Tiritiri Matangi Island
Biodiversity Plan 2013

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TIRITIRI MATANGI
incorporated

Tiritiri Matangi Island Biodiversity Plan 2013

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Cover photos

Clockwise starting from the top left corner:

Takahē - *Porphyrio hochstetteri* (Photo: Neil Davies)

Fluttering shearwater - *Puffinus gavia* (Photo: Simon Fordham)

North Island saddleback - *Philesturnus rufusater* (Photo: Kay Milton)

Grey-faced petrel - *Pterodroma macroptera* (Photo: Simon Fordham)

Wētāpunga (female) - *Deinacrida heteracantha* (Photo: Simon Fordham)

Tanguru chafer beetle - *Stethaspis suturalis* (Photo: Mel Galbraith)

Duvaucel's gecko - *Hoplodactylus duvaucelii* (Photo: Simon Fordham)

White-fronted tern - *Sterna striata* (Photo: Mel Galbraith)

Pōhutukawa - *Metrosideros excelsa*(Photo: Neil Davies)

Tūī - *Prosthemadera novaeseelandiae* feeding on kowhai - *Sophora chathamica* (Photo: Josie Galbraith)

Centre photos:

Tuatara - *Sphenodon punctatus* (Photo: Simon Fordham)

North Island kōkako - *Callaeas wilsoni* feeding on karo - *Pittosporum crassifolium* (Photo: Simon Fordham)

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Many people have contributed to the preparation and production of this Biodiversity Plan. The initial drafts of chapters were written by Shelley Heiss-Dunlop (vegetation), Helen Lindsay (weed management), Kevin Parker (birds), Melinda Rixon and Manuela Barry (reptiles), Corinne Watts (invertebrates), Mel Galbraith (bats) and Callum Bourke and Andrew Nelson (freshwater ecosystem).

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The views expressed in this Plan are those formulated by the Supporters of Tiritiri Matangi (SoTM) in assessing the biodiversity needs of the Island for the period 2013-2023 and beyond. They do not necessarily reflect those of the original contributing authors.

SUMMARY OF RECOMMENDATIONS

2. Management of vegetation on Tiritiri Matangi

2.1 If the Pōhutukawa Project proves successful in increasing species diversity in planted areas, consider implementing a management programme of this kind more widely across the Island. The creation of light wells could also provide an opportunity to introduce additional understorey and canopy species (such as mangeao and taraire) in relatively well-established sheltered habitats.

2.2 Consider planting or seeding hardy canopy species amongst gorse in exposed northern parts of the Island, to assist the revegetation process that will eventually shade out the gorse.

2.3 Monitor the effectiveness of the Island's dams and, where practicable, maintain and/or improve their condition as part of a wetland management programme.

2.4 Improve habitat around wetland areas with new planting based on the list in Table 2.1.

2.5 Enhance the habitat around the Silvester Wetlands by planting a mix of seed-bearing canopy trees in addition to plants listed in Table 2.1.

2.6 Improve the habitat for grassland fauna by planting additional native grasses and ferns with edible rhizomes in rank pasture grass and along track margins.

2.7 Implement an appropriate mowing strategy and management of track margins to ensure sufficient open spaces for takahē.

2.8 Monitor and, where necessary, control the growth of woody species in areas of bracken and muehlenbeckia.

2.9 Enhance the Island's ecological integrity by carrying out a planting programme as indicated in Table 2.2.

2.10 Provide a sanctuary for threatened plant species by planting species listed in Table 2.3.

2.11 Establish a 'threatened plant garden' around the Visitor Centre with appropriate interpretation to increase public awareness of the plight of threatened plants.

2.12 The translocation and establishment of both wild and managed populations on Tiritiri Matangi should be guided by DOC recovery plans, where these are available.

3. Management of the freshwater ecosystem on Tiritiri Matangi

3.1 Undertake a comprehensive survey of Tiritiri Matangi's freshwater flora and fauna to establish the species composition on the Island.

3.2 Assess the access routes for fish migrating from the sea to the ponds, and whether it is possible to improve such access to those ponds/streams that provide suitable habitat for native fish.

3.3 Assess the quality of the ponds' marginal and aquatic vegetation. Suitable aquatic/wetland plants are necessary to provide shade and cover, which will in turn lower the water temperature during summer, provide habitat for native fish and ultimately improve water quality.

3.4 Measure water quality parameters in each of the ponds. This could be a good opportunity to implement a regular monitoring programme in order to assess freshwater ecosystem health and trends.

4. Management of bird populations on Tiritiri Matangi

4.1 Continue to provide supplementary feeding, water and nest boxes as required for management of resident species and for advocacy and research purposes.

4.2 Increase and develop species-based population monitoring to provide a more detailed knowledge base for future management.

4.3 Consider monitoring predator-prey interaction to provide information for future management.

4.4 Increase the food and habitat resources for resident bird populations through 'enhancement' planting of selected appropriate plant species.

4.5 Support long-term research on vegetation community dynamics and changes in bird populations to improve the knowledge base for future management.

4.6 Where appropriate, support research relevant to the genetic management of species on the Island.

4.7 Consider translocating appropriate seabird species (little shearwater, flesh-footed shearwater, Pycroft's petrel) to the Island within the next ten years.

4.8 Monitor the numbers of potentially troublesome bird species and, if necessary, seek to gauge their impact on other species.

5. Management of reptile populations on Tiritiri Matangi

5.1 For moko skink, manage the vegetation so that a matrix of habitats is retained, including naturally open spaces.

5.2 For common gecko, on-going genetic monitoring of this population is recommended to assess whether future genetic management may be required.

5.3 For tuatara, continue with five-yearly monitoring to assess the condition of the population and to determine the long-term success of this translocation.

5.4 Of the species identified as candidates for future translocation to the Island, robust skink, Whitaker's skink and Auckland green gecko should be considered as the first priorities (see Tables 5.1-5.3) within the ten-year period covered by this plan.

5.5 As a preliminary step to the translocation of robust skink and Whitaker's skink, conduct an investigation into the availability of suitable conditions for these species, especially at the driest times of year.

5.6 Institute appropriate long-term vegetation management to ensure that mānuka/kānuka bush areas are maintained for green geckos, and that fragments of this habitat are connected by mānuka/kānuka corridors.

6. Restoration of bats on Tiritiri Matangi

6.1 Engage with national and regional discussions about bat management and translocation.

6.2 Encourage, support and, where appropriate, participate in, research to improve management and translocation techniques for bat species.

6.3 Support and encourage further research on the suitability of Tiritiri Matangi as a site for establishing a bat population.

6.4 Continue communication with expert personnel to determine the possibility of Tiritiri Matangi providing a sanctuary for a displaced population of long-tailed bats should the need arise.

6.5 In the event of a translocation appearing likely, begin considering and planning a monitoring programme to continue for at least ten years after translocation.

7. Management of invertebrate populations on Tiritiri Matangi

7.1 Conduct and/or support research to increase knowledge of the presence and distribution of invertebrates in all habitats on Tiritiri Matangi.

7.2 Ensure the continuation of the long-term survey of ground-dwelling invertebrates in bush areas, conducted by Dr Chris Green since 1993.

7.3 Support the continuation of post-translocation monitoring of wētāpunga to determine whether they establish successfully.

7.4 Continue annual monitoring and control of Argentine ants, together with surveillance at all entry points, indefinitely.

7.5 Research suitable source populations for flax weevil and large darkling beetle and consider introducing them within the period covered by this plan.

7.6 Undertake or support research into the suitability of Turbott's weevil and karo weevil for translocation to the Island in the longer term.

7.7 Conduct a survey of the snail fauna on the Island to determine whether large native land snails are present, and whether there is sufficient prey for large carnivorous snails.

7.8 Depending on the outcome of this survey, research potential source populations of snail species suitable for translocation, including flax snail. This should include liaising with the Giant Snail Recovery Group and Auckland Zoo regarding the possibility of a captive breeding programme as a source of flax snails.

7.9 Consider the great giant scale insect as a possible candidate for translocation.

8. Management of weed species on Tiritiri Matangi

8.1 Continue to fund an annual weed control programme as listed in Table 8.2. This must continue until seed banks are exhausted.

8.2 Review the schedule annually to ensure that the programme takes account of changing circumstances.

8.3 Prevent brush wattles from expanding their range, and progressively control large isolated specimens to reduce seed production.

8.4 Prevent gorse from further colonising open grass spaces and cliff faces.

8.5 Plant or seed hardy native canopy species amongst gorse in exposed areas to assist revegetation.

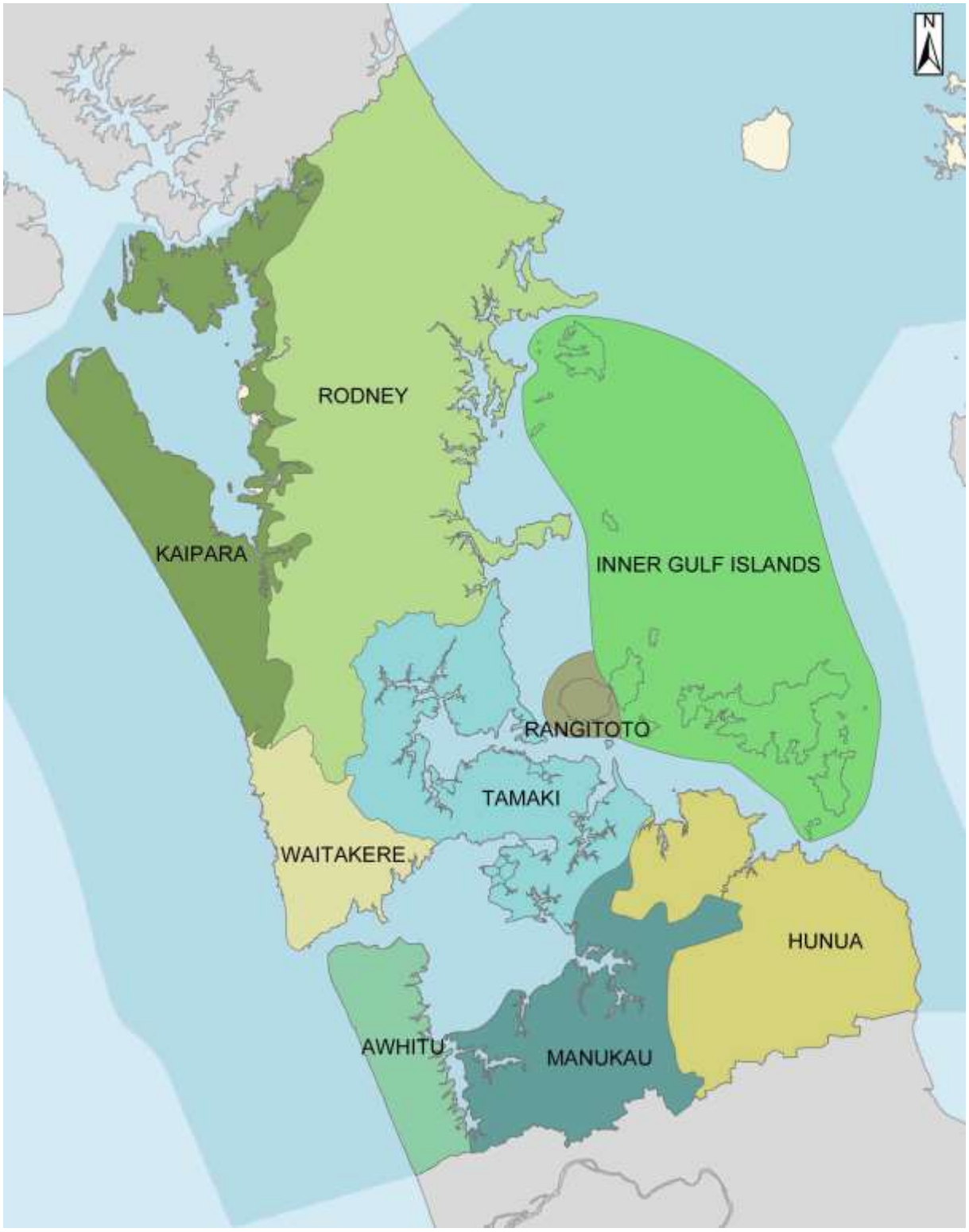
8.6 Continue with the abseiling programme to identify new infestations of boxthorn on the cliffs; this should be done at least every three to four years in the immediate future.

8.7 Encourage contract staff to have an ongoing relationship with the Island so that their knowledge and experience can continue to be used.

8.8 Develop an operational plan to address the issue of Australian ngaio and its hybrids.

8.9 Implement a strategy for the management of native species outside their natural range.

8.10 Species currently present for advocacy purposes, and which are outside their natural range, should be left to live out their lives and be replaced only if they are considered to have continued advocacy value.



Ecological Districts in the Auckland Region (Map included courtesy of Auckland Council)

Please note that the boundaries of some of the ecological districts have been revised since this map was produced, but Tiritiri Matangi is not affected by this.

1. INTRODUCTION

In the early 1970s Tiritiri Matangi was a 220-hectare expanse of pasture, punctuated by a few tiny remnants of forest that had survived a century of farming. Today it is one of the most internationally acclaimed conservation projects in the world and a source of pride for New Zealand. Planted forest clothes two-thirds of the Island and is gradually maturing. The sounds of native birds, some of them no longer seen on the mainland, echo across the Island. Native reptiles – skinks, geckos and tuatara – are flourishing, and the introduction of endangered native invertebrates has begun with the impressive wētāpunga (giant wētā).

The story of how this transformation came about has been told elsewhere.[1] It started with an inspired, and inspiring, group of people who, having recognised that, without intervention, the Island's vegetation would regenerate only very slowly, conceived a plan to plant most of the Island with native trees during the 1980s and '90s. Out of this group came the Supporters of Tiritiri Matangi (Inc.) (SoTM), formed in 1988 to support the Island's restoration. SoTM has since become a partner in the Island's management with the Department of Conservation (DOC).

This Biodiversity Plan has been developed by the Supporters of Tiritiri Matangi (SoTM) to provide direction for the ongoing conservation and management of the Island's flora and fauna. This plan builds on past working plans[2,3] and on previous efforts, including the original planting and translocations of native species. The plan is intended to cover a period of ten years, though timeframes should be considered flexible and reference is made to longer periods where appropriate.

1.1 The historical context

In 1971, after around 100 years of farming, Tiritiri Matangi was designated a Recreation Reserve within the Hauraki Gulf Maritime Park. Nine years later, in recognition of detailed studies carried out on the Island by Auckland University, its designation was changed to 'Scientific Reserve'.[1] The purpose of scientific reserves is 'protecting and preserving in perpetuity for scientific study, research, education and the benefit of the country, ecological associations, plant or animal communities, types of soil, geomorphological phenomena, and like matters of interest' (Reserves Act 1977, section 21, 1). It was decided to continue allowing public access, giving the Island multiple roles: as a site for conservation, research and education, and as a popular tourist destination.

The first working plan for Tiritiri Matangi was produced in 1982.[2] At that time, the word 'restoration' was not part of conservation terminology and the process was seen as a 'reafforestation' project, aimed at giving the public the opportunity to interact with rare native plants and animals which they would not see easily elsewhere. The Foreword of the 1982 Plan expressed this as follows:

> 'The proposal for Tiritiri Island is to create an "open sanctuary" where people … can ultimately view some of the region's rare and endangered animal and plant species within their natural environment. In this way, the island can ... serve as a practical demonstration of the value of wildlife conservation.'

The proposed reafforestation took the form of 'an "enrichment planting" programme with pōhutukawa as the main species, and taraire, karo and kohekohe used to a lesser extent'. Other species were also listed, some of them intended to provide additional nectar, fruit and seeds for native fauna dependent on these food sources.

A second goal of the 1982 Plan was the introduction of selected flora and fauna. The selections included species which probably (and, in the case of takahē, definitely) had never lived on the Island in the past, alongside those whose natural range would have included Tiritiri Matangi. There was no great concern expressed about the presence of kiore (Pacific rats), though it was stated that their effects on translocated species would be closely observed. Concern increased, however, and they were eventually eradicated in 1993, before the next working plan was published.

By the time of the next plan in 1997,[3] planting had increased the bush cover to 60% of the Island. Seven bird species – saddleback, little spotted kiwi, stitchbird, takahē, North Island robin, whitehead and pāteke (brown teal) – had been introduced, joining kākāriki, which had been moved to the Island in 1974. (For a list of translocations onto and off the Island, see Appendix A.)

The role of the University of Auckland in providing a scientific basis for many of the management and/or monitoring proposals had been noted in the 1982 Plan. It was clearly stated that the information gained from research and monitoring could lead to change or modification of the management proposals. In accordance with the Island's official status as a scientific reserve, the research programme has grown to include major contributions and involvement from Massey University, the University of Cambridge (UK) and the Zoological Society of London, with a range of contributions from other tertiary institutions.

1.2 A restoration project?

The 1997 working plan took its lead from DOC's Conservation Management Strategy (CMS) for the Auckland Conservancy (1995-2005),[4] in which Tiritiri Matangi was described as a 'habitat restoration project'. The CMS outlines the policy direction for the Island's ecosystem management as follows:

> 'Restore a thriving indigenous ecosystem representative of the Inner Gulf, capable of supporting a range of common and threatened native animal species, especially birds.'

The Society for Ecological Restoration defines ecological restoration as an 'intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability'.[5] Such an activity requires a restoration goal, an envisaged state towards which the recovering ecosystem is accelerated. This would normally be the original ecosystem – the one that had existed before the damage that necessitated restoration had occurred. Or, if there is insufficient knowledge available on the original ecosystem, it can be a model of what that ecosystem is assumed to have been like. In the case of Tiritiri Matangi, this would be the kind of ecosystem that would have been present on an Inner Hauraki Gulf

island prior to human influence (i.e. typical of the Inner Gulf Islands Ecological District (IGIED – see map p. 8)).

However, the 1997 working plan for the Island was inconsistent in its use of this goal. On the one hand, the plan proposed removing (or allowing to die out) indigenous plant species that had already been introduced, but which were no longer considered appropriate because they were not representative of the Inner Gulf region (1997 working plan,[3] section 4.1.2). On the other hand, there was no suggestion that takahē, only ever resident in the South Island, were unsuitable, nor that artificially-created wetlands should be removed, and the proposals for future translocations included North Island kōkako, which is assumed to have inhabited only much larger land masses. If the plan was to restore, on Tiritiri Matangi, an ecosystem representative of the Inner Hauraki Gulf, this clearly was not intended to be followed strictly, given that there were already instances in which the Island's fauna and flora deviated from this model, and further such deviations were envisaged in the future.

Although it was never stated explicitly, the goal for Tiritiri Matangi, as envisaged in the 1997 working plan, was not so much a restored ecosystem as a 'replacement ecosystem', one that partly reflects the structure and function of the original ecosystem but which deviates from it in particular ways. This is illustrated in Figure 1.1. In the case of Tiritiri Matangi, the envisaged goal deviated from the original ecosystem for two main reasons: because conditions on the Island had changed irretrievably under human influence, and because management decisions were governed by other considerations as well as restoration.

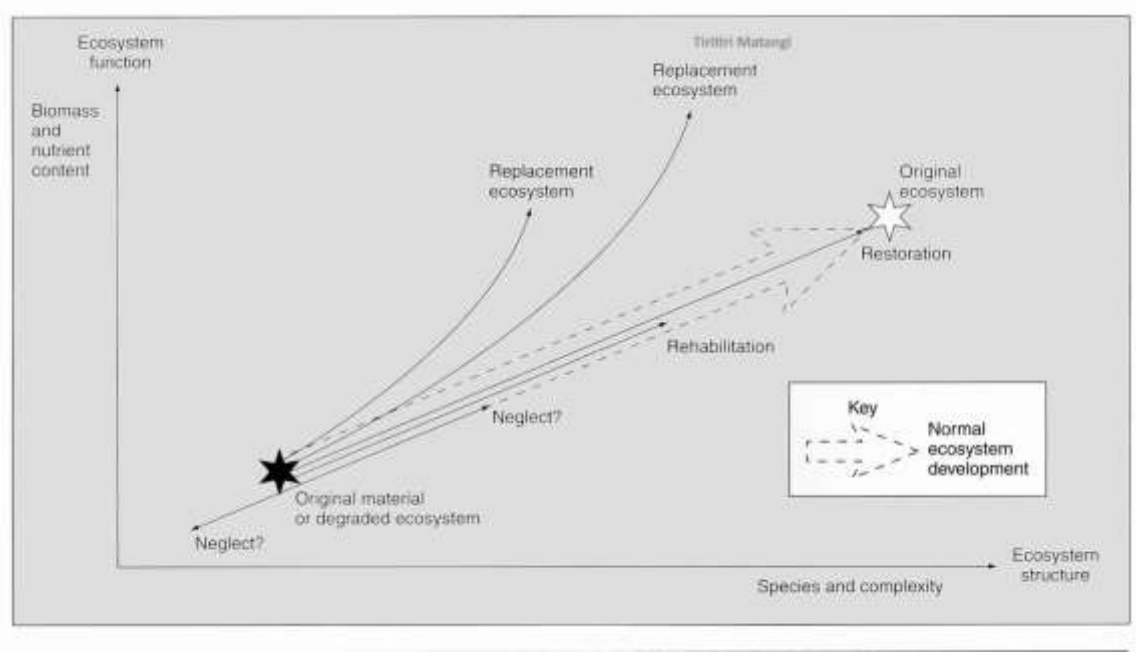


Figure 1.1 The relationship between ecosystem structure and ecosystem function in restoration, illustrating the position of the goal of restoration for Tiritiri Matangi as a replacement ecosystem. (Source: Van Dyke 2003: 308)[6]

In this new biodiversity plan, SoTM endorses the vision of the Island's future implied in the 1997 working plan. If Tiritiri Matangi were a 'pure' restoration project, the aim would be to re-create an ecosystem typical of the Inner Gulf Islands Ecological District (IGIED). The

Island's development so far, plus the guiding principles outlined below, ensure that, while the IGIED will remain as a broad model, it will not limit future management.

1.3 Guiding principles

The overarching framework for all SoTM's activities is provided by the organisation's Strategic Plan,[7] which describes SoTM's vision for Tiritiri Matangi as follows:

> 'We want the Island to be a complex, healthy ecosystem, a haven for New Zealand's native species, a magical place that engages and inspires volunteers and visitors to understand our unique heritage and to make a difference in their own environment.'

The outcome towards which SoTM's conservation activities are directed is expressed in the Strategic Plan as follows:

> 'Tiritiri Matangi will have a healthy functioning ecosystem broadly representative of the Inner Hauraki Gulf Islands Ecological District, but modified to serve the needs of advocacy, species protection, species management, and learning.'

These four guiding principles – advocacy, species protection (sanctuary), species management and learning – are outlined below.

1.3.1 Advocacy

Advocacy in this context means engaging public interest and attention to instil respect and concern for conservation in general and the plight of particular species. The Island as a whole performs an advocacy role by enabling visitors to experience some of New Zealand's most endangered wildlife in 'natural' (though managed) surroundings. Some of the habitats and species already present, and possibly some of those planned for the future, would not have been part of the Island's original ecosystem, but fulfil important advocacy roles. Species that are particularly rare (takahē – classed as 'nationally critical'[8]) or 'nationally endangered' (such as hihi/stitchbird), [8] are especially important for advocacy because it is difficult for people to see them elsewhere. The presence of such species on Tiritiri Matangi provides the opportunity to draw attention to their plight at a national level. In such cases, SoTM considers advocacy to be sufficient justification for a species' presence on the Island (provided it incurs no adverse effects).

1.3.2 Sanctuary

SoTM considers it appropriate that the Island provide sanctuary for native flora and fauna that are threatened or at risk. As a pest-free island, it can play a role in wider conservation programmes which need permanent or temporary safe havens for species or populations whose existence is threatened elsewhere. The need to provide a safe haven for selected species will be allowed to guide management, regardless of whether that species would have been part of the Island's original ecosystem.

1.3.3 Species Management

Tiritiri Matangi is not, and never can be, a self-sustaining ecosystem. The Island does not have the habitat and food resources necessary to sustain all the resident species, and there are times when natural water supplies are inadequate. In such instances, active management is undertaken (e.g. water troughs, supplementary feeding and nest and roost boxes are provide for some bird species). In addition to managing resident species, SoTM supports sustainable translocations to and from Tiritiri Matangi as part of integrated plans that seek to create or sustain new populations on a national basis. SoTM recognises the importance of long-term monitoring to determine the success of such translocations, and will support only projects which include monitoring programmes.

1.3.4 Learning

Tiritiri Matangi is a centre for learning about New Zealand's native flora, fauna and ecology. The Island performs this role through its education programme for schools and by hosting scientific research projects. Some management activities are, and will continue to be, guided by the needs of education and research. For example, nestboxes and shelters are provided for some animal species for the purposes of study, and interpreted plantings will be developed near the visitor centre as an educational resource.

1.4 Broad aims of the biodiversity plan

These guiding principles, together with the model of an Inner Gulf Island ecosystem, define the broad aims of this biodiversity plan.

- To increase the diversity of flora and fauna to make the forested areas on Tiritiri Matangi more representative of an Inner Gulf Island ecosystem
- To provide an exceptional advocacy site, thereby enhancing the general public's knowledge of, and commitment to, the conservation of biodiversity
- To provide a sanctuary for the ongoing conservation of threatened species and populations through maintenance of an ecosystem free of exotic pests
- To provide ongoing supportive management where necessary to ensure the health, viability and success of resident native species
- To provide an outstanding site for scientific research into and education on native flora and fauna.

In pursuing these aims, SoTM will seek to complement and support the efforts of DOC and comply with national recovery plans and regional conservation strategies wherever appropriate.

It is important to make clear that this plan addresses the management of biodiversity within Tiritiri Matangi's terrestrial habitats. The biodiversity of the Island is intricately linked to the ecological processes of the surrounding marine environment. It is recognised that a managed ecosystem should be integrated into a larger ecological matrix (in this case the Hauraki Gulf), but the scale of management inherent in this is beyond the scope of this

document, though management options which include the broader marine environment may be considered in the future.

It is also important to understand that the Island's biodiversity exists alongside other important features. Tiritiri Matangi has had several centuries of human occupation and use, through which it has acquired cultural significance for Māori and other New Zealanders. In the management of the Island's biodiversity, the sensitivity of its archaeological and historic sites will be respected through consultation with appropriate stakeholders.

1.5 Evolution and structure of the biodiversity plan

The preparation of this biodiversity plan began in 2010. SoTM's Biodiversity Sub-committee identified the main components of the Island's ecosystem on which the sections of the plan were expected to focus: native vegetation, weeds, birds, reptiles, invertebrates and bats. In order to draw on the best expertise available, SoTM contracted specialists in five of these component areas to produce initial drafts of chapters (the section on bats was prepared by a member of the Sub-committee). A briefing document was provided as a guide, and the commissioned drafts were received during 2011.

During 2012, the initial chapters were edited and standardised by members of the Sub-committee, who also produced (with external help) the sections on freshwater ecosystems. A draft was submitted to SoTM's Main Committee in January 2013 and to DOC and other stakeholders for consultation in February 2013. Following further modifications in response to comments received, the final Plan was formally adopted by SoTM in September 2013.

The structure of the document, following this Introduction, is outlined briefly below. Most of the chapters follow the same broad pattern, beginning by describing the current situation and management practices, and proceeding to consideration of future translocations and management, followed by a list of recommendations.

Chapter 2 describes the current and future management of native vegetation on Tiritiri Matangi. This is the longest and most complex chapter, primarily because of the numbers of habitats and species involved. Vegetation is seen not only as part of biodiversity to be conserved in its own right, but as a principal component in the habitats of the Island's fauna. For this reason, it seems appropriate to describe it first.

Chapter 3 addresses the management of the freshwater ecosystem on the Island. Some of the freshwater habitats were artificially created through the construction of dams. Like vegetation, fresh water is a major component of the habitats on which animals depend, hence its location before the main sections that address the Island's fauna.

Chapters 4, 5 and 7 deal in turn with the management of Tiritiri Matangi's birds, reptiles and invertebrates. Birds and reptiles are the most studied animals on the Island, and Chapters 4 and 5 are able to present firm proposals for future management and translocations. Much less is known about the Island's invertebrate populations, so the recommendations in Chapter 7 are more provisional, focusing mainly on the need for more research and monitoring.

Chapter 6 is unique in discussing a class of fauna currently not represented at all on the Island, namely mammals. The successful reintroduction of one of New Zealand's two remaining bat species would be a major achievement.

Chapter 8 deals with a major aspect of island biosecurity; it describes the Island's weed control programme and recommends actions that are necessary to keep invasive plant pests under control. The broader biosecurity risks and how they are managed are addressed in Appendix I.

The authors of this plan hope that the guidance it provides will enable Tiritiri Matangi not only to remain a jewel in the crown of New Zealand's conservation programme, but to be a safe haven for an increasing variety of the country's endangered flora and fauna into the indefinite future.

1.6 References

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Tiritiri Matangi Island, showing tracks, place names, topography and ponds

2. MANAGEMENT OF VEGETATION ON TIRITIRI MATANGI

2.1 Current situation

In order to explain how the current vegetation on Tiritiri Matangi came to be as it is, it is helpful to provide a brief historical outline. It is assumed that the Island was originally covered by forest, but was almost completely denuded of its vegetation (and associated terrestrial ecosystems) by a long history of human modification. It is thought that Tiritiri Matangi was occupied by Māori from about 1400 AD until the early 19th century. During this period it is likely that much of the vegetation on Tiritiri Matangi was burnt and cleared to establish year-round crops and to cultivate bracken fern. Pacific rat or kiore were probably introduced to Tiritiri Matangi between 1100 and 1800 AD and had a significant impact on the Island's ecosystem until their eradication in 1993.

Further vegetation modification took place when the Government assumed ownership of Tiritiri Matangi as a lighthouse reserve in 1841 and leased the majority of the Island for farming. Fires, grazing and the introduction of rabbits and goats took a further toll on the remaining bush remnants. Goats, pigs, sheep and cattle were present on Tiritiri Matangi up until 1971, when farming ceased.

Esler's vegetation survey in the mid-1970s recorded four secondary forest remnants (thought to be around 70 years old) persisting in gullies on the northern end of the Island.[1] At the time grazing ceased, a number of plant species were reduced to only a few individuals and/or restricted to sites inaccessible to stock. In 1975 grassland covered 52% of the Island, bracken fern 27%, mānuka and kānuka stands 10%, pōhutukawa trees 6%, kohekohe forest 3%, and māpou stands 1%.

Since the 1980s, the dominant vegetation cover has been transformed from grasslands to a mixed coastal broadleaf forest through a major planting project. Its aim was to 're-create' a forest of similar species composition to the existing remnants, which were dominated by pōhutukawa, with associated coastal broadleaf species such as kohekohe and pūriri. During the main planting period from 1984 to 1994 some 280,000 shrubs and trees of 30 different species were planted. Most of the plants were sourced and grown on the Island, with the exception of a few species that were sourced from the mainland and other offshore islands (Cuvier, Hen, Little Barrier and Rangitoto).

Currently the mixed planted shrublands and forest dominate the vegetation on Tiritiri Matangi. These areas are lacking in species richness, reflecting the limited number of species planted. Many of the earlier planted areas are dominated by pōhutukawa. Localised species which are confined to marginal areas (for example coastal māhoe) do not appear to be dispersing very quickly from their restricted localities, despite the high number of resident birds on the Island.

Forest succession appears to be slow, with limited dispersal of canopy species, while open areas of muehlenbeckia (*Muehlenbeckia complexa*) and bracken fern are slowly being invaded by shrub species. Wetland areas are also in danger of being overtaken by

regenerating forest. The grassland vegetation of mown areas is relatively stable. Little regeneration is happening in rank grassland areas. Track margins are undergoing change because of increased shading by adjacent maturing forest and the invasion of naturalised herbs.

The latest vascular flora surveys[2] have shown that open pasture areas have been reduced to 10% (mainly incorporating mown tracks and rank grassland left to regenerate naturally). The biggest changes have been in the planted regenerating forest now covering 64% of the Island. The remaining areas of natural forest, including scattered mature pōhutukawa trees, have expanded, comprising up to 19% of the vegetation cover. Overall, there has been a net gain of 17% natives, but, more significantly, a 49% increase in exotic species, since records began in 1905. Since the 1970s, there has been a 39% gain in native species (from 186 to 260) and 64% gain in exotic species (from 153 to 251).[2] Esler predicted that, as the woody forest cover increased during succession, the number of exotic species would decline because they prefer open sites.[1] This has not happened; instead, more than two-thirds of the additions to the flora are exotic species.

The slow development of forest succession and the significant increase in exotic flora are not specific to Tiritiri Matangi but reflect regional trends. The situation on the Island would have been much worse, were it not for the intensive weed management programme which controls over half the exotic species present (see Chapter 8).

2.2 Aims and objectives

As explained in the Introduction, this biodiversity plan is governed by the principles of advocacy, sanctuary, species management and learning. Tiritiri Matangi already performs a significant advocacy role for native flora, and is an important site for learning about native plants. The aim of the proposed vegetation management is to achieve more in these directions by enhancing the diversity of the Island's native vegetation, as part of the Inner Gulf Islands Ecological District,[3] and by providing a sanctuary for threatened plants from outside this area. As well as being important in and of themselves, plants are seen, more than most ecosystem components, as providing habitat for other organisms. The management of Tiritiri Matangi's vegetation over the next 10 years will take into account the needs of resident and predicted animal populations, as well as improving the health and diversity of native flora.

The vegetation plan for the next 10 years has three main objectives:

- To manage various habitat types for resident species, plant and animal, and for those being considered for future translocation
- To increase the diversity of native plants by adding species that will make some areas of Tiritiri Matangi more representative of an Inner Gulf Island ecosystem
- To provide a safe haven for plant species that are nationally and/or regionally threatened.

2.3 Management practices and requirements

2.3.1 Weed control

The major threat to Tiritiri Matangi's native vegetation comes from the presence of invasive exotic plants. This threat is addressed through an ongoing weed control programme which is reviewed annually. Its significance is such that it merits a separate chapter of its own (see Chapter 8).

There is one respect in which the ongoing weed control programme could be assisted by planting. Gorse, an invasive weed in open areas, has been left as a nurse plant in some northern parts of the Island. It was assumed that gorse would provide pioneer cover for naturally regenerated species, and that it would eventually be shaded out by these plants. However, natural regeneration is happening very slowly in the more exposed areas. It is recommended that hardy canopy species be planted or seeded amongst the gorse in exposed areas to assist revegetation (see Chapter 8, section 8.3.1.3).

2.3.2 Species diversity in planted areas

As indicated above, many of the planted areas of forest and shrubland are dominated by pōhutukawa. Around 90,000 pōhutukawa were planted in the 1980s, with an expectation that around 30% would survive. In the event, a much higher proportion thrived and have created a closed canopy under which other species fail to establish.

This problem is being addressed through the experimental Pōhutukawa Project, which started in 2010-11 and will run for 15-20 years, with periodic reviews. The aim of this project is to determine whether thinning of pōhutukawa has the potential to increase species diversity. Selective felling of pōhutukawa has created light wells in which the progress of other species is being monitored by students and SoTM volunteers. Control areas, where no felling has been carried out, are being monitored for comparison. The monitoring covers not just native and exotic flora, but the use of these areas by birds, reptiles and invertebrates.

It is too early to make firm recommendations based on this project. Provisionally, if the thinning of pōhutukawa proves successful in increasing species diversity in planted areas of forest and shrubland, it is envisaged that a management programme of this kind could begin during the second half of the period covered by this plan. As well as allowing a greater diversity of existing species to flourish in the planted areas, the creation of light wells could also provide an opportunity to introduce additional understorey and canopy species (such as mangeao and taraire) in relatively well-established sheltered habitats.

2.3.3 Maintaining and enhancing habitats for resident fauna

The current trajectory of natural succession indicates that marginal habitat types are diminishing and will impact on the success of some resident fauna. Seven distinctive habitat types have been recognised on the Island: forest, shrublands, coastal, bracken/muehlenbeckia, grasslands, wetlands and track margins. A recommended planting programme over the next 10 years, discussed in section 2.4 (below), will enrich all of these

distinctive habitat types to benefit a wide range of species. Three types of habitat, wetlands, bracken/muehlenbeckia and grasslands, require different management practices, and so are discussed here.

2.3.3.1 Wetlands

Tiritiri Matangi has both natural and artificially created wetlands, though its dry and windy climate ensures that only the bottoms of some of the valleys stay wet naturally. From past botanical records,[1] it appears there was once a much greater range of wetland plants than is currently present. The recent vegetation survey[2] has highlighted the loss of wetland plants associated with open areas and swampy valley bottoms. Secondary succession forest plants are shading out more light-dependent species such as raupō and *Ranunculus urvilleanus.* A number of species recorded in 1978[1] appear to have gone completely; these include *Centipeda aotearoana, Eleocharis acuta, Lilaeopsis novae-zelandiae* and *Schoenoplectus tabernaemontani*.

Most of the Island's wetland habitat is provided by man-made dams, built as a means of water storage and to support certain endangered species, such as the brown teal/pāteke. Not all these dams hold water effectively, particularly over the summer months. Three of the least effective dams, those at the Wharf Pond, Fisherman's Bay Pond and the upper Silvester Pond, were restored in March 2013. It is recommended that, throughout the period covered by this plan, the effectiveness of these and the Island's other dams be monitored and their condition maintained and/or improved wherever practicable, enabling them to be brought into a wider wetland management programme.

Two wetland areas are worthy of special attention, the first because it provides a model that could be emulated in the other areas, the second because its remote location sets particular conditions for management.

Emergency Landing wetland

The largest surviving natural wetland can be found north-east of Lighthouse Valley, below the two ponds at Emergency Landing. It is supported by three smaller creeks which feed into it via these two ponds. This area has a diverse mix of trees and shrubs, including tree ferns, sedges, rushes, ground ferns, grasses and herbaceous species. Other wetland areas on the Island, both natural and artificially created, could be planted with a similar range of species (listed in Table 2.1). This would improve these habitats for pāteke, spotless crake and potentially some invertebrates, by providing protection and a greater diversity of seasonal food sources.

The Silvester Wetlands

The Silvester Wetlands are two artificially created ponds in the northern part of the Island near Northeast Bay. They are close together but differ in size, depth and aspect. With appropriate planting and management, they could well complement each other by providing a greater array of habitat types and food sources, in this more remote part of the Island, for species which prefer a wetland habitat. The area around the ponds has been left to

regenerate naturally, with limited plantings. In general, the northern end of the Island lacks plant diversity and is currently dominated by early successional species, including cabbage tree, Coprosma species, flax, hangehange, gorse and muehlenbeckia. It is isolated from the more diverse mature forest remnants, so very few new species have colonised this area. The introduction of additional fruit-bearing species would enhance the general food availability, attracting more seed-dispersing birds to the northern end of the Island.

The existing habitat in the vicinity of the two Silvester dams could be enhanced by planting a mix of seed-bearing canopy trees, including kahikatea, taraire, tītoki, kohekohe, pūriri, karaka, tōtara, mangeao, pigeonwood, tawapou, kōwhai and nīkau. Kahikatea could be planted closer to the pond edges to provide some overhanging protection. Wetland plants, such as sedges, rushes and herbaceous ground covers, will improve the habitat for freshwater invertebrates and provide a greater range of seasonal fruit. It is assumed that once a more diverse mix of species is established, creating a damper shady environment, tree ferns and ground ferns will eventually colonise this area.

2.3.3.2 Grasslands

The grassland areas are important for the ongoing support of takahē and a number of reptile species. Takahē utilise a mosaic of habitat types including grasslands, shrublands, swamps and forests. In an island situation they feed mainly on a mixture of native and introduced grasses and bracken fern rhizomes. Historically, takahē on Tiritiri Matangi have been relatively successful in grazing exotic grasses in both mown and unmown areas. It would be advantageous to broaden the range of native grasses on the Island by introducing additional species, including bamboo grass and bush rice grass, Cyperaceae species, and ferns with edible rhizomes. Poaceae species are a favoured food of takahē and need to be planted more extensively across the Island. *Poa anceps* (present but localised) could be widely planted throughout rank pasture grass and track margins, bush rice grass and bamboo grass in the forest and on track margins, and populations of *Hypolepis ambigua* (currently localised) could be scattered across the Island in open shrubby areas.

If natural forest regeneration were to progress unchecked, open grasslands, which are vulnerable to invasion shrubs and by bracken and muehlenbeckia, would slowly diminish. To ensure sufficient open spaces for takahē and some reptile species, a programme is in place to mow open areas and manage track margins.

2.3.3.3 Bracken/muehlenbeckia

Areas of bracken and muehlenbeckia are used by a range of species, including fernbird, kākāriki, little penguin, kiwi and moko skink, which also uses rank pasture grass. Like grassland, areas of bracken and muehlenbeckia are vulnerable to invasion by regenerating trees and shrubs. If this were allowed to happen without control, the bird species would lose an important part of their habitat and moko skinks would decline in numbers and be pushed to the outer, steeper slopes of the Island. It is therefore recommended that the spread of forest-edge plants into these areas be monitored and that some shrubby, woody species already growing in areas of bracken and muehlenbeckia be removed. Any modifications of

this kind need to be carried out with due consideration of the species that use them (for instance to avoid disturbance during the breeding season).

2.4 Options for future planting

Recommendations for future planting on Tiritiri Matangi have two main purposes: to enhance the Island's ecological integrity, making it more representative of an Inner Hauraki Gulf island, and to give sanctuary to threatened species. These purposes overlap, in that the planting of threatened species from the Inner Gulf Islands Ecological District will help to enhance Tiritiri Matangi's ecological integrity.

2.4.1 Enhancing ecological integrity

Currently Tiritiri Matangi represents an advanced replacement ecosystem reflected in the natural regeneration of the forest and the diverse array of fauna it supports. The major planting programme of 1984–94 has accelerated the early successional phase, providing habitat suitable for forest, scrub-dwelling and wetland fauna more rapidly than natural regeneration would have done.

It is often assumed that once pioneer plants are established and keystone species introduced to a restoration site, natural regeneration will take over; re-colonisation of the site will occur via wind and bird dispersal. Given Tiritiri Matangi's close proximity to the mainland (c. 3.5km) and to other nearby Gulf islands, natural introduction of new species could have been expected. However, this process is dependent on other factors besides proximity. The quality of the seed bank where planting took place, and in potential source areas, affects natural regeneration, as does the suitability of habitat available to receive new plants (particularly wind-borne or bird-dispersed species).

There are very few significant seed sources in close proximity to Tiritiri Matangi attracting birds to leave the Island, and there is a limited number of large-fruiting species present on Tiritiri Matangi to attract long-distance dispersers to the Island. Consequently, despite extensive habitat creation and abundant birdlife, only six known native woody species have been naturally introduced to Tiritiri Matangi since 1981. These are putaputawētā, large-leaved coprosma, kahikatea, white maire, *Pseudopanax crassifolius* x P. *lessonii* and the native nīkau palm (which came from Little Barrier Island/Hauturu). There is likely to be a greater exchange of species by birds from the mainland now that the predator-proof fence is completed at Shakespear Regional Park, but native species introductions are still likely to be low in numbers due to the limited availability of local seed sources.

The recent collaboration of the four Inner Gulf Island restoration groups (Motuihe, Motuora, Motutapu and Tiritiri Matangi) with the Department of Conservation has resulted in the development of a joint plant introduction and seed collecting permit for the islands. With the four islands having similar goals and species requirements, seed collection can be shared amongst a much wider group, enhancing the likelihood of obtaining the more uncommon species. The species agreed for planting on the four islands are listed in Appendix B (common species) and Appendix C (threatened and uncommon species).

Because these are general lists for the four islands, they do not include all the species recommended for planting on Tiritiri Matangi (listed in Tables 2.1, 2.2 and 2.3).

2.4.2 Sanctuary for threatened species

The Auckland region has at least 170 threatened plant species, of which 70 are recognised as of national conservation concern. For many threatened plant species, active management on pest-free islands is essential to increase the number of wild populations to ensure their long-term survival. Six nationally and 26 regionally threatened and uncommon species have been recorded on Tiritiri Matangi (see Appendix D). Thirteen of these species are now presumed extinct on the Island, and reintroduction of these species is recommended.

The past restoration efforts on Tiritiri Matangi have created a range of suitable habitats to support a range of endangered plants local to the Auckland Region in a safe refuge. Establishing additional wild self-sustaining populations will aid in ensuring their long-term survival in the Auckland Region by providing plant material for other restoration projects, acting as a safeguard or insurance for threatened plant populations elsewhere.

Just as crucial is the role Tiritiri Matangi can play in advocacy and education by showcasing these species in a 'threatened plant garden' around the Visitor Centre where they are easily accessible for public viewing. The development of a threatened plant garden offers an opportunity to establish populations of rare plants that are extremely vulnerable on the mainland (and other islands), and which may otherwise become extinct in the near future. There is an opportunity to publicise their plight by including interpretation material that highlights their ecological history, current status, past and present distribution patterns, and habitat threats and requirements.

It is recommended that the translocation and establishment of both wild and managed (garden) populations on Tiritiri Matangi are guided by recovery plans developed by the Department of Conservation (DOC), where these are available. Risks associated with establishment of threatened plants can be minimised through appropriate management protocols documented by DOC and by liaising with specialist recovery groups. DOC will also advise on the closest source population (or most endangered) and the conditions required for the introductions.

2.4.3 Recommendations for planting

Recommendations for planting over the period of this plan (10 years) are summarised in Tables 2.2 and 2.3. Table 2.2 lists plants already present on Tiritiri Matangi whose numbers and/or distribution should be increased. Table 2.3 lists absent and threatened species recommended for translocation to Tiritiri Matangi. In both tables, planting numbers recommended are the total number of plants of each species to be planted over the next 10 years. Those species not currently present on the Island (most of those in Table 2.3), were selected on the following basis:

- the species will be within its known natural distribution,

- has been recorded within the IGIED or adjacent coastal mainland, or in a fossil record from the Island, or in a pollen core from the Island or a nearby island.
- The potential exists for appropriate habitat on the Island.

2.5 Recommendations

1. If the Pōhutukawa Project proves successful in increasing species diversity in planted areas, consider implementing a management programme of this kind more widely across the Island. The creation of light wells could also provide an opportunity to introduce additional understorey and canopy species (such as mangeao and taraire) in relatively well-established sheltered habitats.
2. Consider planting or seeding hardy canopy species amongst gorse in exposed northern parts of the Island, to assist the revegetation process that will eventually shade out the gorse.
3. Monitor the effectiveness of the Island's dams and, where practicable, maintain and/or improve their condition as part of a wetland management programme.
4. Improve habitat around wetland areas with new planting based on the list in Table 2.1.
5. Enhance the habitat around the Silvester Wetlands by planting a mix of seed-bearing canopy trees in addition to plants listed in Table 2.1.
6. Improve the habitat for grassland fauna by planting additional native grasses and ferns with edible rhizomes in rank pasture grass and along track margins.
7. Implement an appropriate mowing strategy and management of track margins to ensure sufficient open spaces for takahē.
8. Monitor and, where necessary, control the growth of woody species in areas of bracken and muehlenbeckia.
9. Enhance the Island's ecological integrity by carrying out a planting programme as indicated in Table 2.2.
10. Provide a sanctuary for threatened plant species by planting species listed in Table 2.3.
11. Establish a 'threatened plant garden' around the Visitor Centre with appropriate interpretation to increase public awareness of the plight of threatened plants.
12. The translocation and establishment of both wild and managed populations on Tiritiri Matangi should be guided by DOC recovery plans, where these are available.

2.6 References

1. Esler, A. E. 1978. Botanical Features of Tiritiri Island, Hauraki Gulf, New Zealand. *New Zealand Journal of Botany 16*: 207–226.
2. Cameron, E. K. and N. C. Davies. In press. Changes in the wild vascular flora of Tiritiri Matangi, 1978-2010. *New Zealand Journal of Ecology* (accepted 2012).

3. McEwen, W. M. 1987. *Ecological regions and districts of New Zealand*. Third revised edition in four 1:500,000 Maps. New Zealand Biological Resource Centre Publication No. 5. Department of Conservation, Wellington.

Table 2.1 Species recommended for planting around ponds, dams and in wetland areas (in seasonal order)

Species	Common name	Fruiting	Suitable habitat	Plant or seed source location
Carex inversa (Cyperaceae)	Creeping lawn sedge	All year	Adjacent pond in open dry area of upper Silvester dam	Small colonies scattered in damp and dry grassland over the Island
Carex lambertiana (Cyperaceae)	Forest sedge	All year	Relatively open but shaded sites within tall forest	Bush 1, 22 and Emergency Landing wetland
Schoenus maschalinus (Cyperaceae)	Dwarf bog rush	All year	Ground cover grows in full sun or heavy shade; once established can tolerate mowing	Emergency Landing wetland and Bush 22
Uncinia uncinata (Cyperaceae)	Hook sedge	All year	Forest and open shrubland	Main bush areas
Machaerina rubiginosa (Cyperaceae)		All year	Pond margins (tolerates dry periods)	Emergency Landing wetland
Carex secta (Cyperaceae)	Pukio	October - March	Additional plants in full sun on edges of lower Silvester dam	Emergency Landing wetland and Bush 22
Isolepis reticularis (Cyperaceae)		October - March	Full sun in permanently damp soil adjacent upper Silvester dam	Patch in small shaded wetland, lower Bush 22 near creek
Ranunculus reflexus (Ranunculaceae)	Hairy buttercup	October - March	Tolerates a range of habitats	Emergency Landing wetland
Carex geminata (Cyperaceae)	Cutty grass	October - March	Pond margins	Western creeks
Carex breviculmis (Cyperaceae)	Grassland sedge	October-March	Open grassland in full sun, Silvester wetlands track	Open areas along east coast
Eleocharis acuta (Cyperaceae)	Sharp spike sedge	October - May	Open to partially shaded permanently damp ground and/or partially submerged	Last seen by Esler (1978a) in swampy creeks. Pakihi and Motuihe Islands
Ranunculus amphitrichus (Ranunculaceae)	Waoriki	October - June	Often partially submerged in shallow water, pond margins and moist clearings within forest	Shallow wetlands, stream margin of lower Bush 22 (only location seen post 2005)
Rorippa divaricata (Brassicaceae)	NZ water cress	October - July	Pond and track margins	Translocate
Juncus usitatus (Juncaceae)		October - Sept	Open areas and shrublands around Silvester dams	Wharf Dam

Species	Common name	Fruiting	Suitable habitat	Plant or seed source location
Ranunculus urvilleanus (Ranunculaceae)		November - February	Open creeks, forest gaps, mown track margin; tracks adjacent to both Silvester dams	Emergency Landing wetland
Morelotia affinis (Cyperaceae)	Morelotia	November - April	Clay banks, regenerating shrublands around Silvester dams	Recorded by Cheeseman 1906-09. Translocate
Persicaria decipiens (Polygonaceae)	Swamp willow weed	November - April	Around edges of ponds	Emergency Landing wetland
Rubus australis (Rosaceae)	Swamp lawyer	October - February	Around edges of ponds and forests	McElroy's Bush, Mahurangi, Okura
Rubus cissoides (Rosaceae)	Bush lawyer	November - April	Forest and shrubland Pumphouse and Lighthouse Valleys	Shakespear Regional Park, Wenderholm, Mahurangi West
Potamogeton cheesmanii (Potamogetonaceae)	Red pond weed	December - March	Sheltered ponds, lower Silvester dam	Rotoroa Island
Carex lessoniana (Cyperaceae)	Cutty grass	December - April	Most soils, best in partial shade	NE Bay dam
Carex virgata (Cyperaceae)	Swamp sedge	December - May	Around the ponds in semi-open bush areas above lower Silvester dam	Lower Bush 21 and Little Wattle Valley
Bolboschoenus fluviatilis (Cyperaceae)	Marsh clubrush	December - May	Damp sunny open area adjacent lower Silvester dam	Bunkhouse Dam
Cyperus ustulatus (Cyperaceae)	Giant umbrella sedge	July – April	Open areas near ponds	Open coastal sites, rank pasture and open swampy creek margins
Carex spinirostris (Cyperaceae)	Coastal sedge	September - March	Coastal to lowland forest on banks surrounding ponds, usually in semi-shaded sites	Recorded by Cheeseman 1906-09. Pakihi Island

Table 2.2 Overall species list recommended for enhancement of existing vegetation on Tiritiri Matangi

Species	Common name	Present status	Planting nos.	Priority	Habitat type	Planting Block
Ferns						
Hypolepis ambigua		Localised	H	High	g, bm, t	All
Forest trees and shrubs						
Agathis australis	Kauri	Planted	L	Med	s	LWV/WV
Alectryon excelsus	Tītoki	Planted	MH	Med	c, f	NW/B22/SW/B3,4,5/SE
Alseuosmia macrophylla	Toropapa	Planted	VH	High	f	B1,2,3,4,5,21,22/LWV/WV
Beilschmiedia tarairi	Taraire	Planted/ natural	VH	Med	f	SE/FSB/PC/B3,4,5,6,23/WV
Beilschmiedia tawaroa	Tawaroa	Planted/ natural	M	High	f	B1,2,3,4,5,6,21,22/FSB/WV
Carpodetus serratus	Putaputawētā	Single plant	MH	High	f, s	B1,2,3,4,5,21,22/LWV/WV
Coprosma arborea	Tree coprosma	Low numbers	MH	Med	f, s,	B21,22,23/SW/LWV
Coprosma grandifolia	Large-leaved coprosma	Low numbers	H	High	f	B1,2,3,4,5,21,22,WV
Dacrycarpus dacrydioides	Kahikatea	Low numbers	M	High	f , s	SW/WV/B3,4,5/ FSB
Dodonaea viscosa	Akeake	Low numbers	M	High	c, s	SW/B23/LHB/SE/RDG
Dysoxylum spectibile	Kohekohe	Localised	H	High	c.s	SW/B6,12/LHV/CH
Hebe macrocarpa	Hebe	Single plant VC	VH	High	c, s	RDG/ NW/B23/LWV/FSB/NEB/WV/SE/WF
Hedycarya arborea	Pigeonwood	Localised	M	Med	s	NEB/SW
Hoheria populnea	Lacebark	Low numbers	M	High	s	SW/B6,12/LHV
Knightia excelsa	Rewarewa	Low numbers	VH	High	s	SW/B12/LWV/NWB/FSB
Melicytus novae-zelandiae	Coastal māhoe	Localised	MH	High	c, s	LWV/SE/LHV/WS/B3,4,5
Myoporum laetum	Ngaio	Planted/ localised	H	Med	c, s	SW/SE/NW/B23/FSB
Nestegis lanceolata	White maire	Single plant	M	Med	f	B1,2,21,22,23/WV/LHV

Species	Common name	Present status	Planting nos.	Priority	Habitat type	Planting Block
Ozothamnus leptophyllus	Tauhinu	Localised	M	Low	c, s	B22/LHV/SE/NEB/SW
Pittosporum cornifolium	Tawhirikaro	Planted	MH	Med	f, s	B1,2,3,4,5,21,23,LWV,WV/VC
Planchonella costata	Tawapou	Low numbers	M	High	c, s	NW/B23/NEB/WS/LWV/FSB
Prumnopitys ferruginia	Miro	Planted	L	High	f	B1,2,6,21,22,,23/
Rhabdothamnus solandri	NZ gloxinia	Planted	VH	High	f	B1,2,3,4,5,6,21,22,23/WV/LWV
Rhopalostylus sapida	Nīkau	Low numbers	VH	High	f	B1,2,3,4,5,21,22,23/LHV/CH/NEB/SE/WV/LWV/ WR/VC
Schefflera digitata	Patē	Planted/ few	H	Med	f	B1,2,6,21,22,23/RDG/LWV/WV
Vitex lucens	Pūriri	Widespread	M	High	f	SW/B1,2,6/LHV/WS/CH
Climbers and Epiphytes						
Collospermum hastatum		Single plant	VL	Med	f	B1,2,21,22
Herbaceous species						
Lagenifera pumila	Papataniwhaniwha	Scarce	L	Low	f, s, t	NW/B23/WV/RDG/WR
Linum monogynum	NZ true flax	Localised	M	Low	c, t	WR,B3,4,5,NEB,FSB/RDG/VC
Parietaria debilis	NZ pellitory	Localised	M	Low	c, s, f	WR/NEB/RDG/VC
Persicaria decipiens	Swamp willow weed	Single location	VL	Med	w	SW
Plantago raoulii		single colony	L	Med	c	VC/NW/B23/WR/LWV
Ranunculus acaulis		single colony	L	Med	c, t	VC/WR/SE/WV/B21
Ranunculus anphitrichus	Waoriki	Single colony	M	High	w, t	SW/B21/WV
Ranunculus reflexus	Hairy buttercup	Single colony	M	High	w, t	SW/B21/WV/LHV
Wahlenbergia violacea	Violet harebell	Scarce	L	Low	g, s, t	WR/RDG/SE/WV/NEB/LHV

Species	Common name	Present status	Planting nos.	Priority	Habitat type	Planting Block
Sedges, rushes and grasses						
Austroderia splendens	Coastal toetoe	Very low numbers	H	High	c, s	FSB/NW/SE/B3,4,5/NEB/PC
Machaerina rubiginosa		Low numbers	M	Med	w	SW/WD
Bolboshoenus fluviatilis	Marsh club rush	Low numbers	L	Med	w	SW
Carex breviculmis		Localised	L	Med	f, w	SW
Carex geminata	Cutty grass	Localised	M	Med	w	SW
Carex inversa	Creeping lawn sedge	Localised	M	Low	t, w	SW
Carex lambertiana	Forest sedge	Localised	M	Low	f, w	SW/WV/LWV/LHV/B3,4,5,21
Carex lessoniana	Cutty grass	Single colony	MH	Med	w	LHV/LWV/B6
Carex secta	Pukio	Planted/ localised	L	Low	w	SW
Carex virgata	Swamp sedge	Localised	L	Low	w	SW/LHV
Cyperus ustulatus	Giant umbrella sedge	Localised	VL	Low	w, t	SW
Isolepis reticularis		Single colony	VL	Low	w, t	SW
Juncus usitatus		Single colony	L	Med	s, w	SW/LHV
Schoenus maschalinus	Dwarf bog rush	Localised	M	Med	t, w	RDG/SW/CH/B21/WV/LWV
Poa anceps		Localised	H	High	g, t	WR/SE/PC/NEB/WV/LWV
Uncinia uncinata	Hook sedge	Localised	MH	High	s, f	SW/RDG/B12/WV/WR

KEY

Planting numbers (i.e. numbers recommended for planting)

VL = very low (<10) L = low (10-20) M = medium (20-50)
MH = medium to high (50-100) H = high (100-200)
VH = very high (200-500)

Key continued on next page.

Habitat types

f = forest	s = shrublands	c = coastal	bm = bracken/muehlenbeckia
g = grasslands	w = wetlands/ponds	t = track margins	

Planting blocks (recommended for receiving new plants, see map, p. 36)

B1,2,3, etc. = Numbered bush blocks
CH = Coronary Hill
FSB = Fisherman's Bay
LHV = Lighthouse Valley
LWV = Little Wattle Valley
NEB = Northeast Bay
NW = North West
PC = Pōhutukawa Cove
PHT = Pōhutukawa gaps
RDG = Ridge
SW = Silvester Wetlands
SE = South end (south of buildings)
SW = South West
VC = Visitor Centre
WD = Wharf Dam
WS = Wharf South
WR = Wharf Road
WV = Wattle Valley

Table 2.3 Currently absent and threatened species (*) recommended for introduction to Tiritiri Matangi

Species	Common name	Threat status	Habitat type	Planting nos.	Priority	Planting Block
Forest trees and shrubs						
Aristotelia serrata	Wineberry	absent	s	H	High	B1,2,21,22,WV
Beilschmiedia tawa	Tawa	absent	f	M	High	B1,2,3,4,5,6,21,22/FSB/WV
*Clianthus puniceus**	Kākā beak	nc/ PR	s	M	Med	VC/RDG
*Coprosma acerosa**	Sand coprosma	de	c	M	Med	VC/NEB
Coprosma lucida	Shining karamū	PR	f , s	H	High	SW/SE/LWV/FSB/NW/RDG/WV
Dacrydium cupressinum	Rimu	PR	f	M	High	B1,2,3,4,5,6,21,22/FSB/WV
Elaeocarpus dentatus	Hīnau	PR	f, s	H	High	B1,2,3,4,5,6,21,22/FSB/WV/LWV
Fuschia excorticata	Tree fuchsia	absent	f	VH	High	B1,2,6,12,21,22/WV
Griselinia lucida	Puka	absent	c, s	MH	Med	SW/RDG/LHV/B3,4,5,12,21,22/SE /NW
*Hibiscus richardsonii**	Native hibiscus	nc/absent	c, s	M	Low	VC
*Ileostylus micranthus**	Green mistletoe	nt	c, s	VL	Low	B1,2,22,23
Korthalsella salicornioides	Dwarf mistletoe	absent	s	L	Low	B21
Leptecophylla juniperina	Prickly mingimingi	absent	c, s	M	Med	SW/SE/B22
Litsea calicaris	Mangeao	PR	f, s	VH	High	PHT/NW/B21,22,23
Metrosideros robusta	Northern rātā	absent	f, s	L	Med	B1,2,6,21,22
Olearia rani	Heketara	absent	f	MH	High	B1,2,6,21,22/LHV/WV/ LWV
Phyllocladus trichomanoides	Tānekaha	absent	s, f	L	Low	LWV/WV
Pittosporum tenuifolium	Kōhūhū	PR	s	H	High	SW/SE/LWV/WV/B3,4,5,6,21/ SE/LHV/FSB
Prumnopitys taxifolia	Mataī	absent	f	L	Low	B1,2,6,21,22,23/WV
Pseudopanax crassifolius	Lancewood	absent	s, f	M	Med	RDG/WV/LWV/B12,21,22/SW
*Solanum aviculare**	Poroporo	de/PR	f, s	M	High	B6,21,22/RDG/WV/LWV

Species	Common name	Threat status	Habitat type	Planting nos.	Priority	Planting Block
Climbers and Epiphytes						
Astelia solandri	Perching lily	absent	f	M	Med	B1,2,21,22
Calystegia tuguriorum	NZ bindweed	PR	b/m, t	L	Med	VC/LHV,RDG,WR/NW
Freycinetia banksii	Kiekie	absent	f	L	Low	WV/LWV/LHV/B21,22
Metrosideros diffusa	White rātā	absent	f	M	Med	B1,2,21,22,23/WV
Metrosideros fulgens	Orange rātā	PR	f	M	Med	B1,2,21,22,23/WV
Metrosideros perforata	White rātā	absent	f, s	H	High	SW/LWV/WV/B1,2,21,22,23
Passiflora tetrandra	NZ passionfruit	absent	f	M	High	B21,22,WV
*Sicyos mawhai**	Māwhai	nu/PR	c, s	VL	Med	SE,B5/NW/NEB/WS
Rubus australis	Swamp lawyer	absent	w, f	M	Med	SW/LHV,B1,2,3,21,22/WV/LWV
Rubus cissoides	Bush lawyer	absent	f, s	M	Med	LHV/B1,2,6,21,22/RDG
Herbaceous species						
Centipeda minima subsp. *minima**	Sneezeweed	nc	g, t	L	High	RDG/VC/WR/LHV/B22/NW/B3,4,5
Dactylanthus taylorii†*	Wood rose	de/CD	f	L	Low	B1, RDG, WV
*Daucus glochidiatus**	Native carrot	nc/PR	g, t	M	Low	RDG/VC/SE
Epilobium rotundifolium	Round-leaved willowherb	PR	t, c, w	M	Med	LHV/RDG/SW/B3,4,5,6/WR
*Euphorbia glauca**	Shore spurge	de/PR	c	H	High	VC/FSB/NEB/B6/LWV
Galium propinquum	Māori bedstraw	PR	t, w	M	Med	RDG/LWV/FSB/SW/LHV/B21
*Geranium retrorsum**	Turnip-rooted geranium	nv/PR	g, s	M	Med	SE/SW/VC/CH/WR
Gonocarpus incanus		PR	s,t	M	Med	WR/SR/LHV/WV/LWV
Hydrocotyle moschata	Hairy pennywort	PR	t, w	MH	Low	WR
*Lepidium oleraceum**	Cook's scurvy grass	nv	c, s	MH	Med	VC/NEB/
Lilaeopsis novaezelandiae		PR	c, w	M	Med	B3,4,5
Nertera dichondrifolia		absent	s, f	H	High	WV/LWV/RDG/B1,2,3,4,5,6,21,22
*Picris burbidgeae**	Native oxtongue	ne/absent	c, s, t	M	Med	VC/RDG/CH/SE/NEB/FSB
*Rorippa divaricata**	NZ watercress	nv/absent	c, s, t, w	MH	High	SW/RDG/LHV/LWV/NEB

Species	Common name	Threat status	Habitat type	Planting nos.	Priority	Planting Block
Pimelea urvilleana	Pinātoro	PR/planted VC	c	M	Med	VC/FSB/PC/SE/NEB/NW
Samolus repens	Sea primrose	absent	c	M	Low	VC/FSB/PC/SE/NEB/NW/LWV/LHV/B6
Scleranthus biflorus	Canberra grass	PR	c, t	M	Low	VC/WR/RDG/PC/LWV/FSB/NEB
*Senecio scaberulus**	Native fireweed	nc/PR	c, s, t	M	High	VC/RDG/CH/SE/NEB/FSB/WR/SW
Tetragonia tetragonioides	NZ spinach	nu	c	L	Low	NEB/PC/FSB/LHV/NW/LWV
Urtica incisa	Scrub nettle	PR	f, s	MH	High	VC/RDG/CH/WR/SW/B1,2,21,22/WV/LWV/CH
Sedges, rushes and grasses						
Carex ochrosaccus	Forest sedge	PR	f	MH	Med	SW/FSB/B21,22/LHV/WV/LWV/WV
Carex spinirostris	Coastal sedge	PR	f, w	MH	High	SW/FSB/B21,22/LHV/WV/LWV
Carex testacea	Speckled sedge	PR	c, g, s	MH	High	SW/NEB/
Eleocharis acuta	Sharp spike sedge	PR	w	M	High	LWV/LHV/SW
Gahnia setifolia	Gahnia	absent	s ,t ,w	MH	Med	NW/SW/LWV/WV
Gahnia xanthocarpa	Gahnia	absent	f, w	MH	Med	NW/SW/LWV/WV
Juncus pallidus	Giant rush	PR	s, w	M	Low	LHV/LWV/SW
*Juncus pauciflorus**	Leafless rush	de/PR	c, s, f, w	MH	High	LHV/LWV/SW
Lepidosperma australe	Square-stemmed sedge	PR	w,t	M	Med	LWV/WV/RDG
Libertia ixioides	NZ iris	absent	f, s, t	MH	Med	RDG/CH/B21,22/SW
Microlaena avenacea	Bush rice grass	absent	f,t	H	High	B1,2,3,4,5,21,22/WV
Microlaena polynoda	Bamboo grass	absent	g, s, t	MH	Med	RDG/CH/B6/LWV
Morelotia affinis	Morelotia	PR	s, t	MH	High	SW/B21,22/RDG/WV/LWV
Juncus sarophorus	Fan-flowered rush	PR	g, w	MH	Low	LWV/SW/LHV/FSB/PC/B6,21,22
Schoenus brevifolius	Bog schoenus	PR	s, w	M	Low	LWV/SW/LHV/FSB/PC/B6,21,22
*Schoenus concinnus**		rc/ PR	w	M	Med	LWV/SW/LHV/FSB/PC/B6,21,22
Schoenoplectus tabernaemontani	Kuawa	PR	w	M	Med	LWV/SW/LHV/FSB/PC/B6,21,22

KEY

Threat status

nc = Nationally critical (91 spp.)
ne = Nationally endangered (45 spp.)
nv = Nationally vulnerable (43 spp.)
de = Declining (84 spp.)
re = Recovering (6 spp.)
rl = Relict (20 spp.)
rc = Regionally critical
nu = Naturally uncommon (542 spp.)
nt = Non-threatened

CD = Conservation dependent
PR = Past record on Tiritiri Matangi (presumed extinct)
absent = Absent from Tiritiri Matangi
planted = Planted on Tiritiri Matangi

Habitat types

f = forest
g = grasslands
s = shrublands
w = wetlands/ponds
c = coastal
t = track margins
bm = bracken/muehlenbeckia

Planting numbers (i.e. numbers recommended for planting)

VL = very low (<10)
L = low (10-20)
M = medium (20-50)
MH = medium to high (50-100)
H = high (100-200)
VH = very high (200-500)

Planting blocks (recommended for receiving new plants, see map p. 36)

B1, 2, 3, etc. = Numbered bush blocks
CH = Coronary Hill
FSB = Fisherman's Bay
LHV = Lighthouse Valley
LWV = Little Wattle Valley
NEB = Northeast Bay
NW/B23 = North West/ Bush 23
PHT = Pōhutukawa gaps
PC = Pōhutukawa Cove
RDG = Ridge
SW = Silvester Wetlands
SE = South end (south of buildings)
VC = Visitor Centre
WR = Wharf Road
WS = Wharf South
WV = Wattle Valley

† *Dactylanthus taylorii* was translocated to Tiritiri Matangi in 1998, but very few seeds were sown and it is very unlikely to have survived.

Tiritiri Matangi Island, showing planting blocks listed in Tables 2.2 and 2.3

3. MANAGEMENT OF THE FRESHWATER ECOSYSTEM ON TIRITIRI MATANGI

3.1 Current Situation

There are 12 small dams and several small freshwater streams on Tititiri Matangi Island. The dams are all man-made and were built to store water for fire fighting, to provide water for stock, for the nursery and for dwellings, and habitat for species such as brown teal. The dams vary in their ability to hold water; about half hold water through most of the year, at least one never has, and others hold water temporarily during wetter periods. The ponds created by these dams do not have significant inflow or outflow (except after heavy rainfall) and have a predominantly clay substrate. As a consequence, they are often turbid, stagnant, shallow bodies of water which lack dissolved oxygen and suitable cover and shade to sustain native freshwater fauna. Exceptions to this are the threatened endemic longfin eel (*Anguilla dieffenbachii*) and the non-threatened shortfin eel (*Anguilla australis*), which periodically colonise these ponds. These species are excellent climbers and can move overland to access land-locked ponds if there is sufficient moisture, and can migrate upstream and downstream during high flow conditions. Eels are hardy species that can occupy a range of habitat types, but the continuing decline of longfin eels is of increasing concern. Because Tiritiri Matangi is a small island (220 hectares), all its ponds are close to the sea, making colonisation by eels relatively easy.

Tiritiri Matangi has small but relatively steep-sided catchments that are largely unregulated. As a consequence, the streams are prone to flash-flooding and at times are likely to 'flush-out' resident freshwater fish (with the exception of eels and large galaxiids) during high-flow events. The streams are largely ephemeral and do not provide suitable habitat for native freshwater fish year round. As the regenerating vegetation continues to grow it will make increasing demands on the Island's freshwater resources.

The Bush 1 stream, although ephemeral, provides suitable habitat for some species of native freshwater fish during most of the year, depending on local climatic conditions and on having open, free-flowing access at the outlet to the sea. Some species of mature native freshwater fish are thought to excrete a pheromone signal which attracts their larvae back to natal streams. If access is prevented or blocked off, then the signal will not be 'picked up' by the larvae, and this will ultimately inhibit or prevent recruitment of juveniles and threaten the sustained presence of the species within the stream.

Banded kōkopu (*Galaxias fasciatus*), one of New Zealand's five diadromous whitebait species, have been known to occupy the Bush 1 stream. They are a solitary, cryptic and secretive species, are able climbers and can climb or jump from pool to pool if necessary. Anecdotal reports suggest that they have not been seen in the Bush 1 stream for some years. This could be due to lack of access at the sea outlet, or to the fish having left the stream during particularly dry seasons.

As far as is known, there has never been a comprehensive freshwater flora or fauna survey conducted on Tiritiri Matangi. It is recommended that a survey be undertaken to establish what species are present on the Island and whether there are any obstacles that might prevent upstream migration by fish. There should also be an assessment of the general health of the Island's freshwater ecosystems and how it might be improved.

3.2 Aims and objectives

SoTM have the following aims and objectives for the management of freshwater ecosystems on Tiritiri Matangi over the next ten years:

- Maintain and improve the quality of freshwater habitats on the Island
- Gain comprehensive knowledge of freshwater flora and fauna on the Island.

3.3 Threats

As indicated above, life in the Island's freshwater ponds can be threatened by periodic dry conditions and by the blocking of stream outlets to the sea. In addition to these, the main potential threats would come from invasion by exotic species.

As far as is known, Tiritiri Matangi currently has no exotic invasive freshwater weed or fish. The likelihood of incursions from the major invasive fish threat, gambusia (*Gambusia affinis*), commonly known as mosquito fish, is low due to the strict biosecurity measures visitors must observe, and the Island's distance from the mainland. Gambusia are unfortunately common throughout the Auckland region, can tolerate a range of conditions and are known to outcompete and prey on vulnerable native species.

There is always a threat of an exotic aquatic weed incursion. Weeds such as curled pondweed (*Potamogeton crispus L*.) could be transferred by waterfowl via seed dispersal from nearby Motutapu Island. Fortunately, curled pondweed has a relatively minor impact and usually co-exists with indigenous vegetation, in contrast to the suite of oxygen weeds (e.g. *Egeria densa*), which are much more invasive. The likelihood of an oxygen weed incursion on the Island is low; it would require stem fragments containing lateral buds in order to give rise to new plants. The small size of the ponds on the Island, and their lack of inflow/outflow, would make it relatively easy to control such an incursion by draining the affected ponds and applying an appropriate herbicide.

3.4 Translocation opportunities

Tiritiri Matangi Island would not be a suitable site for the translocation of freshwater fish for numerous reasons, in particular the lack of suitable habitat and the ephemeral nature of the streams, which often lack permanent flow.

There is currently insufficient knowledge available to determine whether the introduction of selected native aquatic invertebrates or plants would be appropriate or feasible.

3.5 Recommendations

1. Undertake a comprehensive survey of Tiritiri Matangi's freshwater flora and fauna to establish the species composition on the Island.
2. Assess the access routes for fish migrating from the sea to the ponds, and whether it is possible to improve such access to those ponds/streams that provide suitable habitat for native fish.
3. Assess the quality of the ponds' marginal and aquatic vegetation. Suitable aquatic/wetland plants are necessary to provide shade and cover, which will in turn lower the water temperature during summer, provide habitat for native fish and ultimately improve water quality.
4. Measure water quality parameters in each of the ponds. This could be a good opportunity to implement a regular monitoring programme in order to assess freshwater ecosystem health and trends.

4. MANAGEMENT OF BIRD POPULATIONS ON TIRITIRI MATANGI

4.1 Current situation

The characteristics of the pre-human avifauna of Tiritiri Matangi are not precisely known. However, it is probable that the dominant element would have been extensive colonies of burrowing seabirds that would have sustained and driven the local ecosystem. The original species assemblage might have included sooty shearwaters, flesh-footed shearwaters, fluttering shearwaters, common diving petrels, Pycroft's petrels, grey-faced petrels, white-faced storm petrels and little shearwaters. The original terrestrial bird fauna probably included many of the species currently present on Tiritiri Matangi, along with absent species such as yellow-crowned parakeet, tomtit, kākā, New Zealand snipe and New Zealand quail. These historical assemblages are a useful basis for restoration. However, New Zealand ecosystems have been drastically altered by humans[1,2] and many of the species that were present are now extinct.

The current bird populations on Tiritiri Matangi can be divided into four categories, as follows:

1. Native species that self-colonised: bellbird, tūī, New Zealand pigeon, grey warbler, shining cuckoo, New Zealand fantail, kingfisher, morepork, welcome swallow, little penguin, pūkeko, spotless crake, reef heron, grey-faced petrel, common diving petrel, white-fronted tern, Caspian tern, red-billed gull, black-backed gull, New Zealand dotterel and variable oystercatcher.

2. Native species that have been successfully translocated: red-crowned parakeet (kākāriki), North Island saddleback, brown teal (pāteke), whitehead, takahē, North Island robin, little spotted kiwi, stitchbird (hihi), North Island kōkako, North Island fernbird and rifleman.

3. Native species that visit but do not breed: North Island kākā, North Island tomtit, long-tailed cuckoo, black shag, little shag and Australasian harrier.

4. Non-native species, some of which breed (for example, brown quail, blackbird, song thrush, Eastern rosella, magpie, myna, starling).

The success of the ongoing management and restoration of Tiritiri Matangi is best demonstrated by the abundant bird populations for which the Island is most famous. This has benefited the self-colonising species and has facilitated the 11 successful translocations.[3] This success is particularly evident in Tiritiri Matangi becoming an important source site for translocations to other restoration sites (six species in more than 20 translocation events since 1997[3]). However, all of the translocations to Tiritiri Matangi have been of terrestrial species, with the exception of one species of waterfowl, the brown teal (pāteke). As mentioned above, seabird species were likely to be much more abundant historically. Grey-faced petrels, common diving petrels and fluttering shearwaters survive as remnant populations, either on Tiritiri Matangi

or on the adjacent islet, Wooded Island. It is probable these species were once much more populous and that several other burrowing seabird species were also present. Given that there are relatively few burrowing seabirds on Tiritiri Matangi, restoration efforts should shift towards establishing new seabird species on the Island. This will represent a significant new direction, and will require considerable resources, time and effort,[4] but it will also represent considerable progress in restoring Tiritiri Matangi to an ecosystem that is more representative of an Inner Hauraki Gulf island.

4.2 Aims and objectives for the management of bird populations on Tiritiri Matangi

SoTM have the following aims and objectives for the management of bird populations on Tiritiri Matangi:

- To provide a sanctuary for the ongoing conservation of threatened species and populations of native birds through maintenance of an ecosystem free of exotic pests
- To provide an exceptional advocacy site, thereby enhancing the general public's knowledge of, and commitment to, the conservation of native birds
- To maintain viable self-sustaining populations of all bird species on the Island where practicable
- To provide ongoing supportive management, where necessary, to meet national recovery goals for native bird species
- To ensure that SoTM contributes to meeting the management goals of national recovery plans where they are available
- To provide robust source populations of native birds for translocation and natural dispersal to other restoration sites.

4.3 Management required for existing bird populations on Tiritiri Matangi

The most critical management task is to maintain the pest-free status of Tiritiri Matangi. For many resident species this is the only management action required to ensure their ongoing viability.

However, several species on the Island will require additional management to maintain healthy populations. This management includes the provision of supplementary food and water, the provision of nesting and roosting sites, population monitoring, habitat management and genetic management. Each of these actions is discussed below, and specific concerns for individual species are listed in Table 4.1.

Several of the species requiring management input have, in the past, been managed by Department of Conservation (DOC) recovery groups. The relationship of recovery groups to the SoTM is also discussed below.

4.3.1 Supplementary feeders

Supplementary feeders are essential for stitchbird (hihi) management.[5,6] The relatively small amount of suitable habitat available for stitchbird on Tiritiri Matangi, and the presence of large numbers of bellbirds and tūī, means that feeders are likely to continue to be required for stitchbirds. While this requires significant effort on the part of DOC staff and SoTM, the maintenance of feeders provides an appealing task for conservation volunteers (endangered species management), a population monitoring tool, and, significantly, an important advocacy tool. Many visitors to Tiritiri Matangi will spend considerable time at an active feeder watching both stitchbirds and bellbirds and the value of this contact should not be underestimated.

4.3.2 Water provision

Water is a relatively scarce resource on Tiritiri Matangi and many species make use of the existing water troughs for bathing and drinking, particularly during the dry summer months. Whilst being directly beneficial to birds on Tiritiri Matangi, the water troughs also provide an outstanding advocacy opportunity by creating a focal point for visitors to observe many species. They should be maintained on a permanent basis.

4.3.3 Nest box provision

Nest boxes are currently provided specifically for stitchbird (hihi), North Island saddleback (tieke) and North Island rifleman. There are also some nest boxes for red-crowned parakeet which were installed for reseach projects. Ongoing provision of stitchbird nest boxes is required for the maintenance of the Tiritiri Matangi population, and to meet the management goals of the DOC Hihi Recovery Plan.

It is unlikely that the provision of North Island saddleback nest or roost boxes is required to maintain the current population on Tiritiri Matangi. North Island saddleback are extremely flexible in choosing nest and roost sites[7,8] and it is likely that most birds on the Island use natural cavities. However, if resources are available North Island saddleback box provision should continue. They provide a useful tool for monitoring nesting success, particularly hatching success (which might be an indicator of inbreeding depression) and recruitment of banded chicks into the breeding population. They also facilitate future research.

It is also unlikely that North Island rifleman will require nest boxes for successful establishment on Tiritiri Matangi. However, they provide similar benefits to the North Island saddleback nest boxes and, based on use in the establishment phase of the population on Tiritiri Matangi, it might be desirable to continue providing nest boxes.

4.3.4 Population monitoring

Accurate long-term population monitoring will be essential on Tiritiri Matangi for identifying population changes that might be linked to habitat changes, genetic diversity, conservation management and translocations to and from the Island. Current population monitoring on Tiritiri Matangi is split between those programmes focussing on intensively managed or researched species (e.g. stitchbird (hihi), North Island robins, takahē and kōkako) and annual general bird population monitoring conducted by the Ornithological Society of New Zealand. SoTM are planning to undertake more intensive species-based monitoring, which will be critical in meeting the objectives of this management plan.

Little monitoring of predator-prey relationships has been carried out on Tiritiri Matangi. This could provide valuable information. For example, by monitoring morepork and what they are eating we could get a better understanding of their impact on stitchbird and rifleman. It is assumed each year that pūkeko are responsible for the demise of the paradise shelduck ducklings and some of the brown teal (pāteke) ducklings, but as there is no monitoring this has never been confirmed.

4.3.5 Successional habitat changes

Tiritiri Matangi is a dynamic habitat and populations and distributions of all species are likely to fluctuate over time. Together, the natural vegetation remnants and the extensive planted areas will eventually form a larger, more mature and extensive coastal forest habitat over much of the Island. The effects of this vegetation change will vary for different bird species, and ongoing successional changes might be further enhanced through targeted supplementary planting, as discussed in Chapter 2, section 2.4 (and summarised in Table 2.2). Such ‘enhancement’ planting will help increase the diversity of flowering and fruiting times within the plant community, thereby increasing food and habitat resources for bird populations.

These vegetation changes will be beneficial as they will increase the available habitat for the many forest bird species that inhabit Tiritiri Matangi. This includes translocated species such as stitchbird (hihi), North Island kōkako, North Island rifleman, little spotted kiwi, whiteheads and robins, and self-colonised species, such as tūī and bellbirds. An increase in forest cover might also encourage the settlement of visitors to Tiritiri Matangi such as North Island tomtits, long-tailed cuckoos, and North Island kākā, as well as increasing the suitability of Tiritiri Matangi for future translocations of birds such as New Zealand snipe.

An increase in forest cover, if left uncontrolled, might lead to population shifts in species that exploit open, edge and shrub habitats. These include North Island saddleback, North Island fernbird, takahē and red-crowned parakeet. All of these species also use forested habitat on the Island, or have been recorded doing so elsewhere,[7] but a reduction in population density is possible without some management to maintain open, edge and shrubby habitats. This issue is discussed in Chapter 2, section 2.3.3. This is likely to be an issue beyond the life of this plan, so as

well as following the recommendations made in Chapter 2, it would be prudent to begin investigating regeneration dynamics for vegetation management in the longer term.

4.3.6 Genetic management

Maintaining genetic diversity and avoiding prolonged population bottlenecks appears to be vital for maintaining long-term population health. While there is ongoing debate as to the population outcomes of low genetic diversity, [9,10,11] it is clear that, wherever possible, genetic diversity should be maximised.[12] This is particularly relevant for translocated populations such as those on Tiritiri Matangi.

Genetic management through ongoing translocations and intervention in breeding will be essential for species such as kōkako and takahē which are present on Tiritiri Matangi as relatively small managed populations. However, supplementary translocations are likely to be much more difficult for populous species such as North Island saddleback and whiteheads. This is because any individuals translocated into these populations are likely to suffer high mortality due to density-dependent effects.[13] This could be mitigated by removing individuals from Tiritiri Matangi prior to any supplementary translocations. However, the numbers removed would need to be very high (at least several hundred birds) to create territorial opportunities and would thus be logistically and ethically challenging. In addition, in some species, such as stitchbird (hihi), density-dependent effects do not seem to predict survival, further complicating supplementary translocations. Egg translocations might be a viable management alternative, but there are still density-dependent problems such as low juvenile survival[13] and subsequent low recruitment rate into the breeding population.

Signs of inbreeding depression have been detected in stitchbird.[14] A supplementary translocation was carried out in 2010 by SoTM in partnership with the Institute of Zoology, London, in an attempt to mitigate this. There is also evidence of a loss of genetic diversity in bellbirds (S. Ballie, *pers. comm.*) and North Island robins[15] but the effect on other bottlenecked populations, such as North Island saddleback, whiteheads and red-crowned parakeets, is unclear. However, in all of these species there is currently no sign of detrimental population level impacts. Therefore, while genetic management might be required for several Tiritiri Matangi populations in the future (Table 4.1) this should be informed by population monitoring and ongoing SoTM support of relevant research that demonstrate both need and techniques by which these goals might be achieved.

4.3.7 Recovery groups

Department of Conservation recovery groups were formed to provide advice on the management and conservation of species at a national level. Of the bird species resident on Tiritiri Matangi, there have been recovery groups associated with stitchbird (hihi), North Island kōkako, brown teal (pāteke), takahē and kiwi. During 2013, the structure of national advisory groups is being reviewed by DOC, and it appears likely that some of the recovery groups for individual species will be replaced

by less specialist groupings. Whatever structures emerge from the review, SoTM have a strong desire to work with them to meet recovery goals whilst maintaining and managing the existing populations of birds on Tiritiri Matangi.

4.4 Future translocation options

In restoring the avifauna of Tiritiri Matangi, the contemporary assemblages of species present on other Hauraki Gulf islands (e.g. Hauturu (Little Barrier), the Mokohinau, Great Barrier, the Hen and Chickens) provide the most relevant guide. By following these examples, a composite ecosystem can be built that is representative of, and complementary to, the Hauraki Gulf region.

Tiritiri Matangi has achieved an outstanding record of successful bird translocations. As a result, there are few candidate terrestrial species remaining for translocation to the Island, but there are several potential seabird candidates. These are considered below and in Table 4.2. Only species that might have naturally occurred within the broad restoration target of the Inner Gulf Islands Ecological District (or their closest surviving relative) are proposed as potential introductions. Several additional species that are considered unsuitable for translocation are listed in Appendix G.

4.4.1 Terrestrial translocations

Several of the candidate species are frequent visitors to the Island and might naturally colonise the Island. The remaining will be technically and logistically challenging or will require high management input.

4.4.1.1 Long-tailed cuckoo (likely)

Long-tailed cuckoos are infrequent visitors to Tiritiri Matangi and are not known to have bred or resided on the Island. This is surprising given the presence of a large fecund population of whiteheads, the sole North Island host for long-tailed cuckoos.

Translocation of long-tailed cuckoos will be technically and logistically challenging. It will likely require egg transfers from whitehead nests at a donor site (e.g. Hauturu) to whitehead nests on Tiritiri Matangi. It is unlikely that SoTM will undertake this project in isolation. However, research investigating the feasibility of translocating long-tailed cuckoos will be undertaken at Massey University (M. Anderson, *pers. comm.*). This will likely create collaborative opportunities for the eventual translocation of long-tailed cuckoos onto Tiritiri Matangi.

4.4.1.2 New Zealand snipe (possible)

It is not known if the New Zealand snipe has ever been present on Tiritiri Matangi but it is likely, as it was once common throughout mainland New Zealand.[7] Tiritiri Matangi likely offers good snipe habitat. However, translocation of snipe will be technically and logistically difficult as the potential source populations are either in the Chatham or New Zealand Subantarctic Islands. It is unlikely that SoTM will

undertake this project. However, SoTM remains open to collaborative projects to reintroduce snipe to the Hauraki Gulf region.

4.4.2 Seabird translocations

Burrowing seabirds are an essential component of New Zealand ecosystems[16] and can have a significant impact through burrowing activity, vegetation modification and, critically, through the massive transference of nutrients via guano deposition, regurgitations and adult, egg and chick mortality.[17,18] Given this critical role, it is desirable to re-establish populations on islands such as Tiritiri Matangi. Natural colonisation of seabird species not currently breeding on Tiritiri Matangi is unlikely. Therefore, chick translocations accompanied by broadcast calls through a speaker playback system may be required to re-establish seabird populations on Tiritiri Matangi.

Burrowing seabird translocation techniques have been successfully developed for eight New Zealand species and these techniques are likely to have broad application for other species.[4] However, seabird translocations represent a significant investment of personal and financial resources as suitable experienced personnel will have to be employed to ensure successful translocation outcomes.[4] Translocation essentially involves an initial trip or trips to locate active burrows at the source location that can be accessed for harvest. On a subsequent trip, chicks of a suitable age are collected, transferred to artificial burrows at the release site and given intensive pre-fledgling care.[4] The initial success of the translocation (released chicks returning to the translocation site) might not be apparent for 1-5 years for several species, and up to 23 years for others.[19,4] It will take much longer to ascertain long term success (>10 years for most species). Despite the challenges, the return of large numbers of breeding seabirds to Tiritiri Matangi would represent a significant advance in restoring the Island to a representative Hauraki Gulf ecosystem. In addition, there might be opportunities to translocate seabirds in conjunction with other restoration groups (for example, the Motuora Restoration Society), thereby sharing costs and combining resources and expertise.

Taylor [20,21] recommended five candidate species for translocation to Tiritiri Matangi (Table 4.2). The suitability of each is discussed below, with three recommended as potential candidates for translocation over the life of this plan.

4.4.2.1 Little shearwater

Little shearwaters have not been translocated before but it is likely that the techniques used for fluttering shearwaters[4] will be successful for this species (G. Taylor, *pers. comm.*). Little shearwaters are currently present in the greater Hauraki Gulf region, with several potential source locations (Table 4.2). Given appropriate resources and commitment, they are a suitable candidate species for translocation to Tiritiri Matangi for ecosystem restoration.

4.4.2.2 Flesh-footed shearwater

Flesh-footed shearwaters have not been translocated before but it is likely that the techniques used for fluttering shearwaters[4] will be successful for this species (G. Taylor, *pers. comm.*). The largest flesh-footed shearwater breeding colonies in New Zealand are on the Hen and Chickens Islands and the birds are frequently seen in the inner Hauraki Gulf region. Given appropriate resources and commitment, they are a suitable candidate species for translocation to Tiritiri Matangi for ecosystem restoration.

4.4.2.3 Pycroft's petrel

Pycroft's petrels are rare endemics that nest in coastal forest and have a relatively restricted range. They have been successfully translocated to Cuvier Island[4] and a translocation programme to Motuora Island began in 2013. Red Mercury is the largest and most suitable source island for translocation and is providing birds for the translocation to Motuora. Given that translocations to Motuora will likely occur over a three-year period, Red Mercury will not be available for a translocation to Tiritiri Matangi until at least 2016. However, given appropriate resources and commitment, they are a suitable candidate species for translocation to Tiritiri Matangi for species conservation and for ecosystem restoration.

4.4.2.4 White-faced storm petrel

The high density of pūkeko (an opportunistic predator that would likely depredate small petrels) on Tiritiri Matangi would make establishment of a white-faced storm petrel colony difficult (G. Taylor, *pers. comm.*). This might be mitigated by establishing a colony under a forest or dense shrubland canopy and avoiding grassland areas (G. Taylor, *pers. comm.*). However, white-faced storm petrels have not been translocated before, so although future habitat changes might increase the suitability of Tiritiri Matangi for this species, they are not recommended for translocation within the timeframe of this plan.

4.4.2.5 Buller's shearwater

Buller's shearwaters are an unlikely candidate for translocation within the timeframe of this plan. They nest only on the Poor Knights Islands and, while it would be desirable to establish a breeding population elsewhere, possible sites for translocation have not been widely discussed. There is also a danger that Buller's shearwater, being an aggressive species, might pose a threat to other seabird populations on the Island.

4.5 Bird pests

Any possible troublesome species such as Australasian magpie, Australasian harrier, Eastern rosella and myna should be monitored. If their numbers are seen to be increasing significantly we should seek to gauge their impact on other species.

4.6 Recommendations

1. Continue to provide supplementary feeding, water and nest boxes as required for management of resident species and for advocacy and research purposes.
2. Increase and develop species-based population monitoring to provide a more detailed knowledge base for future management.
3. Consider monitoring predator-prey interaction to provide information for future management.
4. Increase the food and habitat resources for resident bird populations through 'enhancement' planting of selected appropriate plant species.
5. Support long-term research on vegetation community dynamics and changes in bird populations to improve the knowledge base for future management.
6. Where appropriate, support research relevant to the genetic management of species on the Island.
7. Consider translocating appropriate seabird species (little shearwater, flesh-footed shearwater, Pycroft's petrel) to the Island within the next ten years.
8. Monitor the numbers of potentially troublesome bird species and, if necessary, seek to gauge their impact on other species.

4.7 References

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Table 4.1 Management requirements for bird populations on Tiritiri Matangi Island

Note that '?' under 'long term management requirements' means research and/or monitoring is needed to resolve these questions.

Species	Threat status	Taxonomic status	Short term/ongoing management requirements	Long term management requirements (>10 years)	Management partners
Takahē	B1	Endemic	Metapopulation management for genetic health via translocation and forced pairings.	Maintain edge and open habitats for feeding and successful breeding.	DOC Takahē Recovery Team and SoTM
Stitchbird (hihi)	B2	Endemic	Provision of nest boxes and supplementary feeders. Metapopulation management for genetic health via translocation. Population monitoring.	Increased diversity in flowering and fruiting plants will benefit stitchbird / hihi but supplementary feeding and nest boxes will likely be required in the long term.	DOC Hihi Recovery Group and SoTM
North Island kōkako	B3	Endemic	Metapopulation management for genetic health via translocation. Population monitoring.	Increased diversity in fruiting plants will likely benefit North Island kōkako.	DOC Kōkako Recovery Group, SoTM and Zoos
Northern New Zealand dotterel	B3	Endemic	Population monitoring.		SoTM
North Island kākā	B3	Endemic	Population monitoring.		SoTM
Pied shag	B3	Native	Population monitoring.		SoTM
Caspian tern	B3	Native	Population monitoring.		SoTM
Red-billed gull	B3	Native	Population monitoring.		SoTM
North Island rifleman	D1	Endemic	Short-term provision of nest boxes might be beneficial during establishment.	Ongoing provision of nest boxes? Genetic management?	SoTM
North Island fernbird	D1	Endemic	Population monitoring.	Maintain suitable low scrubby habitats e.g. bracken/flax/muehlenbeckia associations. Genetic management?	Kevin Parker (Massey University) and SoTM
Little penguin	D1	Native	Population monitoring.		SoTM

Species	Threat status	Taxonomic status	Short term/ongoing management requirements	Long term management requirements (>10 years)	Management partners
White-fronted tern	D1	Native	Population monitoring.		SoTM
Brown teal (pāteke)	D2	Endemic	Maintain existing ponds and dams. Population monitoring.	Genetic management?	DOC Pāteke Recovery Group and SoTM
Little spotted kiwi	D2	Endemic	Population monitoring.	Genetic management?	DOC Kiwi Recovery Group and SoTM
Variable oystercatcher	D2	Endemic	Population monitoring.		SoTM
North Island saddleback	D2	Endemic	Provision of nest boxes to increase nest site availability. Population monitoring.	Maintain suitable low scrubby habitats e.g. bracken/flax/muehlenbeckia associations. Ongoing provision of nest boxes? Genetic management?	SoTM
Red-crowned parakeet (kākāriki)	D3	Native	Population monitoring.	Maintain edge and open habitats for feeding and successful breeding. Genetic management?	SoTM
Spotless crake	D3	Native	Population monitoring.		SoTM
Whitehead	NT	Endemic	Population monitoring.	Genetic management?	SoTM
North Island robin	NT	Endemic	Population monitoring.	Genetic management?	Doug Armstrong (Massey Uni) and SoTM
North Island tomtit	NT	Endemic	Population monitoring.	Increased forest habitat might facilitate permanent tomtit colonisation.	SoTM
Grey warbler	NT	Endemic	Population monitoring.		SoTM
Silvereye	NT	Native	Population monitoring.		SoTM
Shining cuckoo	NT	Native	Population monitoring.		SoTM
Welcome swallow	NT	Native	Population monitoring.		SoTM
Morepork	NT	Native	Population monitoring.	Impact on vulnerable species.	SoTM

Species	Threat status	Taxonomic status	Short term/ongoing management requirements	Long term management requirements (>10 years)	Management partners
Kingfisher	NT	Native	Population monitoring.	Impact on shore skink.	SoTM
Fantail	NT	Native	Population monitoring.		SoTM
New Zealand pigeon	NT	Endemic	Population monitoring.		SoTM
Tūī	NT	Endemic	Population monitoring.		SoTM
Paradise shelduck	NT	Endemic	Population monitoring.		SoTM
Pūkeko	NT	Native	Population monitoring.	Impact on brown teal/pāteke, paradise shelduck and takahē.	SoTM
Spur-winged plover	NT	Native	Population monitoring.		SoTM
Australasian harrier	NT	Native	Population monitoring.	Impact on NI kōkako.	SoTM
Black-backed gull	NT	Native	Population monitoring.		SoTM
Grey-faced petrel	NT	Native	Population monitoring.		SoTM
Common diving petrel	NT	Native	Population monitoring.		SoTM
Brown quail	IN	Introduced	Population monitoring.	Maintain edge and open habitats for feeding and successful breeding.	SoTM
Eastern rosella	IN	Introduced	Population monitoring.	Impact on red-crowned parakeet.	SoTM
Myna	IN	Introduced	Population monitoring.	Impact on endemic species.	SoTM
Australian magpie	IN	Introduced	Population monitoring.	Impact on endemic species.	SoTM

Threat status[22]

B1	Threatened, Nationally critical	D2	At risk, recovering
B2	Threatened, Nationally endangered	D3	At risk, relict
B3	Threatened, Nationally vulnerable	NT	Not threatened
D1	At risk, declining	IN	Introduced and naturalised

Table 4.2 Candidate seabird species for possible translocation to Tiritiri Matangi

Species	Threat status	Taxonomic status	Previously translocated?	Potential source islands	Pre-translocation survey	Chick collection	Time frame for translocation
Flesh-footed shearwater	D1	Native	No	Coppermine	January/February	April	2013-2023
Little shearwater	D2	Endemic at sub-species level	No	Lady Alice, Mokohinau, Red Mercury	Late winter/spring	October	2013-2023
Pycroft's petrel	D2	Endemic	Yes	Red Mercury	February	March	2016-2023
White-faced storm petrel	D3	Native	No	Maria	Spring	February	Post 2023
Buller's shearwater	D4	Endemic	No	Poor Knights	Late November	April/May	Post 2023

Threat status[22]

D1 At risk, declining
D2 At risk, recovering
D3 At risk, relict
D4 At risk, naturally uncommon

5. MANAGEMENT OF REPTILE POPULATIONS ON TIRITIRI MATANGI

5.1 Current situation

The 1997 Working Plan for Tiritiri Matangi[1] points out that tuatara and sixteen species of lizards have been recorded from the greater Auckland region. Tuatara and up to twelve species of lizards may once have inhabited Tiritiri Matangi.

Recovery plans at the time when the last working plan was written were developed before the kiore on Tiritiri Matangi had been eradicated. This made Tiritiri Matangi unsuitable as a potential site for rare native species of reptiles. Subsequent recovery plans[2,3] have indicated the suitability of Tiritiri Matangi as a potential site for the establishment of rare native lizard species.

At the time of writing this plan, Tiritiri Matangi has six resident species of reptile: copper skink, moko skink, common gecko, shore skink, Duvaucel's gecko and tuatara. Three of these species, tuatara, Duvaucel's gecko and shore skink, were established through translocations to the Island.

5.2 Aims and objectives

The overall aim of reptile management on Tiritiri Matangi is to increase the diversity of reptiles on the Island. As diversity increases, the functionality of the overall ecosystem is enhanced and increased.

A number of species are listed in this plan for potential translocation to Tiritiri Matangi. In addition to fulfilling the overall aim of reptile management, these proposed translocations will meet specific objectives in accordance with SoTM's guiding principles of advocacy, sanctuary, species management and learning:

- Offering a safe haven to threatened and 'at risk' reptile species on a predator-free island (sanctuary),
- Establishing new populations of threatened and 'at risk' reptile species, increasing the likelihood of their survival (species management),
- Offering the public the opportunity to see native reptile species, thereby increasing public awareness and knowledge of them and their needs (advocacy and learning).

5.3 Management of currently resident species

It is important to monitor the populations of resident species, not only to identify management actions necessary to ensure their survival, but also to detect any changes in population dynamics that might arise out of, or affect, future translocations.

5.3.1 Copper skink (*Oligosoma aeneum*)

The copper skink is the smallest native reptile in New Zealand and they are commonly found in urban gardens throughout the North Island. Despite their widespread distribution, they are still under threat due to development and predation by mammals. A remnant population of copper skinks survived on Tiritiri Matangi and is now thriving throughout most habitat types on the Island.

The number of copper skinks on the Island is unknown. However, population densities have been estimated as 1.7 skinks per square metre in grassland habitat and 1 skink per square metre in young mixed species plantings.[4]

Copper skinks are mainly active during the day but rarely emerge from cover. These secretive skinks generally hide under logs and rocks and typically forage among leaf-litter and beneath low, dense vegetation. Management actions for this species are not required. However, the growth of dense, low vegetation such as muehlenbeckia, flax and leaf-litter-producing plants, together with maintenance of patches of open grassland, will support and encourage growth in this population.

5.3.2 Moko skink (*Oligosoma moco*)

Like the copper skink, the moko skink survived human modification of Tiritiri Matangi, despite severe habitat changes through the farming activities of the past century. This threatened species of lizard is currently classed as 'at risk – "relict"' in the current threat classification list for New Zealand reptiles.[5]

Moko skinks were once widespread throughout the northeast of the North Island and its offshore islands. Habitat destruction and predation by introduced mammalian pests have driven mainland moko skink populations nearly to extinction. On a national level, this species is in partial decline and dependent on conservation, but moko skinks are relatively abundant on Tiritiri Matangi. Population density estimates range from 0.5 per square metre in rank grassland through to 0.1 per square metre in young mixed species plantings.[4]

The only stronghold left on the mainland is the nearby Shakespear Regional Park and associated navy land, together with a remnant population in the Opoutere/Whangamatā area. This makes it particularly important to monitor, manage and protect the Tiritiri Matangi population.

The moko skink is one of the species with a preference for high light environments. This means that vegetation needs to be managed so that a matrix of habitat is retained, including open spaces. Over time, moko skinks will reduce in numbers and be restricted to open spaces, the coastline and tracks.

5.3.3 Common gecko (*Woodworthia maculatus*)

For a long time, It was thought that copper and moko skinks were the only lizards resident on Tiritiri Matangi. The occurrence of gecko footprints in 2004 in a rodent biosecurity tracking tunnel led to the discovery of a remnant population of common geckos. These geckos inhabit the rocky areas along a large portion of the eastern coastline of Tiritiri Matangi. Like most New Zealand reptiles, common geckos are slow to reproduce, so their numbers will build up only slowly.

Preliminary results of a current research project indicate that the genetic diversity of this population is low, which could compromise the population's viability in the long term. No management intervention will be required during the life of this plan, but continuous genetic monitoring of this population is advisable to assess whether future genetic management may be required.

5.3.4 Tuatara (*Sphenodon punctatus*)

Tuatara are of international interest to biologists and are also recognised within New Zealand as species in need of active conservation management. Tuatara are vulnerable to predation by introduced mammals and habitat destruction, as evidenced by the depleted distribution of this unique animal. They once lived throughout the mainland of New Zealand, but have survived in the wild on only 32 offshore islands.

The aims of translocating tuatara to Tiritiri Matangi were to increase the security of northern tuatara (which at the time were deemed a separate sub-species), to test scientifically the success of translocation, and to provide an accessible site where tuatara could be viewed by the general public.

Sixty individuals were released on the Island in 2003. Over 20% of the original founders were recaptured during the five-yearly survey period in 2007/2008. Nests and juvenile tuatara have also been discovered and are evidence that the population is breeding successfully. Five-yearly monitoring is necessary to assess the condition of this population and to determine the long-term success of this translocation. The monitoring procedure is detailed in the long-term lizard monitoring plan.

Most of the islands on which wild populations of tuatara survived are occupied by colonies of breeding seabirds that contribute to the fertility of the soil, and hence to the richness of invertebrate and lizard fauna needed by tuatara. Seabird burrows are also an important habitat resource for tuatara as they typically live and breed in burrows. An increase in seabird numbers is likely to be beneficial to the Tiritiri Matangi tuatara population.

5.3.5 Duvaucel's gecko (*Hoplodactylus duvaucelii*)

The Duvaucel's gecko is New Zealand's largest gecko species. This lizard, like many other New Zealand reptiles, relies on its camouflage to remain undetected by its natural avian predators. The lack of behavioural adaption to the hunting strategies of introduced mammalian predators (which hunt predominantly by smell) made this lizard vulnerable to predation. The combination of high levels of predation, slow reproduction and human-induced habitat loss resulted in the extinction of this species on the mainland and its confinement to off-shore islands.

In 2006, nineteen Duvaucel's geckos were translocated from Korapuki, in the Mercury Islands, to Tiritiri Matangi. This translocation was a trial, to see whether a viable population could be established, and to assess the ability of large ground-dwelling lizards to tolerate potential predation by ground-feeding birds. Several founder females were gravid at the date of release, and subsequent monitoring has revealed several island-born offspring and at least one younger cohort, indicating the occurrence of natural mating on the Island. All individuals (founders and juveniles) captured during the five years following translocation were in good condition, suggesting that resources are sufficient and that the lizards have adapted well to their new environment.

As this translocation was a trial, the population is being supplemented in order to enhance genetic diversity, reduce the chances of inbreeding and ensure the viability of the population in the long term. Massey University, in a joint project with SoTM, have released 32 captive-reared and 60 wild-caught individuals in 2013. These releases will also be experimental, to compare the fitness of wild-caught and captive reared geckos to survive and thrive on the Island. The release of captive-reared animals (of other species as well as Duvaucel's geckos) is likely to be a component of future lizard translocations, and this project will test whether they are as able as wild-caught animals to establish a viable population.

The Duvaucel's gecko population on Tiritiri Matangi will continue to be monitored regularly by Massey University researchers and as part of SoTM's long-term lizard monitoring programme.

5.3.6 Shore skink (*Oligosoma smithi*)

Shore skinks inhabit pebble and boulder beaches, as well as sand dunes, along the north-eastern shore lines of the North Island. They are one of the few reptile species in New Zealand which are not threatened, though they are vulnerable to predation by exotic mammals. Annual reproduction and high fecundity allow populations to expand rapidly once mammalian pests have been eradicated.

Shore skinks from Tawharanui Regional Park were translocated to Tiritiri Matangi in 2006 and the population was supplemented with further captive-reared and wild individuals in 2010. The population is now being monitored under the SoTM long-term lizard monitoring

programme. Annual monitoring since the release indicates that they have established and are breeding on the Island.

5.4 Candidates for future translocations

New Zealand's native reptile species have suffered severe reductions in abundance and distribution due to introduced predators and habitat fragmentation, amongst other human-induced factors. As a result, several species are currently identified as requiring conservation management.

Reptiles form an essential component of functioning native ecosystems. Tiritiri Matangi currently has six resident reptile species. Because the populations of the translocated species are small, and because there is little diversity within the reptile community in most habitat types on the Island, the role of reptiles within the Island's ecosystem is currently limited. Translocations of additional lizard species will help reptiles to fulfil their ecological potential on Tiritiri Matangi.

In recommending particular lizard species for future translocation to Tiritiri Matangi, the following questions were addressed:

- Is the species ecologically important and likely to have been part of a similar island ecosystem?
- Could the species play an advocacy role, e.g. is it likely to be enjoyed by the public over time?
- Might the species interact negatively with resident or proposed invertebrate, reptile or bird species?
- Will sufficient suitable habitat be available for the species through time, given the current vegetation management regime, and the vegetation management recommendations proposed within this plan?
- Is a suitable source population available?
- Is there any possibility that a naturally resident population has remained undetected on Tiritiri Matangi?

On this last question, the current long-term lizard monitoring programme, efforts that have been made to detect green geckos, and numerous surveys of and research on all the resident reptile species, have significantly increased the chances of all currently resident reptile species being detected. Kiore were eradicated in 1993, and it is unlikely that a resident reptile species will have remained undetected for all the intervening years.

In the most recent *Cyclodina* spp. Skink Recovery Plan (1999 – 2004),[3] Tiritiri Matangi is mentioned specifically as a suitable site for the translocation of Whitaker's and robust skinks. The natural distribution of these large lizards is severely restricted and they are highly vulnerable to predation by introduced mammals. Their slow breeding rate means that

populations subject to such predation are unlikely to recover. These mainly nocturnal skinks have specific habitat requirements, as they are particularly prone to cutaneous water loss and need adequate vegetation cover, a deep litter layer and sufficient shelter sites that provide a humid climate. Seabird burrows are frequently used by these lizards as shelters. Burrows of smaller seabirds such as diving petrels may be favoured as they may offer higher humidity and moisture levels than large burrows. The availability of suitably moist conditions on Tiritiri Matangi would need to be investigated carefully (given the dry summers on the Island) before any translocations of these species are considered seriously.

There are only a few natural populations of robust and Whitaker's skinks left in the wild. Harvesting a large number of animals may impact negatively on the natural populations. In order to avoid this, it has been suggested that the secondary (previously translocated) populations on Korapuki Island might be used as sources. Since these populations are, themselves, still relatively small, it is anticipated that a captive-breeding programme for these two species would be required to enhance the numbers for translocation. The breeding programme would be a collaborative effort amongst a number of management and research agencies and interested restoration groups. This would maximise the number of founders to be released on Tiritiri Matangi and manage the genetic diversity amongst the breeders. Supplementation with further wild animals several years later could be an option to enhance/retain maximum genetic diversity of the translocated population and limit negative impacts on the Korapuki population.

The joint introduction of Whitaker's and robust skinks would benefit the conservation of these species by increasing their range and creating additional viable breeding populations.

5.4.1 Robust skink *(Oligosoma alani)*

Robust skinks are currently limited to a few small offshore islands off the northern North Island. Their current New Zealand conservation status is 'recovering', but the moderate-sized wild populations are conservation-dependent. Habitat requirements include good vegetation cover and a thick layer of leaf litter to provide sufficient moisture levels for this lizard. Flax (*Phormium* sp.) is an ideal plant to provide such cover. Tree stumps and fallen logs provide additional cover. These skinks also use seabird burrows as shelters as these provide a cool humid climate. There appears to be a positive relationship between the number of seabird burrows and numbers of robust skinks. In a translocation to Motuopao Island from Matapia Island, Robust skinks were released into disused grey-faced petrel burrows.[6] A similar methodology could be adapted for the transfer of robust skink to Tiritiri Matangi, provided suitable burrows are found. Information relevant to the potential translocation of this species is summarised in Table 5.1.

5.4.2 Whitaker's skink *(Oligosoma whitakeri)*

Only very few small populations are left of this 'nationally endangered' skink, which is highly conservation-dependent. Whitaker's skinks appear to be most active after dusk. Humid environments are optimal for these secretive lizards which utilise seabird burrows, deep

rocky scree and thick vegetation such as muehlenbeckia for foraging activities and shelter. See Table 5.3 for relevant information.

This species has a very low reproductive rate; the rate of increase calculated for a translocated population of Whitaker's skink on Korapuki Island, Mercury Group was 5-9% per year.[3] It would probably take a considerable time to colonise all appropriate habitats on Tiritiri Matangi and would therefore take longer than either robust or Towns's skinks to impact on the Island's invertebrate communities.

As with robust skink, it is anticipated that animals released on Tiritiri Matangi would result from a captive-breeding programme.

5.4.4 Auckland green gecko (*Naultinus elegans*)

This charismatic arboreal lizard inhabits mānuka/kānuka bush and is often active during the day, when it frequently sun basks among the foliage. Its visibility and attractive appearance make it a perfect candidate for educational and advocacy purposes, to raise public awareness and stimulate interest in New Zealand's lizards.

Anecdotal evidence suggests that green geckos may historically have been present on Tiritiri Matangi, but the failure to detect them during several recent surveys suggests that no resident population exists. Any animals persisting are likely to be isolated individuals. Green geckos are recognised as 'at risk – declining' in the current threat classification list for New Zealand reptiles.[5] Scattered populations occur throughout mainly the north-western part of the North Island and on a few offshore islands such as Waiheke, Little Barrier and Great Barrier Island.

Tiritiri Matangi currently provides large enough areas of mānuka/kānuka bush to support a population of green geckos, but long-term vegetation management is required to maintain these areas. Since green geckos do not utilise broadleaf vegetation, the creation of mānuka/kānuka corridors should be considered to connect habitat fragments.

Mainland green gecko populations are often fragmented and small in size and would not sustain a harvest for translocation. Due to increased urban development, the populations are in decline and continuous habitat removal may lead to local extinction. Tiritiri Matangi could serve as a sanctuary for a mainland population that otherwise would become extinct due to habitat removal. Information relevant to the translocation of green geckos is summarised in Table 5.4.

It is recommended that, within the ten-year period covered by this biodiversity plan, the four species discussed above be considered for translocation to Tiritiri Matangi. Auckland green gecko could be introduced in the short term, and habitat surveys could be conducted to assess the suitability of available habitat for the three skink species. It is possible that the skink species could not be introduced until after the period covered by this plan, in order to allow time for the number of seabird burrows to increase.

In the longer term, the four species discussed below might be considered for translocation.

5.4.5 Forest gecko *(Mokopiriakau granulatus)*

Forest geckos occur often in sympatry with green geckos and also show a preference for mānuka/kānuka bush. Tree cavities or loose bark are used as daytime shelters. They are active mainly at night but occasionally sun bask in foliage or near a shelter. Forest geckos are fairly common on the mainland and also occur on several islands varying in size from 28500ha (Great Barrier Island) to 11ha (Motutaiko Island).

Generally, the habitat on Tiritiri Matangi is suitable for forest geckos, but as a nocturnal, cryptic species, they are unlikely to be encountered by visitors and so are not a good candidate for education or advocacy purposes. They can be seen as a potential species for translocation in the longer term.

5.4.6 Pacific gecko *(Dactylocnemis pacificus)*

Pacific geckos are widespread throughout the North Island and on northern offshore islands. They inhabit a range of forest habitats, including regenerating scrub and plantings (ngaio, in particular, is an ideal food and habitat plant). Like forest geckos, they are nocturnal, and so would not be ideal as an advocacy species. Their presence in the nearby Shakespear Regional Park suggests that they may have occurred on Tiritiri Matangi in the past, both when it was connected to Whangaparāoa Peninsula by a land bridge, and later after it separated to form an island.

Tiritiri Matangi has suitable habitat for Pacific geckos, and their translocation to the Island might be ecologically appropriate. It can be considered as a long-term possibility.

5.4.7 Suter's skink *(Oligosoma suteri)*

Suter's skink is the only native egg-laying skink. They utilise rocky platforms and cracks within cliffs, and forage amongst rock pools. Their eggs are laid amongst rocky substrate. Rocky shorelines are present on Tiriti Matangi, but it is currently unknown whether there is sufficient suitable habitat to support a resident population of Suter's skinks. It is therefore recommended that this species should not be considered for translocation to the Island until a thorough survey of the coastline for suitable habitat has been completed.

5.4.8 Ornate skink *(Oligosoma ornata*)

Ornate skinks do not currently coexist with Whitaker's skinks. It is unclear whether these species were sympatric before human colonisation. Ornate skinks are not considered endangered and can reach relatively high densities. Because their potential to impact on Whitaker's skinks is unknown, their translocation to Tiritiri Matangi should not be considered until research has been conducted to assess the potential for competition

between these species. If such research indicates no negative implications, it is nevertheless recommended that at least ten years should elapse between the translocation of Whitaker's skinks and the arrival of ornate skinks on the Island. This places any potential introduction of this species beyond the period covered by this plan.

5.4.9 Towns's skink *(Oligosoma townsi)*

Since the publication of the *Cyclodina* spp. Skink Recovery Plan (1999 – 2004),[3] marbled skinks, which were listed as candidates for translocation to Tiritiri Matangi, have been split into two species: *Oligosoma oliveri* , found in the Poor Knights, Mercury and Alderman Islands and *Oligosoma townsi* (Towns's skink), found in the Mokohinau Islands, Hen and Chicken Islands, Hauturu (Little Barrier Island) and Great Barrier Island. The latter species is listed as 'recovering' but conservation-dependent on the New Zealand Threat Classification list.[5] They are currently known only to occupy coastal sites, especially those with deep boulder substrates. They are not known to co-exist anywhere with Whitaker's skink, so the outcome of placing the two species together is unknown. Their translocation to Tiritiri Matangi should not be considered until their potential impact on Whitaker's skinks has been assessed, and even if such research indicates no negative implications, at least ten years should elapse between the translocation of Whitaker's skinks and the arrival of Towns's skinks on the Island. As in the case of ornate skinks, this places any potential introduction beyond the period covered by this plan.

5.5 Recommendations

1. For moko skink, manage the vegetation so that a matrix of habitats is retained, including naturally open spaces.
2. For common gecko, on-going genetic monitoring of this population is recommended to assess whether future genetic management may be required.
3. For tuatara, continue with five-yearly monitoring to assess the condition of the population and to determine the long-term success of this translocation.
4. Of the species identified as candidates for future translocation to the Island, robust skink, Whitaker's skink and Auckland green gecko should be considered as the first priorities (see Tables 5.1-5.3) within the ten-year period covered by this plan.
5. As a preliminary step to the translocation of robust skink and Whitaker's skink, conduct an investigation into the availability of suitable conditions for these species, especially at the driest times of year.
6. Institute appropriate long-term vegetation management to ensure that mānuka/kānuka bush areas are maintained for green geckos, and that fragments of this habitat are connected by mānuka/kānuka corridors.

5.6 References

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Table 5.1 Information on Robust skink *Oligosoma alani*

Status	Once widely distributed, now range restricted – stable. At risk – recovering.
Habitat requirements	Forest or regenerating scrub with intact, deep leaf litter. Seabird burrows.
Habitat requirements present on Tiritri Matangi?	Survey required. Release at least 500m from other reptile release sites where possible.
Capable of self-sustaining population on Tiritiri Matangi?	Yes, once a deep leaf litter is formed and seabird abundance increases. Relatively mobile, therefore will move to favourable habitat. Release at distance from other large ground dwelling lizards.
Potential interactions with other species	Coexists with Whitaker's skink, marbled skinks and tuatara. Potentially predated by morepork. Preys on invertebrate communities, including large-bodied species.
Annual reproductive rate	Low recruitment rate but higher than Whitaker's skink.
Potential source of population	A breeding population within the Mercury Islands group excluding Middle Island (e.g. Korapuki or Green Island[7]).
Number of individuals	Minimum of 30 individuals. Preferably mix of juveniles, sub-adults and gravid females. Captive-breeding programme advised. Later supplementation with additional 20+ individuals.
Recommended timeframe for translocation	Dependent on habitat survey.

Table 5.2 Information on Whitaker's skink *Oligosoma whitakeri*

Status	Nationally critical – nationally endangered, highly conservation-dependent.
Habitat Requirements	Forest or regenerating scrub with intact, deep leaf litter. Seabird burrows.
Habitat requirements present on Tiritiri Matangi?	Survey required. Release at least 500m from other reptile release sites where possible.
Capable of self-sustaining population on Tiritiri Matangi?	Yes, once a deep leaf litter is formed and seabird abundance increases
Potential interactions with other species.	Coexists with robust skink, marbled skink and tuatara. Unknown interactions with ornate skink. Potentially predated by morepork. Preys on invertebrate communities, including large-bodied species.
Reproductive rate	Low annual reproductive rate.
Potential source of population	Collaborative breeding programme with other restoration trusts taking wild animals from the Mercury Islands group excluding Middle Island (e.g. Korapuki (Towns, 1994)).
Number of individuals	Minimum of 30 individuals. Preferably mix of juveniles, sub-adults and gravid females. Later supplementation with additional 20+ individuals
Recommended timeframe for translocation	Dependent on habitat survey.

Table 5.3 Information on Auckland green gecko *Naultinus elegans*

Status	Widely distributed. Fragmented populations are decreasing. At risk – declining.
Habitat requirements	Forest and bush, particularly mānuka/kānuka shrubland.
Habitat requirements present on Tiritri Matangi?	Yes. Survey needed. Possibilities include top of Bush 22, top of Little Wattle Valley, Lighthouse Valley.
Capable of self-sustaining population on Tiritiri Matangi?	Yes. Mānuka/kānuka shrub should be maintained. Mānuka/kānuka corridors should be considered.
Potential interactions with other species	Avian predators such as morepork and kingfishers may impact on population. Live in sympatry with forest geckos but differ in activity time.
Annual reproductive rate	Low reproductive rate.
Potential source of population	Mainland population threatened by development e.g. Winstone's project.
Number of individuals	30+
Recommended timeframe for translocation	Spring-early summer 2013

6. RESTORATION OF BATS ON TIRITIRI MATANGI

6.1 Current and historical situation

Bats are not known to be extant on Tiritiri Matangi but it is reasonable to assume that they were a part of the original fauna on the Island.

Two species of bat are endemic to New Zealand: the lesser short-tailed bat (*Mystacina tuberculata*), and the long-tailed bat (*Chalinolobus tuberculatus*). A third species, the greater short-tailed bat, is assumed to be extinct. The former distribution of the lesser short-tailed bat is described as being 'widespread in the North Island',[1] while the long-tailed bat is extant across New Zealand. Both species are recorded from islands. Within the Auckland Ecological Region, populations of long-tailed bat currently exist in the Waitakere Ranges, and on Great and Little Barrier Islands.

There is evidence supporting the historical presence of the long-tailed bat on Tiritiri Matangi. It is believed that a bat population roosted in the Royal New Zealand Navy Fortress Observation Tower, after the withdrawal of the military after World War Two. This building was destroyed by the Navy in 1966 and, consequently, so was the bat population.[2] There have been at least two subsequent sightings of single bats reported in 1976 and 1993.[2] It is possible that bats could be confused with swallows disturbed from a roost after dark. The welcome swallow naturalised in NZ in 1958, spreading to Auckland by 1967.[3] Reports of bats in the military building thus pre-date swallow populations, and can be assumed to be accurate. The later sightings remain anecdotal.

Research has been carried out exploring the suitability of Tiritiri Matangi for the re-establishment of bats.[4,5] The principle findings of these projects are:

- Many of the known prey species of both bats species occur on Tiritiri Matangi. Since bats are nocturnal and therefore targeting nocturnal insects, it is likely that there would be little direct competition between them and the Island's other insectivores.
- It is unlikely that a population of long-tailed bats would initially be able to survive on Tiritiri Matangi without roost boxes, due to the low occurrence of natural roost cavities in a young forest, and the potential competition for such cavities by nesting birds.
- Bats are known to travel large distances foraging for food.[6] The carrying capacity of the Island is likely to be limited by the available foraging grounds.

Mammal predators are suspected to be the major threat affecting bat populations nationally.[1] The absence of mammal predators on Tiritiri Matangi makes the Island a possible site for the establishment of a bat population.

The Department of Conservation's bat recovery plan states, among its objectives, 'to raise public awareness of bats and to involve the public in bat conservation'. As an open sanctuary, Tiritiri Matangi is well-known for its advocacy gains. Guided night-walks on the Island have been trialled and proved popular with visitors. Bat sightings would add significantly to visitor experience, and raise public awareness of these little-seen mammals.

6.2 Aims and Objectives for the restoration of a bat population on Tiritiri Matangi

A major difficulty in considering how a new bat population might be established is that bat management and translocation techniques are largely undeveloped and untested. A translocation of short-tailed bats in 2005 was achieved by taking pregnant females into captivity and releasing their offspring on Kapiti Island when they were old enough to fly. This was only partly successful, however. Of the 20 individuals released, only nine were recaptured during monitoring, and these were eventually taken back into captivity due to concerns over parasite infestation.[8] Adult bats have never been translocated successfully in New Zealand, and long-tailed bats have never been kept in captivity. For these reasons, it may be unrealistic to consider establishing a bat population on Tiritiri Matangi within the period covered by this plan. SoTM will therefore take a precautionary approach to the restoration of bats on the Island.

Over the next ten years, SoTM will

- engage with discussion on bat conservation and management taking place at the regional and national levels
- encourage and support research on techniques that might make it more feasible to establish new populations of bats
- if considered suitable, and if the opportunity arises, consider offering Tiritiri Matangi as a possible site for bat translocations that might be planned as knowledge and expertise increases.

6.3 Candidates for translocation

In the absence of well-developed translocation and management techniques, it is too early to form any firm opinions on which bat species might be established on the Island in the future. It is nevertheless worth presenting the following points for consideration.

- The short-tailed bat is the more threatened of the two species (it is classified as ‘nationally endangered’, whereas the northern long-tailed bat is classified as ‘nationally vulnerable’).[9]
- The Department of Conservation recovery plan for bat species[1] favours the establishment of new populations of all extant species and sub-species within their historical ranges. It also states, as a specific objective, ‘to establish new populations of short-tailed bats on suitable islands’.
- Of the two bat species, the long-tailed bat is more common in fragmented/regenerating forest of the kind present on Tiritiri Matangi.
- There are already populations of long-tailed bats present in the Auckland region.

- There is strong evidence that long-tailed bats were present on the Island for an unknown period until 1966. Their return could therefore be seen as a restorative step.
- It is possible that a population of long-tailed bats might be displaced by a development project. In such a rescue situation, Tiritiri Matangi might be a suitable site to test translocation methods.
- In 2013, discussions are taking place about the possibility of establishing short-tailed bats on other Inner Hauraki Gulf islands.
- The short-tailed bat is a major pollinator of Dactylanthus taylorii (wood rose). While this plant, which is in serious decline and conservation dependent,[9] is not currently established on Tiritiri Matangi, there are plans to introduce it (see Table 2.2).

Ultimately, the choice of species to establish on Tiritiri Matangi might depend on which proves more amenable to translocation and captive rearing as expertise in these areas develops. If and when a translocation programme becomes possible, it must include a protocol for long-term monitoring (minimum ten years) using a range of suitable methodologies.

6.4 Recommendations

1. Engage with national and regional discussions about bat management and translocation.
2. Encourage, support and, where appropriate, participate in, research to improve management and translocation techniques for bat species.
3. Support and encourage further research on the suitability of Tiritiri Matangi as a site for establishing a bat population.
4. Continue communication with expert personnel to determine the possibility of Tiritiri Matangi providing a sanctuary for a displaced population of long-tailed bats should the need arise.
5. In the event of a translocation appearing likely, begin considering and planning a monitoring programme to continue for at least ten years after translocation.

6.5 References

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7. MANAGEMENT OF INVERTEBRATE POPULATIONS ON TIRITIRI MATANGI

7.1 Current situation

Tiritiri Matangi Island has experienced considerable human disturbance,[1] resulting in an impoverished invertebrate fauna; it is likely some former species are now extinct on the Island. Our current knowledge of the invertebrate fauna of Tiritiri Matangi is mainly from two sources.

Since 1993, when kiore were removed from the Island, Dr Chris Green (DOC) has been using pitfall traps to carry out monthly monitoring of ground-living invertebrates. Traps set in a mature broadleaf forest remnant have caught more invertebrates than in a younger regenerating forest patch, and the overall abundance of invertebrates has increased since kiore were removed. Several large (>10 mm) species have increased during the monitoring period, including ground wētā and species of prowling spider. This programme was originally set up to determine the effects of kiore eradication. Its importance goes beyond this, however, as the only continuous long-term study of invertebrates on the Island; it is important that it be continued into the future.

In 2001-02, a study of beetle community dynamics on Tiritiri Matangi was conducted by David Clarke (University of Auckland).[2] The beetle communities from six vegetation types were sampled using malaise and pitfall traps. A total of 315 beetle species was sampled, with only 67 (21% of the sample) being introduced species. The most common families collected were rove beetles, weevils, mildew beetles and ground beetles. The highest abundance of ground-dwelling beetles was recorded within pōhutukawa plantings and old mixed species plantings. Remnant forest and old mixed plantings had the highest species richness of ground-dwelling beetles, while the naturally-regenerated bush had the highest species richness of arboreal beetles.

In addition to these two surveys, limited collecting has been carried out on the Island by taxonomists interested in their specialist invertebrate group. While the invertebrate sampling on Tiritiri Matangi indicates that native invertebrates have persisted on the Island, knowledge of the existing invertebrate communities is still far from comprehensive. This, combined with an absence of undisturbed islands nearby to act as ‘reference’ ecosystems, means there is a degree of uncertainty in the restoration process for invertebrates.

Identifying restoration targets using reference systems based on neighbouring unmodified islands has been proposed for the Mercury Islands. In this island group, two reference islands, Green Island and Middle Island, have been naturally free of introduced mammals and show little evidence of modification by fire. Green and Middle Islands have complex forest systems with a distinctive invertebrate fauna dominated by large flightless species. These islands give us a broad understanding of the components of the invertebrate fauna missing from Tiritiri Matangi Island and can act as a basis for restoration.

7.2 Aims and objectives for the management of invertebrate populations on Tiritiri Matangi

The aim of invertebrate management is to increase the overall diversity of invertebrates on the Island, which will, in turn, increase the overall functionality of the ecosystem. Specific objectives of this plan are:

- To carry out the research necessary for future management and possible future introductions
- To introduce selected species that were formerly present and which will enhance the overall integrity of the ecosystem
- To introduce selected threatened species that require a refuge and/or fulfil an advocacy role with the public.

7.3 Management of existing populations

As indicated above, knowledge of invertebrate populations on Tiritiri Matangi is limited. The one long-term survey has been restricted in methodology and habitat (pitfall traps in bush areas) and other surveys have been limited by time or personal interest. There is currently very little management on the Island directed specifically at invertebrates (exceptions being Argentine ants and wētāpunga; see below), though many of the management practices that have been undertaken, such as forest restoration, the eradication of kiore, the provision of fresh water and the maintenance of a matrix of habitats, have undoubtedly benefited a range of invertebrate species. The replanted areas on Tiritiri Matangi Island are still relatively immature (sparse leaf litter and limited forest tiers), but natural regeneration processes over time will slowly improve this and increase the area suitable to allow forest-dwelling invertebrates to thrive.

The greatest need is for more knowledge, to provide a basis for possible management activities. It would be useful to survey the invertebrate fauna on Tiritiri Matangi using a range of entomological monitoring techniques, such as malaise traps or emergence traps, in a variety of habitats, to determine the species present.

This section provides a brief outline of the known current invertebrate fauna on the Island. It is divided into four categories: large flightless species, ecologically important species, threatened species and invertebrate pests.

7.3.1 Large flightless species

Mammal-free offshore islands typically have an invertebrate fauna that is characterised by high abundance and the presence of large-bodied species. The large-bodied taxa of unmodified northern offshore islands include the giant centipede, wētā, large flightless beetles, and giant land snails. The majority of these species are threatened and some have important roles in the ecosystem. In addition, some of these species are iconic ones for New Zealand invertebrate conservation, offering potential for a strong advocacy role with visitors.

Some of these species are present on Tiritiri Matangi, either naturally or as a result of translocations.

7.3.1.1 Wētā

Several medium-bodied wētā species occur naturally on Tiritiri Matangi. A ground wētā (*Hemiandrus pallitarsus)* with a body length of >30 mm is abundant in remnants of mature broadleaf forest. The tree wētā (*Hemideina thoracica),* with a body length of >40 mm, is also present.

Wētāpunga (*Deinacrida heteracantha*; body length 70+ mm) were formerly abundant in forests of northern New Zealand including Northland, Auckland and Great Barrier Island, but their natural range is now restricted to Hauturu/Little Barrier Island. The Threatened Wētā Recovery Plan[3] recommended that new populations of wētāpunga be established on appropriate mammal-free islands. In accordance with this recommendation, a new population was introduced to Tiritiri Matangi in December 2011.

Wētāpunga are an arboreal forest species that spend most of their time above ground, roosting in epiphytes and cavities during the day, and feeding mostly on fresh foliage at night. On Hauturu/Little Barrier Island, they are found in the canopy of second-growth forest. Tiritiri Matangi provides a mammal-free environment with suitable habitat (both young planted forest and coastal forest with large pōhutukawa). Potential predators of juvenile wētāpunga on Tiritiri Matangi include lizards (geckos and skinks), North Island robin, little spotted kiwi, morepork, kingfisher, pūkeko, and North Island saddleback. Wētāpunga survive on Hauturu/Little Barrier Island in the presence of most of these species, but it is assumed that they will take time to establish on Tiritiri Matangi due to the presence of these predators. Their progress will be monitored regularly through the use of tracking tunnels in the area around the release site. To maximise the chances of establishing wētāpunga, only adult and near-adult specimens were introduced, and were provided with bamboo refuges. A captive breeding programme has been established and additional translocations are planned during the period covered by this plan.

7.3.1.2 Large flightless beetles

Large flightless beetles, such as darkling beetles and weevils, occur on unmodified offshore islands. Of the 315 beetle species sampled from Tiritiri Matangi in 2001-02,[2] 73 were native flightless species (24%), but only seven of these species were 10 mm or larger in length. Two medium-large beetle species (*Ctenognathus novaezelandiae* and *Mimopeus elongatus*) are vulnerable to rat predation and have been lost from many rat-infested northern offshore islands. Both species persist on Tiritiri Matangi. Because darkling beetles are an important food item for some native species, they are discussed below in the invertebrate prey section.

7.3.2 Ecologically important species

Invertebrates perform key roles in many ecosystem processes as pollinators, herbivores, detritivores, predators and as prey.

7.3.2.1 Herbivores

Forty-one native herbivorous beetles are known from Tiritiri Matangi, including 10 flightless species. Only one herbivorous beetle (*Mimopeus elongatus*) is large (>10 mm in length).

As far as is known from the limited sampling that has been done, the Hauraki Gulf islands typically have a sparse Lepidoptera fauna (butterflies and moths). Tiritiri Matangi has two species of abundant muehlenbeckia-feeding moths (*Pseudocoremia indistincta* and *Bityla defigurata*) and a number of copper butterflies (*Lycaena* species). Otherwise, little is known about Lepidoptera on the Island.

There is limited information available on the Hemiptera on Tiritiri Matangi. After kiore eradication in 1993, there was a massive crop of seedlings in the forest gullies and on these were the noticeable dimples of the scale insect *Ctenochiton paraviridis*. Since then the densities of birds have increased on the Island, particularly whiteheads, so these herbivorous scale insects have decreased in abundance. The mānuka giant scale insect (*Coelostomidia wairensis),* which feeds on kānuka, is present on the Island and is associated with sooty mould.

Of the four species of herbivorous stick insects known from the Auckland area, only one species, *Clitarchus hookeri,* is present on Tiritiri Matangi. The other three species require mature forest, particularly the presence of podocarps and rātā; their food plants are currently absent from the Island.

7.3.2.2 Detritivores

Detritivorous invertebrates feed primarily on decaying organic matter from either plants or animals and they are an extremely important group within ecosystems. They assist the breakdown of dead animals and plants, returning nutrients held within them back to the ecosystem.

There are a number of detritivorous groups already present on Tiritiri Matangi, including worms, slaters, landhoppers, springtails, mites and some beetles. Native detritivorous beetles have dominated in samples from the Island. Currently, there is insufficient information available to identify detritivorous species which might have been lost from the Island.

7.3.2.3 Invertebrate predators

The largest invertebrate predator, the giant centipede (*Cormocephalus rubriceps*), is present on many northern offshore islands and has been recorded on Tiritiri Matangi. Other common predatory invertebrates, including wētā, spiders, harvestman, and some beetle groups, are all represented on Tiritiri Matangi. The predatory ground wētā are abundant in mature broadleaf forest remnants, and spiders and harvestman appear to be abundant and diverse, though these have not been studied in detail. Several species of prowling spider appear to have increased in abundance since the kiore were removed in 1993. Six species of

native ground beetle occur on the Island, with *Ctenognthus novaezelandiae* being extremely common within pōhutukawa plantings.

Peripatus (species unknown) was recorded on Tiritiri Matangi during the clearing of pampas grass. In 2000 a specimen of *Ooperipatellus* sp. (*Oviparous onychophora*) was collected in one of Dr Chris Green's pitfall traps. Peripatus are vulnerable to habitat disturbance and occur only in habitats with abundant invertebrate prey; their presence (even in low numbers) is therefore regarded as a positive indicator of increasing ecosystem health.

7.3.2.4 Prey for vertebrates and other invertebrates

Invertebrates are an important food resource for reptiles and birds. There are a number of bird species present on Tiritiri Matangi that feed predominantly on invertebrates, including little spotted kiwi, North Island robin, North Island saddleback, morepork, kingfisher, silvereye, rifleman and whitehead. Tuatara, skinks and geckos also feed on invertebrates. The predatory invertebrates present on the Island include the giant centipede, wētā and 74 species of predatory native beetles. The composition and abundance of invertebrate populations on the Island are evidently adequate to sustain a diversity of predators.

7.3.3 Threatened species

As little is known about the abundance and distribution of many invertebrate species it is difficult to assess their conservation status. Nineteen invertebrate species which occur in the Auckland Department of Conservation Conservancy area are listed in *The conservation requirements of New Zealand's nationally threatened invertebrates*.[4] Most of these species require further research to clarify their abundance, habitat requirements, distribution, and taxonomy, and more survey work is needed to determine whether any of them are present on Tiritiri Matangi. Meanwhile, the Island has recently become a refuge for one well-known threatened species, the wētāpunga (see above, section *7.3.1.1*).

7.3.4 Invertebrate pests

In March 2000, the Argentine ant (*Linepithema humile*) was discovered on Tiritiri Matangi, infesting approximately 11ha centred on the wharf. This ant is acknowledged as one of the most invasive ant pests in the world. Its primary effect is to displace all native ant species, and studies in other ecosystems have shown that, in its presence, there is a general loss in both abundance and diversity of the invertebrate community.

A programme to eradicate the Argentine ant from the Island began in February 2001 using 'Xstinguish' ant bait (0.01% fipronil as a paste) applied intensively over the entire infested area. From 2003 the infestation was reduced to small areas of less than 25 square metres at a few sites. Some of these were very small nests that were difficult to detect, so new monitoring methods were developed to improve detection. There have been a number of new incursions, but numbers have been kept very low; no ants were found in 2012, and just one very small nest in 2013. While improved treatment and surveillance techniques have been developed during the programme, keeping the Island free of Argentine ants will require improved biosecurity measures. The species can spread to new sites only by walking

or, in the case of islands, by being brought in, so extra vigilance in searching all materials heading to the Island is required to prevent new incursions. The surveillance at all entry points needs to be continued indefinitely.

The Tasmanian paper wasp is the most common exotic wasp pest on Tiritiri Matangi. Only occasional nests of the Asian paper wasp are seen. There is no known way of eradicating these wasp species, but if nests are evident in areas of high public use, then localised control using fly spray should be sanctioned. There are very few *Vespula* wasps seen and control is required only where nests are found to be close to tracks. Wasps as a group are not present in numbers that pose a significant threat to the Island's ecosystem. Their potential impact is mainly on the visitor experience.

7.4 Candidates for translocation

The limitations in knowledge of the full range of invertebrates on Tiritiri Matangi, and in the wider region, make it difficult to make firm recommendations regarding possible translocations. More research is needed to determine which species could establish on the Island and be of benefit to its developing ecosystem. As the habitats on the Island change, it will become suitable for a wider range of invertebrates. For the period covered by this plan, the number that can reasonably be recommended for translocation is very small. The relevant information on possible candidate species is summarised in Table 7.1. Three categories of invertebrates can be considered:

- Large flightless species, principally large beetles and land snails. These species, which are very unlikely to colonise the Island without translocation, are important from an ecological, and potentially an educational, perspective.
- Ecologically important species (other than large flightless species) which potentially have significant roles in the restored island ecosystem.
- Threatened species, which could benefit from a new sanctuary and may potentially be important for education and advocacy.

7.4.1 Large flightless beetles

There are no records of large weevils on Tiritiri Matangi. However, the flax weevil (*Anagotus fairburni*) would be a suitable candidate for translocation. It is widely distributed, occurring on a number of offshore islands from the Poor Knights to Stewart Island. This species is restricted to its host plant, flax (both *Phormium tenax* and *P. cookianum*); *Phormium tenax* is abundant on Tiritiri Matangi. The weevils are nocturnal, feeding on flax and then retreating to hide among the dead leaves at the base of the flax during the day. A number of new populations of flax weevil have been established on other offshore islands. The species has been recorded on Hauturu/Little Barrier Island and the Marotere Island group, but current population densities are unknown, so further research is required to determine a suitable source population.

Two other species of large weevil, Turbott's weevil (*Anagotus turbotti*) and karo weevil (*Hadramphus pittospori*), occur on northern offshore islands and are classified as 'range

restricted' in the national threat classification list (2005).[5] Turbott's weevil bores into the live wood of ngaio and karaka. The larvae of the karo weevil bore into the live branches, trunks and roots of karo. As the host plants of these two weevil species are present and abundant on Tiritiri Matangi they are possible candidates for translocation to the Island, but further investigation is needed to determine their requirements and suitability. This could take place during the period covered by this plan, but the time frame for translocations will probably lie outside this period.

7.4.2 Macro land snails

Within northern New Zealand there are two groups of giant land snails: the herbivorous flax snails (*Placostylus* sp.) and the carnivorous kauri snails (*Paryphanta* sp.). Typically, on offshore islands, numerous small species and at least one large carnivorous land snail species are present, and on northern islands large herbivorous snails, such as pūpūharakeke, are also present. All flax and kauri snails are under threat from mammalian predation and habitat modification; all are protected and managed under the Giant Land Snail Recovery Plan.[6]

There has been no sampling of land snails on Tiritiri Matangi, and a survey of the snail fauna should be carried out before any introductions are considered. This should take place in the first 2-3 years of the period covered by this plan. If no large native land snails are detected, then introduction should be considered to restore this component of the invertebrate fauna.

The two sub-species of kauri snail require a wet forest habitat; this, along with their northerly distribution, makes them unsuitable for translocation to Tiritiri Matangi. However, the Island is within the range of two other carnivorous land snails: *Rhytida greenwoodi* and *Amborhytida dunniae*. The recommended snail fauna survey should be used to determine whether there is adequate prey (smaller snail species) available for these species. Research is also required into potential source populations of these two species.

Two flax snail species are restricted to northern Northland, while other species have a distribution which stretches south to include the Marotere Islands, the Noises Islands and Great Barrier Island. The Noises populations are a result of a translocation in the 1950s, and those in the Marotere Islands and on Great Barrier Island are thought to be early Māori introductions. The evolution of these snails is closely linked to the physical characteristics of their habitat, in terms of soil properties and vegetation types. In general, the Giant Land Snail Recovery Plan suggests that further introductions outside the ecological range should be avoided. However, there is a tiny population of a 'small form' of flax snail on a stack (Gut Rock) near Fanal Island, in the Mokohinau group. The Giant Land Snail Recovery Group has agreed to attempt to captive-rear this snail for translocation to other Hauraki Gulf islands, including Tiritiri Matangi. Staff at Auckland Zoo are trying to rear the more common flax snail, to test the requirements for a breeding programme, but have not been successful so far. No time frame can be set for potential translocations until this captive-breeding programme shows some success.

7.4.3 Ecologically important species

7.4.3.1 Herbivores

The great giant scale insect (*Coelostomidia zealandica*) is currently not known to be present on Tiritiri Matangi, but its presence on some nearby islands (Te Haupa and Moturekareka Islands) suggests that it was probably there before the forest was cleared for farming. It lives in karo, which is now abundant on the Island. For this reason, it could be considered an appropriate candidate for translocation.

7.4.3.2 Prey for other species

The introduction of the large darkling beetle (*Mimopeus opaculus*) could be considered, as this is a common prey of tuatara where they co-exist. A smaller but similar species (*M. elongates)* is already present on the Island. *Mimopeus opaculus* occurs on islands and in mainland forests and prefers mature forest with a deep leaf litter. This species has been translocated to Korapuki Island but it was six years before establishment was confirmed, at which time it was present in significant numbers. The low diversity and low abundance of reptiles currently on Tiritiri Matangi would help the successful establishment of the large darkling beetle. Research is required into a suitable source population, as the closest known populations are on the Marotere and Mercury Islands.

7.4.4 Threatened species

Only one threatened species is a potential candidate for translocation at the present time: the flax snail, which is discussed above (section 7.4.2).

One 'nationally endangered' species,[5] the wētāpunga (*Deinacrida heteracantha*), has already been introduced to Tiritiri Matangi in December 2011 and is also discussed above (section 7.3.1.1). Further introductions are recommended, and planned, to enable this species to establish on the Island.

Two other species of large wētā also occur on northern offshore islands: the Poor Knights giant wētā (*Deinacrida fallii*) and the Mercury Islands tusked wētā (*Motuwētā isolata*). The former is classified as 'range restricted' and the latter as 'nationally critical'.[5] The Threatened Wētā Recovery Plan[3] recommends that additional populations of these species be established, but Tiritiri Matangi is unlikely to be a preferred location because of its highly modified ecosystem, and because it may be considered too far from these species' natural range.

7.5 Recommendations

1. Conduct and/or support research to increase knowledge of the presence and distribution of invertebrates in all habitats on Tiritiri Matangi.
2. Ensure the continuation of the long-term survey of ground-dwelling invertebrates in bush areas, conducted by Dr Chris Green since 1993.

3. Support the continuation of post-translocation monitoring of wētāpunga to determine whether they establish successfully.
4. Continue annual monitoring and control of Argentine ants, together with surveillance at all entry points, indefinitely.
5. Research suitable source populations for flax weevil and large darkling beetle and consider introducing them within the period covered by this plan.
6. Undertake or support research into the suitability of Turbott's weevil and karo weevil for translocation to the Island in the longer term.
7. Conduct a survey of the snail fauna on the Island to determine whether large native land snails are present, and whether there is sufficient prey for large carnivorous snails.
8. Depending on the outcome of this survey, research potential source populations of snail species suitable for translocation, including flax snail. This should include liaising with the Giant Snail Recovery Group and Auckland Zoo regarding the possibility of a captive-breeding programme as a source of flax snails.
9. Consider the great giant scale insect as a possible candidate for translocation.

7.6 References

1. Chapter 2 of this plan (Management of vegetation on Tiritiri Matangi), section 2.1.
2. Clarke D. 2002. *Beetle community dynamics in a restored ecosystem: An investigation into the invertebrate fauna of Tiritiri Matangi Island*. Unpublished MSc thesis, University of Auckland, Auckland.
3. Sherley G. 1998. *Threatened wētā recovery plan,* Threatened species recovery plan 25. Wellington: Department of Conservation.
4. McGuinness C. 2001. *The conservation requirements of New Zealand's nationally threatened invertebrates*. Wellington: Department of Conservation.
5. New Zealand Threat Classification System lists 2005, available at: http://www.doc.govt.nz/publications/conservation/nz-threat-classification-system/nz-threat-classification-system-lists-2005/
6. Parrish R., G. Sherley and M. Aviss. 1995. *Giant land snail recovery plan:* Placostylus *spp*., Paryphanta *sp*. Threatened species recovery plan 13. Wellington: Department of Conservation.

Table 7.1 Invertebrate species recommended for introduction to Tiritiri Matangi

Species	Conservation status	Habitat requirements	Habitat availability on Tiritiri Matangi	Potential for self-sustaining populations on Tiritiri Matangi	Significant interactions with other species?	Source population	Timeframe for translocation
Flax weevil *Anagotus fairburni*	Not threatened	Feeds on flax and retreats to flax base during the day.	Large areas of flax present	Yes	No	Closest populations Hauturu/Little Barrier Island and Marotere Islands. Research needed into their sustainability.	As soon as source populations with adequate numbers are identified
Large darkling beetle *Mimopeus opaculus*	Not threatened	Inhabits forest, associated with woody debris; adults feed on algae and fungi; larvae found in soil, rotten wood and leaf litter.	Large areas of suitable coastal forest present	Yes; occurs on islands throughout New Zealand	Yes; common prey item of tuatara	Research required; closest population Marotere Islands and Mercury Islands; population sustainability requires investigation	As soon as source populations with adequate numbers are identified
Flax snail *Placostylus* sp.	Most are nationally critical	Inhabits broadleaf forest and scrub, feeds on fallen leaves. When young, lives up to 6m above ground.	Large areas of broadleaf forest and scrub available.	Unknown. Research needed.	No	Research needed. Captive-breeding trial being conducted by Auckland Zoo.	Probably beyond the period covered by this plan.
Great giant scale insect *Coelostomidia zealandica*	Not threatened	Lives on karo.	Karo present and abundant.	Unknown. Research needed.	No	Closest sources are Te Haupa and Moturekareka Islands.	As soon as source populations with adequate numbers are identified.
Turbott's weevil *Anagotus turbotti*	Range restricted	Bores into live wood of ngaio and karaka.	Ngaio and karaka common on the Island.	Unknown, research needed.	No	Research needed.	Beyond the period covered by this plan.
Karo weevil *Hadramphus pittospori*	Range restricted	Larvae bore into live branches, trunks and roots of karo.	Karo present and abundant.	Unknown, research needed.	No	Research needed.	Beyond the period covered by this plan.

8. MANAGEMENT OF WEED SPECIES ON TIRITIRI MATANGI

8.1 Historical outline

Weed control was carried out by ranger Ray Walter and his family from the beginning of the replanting programme in 1984. This initially concentrated on spraying large infestations of Japanese honeysuckle which were present in many of the valleys in the southern part of the Island and controlling weeds around the lighthouse area. Further weed control in the late 1980s was carried out by Chris Clark (ranger) and Graham Ussher (volunteer). In order to ensure appropriate follow up, it was decided in 1998 that Japanese honeysuckle and other weeds should be targeted on a systematic basis.

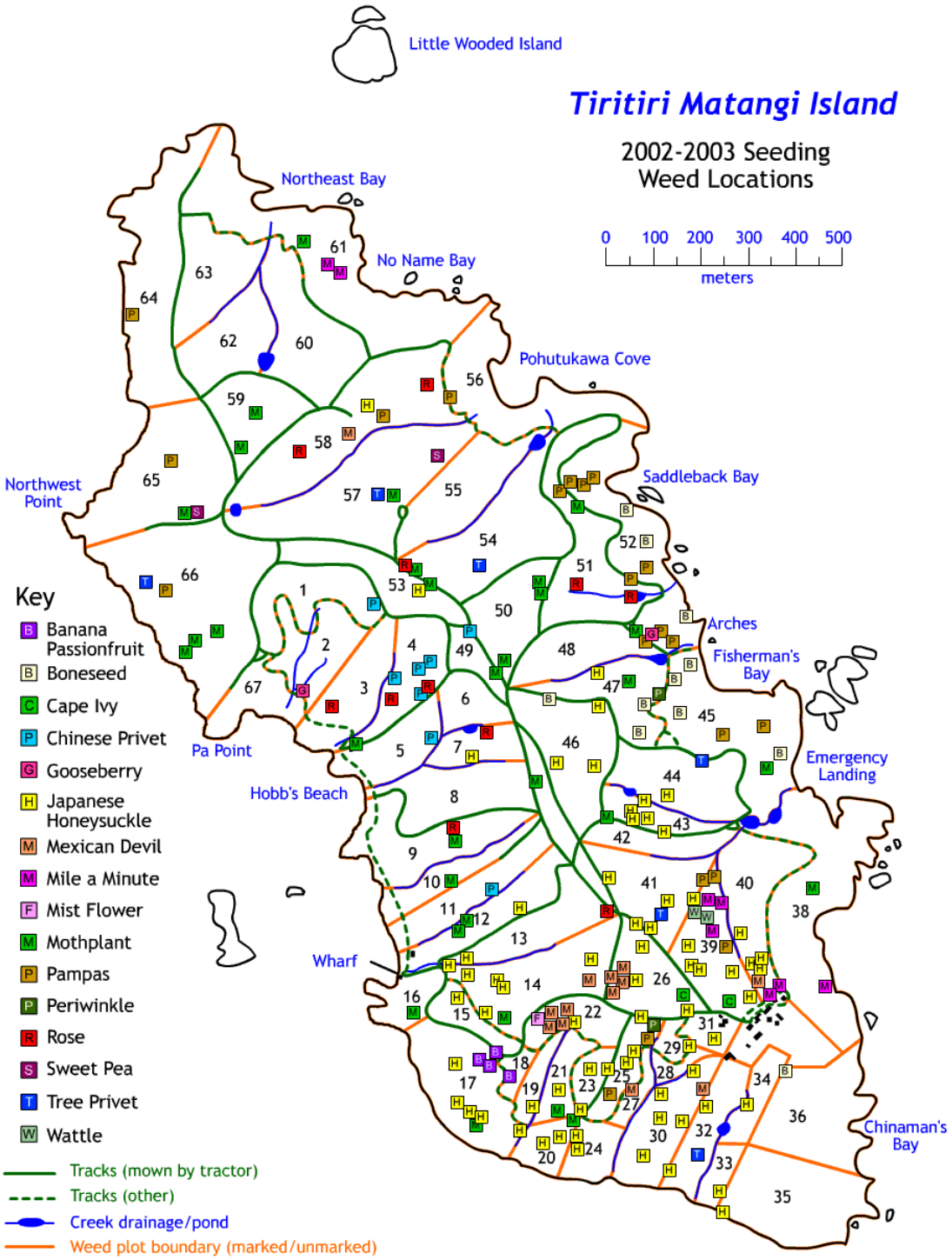
A system of weed control plots was set up to increase consistency of management and recording. These plots were devised and marked by Shaun Dunning who carried out weed control on the Island from 1995 to 2001. However, in 2002 it became apparent to new ranger Ian Price that moth plant and some other invasive species were starting to become more widespread on the Island. There were also invasive weed species such as periwinkle and mile-a-minute present around the lighthouse area, which were not being regularly controlled. It was therefore decided to search the whole Island in one season to determine and record the extent of infestation of all invasive weeds.

In the summer of 2002/2003 the whole Island was grid-searched by Ian Price and a contract weed team. All weeds found were treated, recorded and mapped so that the extent and location of weed infestations could be identified (see Figure 8.1). All sites of seeding weeds were given Global Positioning System (GPS) points and marked so they could be monitored for potential regrowth and seedling germination.

The initial spraying operations and follow-up control were very effective in reducing the impact of large infestations on the regenerating forest and reducing their range; however, new infestations were still able to establish. In the first three years of grid-searching the whole Island, the number of mature weed infestations found decreased by 86% from 211 in 2002 to 29 in 2005. In the following years, juvenile and seedling numbers increased initially for some species, as seed banks were still present at former adult sites. However, the incidence of Japanese honeysuckle (the most widespread weed) decreased dramatically.

As grid-searching was reduced to a partial annual search after 2005, it is not possible to compare figures from year to year. However, in the 2010 – 2011 season only 25 mature plants across all species were found and only two of these were at adult stage (i.e. had previously produced seed).

Figure 8.1. Distribution of mature weed infestations after 2002-2003 search (weed control plots are numbered 1 to 67)



The key to the success of the weed control programme is the consistent approach with constant follow up. This has been possible because of several factors:

- the commitment of SoTM to funding the programme on an ongoing basis
- a consistent strategy
- the dedication of individuals involved in the work
- detailed planning of the annual programme, but with the ability to be flexible depending on what is found
- in recent years the same contractors have been available to do the work each year, allowing them to build knowledge of the Island.

8.1.1 Current weed status

Weed control has continued on an annual basis and efforts have focused on the following:

- follow up control on marked 'active' sites
- grid-searching high risk control plots
- surveillance for new infestations
- abseiling, primarily to control boxthorn on cliff areas.

All invasive weed species are currently maintained at zero density, i.e. all target weeds are searched for and controlled annually (with the exception of those species discussed in section *8.3.1.3*). Zero density means to control all individuals of a target pest while recognising that re-infestation is possible either from outside or from existing seed banks. The term 'seed bank' refers to seeds present in the soil from previous infestations that have not yet germinated.

Table 8.1 outlines the target weeds that have been present on Tiritiri Matangi, and their current status. The figures for mature plants show that most of these are being found at marked monitoring sites. It should be noted that the term 'mature' refers to those plants that are old enough to flower and will only be found at marked sites if seedlings have been missed the previous year. Control is undertaken by volunteers at many of the marked sites and the sites are also checked by the contractor at a time of year that will ensure that any mature plants do not get to seeding stage. Details of past control operations can be found in annual weed control reports and in the Tiritiri Matangi Weed Control Manual,[1] which also gives details of control methods.

8.2 Aims and objectives

One of the broad aims of this biodiversity plan is to provide a sanctuary for the ongoing conservation of threatened species and populations through maintenance of an ecosystem free of exotic pests (see Introduction). 'Exotic pests' in this context includes exotic plant species that have the potential to damage the ecosystem. The weed control has the following specific aims:

- To eradicate all environmentally damaging weeds from Tiritiri Matangi where possible
- Where eradication is not possible, to control all environmentally damaging weeds at zero density
- To identify, at an early stage, any infestations of new pest species and eradicate or control them.

The crucial requirement for effective eradication or control is to prevent plants from dispersing seed.

The target weeds are all species that are listed in the Auckland Regional Pest Management Strategy.[2] However, some other species will be controlled if they are considered to be a potential risk to ecological objectives or are non-native species new to the Island and in low numbers.

8.3 Management practices and requirements

8.3.1 Current weed control programme

There are two current priorities:

- ongoing control of known seed banks
- surveillance to prevent establishment of new seed sources, including abseiling on cliff sites.

8.3.1.1 Control of known established seed banks

There is ongoing work at established seed banks to control germinating plants and prevent further seed production at these sites. This must continue until all seed banks are exhausted, as lack of attention to this would allow many species to reinvade quite quickly. The greatest threats are from those species which have long-lived seed banks and which reach maturity rapidly.

The species in this category with seed banks present are:

- mile-a-minute
- periwinkle
- Mexican devil
- boneseed
- moth plant
- sweet pea bush
- boxthorn.

Sites where seeding weeds have been found are marked and regularly monitored for seedling germination. There are currently 86 monitored sites, of which 74 were active at the end of the three-season grid-searching programme carried out between October 2002 and February 2005. Of these, 59% still have active seed banks eight years from the time of initial control, demonstrating the need for ongoing monitoring and control operations. It is unknown how long these seed banks will remain viable. Twelve new sites have been added to the list since 2005. Only one site is known to have been reinvaded, when a new plant was discovered near the site after it had dispersed seed. There are no longer any active sites of Japanese honeysuckle despite the fact that this was one of the most widespread weeds present. This species does not appear to have built up major seed banks at mature plant sites but still occurs randomly in previously infested valleys.

A site is considered to be active until no plants have been found there for three consecutive years. It is then listed as inactive and no longer requires annual monitoring. No sites of the listed high-risk species are considered to be completely clear until nine years pass without plants present. Large active sites are monitored regularly throughout the year by volunteers to control seedlings, except where the site is too difficult to access. Every active site is also checked annually by the contractors, and inactive sites every three years. Cliff sites are not specifically marked, but these areas are extensively searched by contract abseilers every two years. Detailed records are kept of all weeds found for auditing purposes, to assess the effectiveness of control and to determine the life of the seed banks.

8.3.1.2 Surveillance

The second priority is to ensure that no new weed seed sources establish on the Island. This includes seed sources of existing target species and any new target species which have not previously been recorded and which may arrive from the mainland or other islands. The plots used for surveillance are those which were set up in 2002/03 (see Figure 8.1). Surveillance is carried out by walking transects in all plots on a rotation basis to ensure that all are checked at least once every three years. If more than two juvenile plants of any species are identified at unmarked sites in a control plot, or a seedling infestation is discovered, the relevant plot will be grid-searched the following year. It is assumed that any species starting to spread will be picked up on these transects. This reduces the need to grid-search, which in turn saves cost and damage to vegetation.

This second priority illustrates the need for clear definition of the key plants which should be targeted in the control programme on Tiritiri Matangi. The general brief has been that all weeds listed on the Auckland Regional Pest Management Strategy[2] (RPMS) must be controlled. The current weed control schedule is shown in Table 8.2. The schedule for surveillance and control is kept under review and can be changed if it is found not to be sufficiently effective.

8.3.1.3 Special control strategies

Some species are subject to different control strategies which are discussed below.

Brush Wattle

Brush wattles have been present on Tiritiri Matangi since the beginning of the restoration project and were not included in the weed control programme as they provide food for bellbirds, hihi and tūī in winter. It was expected that they would be shaded out eventually. The presence of this species is generally confined to Wattle Valley. The shading effect has significantly reduced the numbers of mature wattles there over the last 10 years, but many seedlings still germinate. To prevent this species from spreading to other areas, all brush wattles have been controlled where they occur outside plots 17 to 30 (and including plot 26) and on the margins of Wharf Road. It is recommended that brush wattles continue to be prevented from spreading in open areas, and that large isolated specimens be progressively controlled to reduce seed production.

Gorse

Gorse is mostly confined to the northern section of the Island (plots 61 to 67 and parts of plot 56) with isolated patches at three sites (plots 13, 33 and 38). It was not originally included in the control programme as it was being left to grow as a nurse plant. This term refers to the process by which gorse provides pioneer cover for the natural establishment of secondary succession species and is subsequently shaded out. This process is happening very slowly in plots 61 to 63, possibly because the native vegetation in these areas is very low-growing. It is also exposed to high winds from the north-east. In these situations it is recommended to plant (or seed) hardy canopy species to assist the revegetation process.

In areas where gorse has been very slowly expanding and is likely to colonise some large open grass areas, more control is planned. It is an objective of the Biodiversity Plan to maintain open grass areas to support takahē and other grassland fauna. Gorse must be prevented from further colonising these open grass spaces. However, where gorse is contained by vegetation, it will be left to the natural succession process (except where there is enhancement planting).

8.3.2 Current operational requirements

Eighty-six weed sites are currently being monitored, 38 of which are regularly visited by volunteers from SoTM. In the past the lead contractor has liaised with these volunteers and allocated sites. However, since contractors are on the Island for only six weeks of the year, it has been recognised that monitoring would be better managed by someone who is regularly on the Island. A SoTM volunteer co-ordinator for weed monitoring was appointed in spring 2012.

Weed surveillance is most efficiently carried out when plants are flowering. This is the time when it is easiest to identify new incursions or plants that have been missed during the weed control programme. In the past, this work has been carried out by the contractors, but they

cannot cover flowering times of all species. There is also a need to react quickly to reports of weed sightings throughout the year. Volunteers have been found who are willing to take on this role, and training took place in 2012.

8.4 Future requirements for weed control

Weed control will continue to be an important part of island management into the future and its continued success will depend on long-term commitment to funding it. However, if the current programme is maintained the funding required should gradually decrease as the seed banks decline. The situation should be re-assessed each year to ensure that the work carried out is targeted appropriately.

Seed banks for some species may eventually be exhausted, but others may last a very long time and plants germinating from them may continue to appear for many years. Monitoring of active infestation sites will therefore continue to be required for the life of this plan and beyond.

The proximity of the Island to the mainland means that it will be impossible to prevent seed being carried by wind, birds or water from mainland seed sources. Surveillance for new incursions, particularly in coastal areas, will be an ongoing requirement. For this reason, a complete eradication programme has not been attempted. It will always be important to maintain a high level of surveillance and so the cost of an eradication programme is not justified. The current programme is designed to keep costs to a minimum while carrying out enough work to ensure that weeds do not adversely affect the regenerating forest. As the forest matures, habitat for weeds will decrease in many areas, reducing their ability to establish.

It is expected that, when the boxthorn seed bank is further reduced, cliff abseiling will not be required as frequently as at present. However, it is important to keep up the pressure on boxthorn for the life of this plan. The natural erosion of sea cliffs, and subsequent soil disturbance, means that cliffs are some of the most vulnerable locations for weed invasion. Abseiling to identify new infestations on the cliffs before they have time to spread is recommended at least every three to four years in the immediate future.

It is essential to have weed control staff who can spend enough time on the Island to get to know the habitats, the weed distribution and the likely places that they will occur. It is preferable that contract staff be encouraged to have an ongoing relationship with the Island, even though some of the work will be carried out by local volunteers.

The presence of Australian ngaio and its hybrids on the Island was mentioned as a potential problem in the 1997 Working Plan. However, no attempts have, as yet, been made at control. An operational plan should be developed that addresses this issue.

Consideration should be given to elimination, or a mitigation strategy, for native species which are outside their natural range and which have the potential to spread uncontrollably across the Island (and beyond). It is recommended that species present for advocacy

purposes be left to live out their lives and be replaced only if the species is considered to have continued advocacy value.

8.5 Summary of recommendations

1. Continue to fund an annual weed control programme as listed in Table 8.2. This must continue until seed banks are exhausted.
2. Review the schedule annually to ensure that the programme takes account of changing circumstances.
3. Prevent brush wattles from expanding their range, and progressively control large isolated specimens to reduce seed production.
4. Prevent gorse from further colonising open grass spaces and cliff faces.
5. Plant or seed hardy native canopy species amongst gorse in exposed areas to assist revegetation.
6. Continue with the abseiling programme to identify new infestations of boxthorn on the cliffs; this should be done at least every three to four years in the immediate future.
7. Encourage contract staff to have an ongoing relationship with the Island so that their knowledge and experience can continue to be used.
8. Develop an operational plan to address the issue of Australian ngaio and its hybrids.
9. Implement a strategy for the management of native species outside their natural range.
10. Species currently present for advocacy purposes, and which are outside their natural range, should be left to live out their lives and be replaced only if they are considered to have continued advocacy value.

8.6 References

1. Lindsay, H. 2011, *Tiritiri Matangi Weed Control Manual,* Supporters of Tiritiri Matangi.
2. *Auckland Regional Pest Management Strategy* (see http://www.arc.govt.nz/environment/biosecurity/regional-pest-management-strategy-rpms/regional-pest-management-strategy-rpms_home.cfm).

Table 8.1 Target weeds and current status

Name	Status	Mature plants found at marked monitoring sites 2010	Total mature plants found 2010
Apple of Sodom *Solanum linnaeum*	Appears occasionally around the coast and on cliffs, particularly in areas where it was formerly present	N/A	6
Arum lily *Zantedeschia aethiopica*	Found occasionally in gullies, particularly Lighthouse Valley, Little Wattle Valley and the gully above the Bunkhouse Dam. Two monitored infestations behind the beach at Pōhutukawa Cove and behind the beach below the bach.	1	1
Banana passionfruit *Passiflora sp.*	Was originally present in Wattle Valley and around Doug's Alley but appears to have been eradicated.	Nil	Nil
Barberry *Berberis glaucifolius*	Seedlings have been found at starling roost sites and occasional plants found elsewhere.	Nil	Nil
Boneseed *Chrysanthemoides monilifera*	Confined to Fisherman's Bay and occasionally on cliffs north and south of there. Long-lived seed bank so requires intensive annual control.	17	19
Boxthorn *Lycium ferocissimum*	Seed banks still present all around the northern cliffs where infestations were previously present, and on Wooded Island. Requires abseiling and a control programme is carried out every two years.	N/A	8
Brush wattle *Paraserianthes lophanta*	This species is not controlled in Wattle Valley but is regarded as a target weed outside this area. There is one major active site off Coronary Hill along Renske's track. Seedlings often appear along both sides of Wharf Road and are controlled to prevent them spreading along road edges.	Nil	Nil in control area
Buffalo grass *Stenotaphrum secundum*	One patch at North West point.	N/A	N/A
Cape Ivy *Senecio angulatus*	Can occasionally appear around the workshop and lighthouse area, usually as regrowth from old canes lying under grass.	Nil	Nil
Chinese privet *Ligustrum sinense*	Occasional plants found around the Bush 1 and Bush 2 areas.	Nil	Nil

Name	Status	Mature plants found at marked monitoring sites 2010	Total mature plants found 2010
Eleagnus *Eleagnus x reflexa*	Originally present around the bunkhouse area but appears to have been eradicated.	Nil	Nil
Gorse *Ulex europaeus*	Generally only present on the northern part of the Island roughly between North West Point to Northeast Bay and towards North Point. Also small sites near the Wharf Dam, in the gully below the Bunkhouse Dam and at Emergency Landing.	N/A	N/A
Hemlock *Conium maculatum*	Occasional plants found around the generator shed and in other random places around the Island.	Nil	Nil
Japanese honeysuckle *Lonicera japonica*	Occasional plants still appearing in areas which originally had large infestations i.e. all valleys within the vicinity of the lighthouse.	Nil	1
Kikuyu grass *Pennisetum clandestinium*	One patch in the paddock next to the ranger's house	N/A	N/A
Ladder fern *Nephrolepis cordifolia*	Has been present at only two sites: one site in Bush 2 appears to have been eradicated, the other in Bush 23 has occasional plants appearing.	Nil	Nil
Mexican devil *Ageratina adenophora*	Sixteen known sites, five of which are currently active and require annual monitoring.	2	2
Mistflower *Ageratina riparia*	One known site in Wattle Valley appears to have been eradicated.	Nil	Nil
Mile-a-minute *Dipogon lignosa*	Six known sites with active seed banks. The two largest, below the Visitor Centre and off Coronary Hill, are monitored regularly by volunteers. Two are on cliff dump sites that require abseiling.	4	4
Montbretia *Crocosmia x crocosmiiflora*	One site in gully above Bunkhouse Dam	Nil	Nil
Moth plant *Araujia sericifera*	Thirty known sites, monitored regularly by volunteers who remove seedlings. Six of these sites appear to be inactive but are still checked at least once a year.	Nil	Nil

Name	Status	Mature plants found at marked monitoring sites 2010	Total mature plants found 2010
Pampas *Cortaderia jubata and Cortaderia selloana.*	Appears randomly, particularly on cliffs and clay banks and particularly in areas where plants were previously present. Often moves in to new slips, so these need to be monitored.	Nil	2
Periwinkle *Vinca major*	A large seed bank is present all around the lighthouse area and on several dump sites on cliffs. These sites are monitored regularly by volunteers. Three small sites in other parts of the Island appear to have been eradicated.	5	5
Phoenix palm *Phoenix canariensis*	Seedlings have been found at starling roost sites.	Nil	Nil
Purple top *Verbena bonariensis*	Occasional plants found on tracksides and around the workshop and the Wharf Dam.	N/A	Nil
Rhus tree *Toxicodendron succedanea*	Seedlings have been found at starling roost sites, and occasional juvenile plants.	N/A	Nil
Smilax *Asparagus asparagoides*	Only three plants found, sites are monitored.	Nil	Nil
Sweet briar *Rosa rubiginosa*	Occasional plants have been found around the Island, most recently in the gully above the Bunkhouse Dam and adjacent to the bach.	N/A	1
Sweet pea bush *Polygala myrtifolia*	Twelve known sites, mostly in the valleys around the Silvester Wetlands and at North West Point. These have long-lived seed banks, so all are active and are monitored annually.	17	18
Tree lucerne *Chamaecytisus palmensis*	Two sites in the valley above the Wharf Dam have active seed banks.	Nil	Nil
Tree privet *Ligustrum lucidum*	Occasional plants have been found around the lighthouse area and in Bush 21.	Nil	Nil
Woolly nightshade *Solanum mauritianum*	Only one plant found in Bush 2.	N/A	Nil

Table 8.2 Tiritiri Matangi Annual Weed Control Schedule

Timing	Action	Frequency	Responsibility	Contractor hours
September – October (while plants are flowering)	Search the Fisherman's Bay cliffs to control boneseed. Check all other boneseed sites.	Annually	Contractor	16 x 2
October – November	Check northern cliffs from Papakura Pā to Fisherman's Bay to control boxthorn (abseiling required).	Every two years	Abseiling contractors	80 x 3
October – November	Check periwinkle and mile-a-minute on cliff dump sites (abseiling required).	Annually	Abseiling contractors	16 x 2
October – March	Check southern cliffs for new infestations (abseiling required)	Every two years	Abseiling contractors	80 x 3
September – December	If signs of weed spread are picked up in weed surveillance, carry out grid-searches of affected blocks.	As required	Contractors	40 x 4
September – December	Carry out coastal survey.	Annually	Contractor	16 x 2
February	Carry out surveillance to look for flowering pampas in high-risk areas, e.g. cliffs and clay banks.	Annually	Contractor and ranger	16 x 2
February – April	Check Wooded Island (abseiling required).	Annually	Abseiling contractor	8 x 2
All year round	Check all monitoring sites.	At least once annually	Volunteers and contractor	40
All year round	Carry out weed surveillance on a rotation basis with the aim of covering all plots at least once every three years.	At least annually	Contractors and/or volunteers	40 x 2
All year round	Carry out seedling control on all periwinkle and mile-a-minute sites apart from cliff sites.	At least every three months	Volunteers	Ongoing
Spring and autumn	Carry out gorse control to prevent invasion of tracks and open areas.	Annually	Contractor Volunteers Ranger	24

APPENDICES

Appendix A – Summary of translocations on and off Tiritiri Matangi

Species	**Initial translocation to Tiritiri Matangi (TM)**			**Subsequent translocations to TM**	**Total to TM**	**Translocations off TM**	
	Initial date	Number	Source	Number	Number	Date range	Total
Bellbird					**-**	1983, May 2010	**122**
Brown teal	1987	6	Ducks Unlimited	17	**23**		**-**
Diving petrel						2007-09	**190**
Fernbird	Jun 2001	13	Ōrewa	12	**25**		**-**
Kākāriki	Jan 1974	35	Mt Bruce	49	**84**		**-**
Little spotted kiwi	4/7/93	10	Kapiti	8	**18**		
Kōkako	10/8/97	3	Mt Bruce/ Māpara	15	**18**	2002-10	**22**
Quail and chukor	Pre-SoTM				**?**		**-**
Rifleman	Feb 2009	31	LBI	29	**60**		**-**
Robin	12/4/92	44	Mamaku	14	**58**	1999-2007	**99**
Saddleback	25/2/84	24	Cuvier	-	**24**	1990-2013	**218**
Stitchbird	3/9/95	37	LBI	54	**91**	2002-13	**453**
Takahē	26/5/91	2	Maud Is.	16	**18**	2000-13	**19**
Tomtit	14/4/04	32	Hūnuas	-	**32**		
Whitehead	3/9/89	40	LBI	40	**80**	2003-13	**518**
Tuatara	25/10/03	60	Middle Island	-	**60**		
Shore skink	Dec 2006	30	Tawharanui	23	**53**		
Duvaucel's gecko	Dec 2006	19	Korapuki	92	**111**		
Wētāpunga	10/12/11	25	LBI/Butterfly Creek		**25**		

Appendix B – Common plants for translocation to the four Inner Hauraki Gulf Islands (Motuora, Tiritiri Matangi, Motuihe and Motutapu)

Key

T = to be translocated
E = extant (recorded within last 20 years)
(V) = very low numbers to be planted <20
(L) = low numbers to be planted 20-100
(M) = Medium numbers to be planted 100-1000
(H) = High numbers to be planted >1000
(p) = present in pollen record
k = usually only associated with kauri forest so suitable for larger islands only

The criteria used to decide which native species to include for translocation to each island are as follows:

The species is not currently present on the island or is present in very low numbers
The species will be within its known natural distribution
The species has been recorded at some time within the Inner Gulf Islands ecological district
The species has been recorded in the fossil record from the island or
The species has been recorded in a pollen core from the island or an adjacent island and
The potential exists for appropriate habitat on the island

Botanical name	Common name	Motutapu	Motuihe	Tiritiri Matangi	Motuora
Forest trees and shrubs					
Agathis australis	Kauri	E	T (L) (p)	T (L)	
Alectryon excelsus	Tītoki	E	T (M)	E	T (M)
Alseuosmia macrophylla	Toropapa	T (M)	T (M)	T (M)	T (M)
Aristotelia serrata	Wineberry	T (M)		T (L)	
Beilschmiedia tarairi	Taraire	E	E	E	T (H)
Beilschmeidia tawa	Tawa	E	T (M)	T (M)	T (M)
Beilschmiedia tawaroa	Tawaroa	T (M)	T (M)	E	T (M)
Brachyglottis kirkii	Kirk's daisy	T (M)	T (M)		
Brachyglottis repanda	Rangiora	E	T (M)	E	E
Carpodetus serratus	Putaputawētā	T (M)	T (L)	E	T (L)
Coprosma arborea	Tree coprosma	T (M)	E	E	T (M)
Coprosma areolata	Thin-leaved coprosma	T (M)	T (M)	E	T (M)
Coprosma grandifolia	Large-leaved coprosma	T (M)	T (M)	E	T (M)

Botanical name	Common name	Motutapu	Motuihe	Tiritiri Matangi	Motuora
Coprosma lucida	Shining karamū	E	E	T (M)	T (M)
Coprosma macrocarpa	Coastal karamū	E	T (H)	E	E
Coprosma rhamnoides	Twiggy coprosma	E	T (M)	E	E
Coprosma spathulata	k	T (L)			
Corokia buddleioides	Korokio k	T (L)			
Leptecophylla juniperina	Prickly mingimingi	T (M)	T (M)	E	T (L)
Dacrycarpus dacrydioides	Kahikatea	E	T (M) (p)	E	T (V)
Dacrydium cupressinum	Rimu	T (M)	T (M) (p)	T (L)	T (V)
Dracophyllum latifolium	Neinei k	T (L)			
Elaeocarpus dentatus	Hīnau	E	T (L) (p)	T (L)	T (L)
Freycinetia banksii	Kiekie	E (L)	T (L) (p)	T (L)	T (L)
Fuchsia excortica	Tree fuchsia	T (M)	T (L)	T (M)	T (L)
Griselinia lucida	Puka	E (L)	T (L)	T (L)	T (L)
Halocarpus kirkii	Monoao	T	(p)		
Hebe macrocarpa	Hebe	T (M)	T (M)	T (M)	E
Hedycarya arborea	Pigeonwood	E	E	E	T (M)
Hoheria populnea	Lacebark	E	T (H)	E	E
Lagarostrobus colensoi	Silver pine	T	(p)		
Laurelia novaezelandiae	Pukatea	T (L)	T (L) (p)		
Leionema nudum	Mairehau k	T (L)			
Leucopogon fasciculatus	Mingimingi	T (M)	T (M) (p)	E	T (M)
Libocedrus plumosa	Kawaka	T (L)	T (L) (p)		
Litsea calicaris	Mangeao	E	E	T (M)	T (L)
Lophomyrtus bullata	Ramarama	T (L)			
Melicope simplex	Poataniwha	T (L)			
Metrosideros robusta	Northern rātā	T (M)	T (L)	T (L)	
Myrsine salicina	Toro	T			
Nestegis lanceolata	White maire	E	T (L)	T (L)	T (L)
Nestegis montana	Narrow- leaved maire	T			
Nothofagus truncata	Hard beech	T (M)	T (L) (p)		
Olearia furfuracea	Akepiro	E	T (M)	E	E
Olearia rani	Heketara	T (L)	T (L)	T (L)	T (L)
Ozothamnus leptophyllus	Tauhinu		T (L)	E	T (L)
Pennantia corymbosa	Kaikōmako	T (L)			

Botanical name	Common name	Motutapu	Motuihe	Tiritiri Matangi	Motuora
Phyllocladus trichomanoides	Tānekaha	E k	T (M) (p)	T (L)	
Pittosporum eugenoides	Lemonwood	E (H)	T (L)		
Pittosporum cornifolium	Tawhirikaro	T (L)	T (L)	E	T (L)
Pittosporum tenuifolium	Kōhūhū	E	E	T (L)	T (L)
Plagianthus divaricatus	Salt marsh ribbonwood	E (M)	T (L)		
Plagianthus regius	Lowland ribbonwood	T (L)			
Pouteria costata	Tawapou	E	E	E	T (M)
Podocarpus totara	Tōtara	E	T (M)	E	E
Pomaderris kumeraho	Kūmarahou		T (L)	E	T (L)
Prumnopitys ferruginia	Miro	E	T (L) (p)	T (L)	T (V)
Prumnopitys taxifolia	Mataī	E	T (L) (p)	T (L)	T (V)
Pseudopanax crassifolius	Lancewood	E	T (L)	T (L)	T (L)
Quintinia serrata	Tāwheowheo		T (L) (p)		
Rhabdothamnus solandri	NZ gloxinia	T (H)	T (H)	E	T (M)
Rhopalostylus sapida	Nīkau	E (M)	T (M) (p)	E	T (M)
Schefflera digitata	Patē	E	T (L)	E	T (L)
Solanum aviculare	Poroporo	E	E	T (L)	T (L)
Streblus heterophyllus	Small-leaved milk tree	T (L)	T (L)	E	T (L)
Syzygium maire	Swamp maire	E	T (L) (p)		
Toronia toru	Toru k	T	T (L) (p)		
Weinmannia silvicola	Tōwai	T	T (L) (p)		
Climbers					
Clematis paniculata	White clematis	T (L)	T (L)	E	E
Metrosideros carminea	Crimson rātā	T (L)			
Metrosideros diffusa	White rātā	T (L)	T (L)	T (L)	T (L)
Metrosideros fulgens	Orange rātā	T (M)	T (M)	T (L)	T (M)
Metrosideros perforata	White rātā	T (M)	T (M)	T (M)	T (M)
Muehlenbeckia australis	Pōhuehue	E	E	E	T (L)
Parsonsia heterophylla	NZ jasmine	T (L)	E	E	T (L)
Passiflora tetrandra	NZ passionfruit	T (L)	T (L)	T (M)	T (L)
Ripogonum scandens	Supplejack	E (L)	T (L)	E	T (L)
Rubus australis	Swamp lawyer	T (L)	T (L)	T (L)	
Rubus cissoides	Bush lawyer	T (L)	E	T (L)	T (L)

Botanical name	Common name	Motutapu	Motuihe	Tiritiri Matangi	Motuora
Herbaceous species					
Calystegia tuguriorum	NZ bindweed	E	T (L)	T (L)	T (L)
Einadia triandra	Pigweed	T (L)	T (L)	E	T (L)
Einadia trigonos subsp. trigonos	Pigweed	T (L)	T (L)	E	T (L)
Epilobium rotundifolium	Round-leaved willowherb	T (M)		T (L)	
Linum monogynum	NZ linen flax	E	T (L)	E	T (L)
Peperomia urvilleana	Peperomia	E	E	E	T (L)
Selliera radicans	Selliera	E	T (L)	E	T (L)
Tetragonia implexicoma	Native spinach	E	T (L)	E	T (L)
Coastal monocots					
Astelia banksii	Coastal astelia	T	T	E	E
Astelia grandis	Swamp astelia	T			
Astelia solandri	Perching Lily	T	T	T (L)	T
Astelia trinervia	k	T			
Austrostipa stipoides	Coastal immorality grass	E	T	E	T
Carex flagellifera	Glen Murray tussock	T	E	E	
Carex inversa	Creeping lawn sedge	T	E	E	
Carex lambertiana	Forest sedge	T	E	E	E
Carex ochrosaccus	Forest sedge	T	E	T (L)	
Carex pumila	Sand sedge	T	T	E	E
Carex secta	Pukio	E	T	E	
Carex spinirostris	Coastal sedge	T	T	T (L)	T
Carex testacea	Speckled sedge	E		T (L)	
Cordyline pumilio	Dwarf cabbage tree	T (L)	T (L)	E	T (L)
Austroderia splendens (syn. *Cortaderia splendens)*	Toetoe	T	T	E	T
Drymoanthus adversus	Drymoanthus	T	E		
Elymus multiflora	Blue wheat grass		T	E	T
Gahnia lacera	Cutty grass	T	E	E	E
Gahnia setifolia	Gahnia	T		T (L)	T
Gahnia xanthocarpa	Gahnia k	T	E		
Rytidosperma unarede	Bristle grass	T		T (L)	
Poa anceps	Broad-leaved poa	T	E	E	E
Uncinia uncinata	Hook grass	E	E	E	T

Botanical name	Common name	Motutapu	Motuihe	Tiritiri Matangi	Motuora
Swamp and saltmarsh species					
Apodasmia similis	Oioi	E	T	E	E
Machaerina articulata (syn, *Baumea articulata*)	Jointed twig rush	T			
Machaerina juncea (syn. *Baumea juncea*)	Swamp twig rush	E	T	E	
Machaerina teretifolia (syn. *Baumea teretifolia*)	Common twig rush	E	T		
Bolboschoenus fluviatilis	Marsh clubrush			E	T
Bolboschoenus medianus	Purua grass	T	E		
Carex lessoniana	Cutty grass	E	T	E	E
Carex maorica	Māori sedge	T			
Eleocharis acuta	Sharp spike sedge	T	E	T (L)	
Ficinia nodosa	Knobby club rush	T	E	E	E
Isachne globosa	Swamp millet	T		E	
Isolepis cernua	Slender clubrush	T	E	E	E
*Juncus edgariae (*syn*. J. gregiflorus)*	Wīwī	T	E	E	E
Juncus kraussii var. australiensis (syn*. Juncus maritimus var australiensis*)	Sea rush	T			
Juncus pallidus	Giant rush	E			E
Juncus prismatocarpus		T		E	
Juncus sarophorus	Fan-flowered rush	T		E	E
Juncus usitatus		T	E	E	
Lachnagrostis billardierei	Sand wind grass	T	E	T (L)	
Lemna disperma (syn. *Lemna minor*)	Common duckweed	T	E		
Machaerina sinclairii	Machaerina	T		T (L)	
Schoenoplectus tabernaemontani	Kuawa	T		T (L)	
Triglochin striata	Triglochin	T	E	E	E
Typha orientalis	Raupō	E	T	E	

Appendix C – Threatened and uncommon plants for translocation to four Inner Hauraki Gulf Islands (Motuora, Tiritiri Matangi, Motuihe and Motutapu)

Key

T = to be translocated
E = extant (recorded within last 20 years)
(R) = historical record for the island exists

Threat status: Auckland regional threat status is shown in brackets after national threat status.

National threat status[1]

nc = Nationally critical (91 spp.)
ne = Nationally endangered (45 spp.)
nv = Nationally vulnerable (44 spp.)
de = Declining (83 spp.)
re = Recovering (6 spp.)
rl = Relict (20 spp.)
nu = Naturally uncommon (542 spp.)
nt = Non-threatened
dd = Data deficient (35 spp)

Auckland regional threat status[2]

rc = Regionally critical (77 spp)
re = Regionally endangered (23 spp)
rv = Regionally vulnerable (4 spp)
sd = Serious decline (9 spp)
gd = Gradual decline (11 spp)
sp = Sparse (53 spp)
rr = Range restricted (57 spp)
dd = Data deficient (53 spp)

[1] From de Lange, P. J. et al. 2009. Threatened and uncommon plants of New Zealand (2008 revision). *New Zealand Journal of Botany* 47: 61-96.
[2] From Stanley, R., P. J. de Lange and E. K. Cameron. 2005. Auckland regional threatened and uncommon vascular plants list. Auckland Botanical Society Journal 60(2): 152-7.

Botanical name	Common name	Threat status	Motutapu	Motuihe	Tiritiri Matangi	Motuora	Potential seed source
Poa billardierei (syn. *Austrofestuca littoralis*)	Sand tussock	de(rc)				T	Pakiri beach
Calystegia marginata	Small-flowered white bindweed	nu(rc)				T	Ti Point
Centipeda minima subsp. *minima*	Sneezeweed	nc(rc)		T	T		Kawau Island, Little Barrier Island
Coprosma acerosa	Sand coprosma	de(sd)		T	T	T	Te Arai beach
Clianthus puniceous	Kākābeak	nc(rc)		T	T	T	AC Botanical gardens (Moturemu source)
Dactylanthus taylorii	Wood rose	nv(rc)	T	T (R)	T	T	Little Barrier Island, Coromandel
Desmoschoenus spiralis	Pingao	re(sd)		T		T	Mahurangi West,
Euphorbia glauca	Shore spurge	de(rc)		T (R)	T	T	Brown's Island, Little Barrier Island
Fuchsia procumbens	Creeping fuchsia	nu(rr)	T				

Botanical name	Common name	Threat status	Motutapu	Motuihe	Tiritiri Matangi	Motuora	Potential seed source
Ileostylus micranthus	Green mistletoe	nt(rc)		T (R)	T	T	Mahurangi West, Miranda
Korthalsella salicornioides	Dwarf mistletoe	nu(sp)	T	T	T	T	Little Barrier Island
Lepidium flexicaule	Coastal cress	nv		T		T	AC Botanical Gardens
Lepidium oleraceum	Cook's scurvy grass	nv(re)		T	T	T	AC Botanical Gardens (GBI source)
Picris burbidgeae	Native oxtongue	ne(sd)		T	T	T	Casnell Island, Mokohinau Islands,
Pimelea tomentosa		nv(re)		T		T	Waiheke, Great Barrier
Pimelea longifolia	Long-leaved pimelea	dd(re)					
Pisonia brunoniana	Parapara	re(re)				T	Mahurangi, Mangawhai
Pomaderris amoena	Tauhinu	de		T	E	T	Tiritiri Matangi
Rorippa divaricata	NZ watercress	nv(rc)		T	T	T	Fanal Island
Senecio scaberulus	Native fireweed	nc(rc)		T (R)	T (R)	T	Goat Island, Noises Islands, Ponui Island
Sicyos mawhai	Māwhai	nu(re)		T (R)	T (R)	T	Little Barrier Island, Mokohinau Islands
Tetragonia tetragonioides	NZ spinach	nu(rc)		T	T	T	Rangitoto, Casnell Island
Tupeia antarctica	White mistletoe	de(rc)		T		T	Fanal Island

Appendix D – Nationally and regionally threatened and uncommon species of plants occurring on Tiritiri Matangi Island (Table adopted from Cameron, E. K. and N. C. Davies. In press. Changes in the wild vascular flora of Tiritiri Matangi, 1978-2010. *New Zealand Journal of Ecology* (accepted 2012).)

Nationally threatened	**Threat status**	**Present status on Tiritiri Matangi**
Daucus glochidiatus	Nationally Critical	presumed extinct
Hibiscus richardsonii	Nationally Critical	scarce
Senecio scaberulus	Nationally Critical	presumed extinct
Geranium retrorsum	Nationally Vulnerable	presumed extinct
Juncus pauciflorus	Declining	presumed extinct
Solanum aviculare	Declining	presumed extinct
Regionally threatened		
Plantago raoulii	Regionally Critical	local
Ranunculus acaulis	Regionally Critical	scarce
Schoenus concinnus	Regionally Critical	presumed extinct
Epilobium pedunculare	Regionally Endangered	presumed extinct
Scleranthus biflorus	Regionally Endangered	presumed extinct
Sicyos mawhai	Regionally Endangered	presumed extinct
Ranunculus urvilleanus	Serious Decline	locally common
Elymus multiflorus	Gradual Decline	locally abundant
Geranium solanderi s.s	Gradual Decline	occasional
Myoporum laetum	Gradual Decline	occasional
Planchonella costata	Gradual Decline	locally common
Blechnum norfolkianum	Sparse	local
Einadia triandra	Sparse	locally common
Linum monogynum	Sparse	local
Pelargonium inodorum	Sparse	local
Psilotum nudum	Sparse	scarce
Pteris comans	Sparse	occasional
Senecio quadridentatus	Sparse	local
Tmesipteris sigmatifolia	Sparse	scarce
Wahlenbergia vernicosa	Sparse	local
Dichondra aff. *brevifolia*	Range Restricted	local
Ipomoea cairica	Range Restricted	locally common
Centipeda aotearoana	Data Deficient	presumed extinct
Epilobium billardiereanum	Data Deficient	presumed extinct
Epilobium chionanthum	Data Deficient	presumed extinct
Urtica incisa	Data Deficient	presumed extinct

Appendix E – Habitat requirements of threatened plants recommended for planting around the Visitor Centre on Tiritiri Matangi

Species	Common name	Threat status	Habitat requirements
Calystegia marginata	Small-flowered white bindweed	nu(re)	Scrambles over vegetation in open shrublands and bracken and adjacent track margins.
Centipeda minima subsp. *minima*	Sneezeweed	nc(rc)	Wet or dry sites. Open sparsely vegetated ground, with little competition. On walking tracks and mown areas.
Coprosma acerosa	Sand coprosma	de(sd)	Short coastal scrub on cliffs and sandy areas near beaches.
Clianthus puniceous	Kākābeak	nc(rc)	Short coastal scrub, open or partially open. Coastal cliffs, pond margins, and successional habitats.
Daucus glochidiatus	Native carrot	nc(rc)	Coastal, cliff faces, rocky outcrops, grassland and in open forest.
Euphorbia glauca	Shore spurge	de(rc)	Open coastal cliffs, rocky bluffs, mudstone slopes and sand dunes.
Ileostylus micranthus	Green mistletoe	nt(rc)	Coastal shrublands; main hosts: tōtara, kānuka, *Coprosma propinqua*, mānuka and māpou.
Korthalsella salicornioides	Dwarf mistletoe	nu(sp)	Shrublands and forests; main hosts: mānuka and kānuka.
Lepidium oleraceum	Cook's scurvy grass	nv(re)	Around seabird burrows, on coastal slopes, rocky shorelines and gravel beaches.
Picris burbidgeae	Native oxtongue	ne(sd)	Coastal open ground, gravelled margins of roadsides.
Rorippa divaricata	NZ watercress	nv(rc)	Colonises disturbed ground, track margins and around petrel burrows. Partial shade in forest.
Senecio scaberulus	Native fireweed	nc(rc)	Cliffs, coastal scrub, forest margins and clearings, shaded sites among short grasses, banks near sea.
Sicyos mawhai	Māwhai	nu(re)	Coastal and lowland forest on margins. Scrambler.
Tetragonia tetragonioides	NZ spinach	nu(rc)	Open coastal sites, stable sand dunes and stony beaches.

Threat status: Auckland regional threat status is shown in brackets after national threat status. For key, see **Appendix C**.

Appendix F – Bird species list

Native species that have been successfully translocated
Brown teal (pāteke) – *Anas chlorotis*
Little spotted kiwi – *Apteryx owenii*
Fernbird – *Bowdleria punctata*
North Island kōkako – *Callaeas wilsoni*
Rifleman – *Acanthisitta chloris*
North Island robin – *Petroica longipes*
North Island saddleback – *Philesturnus rufusater*
Red-crowned parakeet (kākāriki) – *Cyanoramphus novaezelandiae*
Stitchbird (hihi) – *Notiomystis cincta*
Takahē – *Porphyrio hochstetteri*
Whitehead – *Mohoua albicilla*

Native species that have been unsuccessfully translocated
Tomtit – *Petroica macrocephala*

Native species that have self-colonized (breeding)
Bellbird – *Anthornis melanura*
Caspian tern – *Hydroprogne caspia*
Common diving petrel – *Pelecanoides urinatrix*
Fluttering shearwater – *Puffinus gavia*
Grey warbler – *Gerygone igata*
Grey-faced petrel – *Pterodroma macroptera*
Little penguin – *Eudyptula minor*
Morepork – *Ninox novaeseelandiae*
New Zealand dotterel – *Charadrius obscurus*
New Zealand kingfisher – *Todiramphus sanctus*
New Zealand pigeon – *Hemiphaga novaeseelandiae*
New Zealand fantail – *Rhipidura fuliginosa*
Paradise shelduck – *Tadorna variegata*
Pied Shag – *Phalocrocorax varius*
Pūkeko – *Porphyrio melanotus*
Red-billed gull – *Larus novaehollandiae*
Reef heron – *Egretta sacra*
Shining cuckoo – *Chrysococcyx lucidus*
Silvereye – *Zosterops lateralis*
Southern black-backed gull – *Larus dominicanus*
Spotless crake – *Porzana tabuensis*
Tūī – *Prosthemadera novaeseelandiae*
Variable oystercatcher – *Haematopus unicolor*
Welcome swallow – *Hirundo neoxena*
White-fronted tern – *Sterna striata*

Native species that visit but do not breed
Australasian harrier – *Circus approximans*

Black shag – *Phalacrocorax carbo*
Little shag – *Phalacrocorax melanoleucos*
Long-tailed cuckoo – *Eudynamys taitensis*
Kākā – *Nestor meridionalis*
Tomtit – *Petroica macrocephala*
White-faced heron – *Egretta novaehollandiae*

Non-native species
Australian magpie – *Gymnorhina tibicen*
Blackbird – *Turdus merula*
Brown quail – *Sinoicus ypsilophorus*
Chaffinch – *Fringilla coelebs*
Common myna – *Acridotheres tristis*
Eastern rosella – *Platycercus eximius*
Goldfinch – *Carduelis carduelis*
Greenfinch – *Carduelis chloris*
House Sparrow – *Passer domesticus*
Skylark – *Alauda arvensis*
Song thrush – *Turdus philomelos*
Starling – *Sturnus vulgaris*
Yellowhammer – *Emberiza citrinella*

Appendix G – Bird species currently considered unsuitable for translocation to Tiritiri Matangi (Please note that SoTM will consider future translocation proposals for these and other species if there is a clear management need.)

Species	Threat status*	Taxonomic status	Reasons for unsuitability
Banded rail	Naturally uncommon	Native	Unacceptable impacts on other species likely.
North Island weka	Nationally vulnerable	Endemic	Unacceptable impacts on other species likely.
Kākāpō	Nationally critical	Endemic	Insufficient habitat for a viable self-sustaining population. High management input.
Cook's petrel	Relict	Endemic	Possibly unsuitable habitat and potential competitor with Pycroft's petrel, which is considered more suitable for Tiritiri Matangi.
New Zealand shore plover	Nationally critical	Endemic	Insufficient and unsuitable habitat. Previous failed translocations to the Hauraki Gulf Region.
New Zealand pipit	At risk, declining	Native	Translocation techniques have not been developed. Resident population in the Hauraki Gulf region will likely colonise any suitable habitat on Tiritiri Matangi.
Black petrel	Nationally vulnerable	Endemic	Insufficient habitat.
Spotted shag	Not threatened	Endemic	Translocation techniques have not been developed. Resident population in the Hauraki Gulf region will likely colonise any suitable habitat on Tiritiri Matangi.
Yellow-crowned parakeet	Not threatened	Endemic	Insufficient suitable habitat. High risk of hybridisation with the large population of established red-crowned parakeet.
North Island kākā	Nationally vulnerable	Endemic	Regular visitors but not known to have bred and resided on Tiritiri Matangi. The Island is not large enough for a viable self-sustaining population and any translocation would require continuing supportive management.
North Island tomtit	Not threatened	Endemic	32 translocated in 2004 but failed for unknown reasons. Habitat might currently be unsuitable and the presence of an established population of the closely related North Island robin might have contributed to the failure. Frequent visitors from other populations within the Hauraki Gulf region. The maturation of coastal forest on the Island might facilitate their establishment.

* Miskelly, C. M., J. E. Dowding, G. P. Elliott, R. A. Hitchmough, R. G. Powlesland, H. A. Robertson, P. M. Sagar, R. P. Scofield and G. A. Taylor. 2008. 'Conservation status of New Zealand birds, 2008.' *Notornis* 55, 117-135. Ornithological Society of New Zealand.

Appendix H – Reptile species considered unsuitable for translocation

Species	Conservation status	Reasons for unsuitability
McGregor's skink	Range restricted	High potential to out-compete other native lizard species, making it an unsuitable species to translocate in the presence of endangered, slow-breeding species.
Chevron skink	Nationally endangered	Found in wet, moist habitat (e.g. streams). Tiritiri Matangi is considered too dry a habitat for the introduction of chevron skink. The required number of individuals could prove difficult to source because of low catch rates experienced in the past.
Striped skink	Data deficient	Striped skinks are not generally found in coastal habitats and most sightings have been in wet/swampy areas, so it is unlikely that Tiritiri Matangi Island would provide for adequate habitat. The required number of individuals could again prove difficult to source because of low catch rates.

Appendix I – The management of biosecurity risks to Tiritiri Matangi

As an open sanctuary, to which visitors have free access via their own boats as well as controlled access via a regular ferry service and other concessions, Tiritiri Matangi is vulnerable to invasive alien species. These are unwanted exotic organisms, including weeds, pest animals (vertebrates and invertebrates) and pathogens that are recognised as being particularly damaging to island ecosystems.[1] Organisms considered invasive are those that are 'agents of change'. If introduced to Tiritiri Matangi they would threaten the Island's biodiversity by domination or disturbance. The most likely threats and the measures taken to deal with them are summarized in the following tables.

Table I.1 Current biosecurity threats and their likely sources

Threat	Source
Plants	• Presence of historic weed species. • Weeds distributed by birds from mainland sites or by wind dispersal. • Weeds introduced via humans – seeds in boots, clothing, packs, equipment, building materials, etc.
Invertebrates	• Argentine ants, known to be dispersed in potting mix/bagged plants, building materials (timber), possibly kayaks and dinghies. Known to be established at Gulf Harbour Marina. • Wasp species – already present.
Vertebrates	• Rodents – from visiting boats, in transported containers. • Rainbow skinks – known to be dispersed in potting mix/bagged plants, possibly in visitors' packs, equipment and building materials. • Birds – dispersal from mainland.
Pathogens	• Avian diseases (e.g. beak-and-feather) carried by birds dispersing from the mainland, or from translocated populations.

Table I.2 Measures taken to mitigate biosecurity threats

Pathways	Mitigation required/in place
Visitors via controlled means (ferry passengers, charters, DOC volunteers, etc.)	• Biosecurity 'gateway' in place at ferry departure points – Biosecurity monitors (SoTM volunteers), in high-visibility branded vests, talk to passengers and check their gear prior to departure. All open bags are searched and sealed inside plastic bags before boarding. • Signs at ferry departure points inform passengers about biosecurity threats. • An information card in several languages is given to passengers when they collect their tickets (and returned to the biosecurity monitors before boarding). • Biosecurity message reinforced over ferry public address after departure for the Island. • Signage at the wharf reinforces biosecurity message. • Visitor awareness of biosecurity threat enhanced through Ranger's speech on arrival. • Overnight visitors are informed of biosecurity requirements when they book accommodation. • Volunteers are informed of biosecurity requirements when they register through DOC. • Biosecurity message is part of preparation for school groups to visit the Island.
Boats	• 'Treasure islands' awareness programme – literature available to public; biosecurity monitor and signage at departure wharves ('customs/border'-styled signs), information to boating organisations in the form of illustrated talks, signage at Island access points (wharf, Hobbs Beach, Northeast Bay). • Biosecurity messages reinforced through Coastguard communication network. • Biosecurity warrant system for commercial vessel and tourism operators.
Wharf	• Ferry company is required to undertake rodent control as part of their concession. • Private boats not permitted to lie alongside the Island's wharf, only to drop off and pick up passengers. • Fixed boot brushes are available for cleaning boots at ferry departure points and on the Island wharf.
Plant sources (nurseries)	• Source future plants from sites free of rainbow skink and Argentine ants, e.g. Motuora.
Freight (vehicles, equipment, building materials, etc.)	• All vehicles, equipment and building materials are subject to sanitary measures (DOC standard). • All stock for the shop and small-scale tools and equipment should be in sealed packages.

Table I.3 Measures in place to deal with incursions of unwanted organisms [2, 3]

Plants	• Weed management – regular weed surveillance and management deals with new incursions as well as weeds already present. For detail see Chapter 8 (above) and the Tiritiri Matangi Weed Control Manual.[4]
Rodents	• Coastal perimeter tracking tunnels and poison (brodifacoum) are in place, monitored monthly by SoTM volunteers. • Incursion kits (traps, tunnels, bait, poison) are kept on the Island for rapid response in case of shipwreck or reported sightings of rodents.
Argentine ants	• Annual monitoring and control in known affected area (see Chapter 7, section 7.3.4 above). • Prevent reintroduction by banning known vector mechanisms where practical (e.g. potting mix, potted plants, except from trusted sources). • Subject all building materials, equipment, etc., brought to the Island, to DOC-standard sanitary measures.
Pathogens	• Animals being translocated to the Island are subject to disease screening/sampling using methodologies approved by DOC.

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