

SITE MANAGEMENT PLAN FOR NEW PLYMOUTH COASTAL REVEGETATION PROJECT (New Plymouth)

Reference: OPS 10/12
Date: 4th August, 2010
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Background

The development of the New Plymouth coastal walk/cycleway has been a spectacular success in attracting both local and visitor communities to use and enjoy the foreshore area. The latest stage of this development extends the project to the North with the construction of the spectacular Te Rewa Rewa bridge across the Waiwhakaiho River and walkway across the historical Te Rewa Rewa reserve and Hickford Park to the suburb of Bell Block (Figure 1).



Figure 1. Te Rewa Rewa bridge just east of planting site.

Seaward of the walkway is a back-dune area of rough grass and scrubland including scattered gorse, lupin and broom (Figure 2). The area includes residual native species. The development of the walkway is a joint initiative between New Plymouth District Council, local hapu and Department of Conservation and involves the restoration of associated foreshore area.



Figure 2. Back-dune grass scrubland area proposed for revegetation.

Site selection

The proposed site forms part of an outstanding coastal recreation development of very high use and profile. The back-dune area has potential to contribute an important ecological component to the wider project, enhancing wildlife habitat and providing a significant area of indigenous vegetation. The associated walk/cycleway and Peringa Park Wetland ensure a very high profile for the area. It is located only 5 minutes from the city and access is excellent for site preparation work and for planting day activities.

The proposed site is managed through a joint management agreement between Ngati Tawhirikura and the District Council, named the Rewa Rewa Agreement.

Site characteristics

The site is a back-dune shrubland which has been previously grazed resulting in a relatively open grass sward within gorse, lupin, and broom. Some herbicide spraying has been carried out on larger weed clumps. Individual native species are scattered throughout the site which will also harbour native wildlife. The area is fenced with a post and batten fence and shade cloth (Figure 3). The substrate is sand providing an easy planting medium.

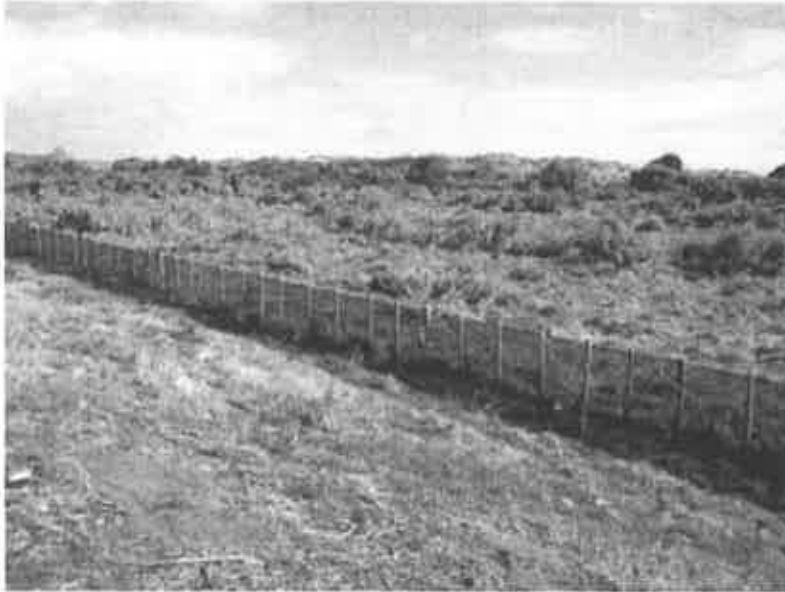


Figure 3 Fenced back-dune planting site.

Site preparation

Because of the native fauna and flora component already on the site a low impact approach to site preparation is indicated, with no broadcast herbicide spraying or weed clearance. The aim will be to provide for inter-planting by spot spraying the grass/weed sward prior to planting, and spraying of the woody weeds in the spring of this year. A series of enrichment plantings will be carried out over the three planting years but preparation for the 2011 planting must be able to accommodate around 5000 plants.

Planting stock

All planting stock will be eco-sourced in accordance with current practice by DoC. Plants will be in good condition and grown to appropriate size classes between PB2 and PB5 according to the species. No root trainer stock will be used. All plants will be heavily watered prior to planting and transported to the site as close to the planting day as possible. Planting in year 2 (2011) would involve approximately 5000 plants (Table 1). Planting density will be such as to ultimately suppress pasture grasses and other weed species. Species to be considered are listed in table 1.

Table 1. Plant species list and numbers by planting year.

Species	Common name	Year 2	No.	Year 3	No.	Year 4	No.
<i>Ficinia spiralis</i>	pingao						
<i>Spinifex sericeus</i>	spinifex						
<i>Carex pumila</i>	sand sedge						
<i>Disphyma australe</i>	native iceplant						
<i>Pimelea villosa</i>	sand pimelea						
<i>Senecio lautus</i>	shore groundsel						
<i>Cassinia leptophylla</i>	tauhinu						
<i>Coprosma acerosa</i>	sand coprosma						
<i>Cortaderia fulvida</i>	toe toe						
<i>Muehlenbeckia complexa</i>	pohuehue						
<i>Phormium tenax</i>	flax						
<i>Cordyline australis</i>	cabbage tree						
<i>Myoporum laetum</i>	ngaio						
<i>Coprosma robusta</i>	karamu						
<i>Pittosporum crassifolium</i>	karo						
<i>Ozothamnus leptophyllus</i>	tauhinu						
<i>Olearia solandri</i>	coastal tree daisy						

<i>Hebe stricta</i>	koromiko						
<i>Corokia cotoneaster</i>	Corokia						
<i>Ficinia spiralis</i>	pingao						
<i>Spinifex sericeus</i>	spinifex						
<i>Carex pumila</i>	sand sedge						
<i>Disphyma australe</i>	native iceplant						
<i>Pimelea villosa</i>	sand pimelea						
Total			5000		3000		2000

Planting

Planting on what is a sandy site will be carried out in September/October with the well watered stock. Best practice supervised planting should be undertaken ensuring adequate planting hole size, fertiliser may be required on local advice. The final product should ensure the plant is in a slight depression by light heeling in, so as to catch future rain. Plants will be delivered on site and may be laid out under supervision.

Maintenance

Survival of all species and general performance will be evaluated in April 2012 and blanking carried out as required in conjunction with the next year's planting. Any weed control requirements will be determined at that time.

Plant provision

Eco-sourced plants will be considered from:

Timeline

Site selection July 2010
Plant list August 2010
Plants sourced August 2010
Site preparation November 2010 and April 2011
Planting October 2011
Planting evaluation April 2012

Same timeline to be applied to plantings in 2012 and 2013

Milestones	Date	Comment
Site visit/local contacts undertaken	29/07/2010	A very high profile site adjoining the very high use walk/cycleway. Some weed control needed but an inter-planting strategy will be used.
Site project plan approved		
Planting stock confirmed/contracted		
Site preparation complete		
Plants and planting materials on site		
Planting current year complete		
Survival assessment/blanking complete		

Budget – 1st Planting Year.

ACTIVITY	COST (\$)	COMMENT
Site preparation		Woody weed spraying, spot spraying grass sward.
Plants (5000)		Cost of plants as detailed in Table 1.
Mulch mats		
Planting spades	5,000	Possible provision of 50 planting spades (budget dependant).
Other		
Total		

Total				

Delivery to site Yes No At additional cost \$

Plant placement on site At additional cost \$

All plants to be well grown for purpose, delivered to site as close as possible to planting day (no more than 2 days before), and to be well watered on delivery.



Graeme Lacock

From: PATTISON, Conrad [pattisonc@npdc.govt.nz]
Sent: Monday, 16 August 2010 2:55 p.m.
To: Mere Mokokaka
Subject: FW: Project Crimson and Waikato University restoration plan species
Attachments: 1-1015608-Project_Crimson_dune_restoration_project_New_Plymouth_Coastal_Walkway-_Site_Management_Plan_(2).doc; Te Rewa Rewa Coastal Planting.pdf

Hi Mere,

Have received the Waikato University draft vegetation restoration plan and have put the recommended species into the Project Crimson document. Our Parks planner has made some changes (highlighted in yellow) to Gordon's document and if you can please review this information and liaise with Gordon Hosking. If every one is happy with the changes and species we will take this info to the Te Rewa Rewa committee for their input. Have included a basic map with the approximate planting area highlighted in pink. I am asking our asset team to produce a more detailed map of the planted area later on when the detail of the plan is being discussed.

Cheers

Conrad Pattison

NPDC District Arborist

06 7596060 extn 8580

027 457 6641

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New Plymouth District Council
Fitzroy to Bell Block Coastal Walkway Extension

Draft Vegetation Restoration Plan

E. J. Coleman, T. S. Cornes & B. D. Clarkson

5 August 2010



Cover photo: Spinifex sandfield in sector 8, New Plymouth Coastal Walkway Fitzroy to Bell Block Extension Area.

Photography by Toni Comes.

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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. This report considers the vegetation restoration of this three km section of the walkway. The long-term goal includes recreating the spinifex sandfield, flax-taupata shrubland and coastal forest vegetation types once dominant in the area as determined by reference ecosystems and historic literature. This plan is based on a rapid qualitative assessment of the present vegetation, undertaken in June, 2010. Planting and weed control strategies are provided, including indigenous species targeted for reintroduction.

Introduction

The north-eastern New Plymouth coast has undergone extensive loss of sand dune habitat since 1889 due to human disturbance, resulting in reductions in sand supply to the coast, 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 became 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). As a result, all Taranaki dunelands are high priority areas for conservation and restoration.

1.1 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 while inland was coastal forest. The dominant shrubland species were flax (*Phormium tenax*), toetoe (*Cortaderia 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, New Zealand lobelia (*Lobelia anceps*), *Poa anceps* and coastal shrubland vegetation.

1.2 Reference Ecosystems

1.2.1 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 and reconstruction i.e. target ecosystems. The Maitahi Scenic Reserve was identified as being one of the only remaining representations of New Plymouth coastal forest found on the immediate coastal strip near New Plymouth. 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 lahatic promontories and a swampy area. Maitahi supports examples of all the vegetation types found in the coastal walkway extension area, with the exception of 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 were used extensively as a reference and represent the indigenous vegetation found on cliff sides and the swampy area. The remaining vegetation occurs on more recently disturbed areas of the reserve, including the interface with surrounding dwellings and farmland, and eroded sections on laharic promontories. These areas display a greater proportion of exotic species.

1.2.2 Waipu Lagoons

The Department of Conservation has listed these spring-fed wetlands 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*.

1.3 Area of Proposed Extension

The proposed coastal walkway extension (Fig. 1) 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 the coastal strip. Sector 3 contains some council plantings and is the westernmost sector incorporating the dairy farm. 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 ends at the 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. This sector is part of the proposed long-term extension to Waitara.

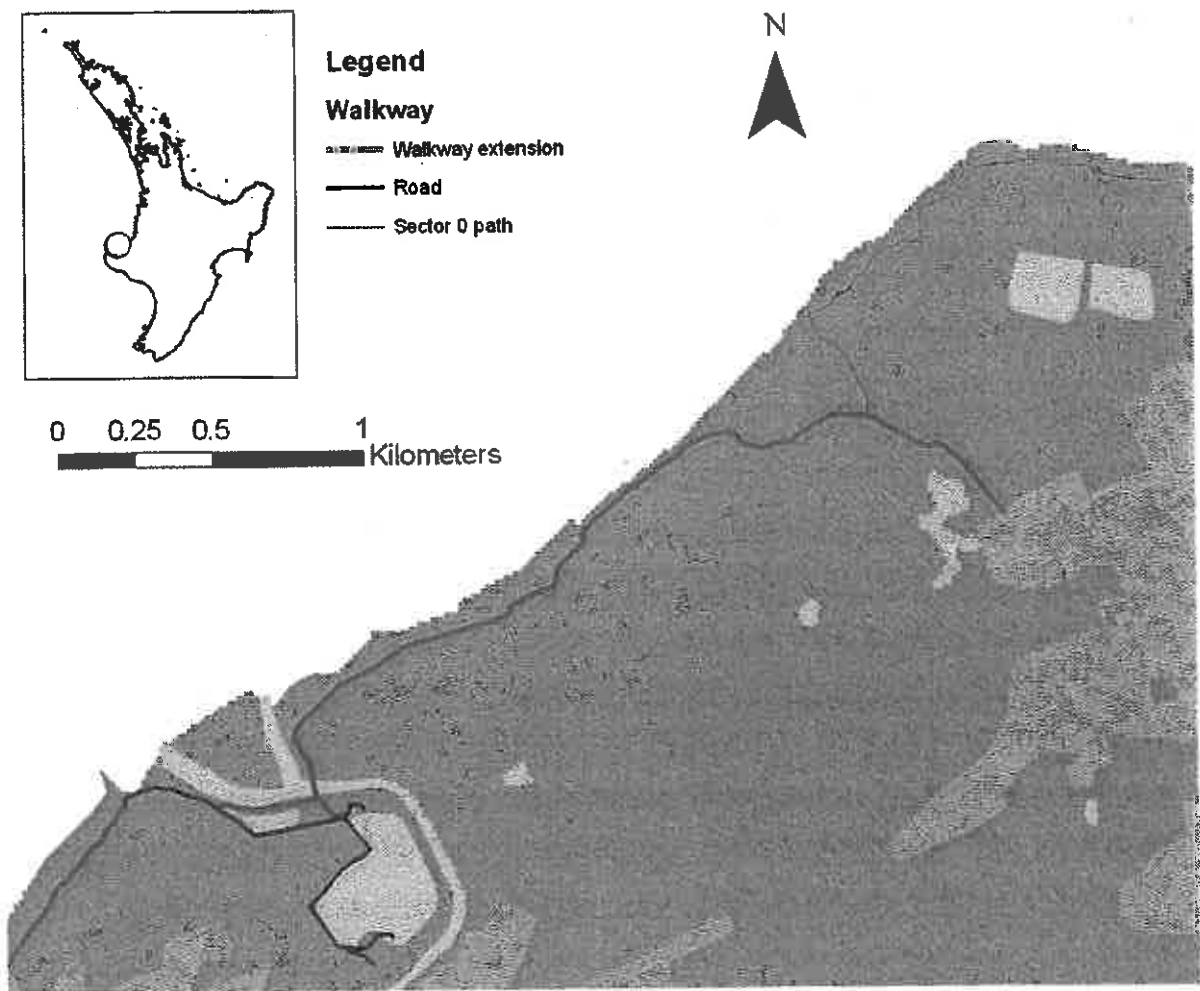


Figure 1 Coastal Walkway Extension Area.

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). However, no other section of the walkway is officially protected, although this is being considered 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 (Fig. 2). 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 than the surrounding soils due to higher levels of silt and clay and the low water table (Roberts & Jarman 1954).

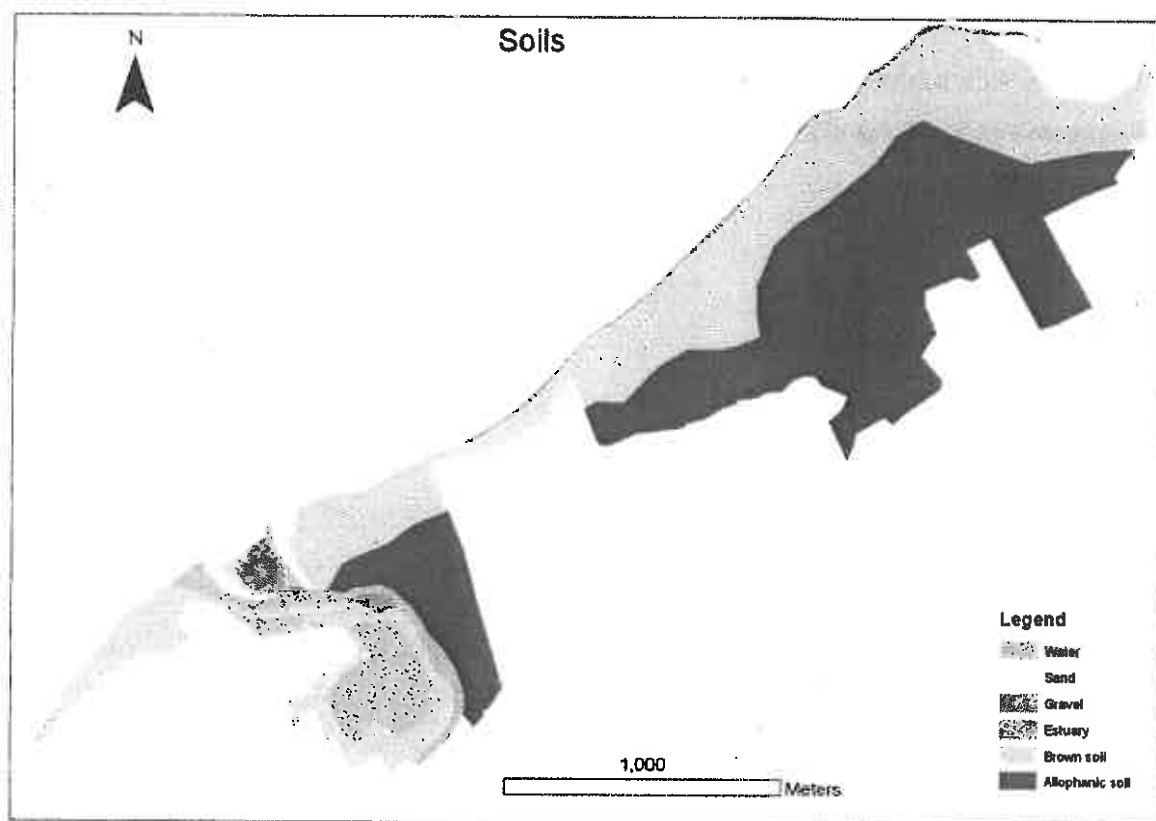


Figure 2 Soil types present in the extension area.

1.0 Rapid Qualitative Vegetation Assessment

2.1 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).

2.2 Vegetation

2.2.1 List of Vegetation Types

1. Spinifex sandfield (sectors 1, 2, 5, 7 & 8)
2. *Ficinia nodosa* sandfield (sectors 0, 6 & 8)
3. Pohuehue-kikuyu grass sandfield (sectors 3,4 & 7)
4. Pasture (all sectors)
5. Flax shrubland (sectors 3,4 & 6)
6. Exotic shrubland (sectors 0,1,2,5,7 & 8)
7. Ngaio shrubland (sectors 2 & 6)
8. Waipu lagoons mixed shrubland (sector 1)
9. Wetland (sectors 1, 6,7 & 8)
10. Glasswort intertidal zone (sector 7)
11. Exotic plantation (sectors 1,2 & 3)
12. Parkland (sectors 0, 6 & 7)

See attached maps in Appendix 2.

2.2.2 Vegetation Descriptions

1. Spinifex sandfield

Found on the foredunes in most sectors, excluding sector 6 (which has no foredune) and sectors 3 & 4 which have a reduced consolidated foredune. At times co-dominant with *Ficinia nodosa*, invading pasture, marram grass or patches of kikuyu grass. Other native species found in this vegetation type 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 (Fig. 3), 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 in stabilised foredunes in sectors 3 and 4 and sector 7, at the southern edge of the delta (Fig. 4). 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 kikuyu grass, pasture and marram grass (displacing the native spinifex), boxthorn, exotic ice-plant and yucca.

4. Pasture

Present in all sectors due to extensive conversion of natural coastal areas for farming, recreation and residential purposes. Pasture is also found throughout the other vegetation types but is restricted to more sheltered environments on the foredune. Common associates 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, haretail, hawbit, hawksbeard, sweet vernal, nasturtium (along the estuary), bracken (sector 5), at times scattered shrubs (mainly gorse, boxthorn and lupin), patches of *Ficinia nodosa* and blackberry.

5. Flax shrubland

Dominant in areas as a result of council enhancement or reconstructive plantings around wetland areas and along the narrow coastal strip (sectors 3 & 4; Fig. 5). Other indigenous species found in this vegetation include cabbage tree, pohuehue, karo, taupata, sand convolvulus, bracken, *Ficinia nodosa*, kawakawa, hybrid *Pseudopanax* spp. and pohutukawa. Exotic species include German ivy and blackberry sprawling over other vegetation, as well as lupin, pampas, gorse, boxthorn and woolly nightshade and pasture species. Infrequent self seeding banksia, *Pinus* sp. and Lawson's cypress also occur.

6. Exotic shrubland

Comprises predominantly of boxthorn, lupin, gorse and pampas occurring together or in monospecific patches (Fig. 6). Found in the more sheltered environments on the leeward sides of the foredune and backdunes in the same sectors as the spinifex sandfields. 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 patches of *Ficinia nodosa*. Problem species include the dominants, exotic grasses (kikuyu grass and pasture species), blackberry, German ivy, *Solanum* spp., patches of 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 plantings in sectors 2 and 6 (Fig. 7), as well as some natural regeneration amongst exotic shrubland in sector 2. Sector 2 plantings 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. Pasture species are present at edges of all sightings of this vegetation type.

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. (Fig. 8). 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 in sectors 1, 6, 7 (Fig. 9) and 8. The littoral zone is typically raupo reedland and on occasion 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

Small monospecific community found in the estuarine zone of the delta in sector 7 (Fig. 10).

11. Exotic plantation

Consists of Lawson's cypress (sectors 1, 2 & 3; Fig. 11) 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 in sector 6 (Fig. 12), the sector 7 carpark and the Mangati Walkway (sector 0). Exotic dominants include coastal banksia, *Pinus* spp., Norfolk pine and patches of 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.

2.3 Problem Weeds

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).

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 (*Cortaderia fulvida* and *C. 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.

More isolated problematic 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.



Figure 3 *Ficinia nodosa* sandfield in sector 0 backswamp (above).

Figure 4 Pohuehue-kikuyu grass sandfield in sector 4 (other species include German ivy in the right foreground and *Ficinia nodosa* in the upper centre (below).



Figure 5 Flax shrubland found along the coastal strip in sector 4 (above).

Figure 6 Boxthorn-gorse shrubland found behind the foredunes in sector 5 (below). Additional species present include *Ficinia nodosa*, dead lupin and pasture species in the foreground and karo in the background.



Figure 7 Council plantings of ngaio-taupata/kawakawa shrubland in sector 6 (above).

Figure 8 Waipu lagoon plantings including surrounding raupo-flax wetland vegetation and mixed shrubland in the background (below).



Figure 9 Raupo reedland and surrounding coastal wetland vegetation present around the Waiwhakaiho lagoons in sector 7.

Figure 10 Glasswort intertidal zone in the Waiwhakaiho River Delta, sector 7.



Figure 11 Lawson's cypress plantations found on private land in sectors 1 & 2.

Figure 12 Parkland vegetation present in sector 6.

3.0 Restoration Recommendations

The following recommendations relate to targeted areas where extensive or enhancement planting can take place, where uncommon indigenous species may be introduced and to areas that can be left to regenerate naturally. In addition, brief guidelines on control of the problematic plants present are provided. 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 essential to achieving these goals. The SER international Primer on Ecological Restoration (2004) recommends multiple approaches, including attribute analysis, which comparatively assesses pre-existing records (this report, additional photographs (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

3.1 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.

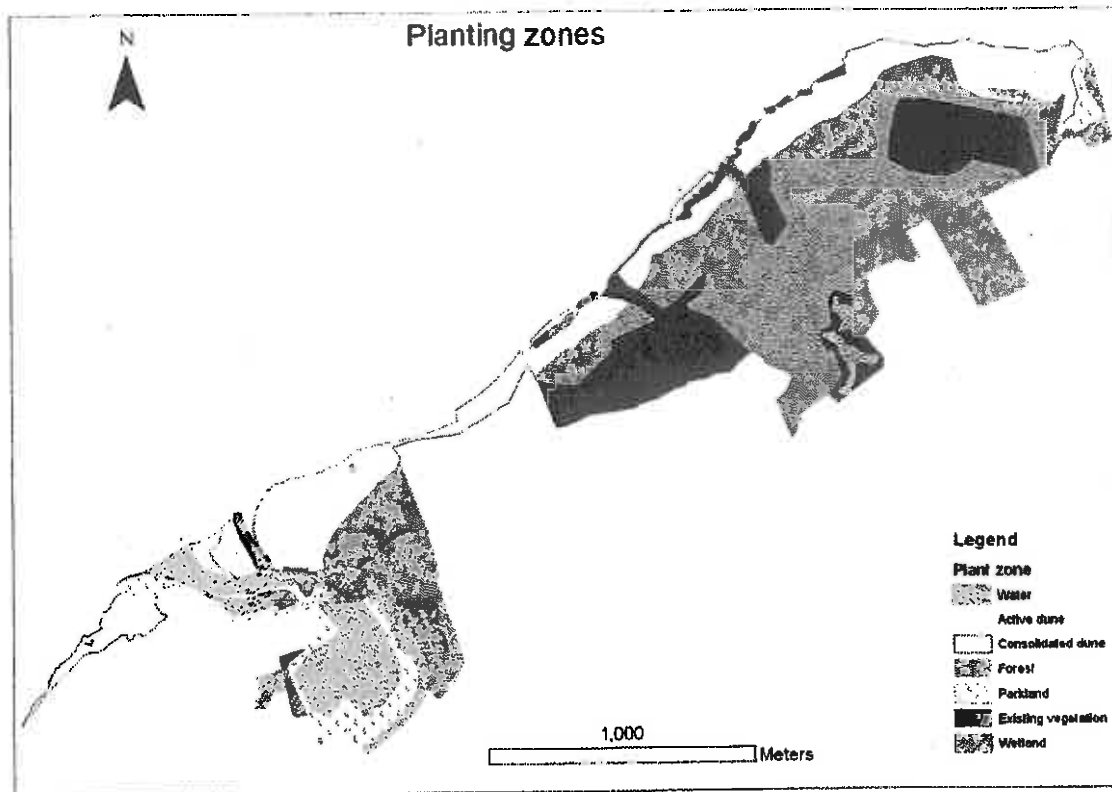


Figure 13 Planting zones for the extension area.

3.1.1 Unconsolidated duneland

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).

Species that can be included in these restoration plantings are as follows:

Active foredunes:

- pingao seedlings (in bare sand areas, approx 50 cm apart)
- spinifex seedlings (space 50 cm to 1 m apart)
- sand sedge (cuttings of runners works best)
- native iceplant
- sand pimelea (cuttings, space 1 m apart; Singers 1998)

Sheltered foredune areas:

- shore groundsel
- tauhinu
- sand coprosma seedlings
- toe toe (*Cortaderia fulvida*)
- pohuehue

3.1.2 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.

Species that can be included in these restoration plantings are as follows:

- flax
- taupata
- toetoe (*Cortaderia fulvida*, *C. toetoe*)
- cabbage tree
- ngaio
- karamu
- karo
- tauhinu
- coastal tree daisy
- koromiko
- *Corokia cotoneaster*

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 additional species can be added including:

- rangiora
- kawakawa
- hangehange
- ground cover species; sweet fern, *Poa anceps*, *Carex flagellifera*, shining spleenwort, bristle grass, gully fern, native sea celery and toatoa.

3.1.3 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.

Species that can be included in these restoration plantings are as follows:

- mahoe
- pigeonwood
- kohekohe
- whau
- puriri
- karaka
- ngaio

Mamaku and silverfern tree ferns will regenerate without assistance.

3.1.4 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.

Species that can be included in these restoration plantings are as follows:

Littoral zone:

- raupo
- kuawa
- kuta
- giant rush
- sharp spike sedge

Riparian zone:

- *Ficinia nodosa*
- *Carex virgata*, *C. secta*, *C. flagellifera* and *C. germinata*
- toetoe (*C. fulvida* and *C. toetoe*)

- cabbage tree
- flax
- kiokio
- swamp kiokio
- New Zealand lobelia
- kotukutuku
- whau
- karamu
- umbrella sedge
- oioi

Mamaku treefern and other ferns will establish without assistance. Other possibilities not in historical records or Maitahi Scenic Reserve, but present in the Waipu lagoons, include; swamp millet (*Isachne globosa*; also currently found in the extension area), baumea (*B. rubiginosa*), grass-leaved rush (*Juncus planifolius*) and *Muehlenbeckia australis*.

3.1.5 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.

3.1.6 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.

3.2 Weed Control

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.

4.0 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.

5.0 Acknowledgements

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Appendix 1: Species List

* indicates presence in sector

Species		Sector									
Scientific name	Common name	0	1	2	3	4	5	6	7	8	
<i>Acacia sp.</i>	acacia							*			
<i>Agapanthus praecox</i>	agapanthus		*						*	*	
<i>Allium triquetrum</i>	garlic weed								*		
<i>Ammophila arenaria</i>	marram grass	*	*	*	*		*		*	*	
<i>Anthoxanthum odoratum</i>	sweet vernal								*	*	
<i>Araucaria heterophylla</i>	norfolk pine	*	*	*				*			
<i>Araujia sericifera</i>	moth plant							*			
<i>Asplenium oblongifolium</i>	shining spleenwort							*			
<i>Bambusa sp.</i>	bamboo							*	*		
<i>Banksia integrifolia</i>	coast banksia	*		*	*			*		*	
<i>Blechnum minus</i>	swamp kiokio		*					*			
<i>Calystegia solanella</i>	sand convolvulus		*	*	*		*		*	*	
<i>Camellia sp.</i>	camellia		*								
<i>Carex sp.</i>								*			
<i>Carex virgata</i>	swamp sedge							*			
<i>Carpobrotus edulis</i>	ice-plant	*	*	*	*		*			*	
<i>Chamaecyparis lawsoniana</i>	Lawson's cypress		*	*	*						
<i>Conyza sumatrensis</i>	fleabane						*			*	
<i>Coprosma repens</i>	taupata	*	*	*	*	*	*	*	*	*	
<i>Coprosma robusta</i>	karamu		*								
<i>Cordyline australis</i>	cabbage tree	*	*	*		*		*	*	*	
<i>Cortaderia selleana</i>	pampas	*	*	*				*	*	*	
<i>Corynocarpus laevigatus</i>	karakā		*					*			
<i>Crepis capillaris</i>	hawksbeard	*									
<i>Cupressus macrocarpa</i>	macrocarpa	*	*	*				*			
<i>Cyathea dealbata</i>	silverfern		*								
<i>Cyathea medullaris</i>	mamaku	*	*	*				*	*		
<i>Cyperus alternifolius</i>	umbrella sedge	*						*			
<i>Cytisus scoparius</i>	wild broom						*				
<i>Dactylis glomerata</i>	cocksfoot				*	*	*	*	*	*	
<i>Delairea odorata</i>	german ivy	*	*	*	*	*	*	*	*	*	
<i>Dodonaea viscosa</i>	ake ake	*						*			
<i>Eleocharis acuta</i>	common spike rush		*							*	
<i>Eleocharis sphacelata</i>	kuta		*								
<i>Entelea arborescens</i>	whau							*			
<i>Euphorbia pepus</i>	milkweed		*								
<i>Festuca arundinacea</i>	tall fescue						*		*		
<i>Ficinia nodosa</i>	knobby clubrush	*	*	*	*	*	*	*	*	*	
<i>Foeniculum vulgare</i>	fennel	*						*		*	
<i>Fumaria muralis</i>	fumaria		*								
<i>Haloragis erecta</i>	toatoa							*	*	*	
<i>Hebe sp.</i>			*					*			
<i>Hedera helix</i>	ivy									*	
<i>Hedychium gardnerianum</i>	kahili ginger							*			
<i>Hierochloa redolens</i>	karetu								*	*	
<i>Holcus lanatus</i>	yorkshire fog	*	*				*	*		*	
<i>Hypochaeris radicata L.</i>	catsear	*	*				*			*	

<i>Spinifex sericeus</i>	spinifex	*	*	*	*	*	*	*
<i>Stachys arvensis</i>	staggerweed		*					
<i>Stachys sylvatica</i>							*	
<i>Taraxacum officinale</i>	dandelion	*	*	*				*
<i>Tetragonia tetragonioides</i>	nz spinach		*					
<i>Tradescantia fluminensis</i>	wandering jew						*	
<i>Trifolium pratense</i>	red clover	*	*			*		*
<i>Trifolium repens</i>	white clover	*	*			*		*
<i>Tropaeolum majus</i>	nasturtium						*	*
<i>Typha orientalis</i>	raupo		*				*	*
<i>Ulex europaeus</i>	gorse	*	*	*	*	*	*	*
<i>Viscia hirsuta</i>	hairy vetch						*	
<i>Vitex lucens</i>	puriri						*	
<i>Yucca filamentosa</i>	yucca	*	*			*		*
<i>Zantedeschia aethiopica</i>	arum lily	*	*					

Appendix 2: Sector Maps

