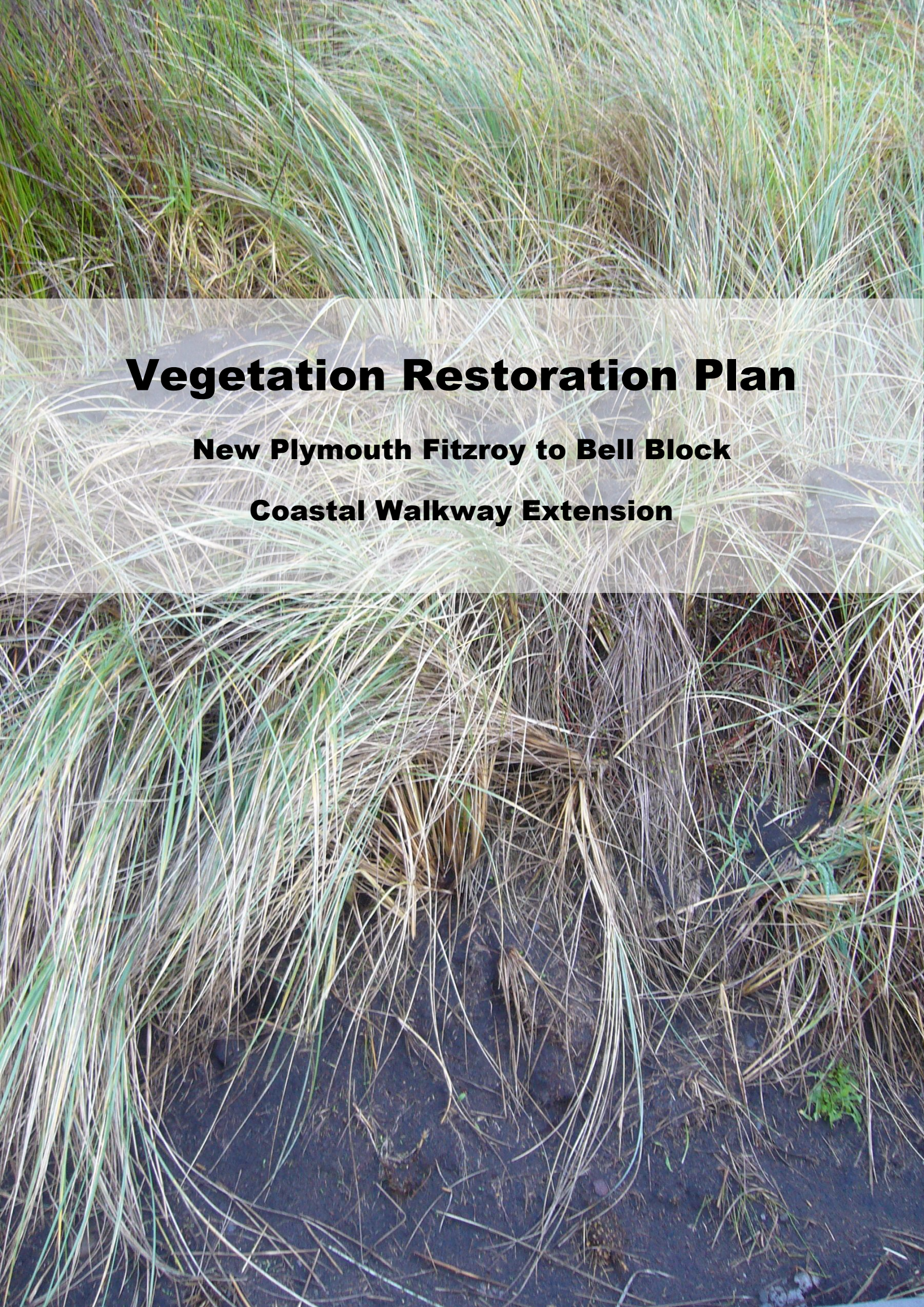

Vegetation Restoration Plan

New Plymouth Fitzroy to Bell Block

Coastal Walkway Extension

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New Plymouth Fitzroy to Bell Block Coastal Walkway Extension

CBER Contract Report 125

Client report prepared for

New Plymouth District Council

by

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THE UNIVERSITY OF WAIKATO
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Executive Summary

In 1999, the New Plymouth District Council began construction of its award winning coastal walkway. Along with providing an area for recreation, this new walk and cycle path serves as an alternate route for commuting along the city away from arterial roads. The New Plymouth District Council is in the process of extending this walkway a further three kilometres from Fitzroy Motor Camp to Ellesmere Avenue, Bell Block. This will encompass Peringa Park, Hickford Park and the Mangati Walkway, with completion expected by mid 2010. As part of this $4.2 million project, the District Council aims to restore the surrounding native duneland vegetation. The Centre for Biodiversity and Ecology Research (University of Waikato) was contracted by the New Plymouth District Council to provide a vegetation restoration plan for the Fitzroy to Bell Block section of the coastal walkway. This report considers the current vegetation of this three km section of the walkway, based on a rapid qualitative assessment undertaken in June, 2010. The target ecosytems *Spinifex* sandfield, flax-taupata shrubland and coastal forest vegetation types once dominant in the area are described in detail. Restoration recommendations are included to assist in the recreation of these ecosystems, including planting zones, weed control strategies and ongoing monitoring objectives.

Introduction

The north-eastern New Plymouth coast has undergone extensive loss of sand dune habitat since 1889. Primary drivers for this include reduced sand inputs along the coast (sand extraction activities), destabilisation of active duneland via removal of vegetation and frequent levelling of duneland for farming and residential development (Gibb 2003). The three kilometre section of the proposed walkway extension consists of Holocene dunes that formed around 6500 years ago, and have since eroded at an estimated rate of one to two metres per year (Gibb 2003). To offset dune erosion, marram grass (*Ammophila arenaria*) was introduced into New Zealand in 1870, as it is a more aggressive dune coloniser than the native sand binders. Later, tree lupin and macrocarpa (*Cupressus macrocarpa*) were extensively planted to achieve secondary and tertiary cover on the dunes, provide shade, and counter the nitrogen deficiency of the soils (Whitehead 1964). However, these species have since become serious threats to the distribution of the indigenous duneland vegetation. Since the early 1900's an estimated 70% of active duneland and associated indigenous vegetation has been lost in New Zealand (Cockayne 1911; Hilton 2006). Due to considerable agricultural development of the immediate coast and the prevalence of volcanic conglomerate cliffs, Taranaki has one of the most reduced dunelands in New Zealand (Partridge 1992). Taranaki dunelands represent a unique assemblage of species of high priority for conservation and restoration.

Historical botanical accounts

Several historical accounts of vegetation in the New Plymouth area are available, beginning with Dieffenbach's (1843) 'Travels in New Zealand'. He described the coastal lagoon and cliff vegetation of Paritutu and the Sugarloaf Islands. Buchanan (1869) also briefly documented the flora of these islands in his botanical description focused on a visit to Mt Taranaki. An early settler of the region, Harry Kitchingman, outlined a historical account of the dominant species of the Mt. Taranaki ringplain (1898 – 1923) based on his experience as a bush feller. Cockayne (1909, 1911 & 1922) undertook extensive vegetation surveys of the coastal dunelands and surrounding vegetation. Druce (1972) surveyed the vascular flora of the Western

Taranaki coast between Waitara and Hawera. McGlone (1980) and Wilmshurst *et al.* (2004) used pollen and macrofossil records to determine vegetation composition prior to human arrival on Mt Taranaki and the coastal region of Northern Taranaki.

Based on these accounts, the vegetation present before European settlement (after some modification via Maori settlement impacts) comprised of coastal shrubland on the steeper shores and dune cliffs and coastal forests found further inland. The dominant shrubland species were flax (*Phormium tenax*), toetoe (*Austroderia fulvida* and *C. toetoe*), taupata (*Coprosma repens*), cabbage tree (*Cordyline australis*), karamu (*Coprosma robusta*), karo (*Pittosporum crassifolium*), stunted kohekohe (*Dysoxylum spectabile*), rangiora (*Brachyglottis repanda*), karaka (*Corynocarpus laevigatus*), ngaio (*Myoporum laetum*) and bracken (*Pteridium esculentum*). Other species present include koromiko (*Hebe stricta var. macroura)*, coastal tree daisy (*Olearia solandri*), tauhinu (*Ozothamnus leptophyllus*) and *Corokia cotoneaster*. Ground cover included interspersed sweet fern (*Pteris macilenta*), *Poa anceps,* bristle grass (*Rytidosperma unarede*), gully fern (*Pneumatopteris pennigera*), shining spleenwort (*Asplenium oblongifolium*), sand coprosma (*Coprosma acerosa*) and herbs such as sea celery (*Apium prostratum*), toatoa (*Haloragis erecta)* and rauhuia (*Linum monogynum*).

Additional species found in forests further inland included kawakawa (*Macropiper excelsum*) and mahoe (*Melicytus ramiflorus*) (Kitchingman unpub.), pigeonwood (*Hedycarya arborea*), hangehange (*Geniostoma ligustrifolium*), puriri (*Vitex lucens*) and whau (*Entelea arborescens*).

In swamps and lagoons, the bulrushes raupo (*Typha orientalis*) and kuawa (*Schoenoplectus tabernaemontani*) dominated the littoral zone, with various sedges and reeds including *Ficinia nodosa*, kuta (*Eleocharis sphacelata*), giant rush (*Juncus pallidus*), sharp spike sedge (*Eleocharis acuta*), oioi (*Apodasmia similis*), *Carex virgata, C. secta, C. flagellifera* and *C. germinata*. Toetoe, cabbage tree, flax, karamu, mamaku tree fern, whau, kiokio (*Blechnum novae-zealandiae* and *B. minus*) and kotukutuku (*Fuchsia excorticata*) dominated the interface between reedland and coastal shrubland.

Active duneland vegetation was dominated by the ‘sand binders’ spinifex (*Spinifex sericeus*), pingao grass (*Desmoschoenus spiralis*), sand sedge (*Carex pumila*),

toetoe and sand convolvulus (*Calystegia solanella*). Other species present (the 'sand collectors' of Cockayne 1911) included sand coprosma (*Coprosma acerosa*), sand daphne (*Pimelea* aff. *arenaria*), tauhinu and *Ficinia nodosa*. In addition the Taranaki foredunes supported the native ice-plant and shore groundsel (*Senecio lautus* subsp. *lautus)*. Exposed rocky shores contained prostrate taupata, pohuehue, flax, the native ice-plant (*Disphyma australe* subsp. *australe*), New Zealand lobelia (*Lobelia anceps*), *Poa anceps* and coastal shrubland vegetation.

Reference Ecosystems:

The Maitahi Scenic Reserve

A reference ecosystem is an invaluable tool when guiding restoration efforts and ideally provides information on what species and communities can be considered for reintroduction. The Maitahi Scenic Reserve (just south of New Plymouth), is one of the few remaining representations of northern Taranaki coastal forests, once found right along the immediate coastal strip. This small reserve, approximately 0.75 ha in extent, is located 18 km southwest of New Plymouth. A survey undertaken in 1980 (Clarkson & Boase 1982), noted the reserve contains some species now uncommon in the district including the native angelica (*Scandia rosifolia*) and *Peperomia urvilleana.* The reserve consists of rocky shores surrounded by cliff vegetation, two laharic promontories and a swampy area. Maitahi provides good examples of indigenous shrub and wetland vegetation but contains no active duneland vegetation. The six main vegetation types present are:

1. Karaka-taupata/flax
2. Taupata-flax-gorse
3. Flax-gorse
4. Raupo-flax-karamu-toetoe
5. Boxthorn-taupata/flax-gorse
6. Pasture

Vegetation types 1 and 4 represent more intact indigenous vegetation likely once found on sloping and swampy areas in the coastal walkway extension area.

Waipu Lagoons

The Department of Conservation has listed these spring-fed wetlands (Fig. 1) as a Protected Natural Area due to their wildlife values (New Plymouth District Council 2008). Druce (1972) documented the native vegetation found at these lagoons between 1964 and 1973, later revising this in 1989. Native vegetation present on the edges of the lagoons include the sedges *Baumea rubiginosa*, *Carex secta, C. virgata, Eleocharis acuta* and *E. sphacelata*, with *Juncus planifolius, Isachne globosa*, raupo and flax. Other species found in the riparian zone included cabbage tree, taupata, kawakawa, mahoe*, Azolla filiculoides*, kiokio, swamp kiokio, the mamaku tree fern, *Hypolepis ambigua, Calystegia sepium, Muehlenbeckia australis* and *Cotula australis.* Species recorded as present but uncommon included karamu, pohuehue, umbrella sedge, *Schoenus maschalinus*, *Juncus edgariae, J. prismatocarpus,* wheki, *Diplazium australe, Pteris tremula,* toetoe and the herbs *Centella uniflora, Epilobium pallidiflorum*, *Gratiola sexdentata, Haloragis erecta, Hydrocotyle pterocarpa* and *Solanum americanum.*

Figure 1 Waipu lagoon is useful as reference ecosystem as it contains many of the indigenous species typically found in the area.

Area of Proposed Extension

The proposed coastal walkway extension has previously been conveniently divided into eight sectors for reporting purposes by the District Council. We used this same approach when conducting our rapid survey. Sectors 1 and 2 begin at Hickford Park, Bell Block, and include the Waipu Lagoons, dairy pasture, two private forest plantations and a large section of coastal strip. Sector 3 contains council plantings and area currently farmed (dairy). Sectors 4 and 5 are a thin coastal strip adjacent to the Bell Block golf course. Sectors 6 and 7 include the Peringa Park, Lake Rotomanu and the Waiwhakaiho River delta and lagoons. Sector 8 contains a larger duneland area that extends to Fitzroy Motor Camp. Sector 0 refers to the land north of sector 1 extending to Ellesmere Avenue at the Bell Block end. This sector incorporates the oxidation ponds, extensive duneland vegetation, dairy pasture and the Mangati Walkway and is part of the proposed long-term extension to Waitara.

In 1987 the District Council initiated protection of the coastal duneland in sectors 1, 2 and 3 and implemented a planting and dune stabilisation project (Hickford Park Management Plan 1991). No other section of the walkway is officially protected, although this is under consideration for sector 8 (Coastal Reserves Management Plan 2008). Sectors 6 and 7 involve areas containing council parks development planting including wetland planting around the Waiwhakaiho Lagoons, the western inlet into Lake Rotomanu, carpark areas and the existing parkland vegetation.

The geology of this area is uplifted marine terrace covered in Egmont derived Tephra (Bayfield & Benson 1986). Sectors 0 and 8 represent relatively large sand dune areas but show little form, with some evidence of transverse sequences in sector 8 (Gibb 2003). Sand is the dominant feature of both soils and shores in the surveyed area (see soils map in Appendix B). A strip of gravel beach runs from sector 1 to sector 4, with the remainder of the beaches consisting of sand. The areas of active sand dunes have no soil profile as the instability of the land prevents any from forming. Small amounts of organic matter can be found in these areas from the plant cover. Active sand dunes are unstable, highly drained and contain low levels of nutrients.

The major soil type of the area is Patea Sand (Roberts & Jarman 1954). This is a young soil classed as a typic sandy brown soil (Hewitt, 1998). The soil profile is 15-45 cm deep atop grey dune sand. On the flat to rolling land above the sand dunes the soil transitions into New Plymouth brown loam (Roberts & Jarman 1954). It is a vitric orthic allophanic soil (Hewitt, 1998). Along with sand this soil also contains high amounts of weathered volcanic ash, creating an allophanic soil. This soil is slightly more impermeable and higher nutrient levels than Patea Sand. Soils and sand washed down from surrounding hills make up the alluvium soil found adjacent to the river. This soil has high nutrient levels and is slower draining then the surrounding soils due to higher levels of silt and clay and the low water table (Roberts & Jarman 1954).

Replace map so it contains; city context (Bell block and Fitzroy), zone outlines and landscape features (Waiwhakaiho Lagoons/river, Lake Rotomanu, Waipu Lagoons, Hickford Park, Peringa Park, Bell Block golf course etc.).

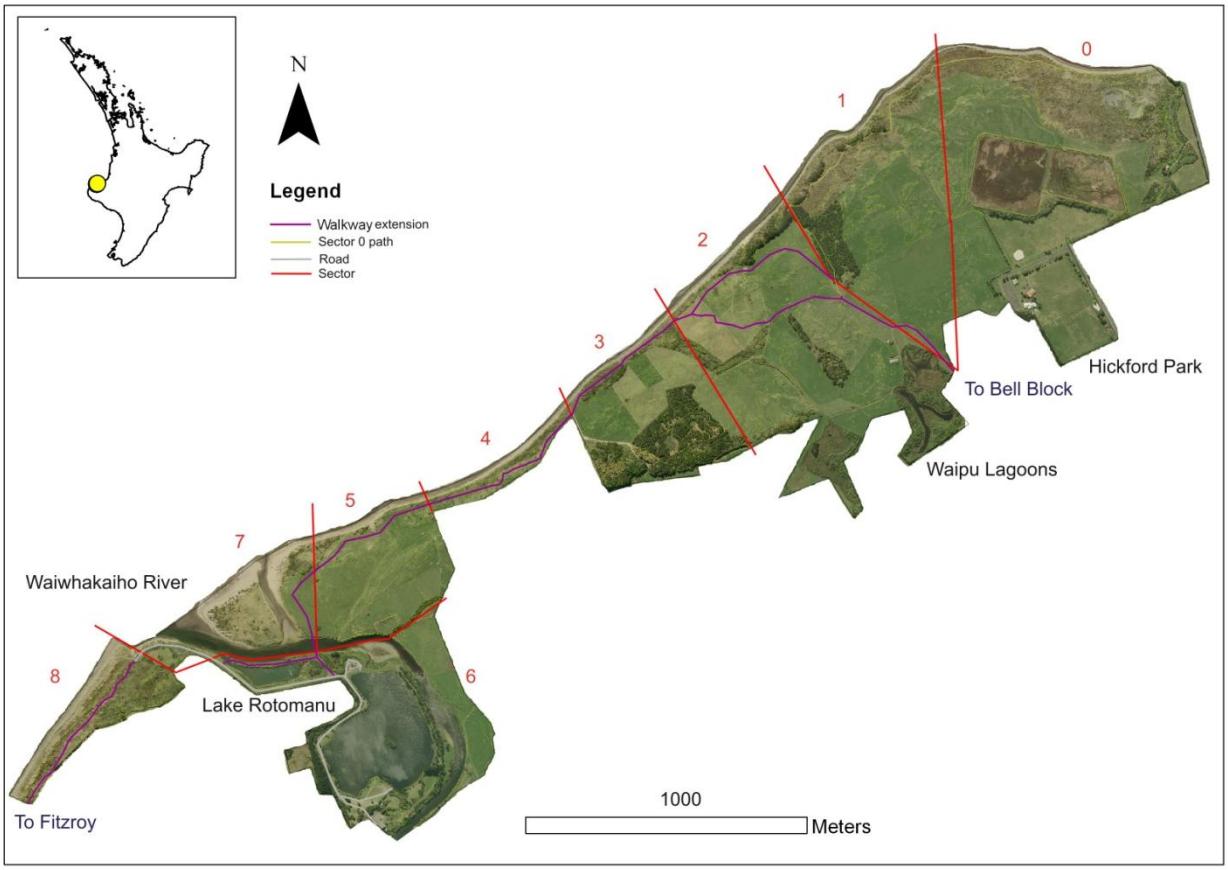

Figure 2 Coastal walkway extension area showing the zones utilised by the District Council.

Rapid Qualitative Vegetation Assessment

Flora

Rapid vegetation surveys were conducted at each sector on the 29th and 30th of June, 2010, to describe the broad vegetation types present, identify problem weed species and provide a comprehensive species list. During the rapid surveys, 114 species were noted (species list, Appendix 1). The majority (60%) of species were exotic. Of these, 60% were found in more than one sector. Yellow tree lupin, German ivy and kikuyu grass were found in every sector. Marram grass, pampas, exotic ice-plant, boxthorn, inkweed, *Pinus* spp., *Solanum* spp., blackberry, coast banksia, gorse and pasture species were also widespread. Widespread natives included taupata, flax, spinifex, karo, pohuehue, cabbage tree, mamaku tree fern, *Ficinia nodosa*, kawakawa, pohutukawa (planted) and sand convolvulus.

Historical records indicate pohutukawa's southern limit occurs around Mimi (Kirk 1889) or Urenui (Allan 1961; Cheeseman 1906), and the species has probably never naturally occurred in the extension area. However, planting of this species is popular with the public and existing District Council plantings in the Mangati Walkway include pohutukawa of unknown provenance. Any future planting of pohutukawa should include individuals of known local provenance that are ideally propagated from older individuals in remnants North of Mimi (Simpson 1997).

Vegetation

1. Spinifex sandfield

Found on the large foredune areas, good examples are found in sectors 1 and 8. At times, this vegetation type is co-dominant with *Ficinia nodosa*, pasture, marram grass or patches of kikuyu grass. Other native species found include taupata (often prostrate), small flax, cabbage tree, karo, pohuehue, sand convolvulus and New Zealand spinach. Potentially problematic species include the exotic ice-plant (*Carpobrotus edulis*) which forms mono-specific patches, smothering other species, and the nitrogen fixers, gorse and lupin, which alter soil attributes. Boxthorn and pampas are potentially displacing the native range of taupata and toetoe respectively. Marram grass, kikuyu grass and pasture species have substantially invaded this

vegetation type and German ivy and yucca are common in places. Other weeds present include gravel groundsel, blackberry and fennel.

2. *Ficinia nodosa* sandfield

Present extensively in the dunelands and backswamps of sectors 0 and 8, but also occurs adjacent to the boulder beaches and in council plantings. On the active dune, associates include spinifex, kikuyu grass, marram grass and exotic ice-plant. Prostrate taupata, pampas, windshorn boxthorn and flax co-exist on the rocky shore and flax, pasture spp., German ivy, broomrape, blackberry, pohutukawa, karo, cabbage tree, pampas and exotic shrubs share the consolidated duneland and backswamp areas. *Ficinia nodosa* is also present co-dominant with oioi (*Leptocarpus similis*) in a small council carpark planting (sector 6) with interspersed *Carex* spp., umbrella sedge and exotic pasture species.

3. Pohuehue-kikuyu grass sandfield

Found on the stabilised foredunes (sectors 3 and 4 and sector 7) at the southern edge of the delta. Native associates include *Spinifex*, sand convolvulus, flax, *Ficinia nodosa*, prostrate taupata, small boxthorn with pohutukawa and hybrid *Psuedopanax* spp. occurring at the interface with shrubland. Problem species include marram grass, kikuyu grass, pasture spp., boxthorn, exotic ice-plant and yucca.

4. Pasture

Present in all sectors coinciding with agricultural, recreational and residential development. Range is restricted on the foredune (only sheltered micro-sites). Common species include Yorkshire fog, tall fescue, fleabane, sorrel, kikuyu grass, catsear, paspalum, mercer grass, dandelion, spurrey, catchfly, narrow-leaved plantain, milkweed, lotus, medick, sow thistle, cocksfoot, clover, harestail, hawbit, hawksbeard, sweet vernal, nasturtium (estuary), bracken and *Ficinia nodosa*.

5. Flax shrubland

Found as a result of council enhancement or reconstructive plantings around wetland areas and along the narrow coastal strip (sectors 3 and 4). Other indigenous species present include cabbage tree, pohuehue, karo, taupata, sand convolvulus, bracken, *Ficinia nodosa*, kawakawa, hybrid *Pseudopanax* spp. and pohutukawa.

Exotic species include German ivy, blackberry lupin, pampas, gorse, boxthorn, woolly nightshade and pasture species. Infrequent self seeding banksia, *Pinus* spp. and Lawson's cypress also occur.

6. Exotic shrubland

The dominant species are boxthorn, lupin, gorse and pampas occurring together or in monospecific patches. Found in sheltered sites on the consolidated dunes (leeward sides of the foredune and on the backdunes). This vegetation has likely replaced the native equivalent of taupata-flax shrubland. Native species found here include *Spinifex*, cabbage tree, pohuehue, flax, karo (co-dominant in sectors 0 & 2), hybrid *Pseudopanax* spp., taupata, pohutukawa, kawakawa, ngaio and *Ficinia nodosa*. Problem species include exotic grasses), blackberry, German ivy, *Solanum* spp., agapanthus, inkweed, yucca, wild *Pinus* spp. and isolated sightings of oleander, wild broom, Brazilian pepper and wandering Jew (sector 7).

7. Ngaio shrubland

Ngaio dominant vegetation occurs as a result of council plantings (sectors 2 and 6), as well as some natural regeneration within exotic shrubland (sector 2). Council plantings (sector 2) consist of a fenced off riparian strip extending from the sea inland almost to the Waipu Lagoon with a predominantly flax and kawakawa understorey. Cabbage tree, karo, mamaku tree fern, pohutukawa, mahoe, macrocarpa, Norfolk pine, gorse, lupin, *Solanum* spp., banksia, pampas, pohuehue, blackberry and German ivy were also found here. Sector 6 plantings include ngaio-taupata/kawakawa shrubland with small amounts of karo and cabbage and German ivy growing over the shrubs.

8. Waipu lagoons mixed shrubland

Vegetation surrounding the wetland includes cabbage tree, karamu, kawakawa, flax, pohutukawa, ngaio, taupata, karaka, *Olearia solandri*, karo and *Psuedopanax* sp. Ferns present include silverfern, mamaku and kiokio. Camellia, *Hebe* sp., *Prunus* sp. and arum lily were found, probably due to the proximity of residential gardens. Staggerweed, blackberry, black nightshade, pasture species and German ivy were also common.

9. Wetland

This vegetation was present surrounding coastal lagoons and small wetland areas (sectors 1, 6, 7 & 8). The littoral zone is typically raupo reedland with varying associates such as giant rush (*Juncus pallidus*), tapertip rush (*Juncus acuminatus*), flax, sharp spike sedge, swamp millet, *Ficinia nodosa*, pasture species, nasturtium and kikuyu grass. The surrounding shrubland often contains extensive flax and cabbage tree (co-dominant in sectors 7 & 8) with kawakawa, karamu, ngaio, mahoe, mamaku treefern, mapou, lupin, fennel, pampas, kiokio, blackberry and hounds tongue. Exotic species invasion is the predominant threat to this vegetation type, particularly from pasture and kikuyu grasses.

10. Glasswort estuarine zone

Consists of a small monospecific community found in the estuarine zone of the Waiwhakaiho delta (sector 7).

11. Exotic plantation

Consists of Lawson's cypress (sectors 1, 2 and 3) and coastal banksia (sector 3) plantations. Both support varying degrees of native regeneration, namely of kawakawa, karo, flax, taupata and pohuehue. Under the Lawson's plantation New Zealand spinach, mahoe, *Pseudopanax* hybrids and karamu were found and tainui occurred under the banksia. However pasture and blackberry invasion is common on the edges along with exotic herbs and shrubs under the Lawson's cypress including lupin, gorse, boxthorn, inkweed, woolly nightshade, German ivy and self seeding banksia and Lawson's cypress.

12. Parkland

Planted trees and shrubs amongst pasture surrounding Lake Rotomanu (sector 6), the carpark (sector 7) and the Mangati Walkway (sector 0). Exotic dominants include coastal banksia, pine, Norfolk pine and agapanthus. Common natives are kawakawa, karo, pohutukawa, karaka and cabbage tree. Cottonwood, scented fern, shining spleenwort, tender brake and whau are present. There are many pest plants present in this vegetation type including wandering Jew, mothplant, lupin, German ivy, kahili ginger, inkweed, crack willow, phoenix palm, acacia, *Solanum* spp. and gorse.

Figure 3 From left to right; above, centre, below:

A. **Spinifex sandfield** on the active duneland (sector 8).
B. ***Ficinia nodosa* sandfield** in backswamp areas of sector 0.
C. **Pohuehue-kikuyu grass sandfield** (sector 4) with German ivy and *Ficinia nodosa*.
D. **Pasture** pocket close to the shore (sector 0).
E. **Flax shrubland** found along the coastal strip in sector 4.
F. **Exotic shrubland** (sector 5) in this case dominated by boxthorn and gorse.

Figure 4 From left to right: above, centre, below:

G. **Ngaio shrubland** planting along the riparian strip (sector 2).
H. **Waipu lagoon shrubland** (sector 2) showing flax, tree ferns, cabbage and karamu etc.
I. **Wetland** vegetation in sector 7 (the far bank has been planted).
J. **Glasswort intertidal zone** on the Waiwhakaiho River Delta (sector 7).
K. **Exotic plantation** of Lawson cypress (sector 2).
L. **Parkland** vegetation around Lake Rotomanu (sector 6).

Degrading Factors

Problem weeds outlined in the Taranaki Regional Council Pest Plant Strategy (2007) and that occur in the coastal walkway extension area include; pampas (targeted for eradication), gorse, wild broom, kahili ginger (containment pest plants), woolly nightshade and oxygen weed (surveillance pest plants). More isolated problematic weed species include occasional mothplant, crack and grey willow, wild broom, arum lily, kahili ginger and wandering Jew, which should immediately be removed before they have a chance to become a major problem. Self seeded banksias should also be removed.

Weeds invading vulnerable spinifex sandfield vegetation include marram grass, kikuyu grass, yucca, pasture species and the exotic ice-plant. Marram grass is widespread and tends to displace the native sand binders (Johnson 1982), while the exotic ice-plant has all but completely replaced the native species (*Disphyma australe*). Pampas is found throughout the extension area, excluding the central sectors of 3, 4 and 5 and is much more abundant than the native toetoes (*Austroderia fulvida* and *A. toetoe*). German ivy and blackberry are common, potentially smothering native shrubs and preventing regeneration. Boxthorn is a major threat to the distribution of taupata and other native shrubs and appears in every sector except 6. Lupin and gorse are also widespread, and have the additional impact of being nitrogen fixers on the surrounding vegetation.

Rabbit sign was frequently noted throughout the sectors in open areas, particularly amongst the pasture and spinifex duneland vegetation types. Due to the amount of sign present in the spinifex dunelands, it is likely there is significant spinifex browsing. Rabbits will also graze many other indigenous duneland species such as pingao and sand tussock (Bergin 2008), and could have catastrophic impacts on seedlings.

The other major threats to indigenous vegetation include fire risk and human related disturbance. The spinifex dunelands are particularly vulnerable to fire risk due to the abundance of dry, low lying vegetation and driftwood. Human disturbance was most prominent in the parkland areas and in the sectors where the path had not yet been constructed. This occurred mostly as trampling damage along tracks, but some rubbish was noted (particularly glass bottles).

Restoration Recommendations

The goals identified by the New Plymouth District Council for this restoration project include:

1. Restoring indigenous ecosystems present in the area prior to anthropogenic influences
2. Coastal erosion prevention
3. Adding to existing citywide community, ecological and aesthetic values

Implementing a monitoring programme is an essential step to assess progress towards these goals. The SER international Primer on Ecological Restoration (2004) recommends multiple approaches, including attribute analysis, which comparatively assesses pre-existing records (this report, photopoints or permanent plots could be useful here) against current conditions for required ecosystem attributes, such as species composition and richness, ecosystem function, physical site characteristics, integration with the surrounding landscape, threat management and ecosystem resilience and sustainability.

Specifically, monitoring parameters could include quantification of:

- planting survival
- vegetation cover
- weed abundance and regeneration
- indigenous species abundance and regeneration
- rates of erosion
- changing soil characteristics
- fauna composition

The following recommendations outline areas or planting zones where extensive or enhancement planting can take place, where uncommon indigenous species may be introduced and areas that can be left to regenerate naturally. Brief guidelines are provided for the control of specific pest species and the management of other major restoration threats.

Planting Zones:

The advantages of using a successional framework in planting (planting species in the order they would naturally colonise a site) are now widely recognised including maximised species growth and survival rates, increased resistance to weed invasion and ensuring the long-term ecological outcomes are consistent with the target ecosystem. In the extension area the unconsolidated dunelands are initially colonised by the pioneering sand binder's spinifex and pingao. Later additional species enter, such as pohuehue, toetoe and sand coprosma that help to further stabilise and build up soils (increase organic matter and enhance nutrient and water holding capacity), becoming consolidated dunelands. Coastal shrubland communities can then form, mainly dominated by flax and taupata, which on exposed sites terminate the successional sequence until further disturbance. However, in more sheltered coastal environments coastal forest can develop containing whau, ngaio, stunted kohekohe and puriri. If later successional species are planted too early, or species are planted in unsuitable habitat, they may not survive due to insufficient soil nutrients and shelter, wasting valuable financial and community resources.

Central to New Plymouth's identity is the proximity of Mount Taranaki to the sea. Maximising integration along this environmental continuum is a long-term ecological goal for the city. This is achievable via planting along potential habitat corridors such as river margins. In the coastal walkway extension, the Waiwhakaiho River and Mangati Stream banks present such an opportunity, allowing the dispersal of indigenous species and migration of fauna.

In most cases initial clearance of regional and local pests will be required (Pest Management Strategy, Taranaki Regional Council 2007). It is essential this is undertaken in concert with immediate planting efforts, otherwise the full benefit of weed control will not be achieved. It is suggested that restoration progress be completed in stages, to enable efficient use of resources, such as using the sectors already defined by the District Council, and rotate planting, weed control and monitoring efforts between these. The duneland, shrubland and coastal forest areas are the zones targeted for extensive planting and restorative efforts (see Fig. 13).

Additional potential sites for wetland establishment also are identified, but much of the parkland and existing exotic plantations are to be left intact.

Using planting stock of known and local provenance is strongly recommended to sustain the genetic integrity of planted populations (Simpson 1991). This enables preservation of accumulated genetic adaptations to local environments, habitats and climate. The genetic diversity within populations varies substantially between species and as a result some species are more clearly defined into ecotypes, such as the North Taranaki pohutukawa. Sourcing seedlings from local nurseries that collect seed from native remnants within the Taranaki region is ideal.

1. Unconsolidated Duneland (active dune)

The native vegetation colonising active dunes in New Zealand is not a large or diverse group (Hilton 2006). The predominant sand binders are pingao and spinifex grasses. Pingao pioneer's a site and spinifex establishes via seeding within pingao, later becoming dominant (Whitehead 1964). Extensive introduction of marram grass for dune stabilisation early last century has severely restricted the habitat range of our native sand binders. However, recent research into plant and animal diversity in marram grass vs. native sand binder dominated dunes, has revealed greater biodiversity (of both flora and fauna) is present in marram grass dominated systems (Jamieson 2010), and so elimination is not recommended at this stage. In addition, marram grass is usually more prevalent on the landward face of the foredune as it is not as tolerant of salt laden winds as the native sand binders (Esler 1978).

Recommendations include increasing indigenous vegetation cover and the diversity of restoration plantings, while leaving marram grass populations in place until vegetation cover and richness is sufficient for restoration goals. Later, staged removal of marram grass can be considered. Progress in duneland restoration has already been initiated by the District Council in other areas south of the walkway extension, and in sector 8, in the form of enhancement planting of pingao and spinifex. These sites can be useful guides for advanced stages in the successional planting sequence.

Currently planting sand-binding species is most effectively done using seedlings. This can be expensive, especially in the case of spinifex which has a low average

germination rate of 60% (Bergin 1999), so in areas where reasonable cover already exists, such as sector 8, existing populations could be left to recover naturally. When planting the native sand binders, it is advisable to add a slow release NPK fertiliser (30g) and plant seedlings deep in autumn or spring (Bergin 1999; Bergin & Kimberley 1999). Any planting of the native sand binders should be focussed on the seaward face of the foredune due to minimise competition from marram grass and maximise benefits in erosion prevention (Bergin & Kimberley 1999).

Pingao seedlings (in bare sand areas, approx 50 to 70 cm apart), spinifex seedlings (space 50 cm to 1 m apart) with interspersed sand sedge (cuttings of runners works best), sand pimelea (cuttings, space 1 m apart; Singers 1998) and the native iceplant (cuttings or seed, take care with source).

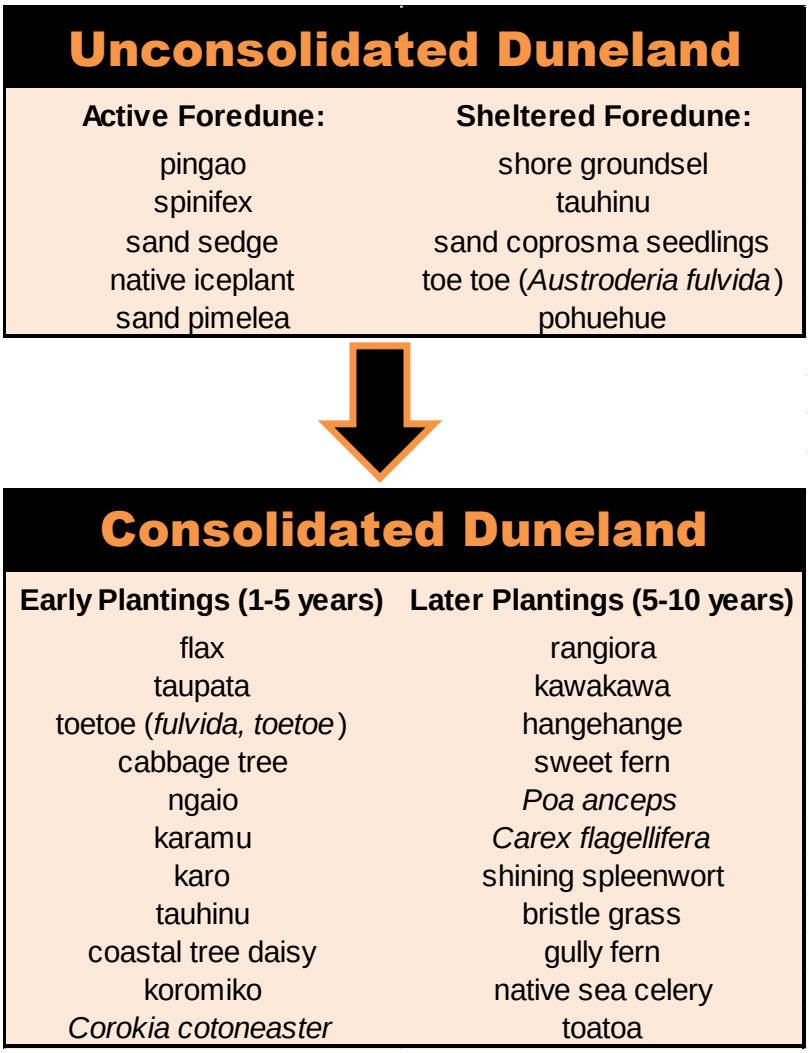

Figure 5 Summary duneland planting list.

2. Consolidated Duneland

This vegetation type naturally occurs in stabilised dune areas with higher levels of organic material present (developing soils). It is currently occupied by a variety of vegetation types from pohuehue-kikuyu grass vineland, boxthorn-lupin-gorse shrubland to pasture and is represented to some extent in the council plantings in sectors 3 & 4.

Recommended areas for establishment of this vegetation type are present in all sectors excluding sandy foredunes (spinifex sandfields) and backswamp areas dominated by *Ficinia nodosa* in sectors 8 and 0. Early shrubland plantings on the exposed coastal strip should include hardy species, quick to create shelter for later successional species.

Planting extensive flax and toetoe will also assist in controlling exotic shrub populations, such as gorse, pampas, boxthorn and lupin and shade out most pasture species. In rocky shore environments shore lobelia, rauhuia, taupata, flax and the native iceplant can also be introduced. Complete cover should be achievable in 5 years (based on Council plantings of coastal flax shrubland in the area), after which the more shade tolerant, shelter loving species can be added.

3. Inland forest

Forest development is a long-term outcome of coastal shrubland communities in areas where the soil is capable of supporting the more nutrient demanding species and additional shelter is available once the canopy has closed and away from strong salt-laden winds. Loamy soils capable of supporting this vegetation were observed in the parkland areas, the dairy farm and surrounding the wetland vegetation at Waipu lagoon. The tree ferns will regenerate into these conditions without assistance.

4. Parkland

Recommended enhancement planting of natives (target species are listed in the wetland section) along the riparian zones of the Waiwhakaiho River (sectors 5, 6 and 7) and the Mangati Stream (sector 0). Removal of potential problem species, particularly in sector 6, is strongly recommended.

5. Existing vegetation patches

No planting is required. Lawson's cypress and banksia plantations should be left intact for sand stabilisation and to facilitate native understorey recovery. Removal of self seeding individuals from all areas is recommended.

6. Wetland

Extensive plantings have already been successfully undertaken surrounding the Waipu and Waiwhakaiho lagoons. Three additional sites have been targeted for the establishment of small wetlands which include backswamp areas in sectors 0 and 5 that naturally contain a raised water table and a small wetland by the carpark in sector 6 (see Fig. 13). Extending the plantings around the small wetland community currently found in sector 8 is also a valuable wetland addition. The tree ferns and other ferns will establish without assistance. Other species present in the Waipu lagoons, but not in historical records or the reference ecosystem (Maitahi Scenic Reserve) include; swamp millet (*Isachne globosa*; also currently found in the extension area), baumea (*B. rubiginosa*), grass-leaved rush (*Juncus planifolius*) and *Muehlenbeckia australis.*

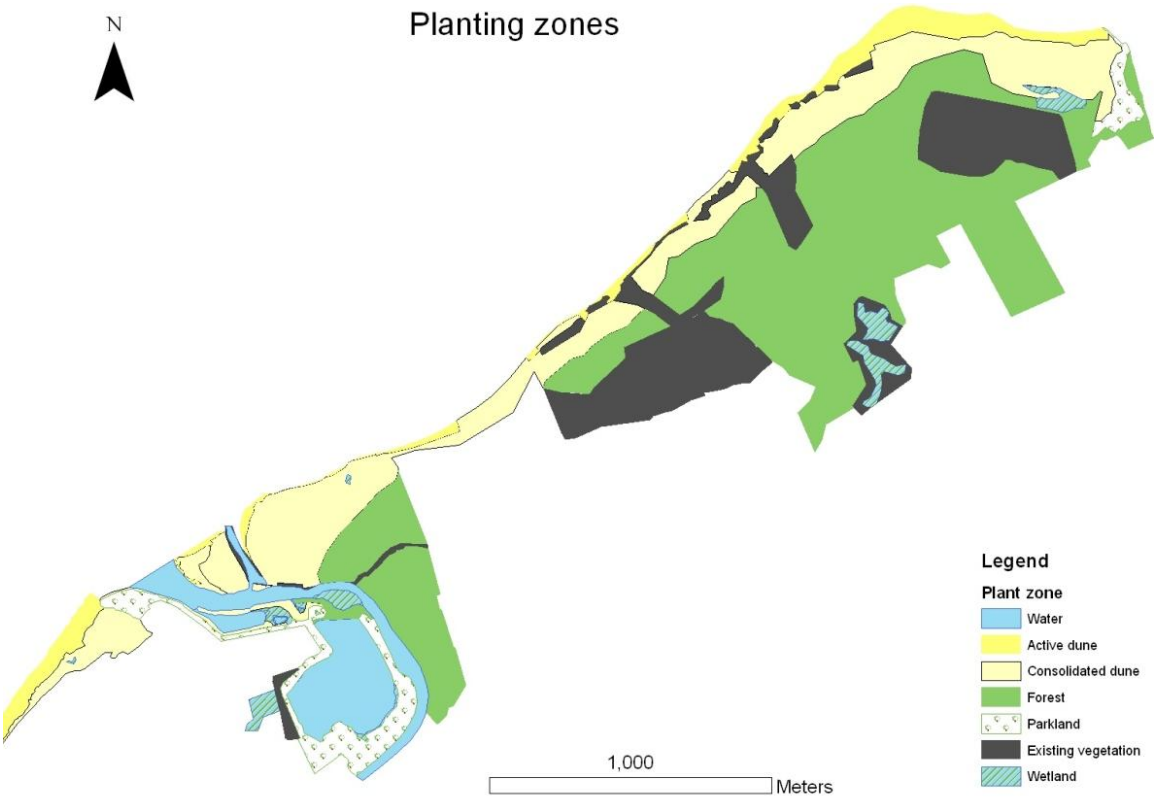

Figure 6 Coastal walkway extension plant zones.

Pest Control Methods

Species suggested for immediate control include pampas, gorse, wild broom, kahili ginger, mothplant and wandering Jew. Most of these are already targeted by the District Council, however mothplant and wandering Jew have been added due to the small-scale nature of removal required. Dieback of gorse and yellow tree lupin has already been noted in sectors 0, 1 and 4, which may be due to spraying. Species targeted for removal during planting include boxthorn, yellow tree lupin, blackberry, exotic ice-plant, German ivy, arum lily and yucca. Marram grass removal can be actioned after dunelands stabilise if required. Pasture and kikuyu grasses can be left as they will be outcompeted once the shrub tier develops. Removal of self seeding pines, macrocarpa, banksia and Lawson's cypress is recommended but plantations can be left intact to provide additional ecosystem function (shelter for regenerating natives) and to stabilise soils.

Tordon brushkiller is useful to control boxthorn, gorse and blackberry, either as a spray or paste. Glyphosate sprays may be required to control pampas (Starr *et al.* 2003). Lupin can be controlled using Hydrocotyle killer (75ml/10L). Mechanical removal is sufficient for kahili ginger, mothplant, wandering jew, yucca, wild broom and exotic ice-plant infestations.

An effective monitoring programme needs to be implemented at the commencement of weed control. This could be implemented in the form of before and after photography or survivorship surveying. Regular release (annually) is crucial in the first 5 years of restoration planting. Particularly in the case of the active dunelands, as the native sand-binders are slow to establish cover.

Regular control of rabbits is recommended (e.g. Pindone), particularly during planting of the foredunes. On completion of the walkway, constructed paths and fencing is likely to direct human traffic and minimise impacts of human related disturbance, signage is also likely to be helpful. A fire risk analysis is recommended to assess impacts and responses to this form of vegetation disturbance.

Conclusions

The construction of the Fitzroy to Bell Block Coastal Walkway Extension is close to successful completion. Once infrastructure is in place concerted efforts in weed control and planting can commence. The goal for plantings is to reconstruct spinifex sandfield, flax-taupata shrubland and coastal forest vegetation types once dominant in the area. In particular the spinifex sandfield communities should be a focus, as they are severely under-represented in the district. Restoration recommendations include planting indigenous species in a successional framework to maximise species survival and restoration success, ecosourcing seedlings from local nurseries and undertaking initial weed control at the time of planting. On-going monitoring of plantings and weeds is required at least annually for the first 5 years. Defining monitoring criteria before restoration efforts begin is required if progress towards goals is to be measurable. The vegetation restoration of the coastal walkway extension has potential to significantly enhance an already valuable ecological resource, provide a more authentic natural heritage experience and complement an internationally recognised asset of the city of New Plymouth.

Acknowledgements

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Appendix A: Species List

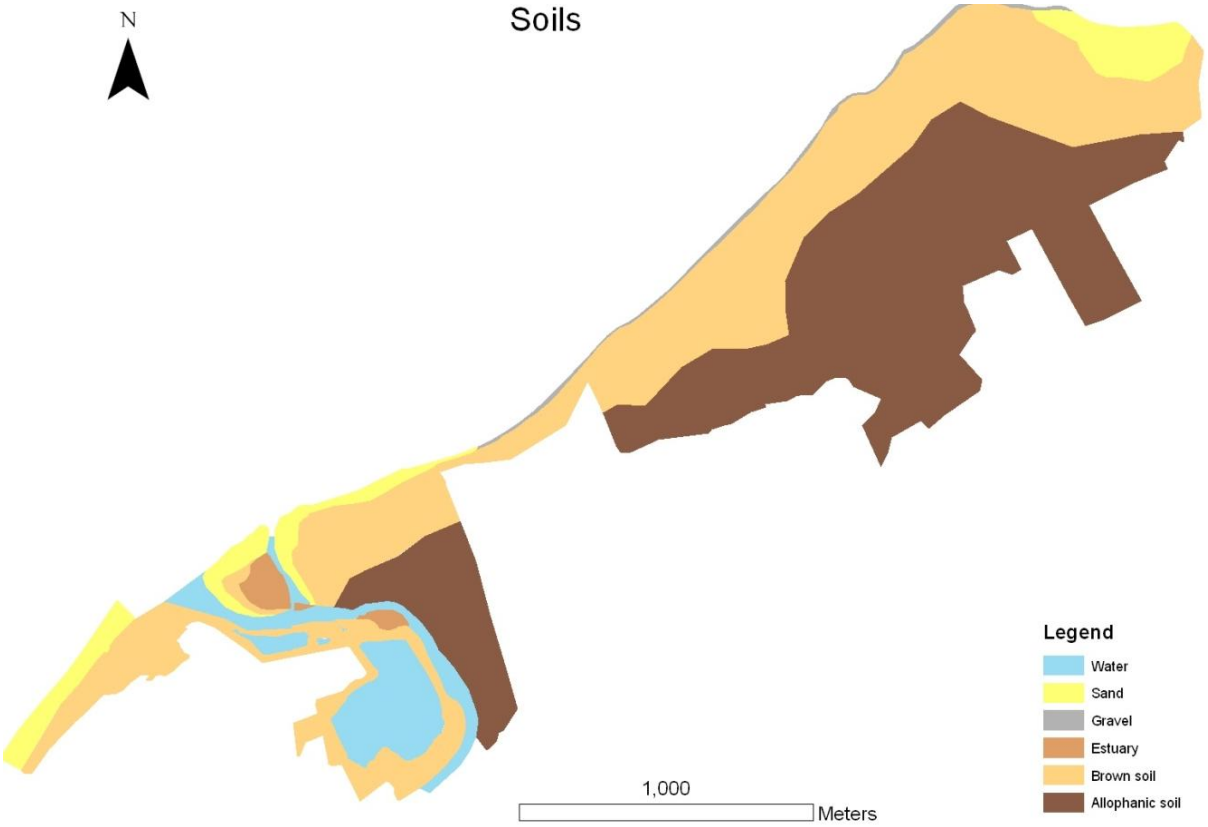
* present in sector

Scientific name	Common name	0	1	2	3	4	5	6	7	8
Acacia sp.	acacia							*		
Agapanthus praecox	agapanthus		*						*	*
Dodonaea viscosa	ake ake	*						*		
Zantedeschia aethiopica	arum lily	*	*							
Bambusa sp.	bamboo							*	*	
Solanum nigrum	black nightshade		*	*		*		*		*
Rubus fruticosus	blackberry	*	*	*	*	*	*		*	*
Lycium ferocissimum	boxthorn	*	*	*	*	*	*		*	*
Pteridium esculentum	bracken fern					*	*			
Schinus terebinthifolius	brazilian pepper									*
Orobanche minor	broom rape									*
Cordyline australis	cabbage tree	*	*	*		*		*	*	*
Camellia sp	camellia		*							
Carex sp.	carex sedge							*		
Silene gallica	catchfly	*	*							
Hypochaeris radicata L.	catsear	*	*				*			*
Banksia integrifolia	coast banksia	*		*	*			*		*
Olearia solandri	coastal tree daisy		*							
Dactylis glomerata	cocksfoot				*	*	*	*	*	*
Eleocharis acuta	sharp spike sedge		*	`						*
Salix fragilis	crack willow							*		
Ranunculus repens	creeping buttercup		*					*		
Taraxacum officinale	dandelion	*	*	*						*
Osteospermum fruticosum	dimorphotheca									*
Foeniculum vulgare	fennel	*						*		*
Phormium tenax	flax	*	*	*	*	*	*	*	*	*
Conyza sumatrensis	fleabane						*			*
Prunus sp.	flowering cherry		*							
Fumaria muralis	fumaria		*							
Allium triquetrum	garlic weed								*	
Delairea odorata	german ivy	*	*	*	*	*	*	*	*	*
Juncus pallidus	giant rush								*	
Sarcocornia quinqueflora	glasswort								*	
Ulex europaeus	gorse	*	*	*		*	*	*	*	*
Senecio skirrhodon	gravel groundsel						*		*	*
Viscia hirsuta	hairy vetch							*		
Lagurus ovatus	harestail									*
Leontodon taraxacoides	hawkbit		*							*
Crepis capillaris	hawksbeard	*								
Hebe sp.	hebe		*					*		
Stachys sylvatica	hedge woundwort							*		
Carpobrotus edulus	S. African ice-plant	*	*	*	*		*			*
Phytolacca octandra	inkweed		*	*		*		*		*
Hedera helix	ivy									*
Hedychium gardnerianum	kahili ginger							*		
Corynocarpus laevigatus	karaka		*					*		
Coprosma robusta	karamu		*							
Hierochloe redolens	karetu								*	*

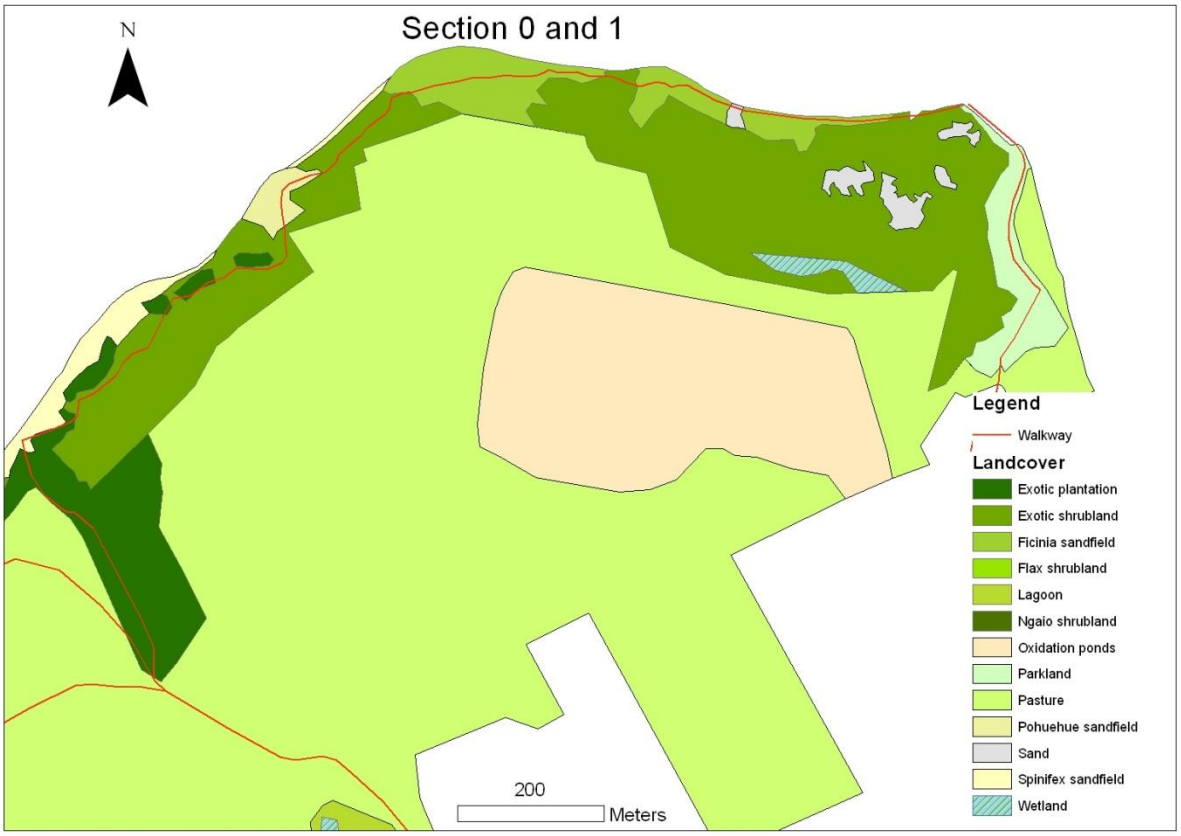
Pittosporum crassifolium	karo	*	*	*	*	*	*	*	*	*
Macropiper excelsum	kawakawa		*	*	*	*		*	*	
Pennisetum clandestinum	kikuyu grass	*	*	*	*	*	*	*	*	*
Ficinia nodosa	knobby clubrush	*	*	*	*	*	*	*	*	*
Pittosporum tenuifolium	kohuhu		*							
Microsorum pustulatum	kowaowao								*	
Eleocharis sphacelata	kuta		*							
Chamaecyparis lawsoniana	Lawson's cypress		*	*	*					
Lotus pedunculatus	lotus							*		
Cupressus macrocarpa	macrocarpa	*	*	*				*		
Melicytus ramiflorus	mahoe		*	*					*	
Cyathea medullaris	mamaku	*	*	*				*	*	
Myrsine australis	mapou								*	
Ammophila arenaria	marram grass	*	*	*	*		*		*	*
Medicago nigra	medick	*								
Paspalum distichum	mercer grass							*		*
Euphorbia peplus	milkweed		*							
Araujia sericifera	moth plant							*		
Plantago lanceolata	narrow-leaved plantain						*		*	*
Tropaeolum majus	nasturtium							*	*	
Myoporum laetum	ngaio			*				*		
Araucaria heterophylla	norfolk pine	*	*	*				*		
Tetragonia tetragonioides	nz spinach		*							
Leptocarpus similis	oioi							*		
Nerium oleander	oleander									*
Lagarosiphon major	oxygen weed							*		
Cortaderia selloana	pampas	*	*	*				*	*	*
Paspalum dilatatum	paspalum							*		*
Phoenix canariensis	phoenix palm							*		
Lindernia ciliata	pimpernel									*
Pinus sp.	pine	*	*	*		*		*		*
Muehlenbeckia complexa	pohuehue	*	*	*	*	*	*		*	*
Metrosideros excelsa	pohutukawa	*	*	*		*		*	*	*
Pseudopanax hybrid	pseudopanax		*			*			*	*
Vitex lucens	puriri							*		
Typha orientalis	raupo		*					*	*	
Trifolium pratense	red clover	*	*				*			*
Calystegia solanella	sand convolvulus		*	*	*		*		*	*
Paesia scaberula	scented fern							*		
Asplenium oblongifolium	shining spleenwort							*		
Cyathea dealbata	silverfern		*							
Rumex acetosella	sorrel		*							
Sonchus oleraceus	sow thistle	*	*							
Spinifex sericeus	spinifex	*	*	*	*		*		*	*
Spergula arvensis	spurrey	*								
Stachys arvensis	staggerweed		*							
Blechnum minus	swamp kiokio		*					*		
Isachne globosa	swamp millet		*							
Carex virgata	swamp sedge							*		
Anthoxanthum odoratum	sweet vernal								*	*
Pomaderris apetala var. maritima	tainui				*			*		*
Festuca arundinacea	tall fescue						*		*	
Juncus acuminatus	tapertip rush								*	

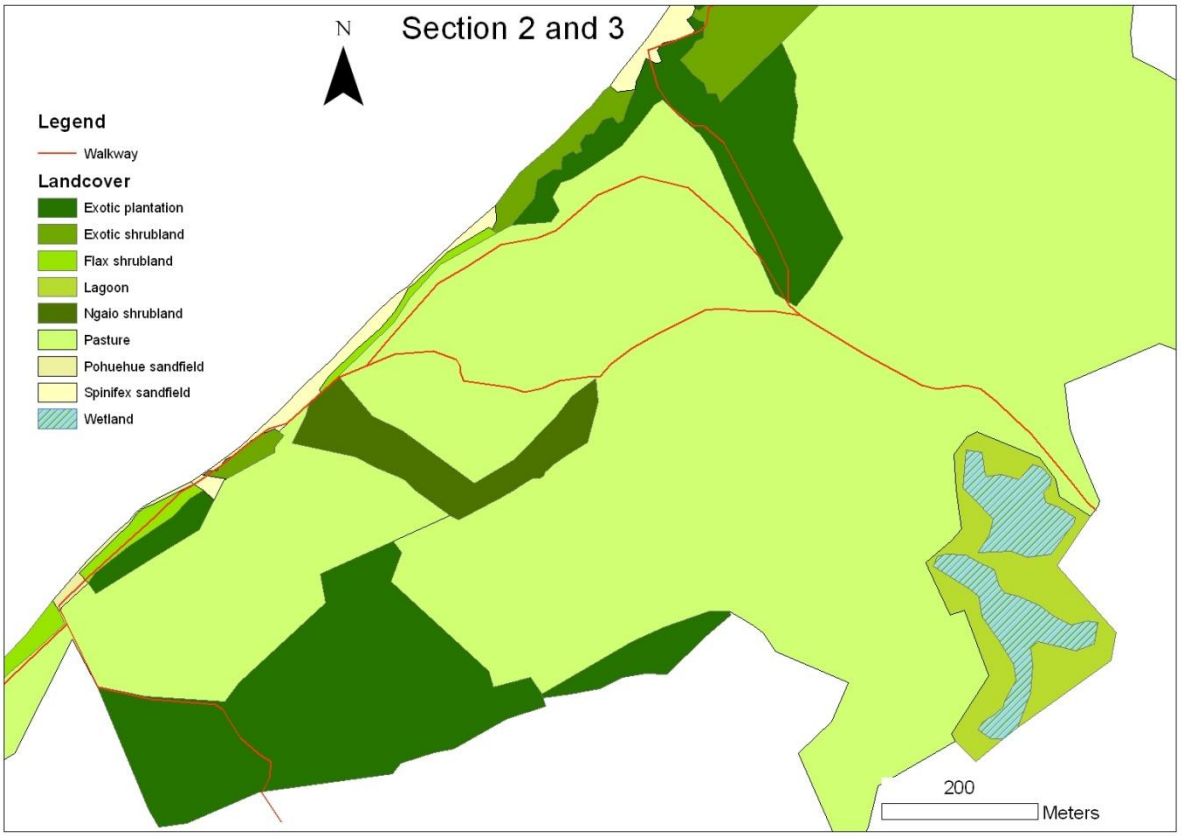
Ozothamnus leptophyllus	tauhinu							*		*
Coprosma repens	taupata	*	*	*	*	*	*	*	*	*
Pteris tremula	tender brake							*		
Haloragus erecta	toatoa							*	*	*
Lilium formosanum	trumpet lily									*
Cyperus alternifolius	umbrella sedge	*						*		
Tradescantia fluminensis	wandering jew							*		
Entelea arborescens	whau							*		
Trifolium repens	white clover	*	*				*			*
Cytisus scoparius	wild broom						*			
Solanum mauritianum	woolly nightshade	*	*	*				*		
Lupinus arboreus	yellow tree lupin	*	*	*	*	*	*	*	*	*
Holcus lanatus	yorkshire fog	*	*				*	*		*
Yucca filamentosa	yucca	*	*				*		*	*

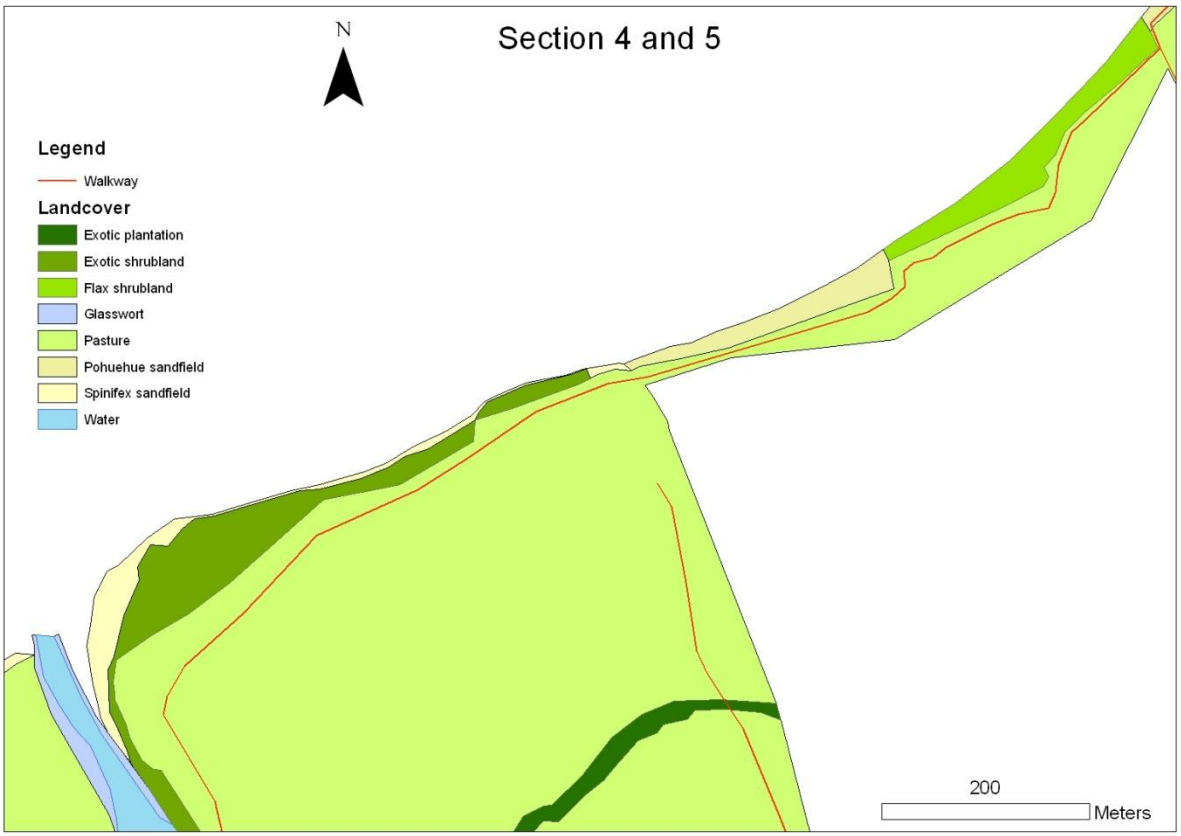
Appendix B: Soils Map

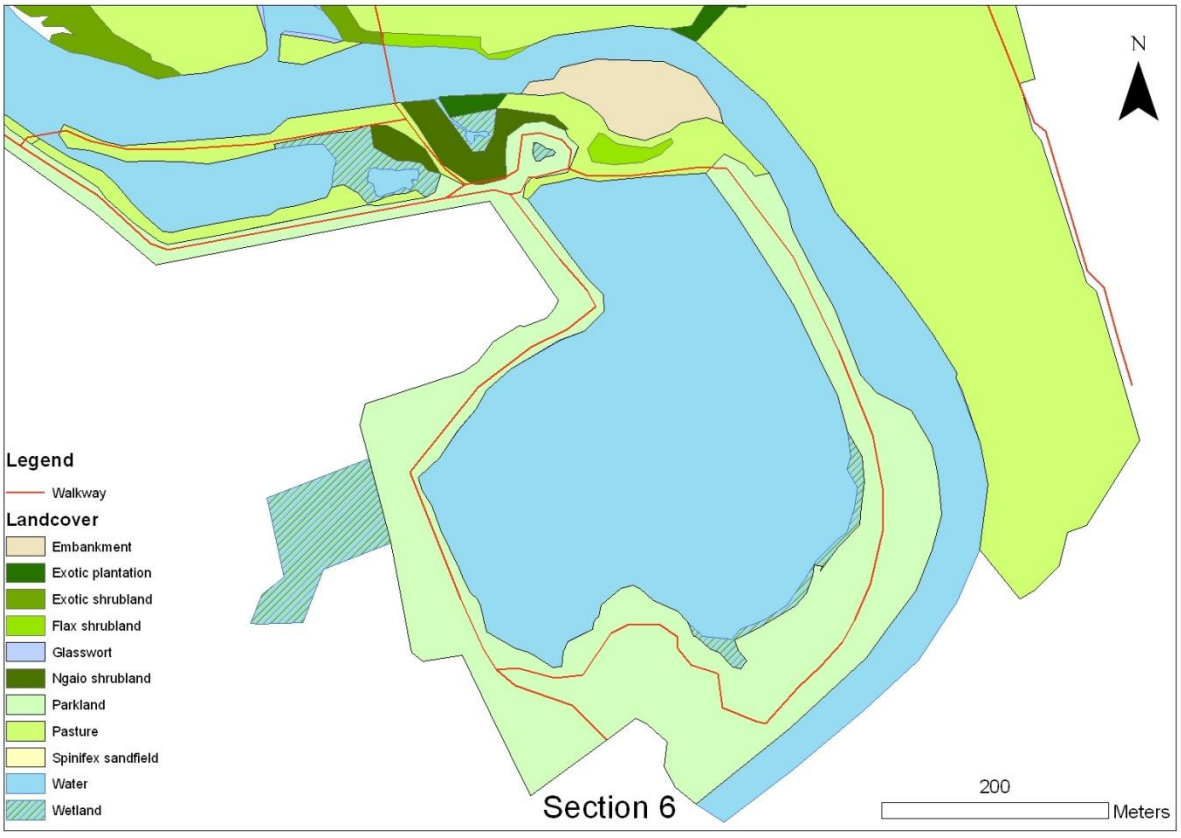


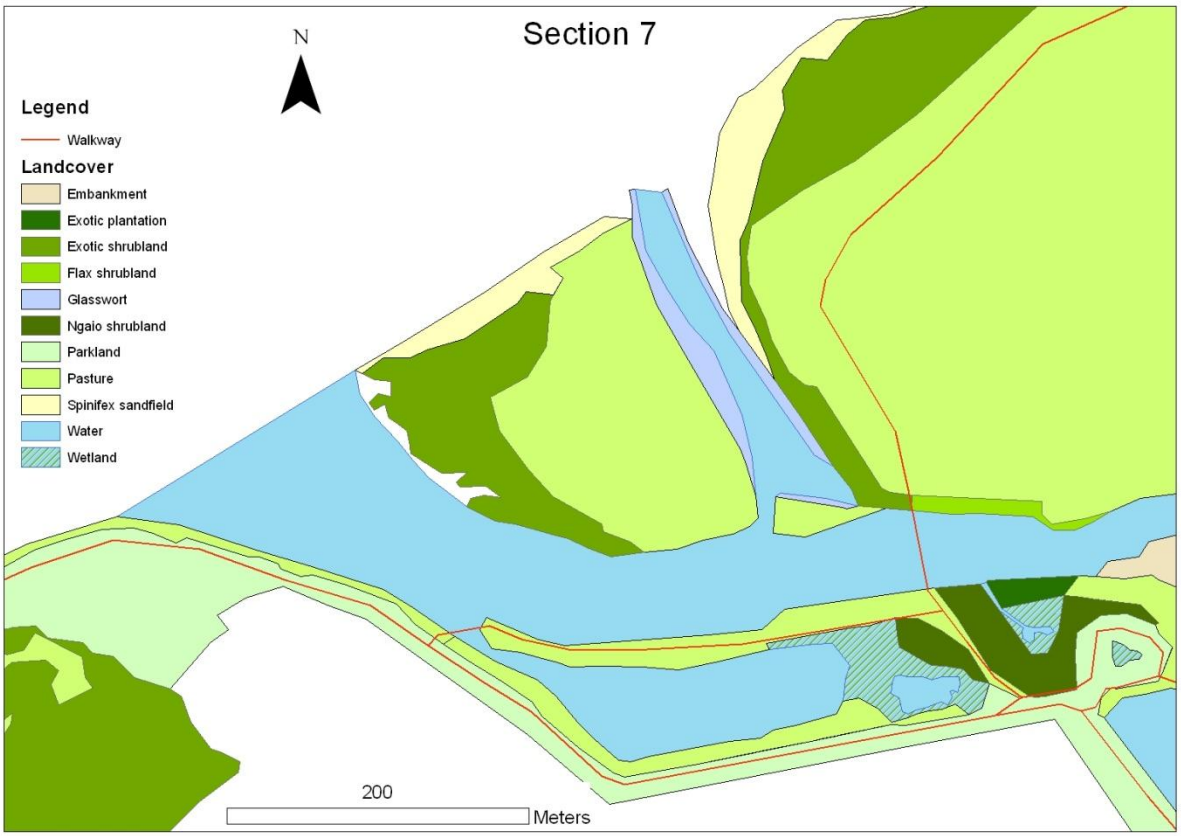
Appendix C: Sector Maps

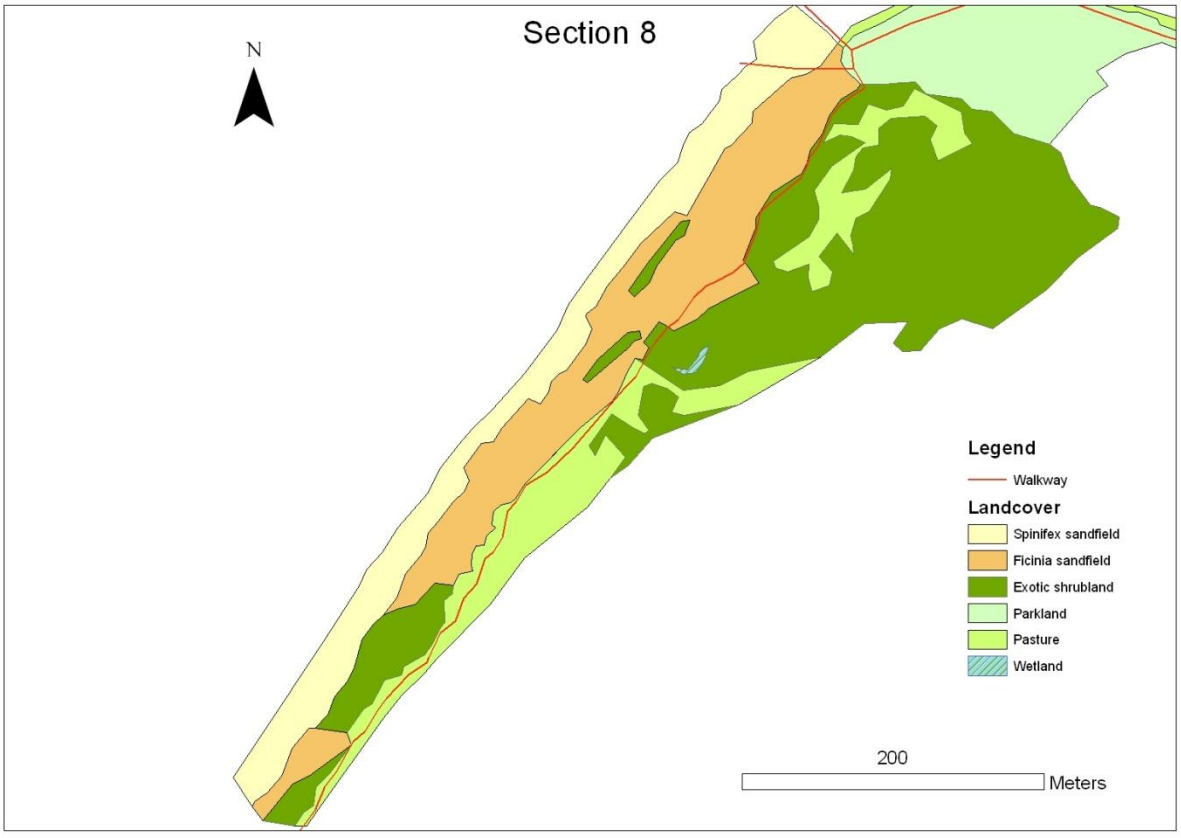





Section 4 and 5
N
Legend
Walkway
Landcover
Exotic plantation
Exotic shrubland
Flax shrubland
Glasswort
Pasture
Pohuehue sandfield
Spinifex sandfield
Water
200
Meters


N
Legend
Walkway
Landcover
Embankment
Exotic plantation
Exotic shrubland
Flax shrubland
Glasswort
Ngaio shrubland
Parkland
Pasture
Spinifex sandfield
Water
Wetland
Section 6
200
Meters


Section 7
N
Legend
Walkway
Landcover
Embankment
Exotic plantation
Exotic shrubland
Flax shrubland
Glasswort
Ngaio shrubland
Parkland
Pasture
Spinifex sandfield
Water
Wetland
200
Meters


Section 8
N
Legend
Walkway
Landcover
Spinifex sandfield
Ficinia sandfield
Exotic shrubland
Parkland
Pasture
Wetland
200
Meters