Manaaki Whenua
Landcare Research

Restoration options for Tuamotu Island, Gisborne

Envirolink Grant: 1846–GSDC149

Prepared for: Gisborne District Council

June 2018

Restoration options for Tuamotu Island, Gisborne

Contract Report: LC3212

Beverley R. Clarkson, Robbie Price

Manaaki Whenua – Landcare Research

Reviewed by:	*Approved for release by:*
Sarah Richardson	Gary Houliston
Researcher	Portfolio Leader – Enhancing Biodiversity
Manaaki Whenua – Landcare Research	Manaaki Whenua – Landcare Research

Contents

Summary

Project and Client

- Gisborne District Council contracted Manaaki Whenua – Landcare Research to develop options for the ecological restoration of Tuamotu Island. Although the island has been highly modified, it is of high cultural significance to mana whenua, Ngāti Oneone.

Objectives

- Identify existing ecological values focusing on indigenous vegetation.
- Undertake an on-site visit to assess the current ecological values.
- Develop an ecological restoration management strategy.

Methods

- Vegetation types were delineated on an aerial photo, characteristic species within each type described, and species lists compiled during an on-site visit. These were compared with a previous ecological survey undertaken in 1990.
- Options for restoration were assessed and recommendations provided.

Results

- Eight vegetation types, ranging from secondary native forest and flaxland, to exotic-dominated grassland, herbfield and vineland were mapped and described. Twenty-three native plant species, 46 exotic plant species, and 9 fauna species were recorded.
- Compared with 1990, the native forest type has expanded. However, there has been significant loss of land due to erosion, which, together with expansion and growth of exotic weeds, have resulted in loss of habitat for native species.

Restoration Plan

- Four ecological units (vegetation type and landform) were proposed for restoration.
- Plant species, site preparation, maintenance and monitoring approaches were provided for the two largest ecological units, 1) coastal forest on hillslope and terrace, and 2) whahariki flaxland on steep hillslope.
- Surveillance and control of weeds were the main actions recommended for the two smallest units, 3) sandfield and 4) rockland, which are naturally sparsely vegetated or bare.

Recommendations

- Consult with Ngāti Oneone on mana whenua cultural priorities and aspirations, and refine restoration plan to protect cultural and historic values.
- Identify the presence and abundance of introduced pest animals present on the island.

- Prepare site and control troublesome weed and pest species.
- Plant appropriate eco-sourced species (including threatened species) typical of similar habitats nearby.
- Instigate a site maintenance programme.
- Establish a monitoring programme to assess the effectiveness of the restoration and enable adaptive management approaches.
- Consider enrichment planting at relevant successional stages throughout the planting programme.

1 Introduction

The purpose of this project was to assess the best options for undertaking the ecological restoration of Tuamotu Island. Tuamotu Island is the sole island in the Turanga Ecological District, and, as a pā and urupā (burial site), is of high cultural significance.

There is a co-management arrangement between the Gisborne District Council and Ngāti Oneone who are mana whenua for the island. The local iwi is interested in re-engaging with Tuamotu, which includes its restoration. To achieve that goal, Council and Ngāti Oneone need independent advice as to the most appropriate approaches for long-term ecological restoration of Tuamotu Island.

Gisborne District Council contracted Manaaki Whenua to undertake the vegetation survey, and provide options and approaches for restoration.

2 Background

2.1 Overview

The objective of restoring Tuamotu Island to native vegetation was initiated more than a decade ago when Ngāti Oneone, the Tairāwhiti Polytechnic, Gisborne District Council, and the Department of Conservation formed a trust to reforest Tuamotu Island and provide a safe place for threatened plant species (Phillips 2005).

An archaeological survey in 2005 identified defensive earthworks, middens, and terracing over most of the island, and steep faces and scarps associated with more recent (1880s – 1920s) quarrying on the northern and western sides (Phillips 2005). It also assessed the likely impacts of a proposed planting programme to reforest the island and provided recommendations to minimise adverse effects on historic values.

The Gisborne District Council and Ngāti Oneone co-management arrangement is now developed to the extent that progressing the long-term restoration agreement is possible. This vegetation-based report will contribute to the overall goal of incorporating environmental and cultural aspirations for the long-term restoration of Tuamotu Island.

2.2 Setting

Tuamotu is a small moderately steep-sided island, little more than 2 ha in area, and reaching 38 m above sea level. It is located off Gisborne's Sponge Bay, from which it is accessible by foot at low tide. Soils are classified as Typic Orthic Recent (Land Resource Information Systems https://lris.scinfo.org.nz/), which have developed on erosion-prone Miocene sandstone and mudstone. The topography is characterised by a low terrace to the east, which merges westward into hillslopes of the main ridge to the trig station, and steep to sheer cliffs surrounding most of the island, ranging from 3 to 4 m high at the eastern extremity to 20 m or more at the west.

The island comprises secondary native and exotic vegetation types that have developed following periodic occupation, burning, and farming by Māori, and later, European. It was occupied in 1769 when Captain Cook arrived in Poverty Bay (pā names provided include Uruhangenge: McKay 1966; Ruruhangenge, Ruruhangehange and Rarohau: Phillips 2005). The island has been further modified by quarrying in the late 19th and early 20th centuries, particularly on the north-western and eastern faces, to extract rock used in the construction of Gisborne Harbour (Phillips 2005).

2.3 Previous ecological surveys

Tuamotu Island was identified as a Recommended Area for Protection (RAP) in a Protected Natural Area Programme (PNAP) survey of the Turanga Ecological District undertaken nearly 30 years ago (Clarkson & Clarkson 1991). Vegetation types were mapped and described, and a vascular plant species list compiled. Although dominated by exotic vegetation, pockets of native forest and flaxland indicated the island had high restoration potential.

3 Objectives

- Identify existing ecological values focusing on indigenous vegetation.
- Undertake an on-site visit to obtain an updated baseline survey of the current state of the island's biodiversity (vegetation-based) values.
- Collate and report on the results of the survey, and develop an ecological restoration management strategy identifying the best options for restoration.
- Provide Ngāti Oneone with the survey results and ecological restoration recommendations to enable incorporation of cultural priorities and aspirations, and refinement of the overall restoration plan.

4 Methods

The island was visited on 20 April 2018 to survey the current vegetation and flora. Vegetation types were delineated on an aerial photo, characteristic species within each type described, and species lists of vascular native and exotic plant species compiled. The vegetation types were delineated using Geographic Information System (GIS). Results were with the PNAP survey of Tuamotu Island, visited on 8 April 1990 (Clarkson & Clarkson 1991; BD and BR Clarkson, unpublished data) to assess changes that have occurred over the past three decades. Options for ecological restoration were assessed and recommendations provided.

Figure 1 Tuamotu Island vegetation map. Vegetation Units (Types): 1; Karaka-karo forest, 2; Whahariki-boneseed flaxland, 3; Sandfield, 4; Cocksfoot-tall fescue grassland, 5; Cape ivy vineland, 6; Fennel-whahariki-boneseed herbfield, 7; Blackberry/tall fescue-cocksfoot grassland, 8; Rockland.

5 Results

5.1 Main vegetation types and features

5.1.1 Vegetation map

Eight vegetation types were delineated and described (Fig. 1):

1 Karaka-karo forest, 0.37 ha

2 Whahariki-boneseed flaxland, 0.58 ha

3 Sandfield, 0.02 ha

4 Cocksfoot-tall fescue grassland, 0.01 ha

5 Cape ivy vineland, 0.17 ha

6 Fennel-whahariki-boneseed herbfield, 0.66 ha

7 Blackberry/tall fescue-cocksfoot grassland, 0.11 ha

8 Rockland, 0.44 ha

1 Karaka-karo forest

Karaka (*Corynocarpus laevigatus*) up to 8 m tall dominated the south-western slopes of the island. Karo (*Pittosporum crassifolium*) was a common canopy component, particularly on the margins and in more open areas, and a single large-spreading pohuehue (*Muehlenbeckia australis*) vine was noted. The understory and groundcover layers in the forest proper were relatively bare (Fig. 2), apart from locally abundant patches of kawakawa (*Piper excelsum* subsp. *excelsum*). Seedlings of karaka, karo, and kawakawa occurred on the lower slopes and more open areas, with occasional taupata (*Coprosma repens*), boxthorn (*Lycium ferocissimum*), and blackberry (*Rubus fruticosus* agg.) on the less well-developed forest margins.

A slip on the southernmost edge of the forest was regenerating in a variety of exotic herbs, grasses and shrubs, e.g. tree mallow (*Malva arborea*). Here we found a single individual of ngaio (*Myoporum laetum*) about 1.5 m in height, which probably had been planted. A similar-sized specimen of puka/pukanui (*Meryta sinclairii*) growing nearby was also assumed to have been planted because this species is endemic to Three Kings Islands, northern North Island.

Figure 2 Karaka-karo forest showing bare understory and ground cover layers.

2 Whahariki-boneseed flaxland

The western slopes below the trig station were relatively steep (averaging 45–50°) and clothed in mosaics of mainly whahariki (*Phormium cookianum* subsp. *hookeri*) flaxlands, and boneseed (*Chrysanthemoides monolifera* subsp. *monilifera*) shrublands (Fig. 3). A range of herbs, grasses and shrubs was also present, especially exotics such as tree mallow, prairie grass (*Bromus willdenowii*), cocksfoot (*Dactylis glomerata*), and common vetch (*Vicia sativa*; these plants had died back at the time of survey and identification was not confirmed), with occasional native species including karo, pinatoro (*Pimelea carnosa*), tauhinu (*Ozothamnus leptophyllus*), and tutu (*Coriaria arborea* subsp. *arborea*).

Figure 3 Whahariki-boneseed flaxland on the western slopes below the trig.

3 Sandfield

Small sandy slopes rose gently from the beach to the terrace on the north-eastern margin of the island. These were mostly sparsely vegetated, comprising admixtures of harestail (*Lagurus ovatus*), sea couch (*Elytrigia pycnantha*), boneseed, spinifex (*Spinifex sericeus*), and rauparaha (*Calystegia soldanella*).

4 Cocksfoot-tall fescue grassland

The easternmost part of the island's flat terrace was covered with a range of exotic grasses, especially cocksfoot and tall fescue (*Lolium arundinaceum* subsp. *arundinaceum*), along with wīwī (*Ficinia nodosa*) and tree mallow, growing in the sandy soil. The terrace was edged by low cliffs rising 3–4 m above the beach, which supported occasional iceplant (*Disphyma australe*), boxthorn, rauparaha, and dwarfed plants of taupata (*Coprosma repens*).

5 Cape ivy vineland

Dense carpets of cape ivy (*Senecio angulatus*) up to 1.2 m in height (averaging 80 cm) scrambled over much of the flat terrace west of the Cocksfoot-tall fescue grassland (Type 4). In places the cape ivy cover was so dense that no other species was present (Fig. 4). Occasional planted Norfolk Island pine trees (*Araucaria heterophylla*) up to 12 m in height were emergent above the cape ivy, and other smaller trees and shrubs such as karo, taupata, and boxthorn, grew around the margins.

Figure 4 Cape ivy vineland forms a carpet around a lone Norfolk Island pine.

6 Fennel-whahariki-boneseed herbfield

West of the Cape ivy vineland type, the vegetation was more mixed and dominated variously by fennel (*Foeniculum vulgare*) up to 2 m tall, and patches of whahariki (up to 1.5 m), boneseed, along with occasional cocksfoot, wiwi, cape ivy, harestail, rauparaha, and tree mallow. A few tall planted Norfolk pine and flowering gum trees (*Eucalyptus ficifolia*) emerged above the herbfield, along with occasional karo, taupata, and kawakawa shrubs.

7 Blackberry/tall fescue-cocksfoot grassland

The ridge along the top of the island comprised a mixture of exotic grasses particularly tall fescue and cocksfoot, and patches of blackberry. Dead patches of the annual, flowering pea, were also present. Māori earthworks and ditches running east-west, were observed in this relatively open vegetation type.

8 Rockland

The rock-strewn boulder beach above MHWS and adjoining sheer cliffs, mostly formed from previous quarrying operations, were generally devoid of vegetation.

9 Other features

Several midden sites, as evidenced by abundant shell deposits, occurred on the island, e.g. in the karaka forest and Cape ivy vineland. The ditches noted on the ridgetop blackberry/tall fescue-cocksfoot grassland (Type 7) continued into the adjoining upper slopes of the fennel-whahariki-boneseed herbfield (Type 6), but were obscured by dense vegetation.

Erosion and slipping, were noted in the karaka forest, and to a lesser extent on the cliffsides elsewhere. The potential loss of land is an ongoing threat for the long-term sustainability of the island (see Section 5.5).

Figure 5 Looking westward from Cocksfoot-tall fescue grassland to Cape ivy vineland to Fennel-whahariki-boneseed herbfield to the main ridge. Norfolk pine trees are prominent on the skyline.

Figure 6 Looking eastward from near the summit to the eastern terrace.

5.2 Flora and fauna

5.2.1 Flora

Seventy-six vascular plant species were recorded during the survey: 30 natives and 46 exotics (Appendix 1, 2). None of the native plants is currently classified as threatened (de Lange et al. 2018).

Although the island was dominated by exotic species, probably only a handful could be considered as troublesome. These include cape ivy, boneseed, and boxthorn, which were locally common to widespread in open habitats over the island. Additionally, small patches of blackberry and two small trees of common olive (*Olea europaea* subsp. *europaea*) were present. One individual of tree privet was growing in the northern sector of the Fennel-whahariki-boneseed herbfield, and one clump of pampas occurred in the middle of the Whahariki-boneseed flaxland. Planted exotic trees of Norfolk Island pine, flowering gum, and, to a lesser extent, Chinese windmill palm (*Trachycarpus fortunei*), stood prominent against the skyline (Figs 5, 6). Most of the remaining exotics were early successional low-growing, light-demanding herbs and grasses, which would potentially be outcompeted with restoration and succession to native forest.

5.2.2 Fauna

Although fauna was not a focus of the survey, nine fauna species, comprising 6 natives and 3 exotics, were recorded (Appendix 3). Again, none is currently classified as threatened (Robertson et al. 2017).

Of note were two seabirds (?tītī/grey-faced petrel), which were disturbed from under a boxthorn thicket near the eastern extremity of the Karaka-karo forest (Type 1). In addition, several old bait stations were encountered on the island, indicating previous predator control operations, which were probably established to protect the seabird nests.

Brown garden snails (*Cornu aspersum*) were noted over most of the island, being particularly abundant on tall flower stalks of fennel in the Fennel-whahariki-boneseed herbfield (Type 6; Fig. 7). In addition, large numbers of old empty shells of the snail lay scattered over the ground in most vegetation types.

Figure 7 Brown garden snails clustered on dead fennel flower stalks.

5.3 Vegetation and flora comparisons: 1990–2018

The 1990 survey identified nine vegetation types: karaka forest on hillslope, whahariki flaxland on hillslope, sandfield on sand hillslope, fennel-*Isolepis* (*Ficinia*) herbfield on lower hillslope, *Isolepis*–fennel sedgeland on colluvial toeslope, ice plant herbfield on terrace, fennel-tree mallow herbfield on ridge, cape ivy vineland on terrace, and cocksfoot grassland on terrace. These were delineated on a sketch map, along with the comment that the cliffs were sparsely vegetated or otherwise bare.

Most vegetation types have changed in extent and species composition over the last 3 decades; however, most of these changes are due to successional processes typical of modified secondary vegetation and the limited suite of species available. Changes include:

- significant expansion of the Cape ivy vineland into surrounding herbaceous vegetation types on the eastern terrace.
- expansion of the karaka-dominated forest type in multi-directions from its central core.
- overall growth in height of the tall tree species, e.g. karaka, Norfolk Island pine.

Other changes have been caused by the loss of land due to erosion. The most obvious loss was a narrow extension of the terrace at the eastern extremity, which, in 1990, was dominated by ice plant and used as a sea-bird roost. The ice plant herbfield vegetation type is now absent from the island. In addition, erosion of south-facing cliffs and slopes, which are exposed to the open ocean, is ongoing, e.g. southern slopes in the Karaka-karo forest (Type 1).

There is also evidence of species loss since 1990. Seven native species, recorded in 1990, were not observed in 2018: red bidibid (*Acaena anserinifolia*), New Zealand celery (*Apium*

prostratum subsp. *prostratum*), shining spleenwort (*Asplenium oblongifolium*), *Dichondra repens*, kowaowao (*Microsorum pustulatum* subsp. *pustulatum*), small-leaved pohuehue (*Muehlenbeckia complexa*), and *Poa anceps* (Appendix 1). Some of these could have been casualties of habitat loss and erosion, or outcompeted by other species; however, other 'missing species' may still persist in inaccessible areas.

6 Restoration Plan

6.1 Ecological restoration units

The island would have originally been dominated by coastal forest, apart from sites too steep or unstable to support trees. Non-forest sites would have included relatively steep cliffs, which provide open habitats favoured by herbaceous and shrub species, and loosely consolidated sands, which are typically sparsely vegetated by herbaceous sand dune species. Species compositions would have changed over time, from the Prehuman Zone (Wilmshurst et al. 2013), when sea-birds were a dominant influence, through the Māori Gardening Zone, during which the island was cultivated and managed, to the European Zone, in which large suites of novel plant and animal species were introduced.

Any long-term ecological restoration should aim to re-create a sustainable native ecosystem comprising vegetation types adapted to the environmental conditions provided by each habitat. On Tuamotu, it should also incorporate both cultural and natural ecological systems, given the long history of modification, high cultural significance, and original intention for the island to be a refuge for threatened species (Phillips 2005). We focus on species (including threatened species) that grow naturally in the area, except perhaps for karaka, which was known to be widely planted by Māori as a food source. However, as karaka is currently widespread in the Gisborne district, well-adapted to salt-laden winds and exposed coastal habitats, and a dominant tree on Tuamotu Island, it would be a priority for restoration.

This ecological restoration plan is presented from an ecological perspective. Cultural and archaeological values will need to be incorporated to refine the plan in consultation with Ngāti Oneone to ensure it reflects priorities and aspirations of mana whenua.

The ecological units (EU: vegetation type and/or landform) proposed in the restoration of Tuamotu Island are:

1 Coastal forest on hillslope and terrace (vegetation types 1, 4, 5, 6, 7). Total=1.32 ha;

2 Whahariki flaxland on steep hillslope (vegetation type 2). Total=0.58 ha;

3 Sandfield (vegetation type 3). Total=0.02 ha;

4 Rockland (vegetation type 4). Total=0.44 ha.

Restoration plantings for the main phase of the restoration are recommended for only the first two ecological units (EU1, EU2), with the focus being on weed control for the remaining two units (EU3, EU4). Open, skeletal habitats such as these (EU3, EU4) present a challenge to ecological restoration as they are vulnerable to weed invasions and difficult

to manage without weed control in perpetuity. Restoring adjacent native forest will help reduce propagule pressure but realistically, open habitats close to human settlements will require ongoing management.

6.2 Coastal forest on hillslope and terrace

Most of the restoration effort should be concentrated on re-establishing coastal forest over the island. The selection of plants should be based on species already present on Tuamotu Island, and supplemented by species characteristic of nearby remnants scattered along the coast, including offshore islands (e.g. Pourewa Island, Tolaga Bay, Daniel 1985). As mentioned above (section 5.3), the shorter-statured exotic species should become less of a problem once native forest cover and structure develops. However, some site preparation and weed control, as well as on-going maintenance (see sections 6.6–6.7) will be necessary to maximise restoration success.

Species recorded in the patch of secondary forest patch (vegetation type 1) provide a sound basis for forest expansion and restoration (Table 1). The most important species are karaka and karo; however, ngaio should also be planted (despite only one individual being recorded during the survey) as it has proved to be tolerant of summer droughts in restoration plantings on nearby Kaiti Hill (L. Dickinson, pers. comm. 2018). Ngaio would probably be able to tolerate the drought-prone sandy soils of easternmost extremity of the terrace (Type 4: Cocksfoot-tall fescue grassland) better than most other species plantings. Pōhutukawa (*Metrosideros excelsa*) is another potential species for restoration as it originally grew around Gisborne (Bylsma et al. 2014), and, as an important coloniser of rock faces, it would help mitigate cliff erosion. Species such as taupata and kawakawa should be able to establish naturally as seed sources are already present on the island; however, taupata could usefully be expanded by planting, as it prefers open sites, whereas kawakawa prefers some shelter. Whaririki (*Phormium cookianum* subsp. *hookeri*) would be suitable on the margins of the forest and in more open sites, providing temporary vegetative cover until the forest develops. Other early successional species to consider are rangiora (*Brachyglottis repanda*) and karamu (*Coprosma robusta*), which grow on the nearby cliffs of Tuaheni Point.

Once an initial forest cover is established, after approximately 5–10 years, enhancement planting of later successional species could be considered. This includes understorey species such as kowaowao (*Microsorum pustulatum* subsp. *pustulatum*) and shining spleenwort (*Asplenium oblongifolium*), which were present in the karaka forest in 1991. Other forest species will arrive naturally as the forest develops. For example, since 1990, two new species have arrived in the forest understorey: bird-dispersed putaputaweta (*Carpodetus serratus*; two seedlings noted) and wind-dispersed brake fern (*Pteris tremula;* one small clump).

Enrichment planting using threatened and at risk species (de Lange et al. 2018) that grow (or once grew) naturally in similar habitats in the Gisborne District should also be considered throughout the planting programme. Suitable species include Wairoa koromiko, classified as At Risk – Naturally Uncommon, which occurs close by on Kaiti Hill (Clarkson & Clarkson 1991), raukumara (*Brachyglottis perdicioides*), classified as Threatened – Nationally Critical, which grows at Makarori Beach (Clarkson & Clarkson

1990), as well as turepo (*Streblus banksii*), classified as At Risk – Relict, which is present on Pourewa Island (Daniel 1985). These shrubs prefer open sites with sufficient soil development, e.g. on forest margins or moderate to steep slopes.

Table 1 Recommended species for initial restoration plantings according to ecological unit

Scientific Name	Common Name	Life form	Amount
Coastal Forest on Hillslope/Terrace			
Brachyglottis repanda	Rangiora	shrub	Low
Coprosma repens	Taupata	shrub	Low
Coprosma robusta	Karamu	shrub	Low
Corynocarpus laevigatus	Karaka	tree	High
Metrosideros excelsum	Pōhutukawa	tree	Med
Myoporum laetum	Ngaio	tree	High
Piper excelsum subsp. *excelsum*	Kawakawa, Pepper tree	shrub	Med
Pittosporum crassifolium	Karo	small tree	Med
Whahariki Flaxland on Steep Hillslope			
Coprosma repens	Taupata	shrub	Low
Ozothamnus leptophyllus	Tauhinu	shrub	Med
Phormium cookianum subsp. *hookeri*	Whahariki, Mountain flax	herb	High
Pimelea carnosa	Pinatoro	shrub	Low
Piper excelsum subsp. *excelsum*	Kawakawa, Pepper tree	shrub	Low
Pittosporum crassifolium	Karo	small tree	Low
Veronica stricta var. *macroura*	Koromiko	shrub	Low

6.3 Whahariki flaxland on steep hillslope

Restoration in this vegetation type should be focused on expansion of native species, and removal of troublesome exotics. Plantings of species able to tolerate the thin, drought-prone soils and salt-laden winds are recommended, especially those already present such as whahariki, tauhinu (*Ozothamnus leptophyllus*) and pinatoro. In pockets with more soil development, shrubs such as karo and taupata would be suitable, along with the coastal koromiko, *Veronica stricta* var. *macroura*, which is not on Tuamotu, but grows on coastal cliffs nearby (Table 1).

6.4 Sandfield

As this habitat was very small (0.02 ha), restoration should be concentrated on removal of exotics to allow the native plants adapted to the unstable, drought-prone sandy soils to persist and expand, rather than introducing new plantings. Native sandfield species recorded on Tuamotu Island were spinifex (*Spinifex sericeus*), rauparaha (*Calystegia soldanella*) and wīwī (*Ficinia nodosa*).

6.5 Rockland

This habitat was generally unvegetated and main restoration actions should comprise surveillance for, and removal of, invasive weed species.

6.6 Site preparation

Site preparation before planting is also necessary to ensure success of the plantings and facilitate natural successional processes to native-dominated ecosystems. This includes control of troublesome exotic plant and animal species. The main exotic plant species to be removed, either by hand or chemical control, are cape ivy, blackberry, boneseed, boxthorn, Chinese windmill palm, common olive, flowering gum, Norfolk Island pine, plum, pampas, and tree privet. Some of these species, e.g. cape ivy, boneseed, are already widespread. Others such as tree privet and pampas are limited to a single occurrence; however, most of these species have the potential to spread rapidly and outcompete native plants.

Control of pests is important as plant browsing and seed predation would limit both short-term and long-term restoration success. No information is available on the presence of animal pests, apart from brown garden snails. However, the presence of old bait stations, the proximity of the island to the mainland, and the long history of modification, indicates further investigation is needed to determine what pests live on the island and which may need to be controlled.

The large population of brown garden snails should be controlled at a whole-island scale, either using snail bait operations (organic and non-organic baits are available), or other means. Planting trials of the Threatened Nationally Critical (de Lange et al. 2018) shrub kakabeak (*Clianthus puniceus* incl. *C. maximus*) on the island in the early 1990s by Department of Conservation (Gisborne District Council 2018) were unsuccessful because of intensive browsing by brown garden snails (Shaw & Burns 1997). Some other suggestions to control the snails that could be investigated include the use of hens, or weka (with appropriate mana whenua consultation) for a period before planting.

6.7 Planting and Monitoring

A planting density of approximately one plant per square metre is recommended to achieve rapid cover and reduce future costs for weed control. Planting can be less dense where natives are already growing at the site, e.g. around existing karo and taupata, or in sites such as rock crevices or pockets on steep slopes where soil has accumulated. Plants should be at least 1–1.5 m tall, especially the coastal forest habitat plants, to avoid being overtopped by faster-growing exotic species. Where possible, plants should be eco-sourced from coastal and semi-coastal sites in the Turanga Ecological District, or close by.

Ongoing periodic maintenance of the site will be required after the initial planting, particularly in the first few years. This would be concentrated mainly on weed control, pest control, and plant replacements if necessary. Watering of some plants may also be required during drought periods in the early years of plant establishment. Establishing a

vegetation monitoring programme is recommended to assess the effectiveness of restoration efforts and allow adaptive management as the restoration progresses. This may involve permanently marked vegetation quadrats to monitor success of the plantings, permanently marked photopoints, and other scientific or mātauranga Māori monitoring components.

7 Recommendations

- Consult with Ngāti Oneone on mana whenua cultural priorities and aspirations, and refine restoration plan to protect cultural and historic values.
- Identify pest animal presence and abundance to inform establishment of a relevant pest control programme.
- Prepare site and control troublesome weed and pest species
- Plant appropriate eco-sourced species (including threatened species) typical of similar habitats in the Turanga Ecological District or southern parts of the adjacent Waiapu Ecological District.
- Instigate a site maintenance programme, and preferably a restoration project manager to oversee and organise restoration activities and reporting.
- Establish a monitoring programme to assess the effectiveness of the restoration and enable adaptive management approaches.
- Consider enrichment planting at relevant successional stages throughout the planting programme, e.g. late successional species can be introduced once coastal forest cover has been established.

8 Acknowledgements

We thank Dionne Hartley, Gisborne District Council and Don McLean, Gisborne District Council/Department of Conservation for assistance in the field, and Cliff Blumfield, Wainui Dive, for providing boat transport to the island. We also thank Murry Cave, Gisborne District Council, who organised the project and supplied aerial photos, Bruce Clarkson, University of Waikato, and Sarah Richardson, Manaaki Whenua – Landcare Research who reviewed and improved the report, and Anne Austin, Manaaki Whenua – Landcare Research who edited the final draft.

9 References

Atkinson IAE 1985 Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand. New Zealand Journal of Botany 23: 361–378.

Bylsma RJ, BD Clarkson BD, & JT Efford JT 2014. Biological flora of New Zealand 14: *Metrosideros excelsa*, pōhutukawa, New Zealand Christmas tree, New Zealand Journal of Botany 52(3): 365–385.

Clarkson BD, Clarkson BR 1990. New plant records from the Gisborne Land District. Rotorua Botanical Society Newsletter 19: 17–23.

Clarkson BR, Clarkson BD, 1991. Turanga Ecological District. New Zealand Protected Natural Areas Programme No. 14. Gisborne, Department of Conservation. 131 p. ISBN 0-478-01276-4.

Daniel L 1985. Pourewa Island, East Coast, North Island. Rotorua Botanical Society Newsletter 5: 24–34.

de Lange PJ, Rolfe JR, Barkla JW, Courtney SP, Champion PD, Perrie LR, Beadel SM, Ford KA, Breitwieser I, Schönberger I, Hindmarsh-Walls R, Heenan PB, Ladley K 2018. Conservation status of New Zealand indigenous vascular plants, 2017. New Zealand Threat Classification Series 22. Wellington, Department of Conservation.

Druce AP 1980. Trees, shrubs, & lianes of New Zealand (including wild hybrids). Lower Hutt, Botany Division, DSIR. 87 p.

Gisborne District Council 2018. Tairawhiti Reserve Management Plan: G11 Schedule: Protection Management Areas. Gisborne, Gisborne District Council http://www.gdc.govt.nz/assets/Tairawhiti-Plan/TRMP-Schedules/G11-Schedule.pdf accessed 18 June 2018.

MacKay JA 1966. Historic Poverty Bay and the East Coast, North Island, New Zealand. 2nd edn. Gisborne, JG MacKay.

Phillips KJS 2005. Archaeological survey of Tuamotu Island, Gisborne. Napier, Department of Conservation.

Robertson HA, Baird K, Dowding JE, Elliott GP, Hitchmough RA, Miskelly CM, McArthur N, O'Donnell CFJ, Sagar PM, Scofield RP, Taylor GA 2017. Conservation status of New Zealand birds 2016. New Zealand Threat Classification Series 19. Wellington, Department of Conservation.

Shaw WB, Burns BR 1996. The ecology and conservation of the endangered endemic shrub, kowhai-ngutukaka *Clianthus puniceus*. Biological Conservation 81: 233–245.

Wilmshurst JM, Moar N, Wood J, Bellingham P, Findlater AM, Robinson JJ, Stone C 2013. Use of pollen and ancient DNA as conservations baselines for offshore islands in New Zealand. Conservation Biology 28: 202–212.

Appendix 1 – Tuamotu Island Native Vascular Plant Species List

Scientific Name	Common Name	Life Form
Acaena novae-zelandiae (C&C 1991)	Red bidibid	Herb
Apium prostratum subsp. *prostratum* (C&C 1991)	NZ celery	Herb
Asplenium oblongifolium (C&C 1991)	Shining spleenwort	Fern
Calystegia soldanella	Rauparaha, Shore bindweed	Climber
Carpodetus serratus	Putaputaweta, Marbleleaf	Tree
Coprosma repens	Taupata	Small tree
Coriaria arborea var. *arborea*	Tutu	Small tree
Corynocarpus laevigatus	Karaka	Tree
Dichondra repens (C&C 1991)	Dichondra	Herb
Disphyma australe subsp. *australe*	Horokaka, NZ iceplant	Herb
Epilobium nummulariifolium	Creeping willowherb	Herb
Ficinia nodosa	Wiwi, Knobby clubrush	Sedge
Haloragis erecta subsp. *erecta*		Subshrub
Meryta sinclairii (planted)	Puka	Tree
Microsorum pustulatum subsp. *pustulatum* (C&C 1991)	Kowaowao, Hound's tongue	Fern
Muehlenbeckia australis	Pohuehue	Climber
M. complexa (C&C 1991)	Small-leaved pohuehue	Climber
Myoporum laetum	Ngaio	Tree
Ozothamnus leptophyllus	Tauhinu	Shrub
Phormium cookianum subsp. *hookeri*	Whaririki, Mountain flax	Herb
Pimelea carnosa	Pinatoro	Shrub
Piper excelsum subsp. *excelsum*	Kawakawa, Pepper tree	Tree
Pittosporum crassifolium	Karo	Tree
Poa anceps (C&C 1991)	Broad-leaved poa	Grass
Pseudopanax sp. (nursery hybrid)		Shrub
Pteris tremula	Shaking brake fern	Fern
Rytidosperma gracile		Grass
Senecio lautus	Shore groundsel	Herb
Solanum laciniatum	Poroporo	Shrub
Spinifex sericeus	Kowhangatara, Spinifex	Grass

C&C 1991: recorded in Clarkson & Clarkson (1991), but not seen in the 2018 survey

Life form categories follow Atkinson (1985) and Druce (1980)

Appendix 2 – Tuamotu Island Exotic Vascular Plant Species List

Scientific Name	Common Name	Life Form
Anagallis arvensis subsp. *arvensis*	Scarlet pimpernel	Herb
Araucaria heterophylla (planted)	Norfolk Island pine	Tree
Atriplex prostrata	Orache	Herb
Brassica rapa var. *deifora*	Wild turnip	Herb
Bromus willdenowii	Prairie grass	Grass
Catapodium rigidum	Hard grass	Grass
Chrysanthemoides monolifera subsp. *monilifera*	Boneseed	Shrub
Cirsium arvense	Californian thistle	Herb
Cirsium vulgare	Scotch thistle	Herb
Cortaderia selloana	Pampas	Grass
Dactylis glomerata	Cocksfoot	Grass
Elytrigia pycnantha	Sea couch	Grass
Erigeron sumatrensis	Broad-leaved fleabane	Herb
Eucalyptus ficifolia (planted)	Flowering gum	Tree
Euphorbia peplus	Milkweed	Herb
Foeniculum vulgare	Fennel	Herb
Galium aparine	Cleavers	Herb
Gamochaeta coarctata	Common cudweed	Herb
Geranium molle	Dove's foot cranesbill	Herb
Helminthotheca echinoides	Oxtongue	Herb
Hypochaeris radicata	Catsear	Herb
Lagurus ovatus	Harestail	Grass
Ligustrum lucidum	Tree privet	Tree
Lolium arundinaceum subsp. *arundinaceum*	Tall fescue	Grass
Lycium ferocissimum	Boxthorn	Shrub
Malva arborea	Tree mallow	Herb
Olea europaea subsp. *europaea*	Common olive	Tree
Orobanche minor	Broomrape	Herb
Oxalis pes-caprae	Bermuda buttercup	Herb
Phytolacca octandra	Inkweed	Herb
Plantago lanceolata	Narrow-leaved plantain	Herb
Plantago major	Broad-leaved plantain	Herb
Polycarpon tetraphyllum	Allseed	Herb
Prunus X domestica	Plum	Tree
Ranunculus sp	Buttercup	Herb
Rubus fruticosus agg.	Blackberry	Shrub

Senecio angulatus	Cape ivy	Climber
Senecio glastifolius	Pink ragwort, Holly-leaved senecio	Herb
Solanum nigrum	Black nightshade	Herb
Sonchus arvensis	Perennial sow thistle	Herb
Sonchus oleraceus	Sow thistle	Herb
Sporobolus africanus	Ratstail	Grass
Stellaria media	Chickweed	Herb
Symphyotrichum subulatus	Sea aster	Herb
Trachycarpus fortunei	Chinese windmill palm	Palm
Vicia sativa (annual – no live foliage)	Common vetch	Climber

Appendix 3 – Tuamotu Island Fauna Species List

Scientific Name	Common Name	Biostatus
Apis mellifera	Honey bee	Exotic
Cornu aspersum	Brown garden snail	Exotic
Fringilla coelebs	Chaffinch	Native
Polistes chinensis	Paper wasp	Exotic
Pterodroma macroptera gouldi?	Tītī, Grey-faced petrel?	Native
Rhipidura fuliginosa	Pīwakawaka, New Zealand fantail	Native
Sterna striata	Tara, White-fronted tern	Native
Vanessa gonerilla	Red admiral butterfly	Native
Zosterops lateralis	Silvereye	Native