionidae	<i>Notacalles</i> sp(p.)	Native
Curculionidae	<i>Nyxetes bidens</i>	Native
Curculionidae	<i>Oropterus coniger</i>	Native
Curculionidae	<i>Paelocharis</i> sp(p.)	Native
Curculionidae	<i>Paromalía nigricollis</i>	Native
Curculionidae	<i>Paromalía vestita</i>	Native
Curculionidae	<i>Peristoreus</i> sp(p.)	Native
Curculionidae	<i>Phronira</i> sp(p.)	Native
Curculionidae	<i>Phrynixus</i> sp(p.)	Native
Curculionidae	<i>Psepholax</i> sp(p.)	Native
Curculionidae	<i>Rhadinomus acuminatus</i>	Native
Curculionidae	<i>Rhopalomerus picipennis</i>	Native
Curculionidae	<i>Rhynchodes ursus</i>	Native
Curculionidae	<i>Scelodolichus</i> sp(p.)	Native
Curculionidae	<i>Scolopterus aequus</i>	Native
Curculionidae	Scolytinae; Xyleborini sp(p.)	Introduced
Curculionidae	<i>Sitona lepidus</i>	Introduced
Curculionidae	<i>Stilbopsis polita</i>	Native
Curculionidae	<i>Styphlotelus fascicularis</i>	Native
Curculionidae	<i>Sympedius</i> sp(p.)	Native

Family	Species	Status
Curculionidae	<i>Trinodicalles conicollis</i>	Native
Curculionidae	<i>Trinodicalles</i> sp(p.)	Native
Curculionidae	Tropiporini sp(p.)	Native
Curculionidae	<i>Tychanopais</i> sp(p.)	Native
Curculionidae	<i>Tychanus</i> sp(p.)	Native
Curculionidae	<i>Zeacalles incultus</i>	Native
Curculionidae	<i>Zeacalles</i> sp(p.)	Native
Dermestidae	<i>Hexanodes vulgata</i>	Native
Dryopidae	<i>Parnida</i> sp(p.)	Native
Elateridae	<i>Agrypnus variabilis</i>	Introduced
Elateridae	<i>Amphiplatys lawsoni</i>	Native
Elateridae	<i>Conoderus</i> sp(p.)	Native
Elateridae	Elateridae sp(p.)	Native
Elateridae	<i>Oxylasma</i> sp(p.)	Native
Elateridae	<i>Panspoeus guttatus</i>	Native
Elateridae	<i>Sphaenelater collaris</i>	Native
Endomychidae	<i>Holoparamecus</i> sp(p.)	Native
Erotylidae	<i>Cryptodacne nui</i>	Native
Erotylidae	<i>Cryptodacne</i> sp(p.)	Native
Erotylidae	<i>Hapalips prolixus</i>	Native
Euxestidae	<i>Hypodacnella rubripes</i>	Native
Histeridae	<i>Aulacosternus zelandicus</i>	Native
Histeridae	<i>Parepierus</i> sp(p.)	Native
Hydrophilidae	<i>Adolopus</i> sp(p.)	Native
Hydrophilidae	<i>Cercyon</i> sp(p.)	Introduced
Hydrophilidae	<i>Cyloma guttulatus</i>	Native
Hydrophilidae	<i>Cyloma lawsonus</i>	Native
Hydrophilidae	<i>Cyloma</i> sp(p.)	Native
Hydrophilidae	<i>Cyloma stewarti</i>	Native
Hydrophilidae	<i>Exydrus gibbosus</i>	Native
Hydrophilidae	<i>Saphydrus</i> sp(p.)	Native
Hydrophilidae	<i>Tormissus linsi</i>	Native
Latridiidae	<i>Aridius</i> sp(p.)	Introduced
Latridiidae	Corticariinae sp(p.)	Native
Latridiidae	<i>Enicmus</i> sp(p.)	Native
Latridiidae	<i>Lithostygnus</i> sp(p.)	Native
Leiodidae	<i>Agyrtodes hunuensis</i>	Native
Leiodidae	<i>Agyrtodes</i> sp(p.)	Native
Leiodidae	<i>Baeosilpha rufescens</i>	Native
Leiodidae	<i>Camiarus</i> sp(p.)	Native
Leiodidae	Cholevinae sp(p.)	Native
Leiodidae	<i>Colon hirtale</i>	Native
Leiodidae	<i>Inocatops</i> sp(p.)	Native

Family	Species	Status
Leiodidae	<i>Isocolon</i> sp(p.)	Native
Leiodidae	n. g. "Agaricalodes" n. sp(p.)	Native
Leiodidae	<i>Zeadolopus</i> sp(p.)	Native
Leiodidae	<i>Zeadolopus validipes</i>	Native
Lucanidae	<i>Dendrobax earlii</i>	Native
Lucanidae	<i>Mitophyllus parrianus</i>	Native
Lucanidae	<i>Paralissotes planus</i>	Native
Melandryidae	Gen. nov. sp(p.) nov.	Native
Melandryidae	<i>Hylobia</i> sp(p.)	Native
Melandryidae	Orchesiini n.g. n.sp(p.)	Native
Melyridae	Melyridae sp(p.)	Native
Mycetophagidae	<i>Nototriphyllus</i> sp(p.)	Native
Nitidulidae	<i>Cryptarcha optanda</i>	Native
Nitidulidae	<i>Epuraea</i> sp(p.)	Native
Nitidulidae	<i>Soronia asperella</i>	Native
Nosodendridae	<i>Nosodendron</i> sp(p.)	Native
Oedemeridae	<i>Thelyphassa</i> sp(p.)	Native
Ptiliidae	<i>Cissidium foveolatum</i>	Native
Ptiliidae	<i>Kuschelidium maori</i>	Native
Ptiliidae	<i>Nellosana</i> sp(p.)	Native
Ptiliidae	<i>Notoptenidium</i> sp(p.)	Native
Ptiliidae	Ptiliidae sp(p.)	Native
Ptiliidae	<i>Ptiliodes</i> sp(p.)	Native
Salpingidae	<i>Diagrypnodes wakefieldi</i>	Native
Salpingidae	Salpingidae sp(p.)	Native
Scarabaeidae	<i>Acrossidius tasmaniae</i>	Introduced
Scarabaeidae	<i>Aphodius granarius</i>	Introduced
Scarabaeidae	<i>Costelytra zealandica</i>	Native
Scarabaeidae	<i>Heteronychus arator</i>	Introduced
Scarabaeidae	<i>Odontria magna</i>	Native
Scarabaeidae	<i>Odontria</i> sp(p.)	Native
Scarabaeidae	<i>Saphobius edwardsi</i>	Native
Scarabaeidae	<i>Saphobius fulvipes</i>	Native
Scarabaeidae	<i>Saphobius inflatipes</i>	Native
Scarabaeidae	<i>Saphobius</i> sp(p.)	Native
Scarabaeidae	<i>Saphobius squamulosus</i>	Native
Scarabaeidae	<i>Saprosites</i> sp(p.)	Native
Scarabaeidae	<i>Stethaspis longicornis</i>	Native
Scarabaeidae	<i>Stethaspis</i> sp(p.)	Native
Scirtidae	<i>Amplectopus</i> sp(p.)	Native
Scirtidae	<i>Atopida</i> sp(p.)	Native
Scirtidae	<i>Cyphanodes vestitus</i>	Native
Scirtidae	<i>Cyphon</i> sp(p.)	Native

Family	Species	Status
Scirtidae	<i>Cyprobius</i> sp(p.)	Native
Scirtidae	Scirtidae sp(p.)	Native
Silvanidae	<i>Brontopriscus pleuralis</i>	Native
Silvanidae	<i>Cryptamorpha brevicornis</i>	Native
Staphylinidae	<i>Agnosthaetus</i> sp(p.)	Native
Staphylinidae	Aleocharinae sp(p.)	Native
Staphylinidae	<i>Anabaxis foveolata</i>	Native
Staphylinidae	<i>Anotylus</i> sp(p.)	Introduced
Staphylinidae	<i>Baeocera</i> sp(p.)	Native
Staphylinidae	<i>Brachynopus latus</i>	Native
Staphylinidae	<i>Brachynopus</i> sp(p.)	Native
Staphylinidae	<i>Eupines</i> sp(p.)	Native
Staphylinidae	Euplectitae sp(p.)	Native
Staphylinidae	<i>Faronini</i> sp(p.)	Native
Staphylinidae	<i>Gastrobothrus</i> sp(p.)	Native
Staphylinidae	<i>Hamotulus</i> sp(p.)	Native
Staphylinidae	<i>Hyperomma</i> sp(p.)	Native
Staphylinidae	<i>Maorothius</i> sp(p.)	Native
Staphylinidae	<i>Microsilpha</i> sp(p.)	Native
Staphylinidae	<i>Myllaena</i> sp(p.)	Native
Staphylinidae	<i>Nototorchus ferrugineus</i>	Native
Staphylinidae	Omalinae sp(p.)	Native
Staphylinidae	Oxytelinae sp(p.)	Native
Staphylinidae	Paederinae sp(p.)	Native
Staphylinidae	<i>Paraconosoma</i> sp(p.)	Native
Staphylinidae	<i>Paratorchus</i> sp(p.)	Native
Staphylinidae	<i>Phanophilus comptus</i>	Native
Staphylinidae	Pselaphini sp(p.)	Native
Staphylinidae	<i>Quedius longiceps</i>	Native
Staphylinidae	<i>Quedius</i> sp(p.) (big)	Native
Staphylinidae	<i>Sagola</i> sp(p.)	Native
Staphylinidae	Scaphidiinae sp(p.)	Native
Staphylinidae	Scydmaeninae sp(p.)	Native
Staphylinidae	<i>Sepedophilus</i> sp(p.)	Native
Staphylinidae	<i>Silphotelus nitidus</i>	Native
Staphylinidae	<i>Sytus</i> sp(p.)	Native
Staphylinidae	<i>Tachyporus nitidus</i>	Introduced
Staphylinidae	<i>Tramiathaea cornigera</i>	Native
Staphylinidae	<i>Zeoleusis virgula</i>	Native
Tenebrionidae	<i>Archaeoglenes costipennis</i>	Native
Tenebrionidae	<i>Artystona</i> sp(p.)	Native
Tenebrionidae	<i>Exohadrus volutithorax</i>	Native
Tenebrionidae	<i>Kaszabadelium aucklandicum</i>	Native

Family	Species	Status
Tenebrionidae	<i>Lorelus</i> sp(p.)	Native
Tenebrionidae	<i>Menimus</i> sp(p.)	Native
Tenebrionidae	<i>Tanychilus metallicus</i>	Native
Tenebrionidae	<i>Wattadelium</i> sp(p.)	Native
Tenebrionidae	<i>Xylochus</i> sp(p.)	Native
Trogossitidae	<i>Grynomia</i> sp(p.)	Native
Trogossitidae	Rentoniinae sp(p.)	Native
Ulodidae	<i>Brouniphyllax</i> sp(p.)	Native
Ulodidae	<i>Syrphetodes obtusus</i>	Native
Ulodidae	<i>Syrphetodes</i> sp(p.)	Native
Zopheridae	<i>Ablabus</i> sp(p.)	Native
Zopheridae	<i>Chorasus</i> sp(p.)	Native
Zopheridae	<i>Ciconissus</i> sp(p.)	Native
Zopheridae	<i>Epistranus</i> sp(p.)	Native
Zopheridae	<i>Glenentela</i> sp(p.)	Native
Zopheridae	<i>Notocoxelus</i> sp(p.)	Native
Zopheridae	<i>Pristoderus bakewelli</i>	Native
Zopheridae	<i>Pristoderus</i> sp(p.)	Native
Zopheridae	<i>Pristoderus tuberculatus</i>	Native
Zopheridae	<i>Pycnomerus</i> sp(p.)	Native
Zopheridae	<i>Rytinotus squamulosus</i>	Native
Zopheridae	<i>Syncalus</i> sp(p.)	Native
Zopheridae	<i>Tarphiomimus indentatus</i>	Native
Diptera (flies)		
Piophilidae	<i>Piophila casei</i>	Introduced
Heteroptera (true bugs)		
Aradidae	<i>Acaraptera myersi</i>	Native
Aradidae	<i>Tretocoris grandis</i>	Native
Pentatomidae	<i>Glaucias amyoti</i>	Introduced
Hymenoptera (ants, wasps and bees)		
Bethylidae	<i>Apenesia tofti</i>	Native
Orthoptera (weta)		
Anostomatidae	<i>Hemiandrus pallitarsis</i>	Native
Anostomatidae	<i>Hemideina thoracica</i>	Native
Rhaphidophoridae	' <i>Neonetus</i> ' sp. 1	Native
Rhaphidophoridae	<i>Gymnoplectron acanthocerum</i>	Native
Rhaphidophoridae	<i>Gymnoplectron</i> sp. 1	Native
Rhaphidophoridae	<i>Pachyrhamma</i> sp. 1	Native
Rhaphidophoridae	<i>Pleioplectron diversum</i>	Native
Rhaphidophoridae	<i>Pleioplectron</i> sp. 1	Native
Phasmatodea (stick insects)		
Phasmatidae	<i>Clitarchus hookeri</i>	Native
Phasmatidae	<i>Asteliaphasman jucundum</i>	Native

Family	Species	Status
Oligochaeta (earthworms)		
Acanthodrilidae	<i>Deinodrilus agilis</i>	Native
Acanthodrilidae	<i>Rhododrilus macroseptus</i>	Native
Acanthodrilidae	<i>Rhododrilus robustus</i>	Native
Acanthodrilidae	<i>Rhododrilus</i> species 1	Unknown
Lumbricidae	<i>Eisenia japonica</i>	Introduced
Lumbricidae	<i>Lumbricus rubellus</i>	Introduced
Lumbricidae	<i>Octolasion cyaneum</i>	Introduced
Megascolecidae	<i>Amyntas species</i>	Introduced
Megascolecidae	<i>Megascolex</i> species	Unknown
Megascolecidae	<i>Megascolides mauricus</i>	Native
Megascolecidae	<i>Megascolides raglani</i>	Native
Megascolecidae	<i>Megascolides</i> species 1	Unknown
Megascolecidae	<i>Megascolides</i> species 2	Unknown
Sphaerotheriida (pill millipedes)		
Procyliosomatidae	<i>Procyliosoma decayi</i>	Native
Procyliosomatidae	<i>Procyliosoma tuberculatum</i>	Native

Appendix 4: Fungi recorded at Maungatautari

List compiled from data in the New Zealand Fungarium (PDD) Collection and International Collection of Microorganisms from Plants (ICMP). Manaaki Whenua – Landcare Research manages both these databases. Holotype is the specimen upon which the description and name of a new species is based.

Species	Fungal group	Notes
<i>Heteroconium</i> sp.	microfungus	Collected from dead stem of <i>Ripogonum scandens</i> (kareao; supplejack)
<i>Brachydesmiella biseptata</i> G. Arnaud ex S. Hughes 1961	microfungus	Host is kareao
<i>Chloridium</i> sp.	microfungus	Collected from dead stem of kareao
<i>Corynespora</i> sp.	microfungus	Collected from dead stem of kareao
<i>Corynespora ripogoni</i> McKenzie	microfungus	Host is kareao; Holotype
<i>Cystodermella</i>	mushroom	
<i>Dermatea fumosa</i> Cooke & W. Phillips 1879	discomycete	On fallen wood
<i>Ellisembia adscendens</i> (Berk.) Subram.	microfungus	Host is kareao
<i>Sporidesmium adscendens</i> Berk. 1840	microfungus	Host is kareao
<i>Ellisembia maungatautari</i> McKenzie	microfungus	Host is kareao; Holotype
<i>Heimiomyces atrofulvus</i>	mushroom	Collected from log
<i>Helminthosporium palmigenum</i> Matsush. 1971	microfungus	Host is kareao
<i>Helminthosporium velutinum</i> Link 1809	microfungus	Host is kareao
<i>Mikronegeria fuchsiae</i> P.E. Crane & R.S. Peterson 2007	rust	Host is <i>Fuchsia excorticata</i> (kotukutuku; tree fuschia)
Pezizellaceae Velen. 1934	discomycete	Collected from fallen leaf of <i>Knightia excelsa</i> (rewarewa)
<i>Phaeoisaria clematidis</i> (Fuckel) S. Hughes 1958	microfungus	Host is kareao
Phialocephala W.B. Kendr. 1961	microfungus	Host is kareao
<i>Phragmocephala atra</i> var. <i>stenophora</i> S. Hughes 1978	microfungus	Collected from dead stem of kareao
<i>Septoria</i> sp.	microfungus	Collected from dead stem of kareao
<i>Solicorynespora maungatautari</i>	microfungus	Holotype
<i>Sporidesmiella hyalosperma</i> (Corda) P.M. Kirk 1982 var. <i>hyalosperma</i>	microfungus	Host is kareao
<i>Sporidemiella parva</i> var. <i>parva</i> (M.B. Ellis) P.M. Kirk	microfungus	Host is kareao
<i>Sporidesmium flagellatum</i> (S. Hughes) M.B. Ellis 1958	microfungus	Host is kareao
<i>Pseudospiropes nodosus</i> (Wallr.) M.B. Ellis 1971	microfungus	Host is kareao
<i>Pseudospiropes simplex</i> (Kunze) M.B. Ellis	microfungus	Host is kareao
<i>Tretospeira ugandensis</i> (Hansf.) Piroz.	microfungus	
<i>Trichopeziza</i> Fuckel 1870 [1869-70]	discomycete	Collected from dead twigs of shrub
<i>Xenosporium boivinii</i> S. Hughes 1978	microfungus	Host is kareao

Appendix 5 – Published, available and submitted papers and reports about or highly relevant to Maungatautari

Contributors: John Innes, Corinne Watts, Neil Fitzgerald (Manaaki Whenua – Landcare Research), Shelley Myers (EcoQuest Education Foundation), Tony Roxburgh (Waipa District Council), Bruce Burns (University of Auckland), Kiri Joy Wallace (University of Waikato), Kate Richardson (Wildlands Consultants).

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[Agencies who did (not necessarily funded) the work are in square brackets after each reference; papers are in chronological order within topics]

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