SAND DUNE VEGETATION AND CONDITION MONITORING AND MANAGEMENT RECOMMENDATIONS, TAURANGA ECOLOGICAL DISTRICT

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Report No. 1915

Prepared for:

ENVIRONMENT BAY OF PLENTY
P.O. BOX 364
WHAKATANE

Wildland CONSULTANTS

WILDLAND CONSULTANTS LTD, 99 SALA STREET, P.O. BOX 7137, TE NGAE, ROTORUA
Ph 07-343-9017, Fax 07-343-9018, email ecology@wildlands.co.nz, www.wildlands.co.nz

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PROJECT TEAM

Matt Renner - field work, report preparation.
Sarah Beadel - field work, report preparation.
Roger Bawden - GIS mapping.
Chris Bycroft - field work.

Reviewed and approved for release by:

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Sarah Beadel
Director
Wildland Consultants Ltd

1. INTRODUCTION

Sand dunes are a prominent feature of the Bay of Plenty Coastline. Within the Tauranga Ecological District 1.3% of the terrestrial area is covered by indigenous vegetation on sand dunes, and some of the largest remaining tracts of indigenous vegetation, and 40% of remaining natural areas within the coastal zone are on sand dunes.

Environment Bay of Plenty (BOP) commissioned Wildland Consultants to map vegetation and assess condition in "wild undeveloped" areas on sand dunes within the Tauranga Ecological District. Information on the composition of vegetation units, and the cover abundance of exotic species present within those units, as well as condition and impact factors associated with all vegetation units were collected as a component of this study.

This is the second of two reports describing outcomes of the dune vegetation study. The first report describes the methods for mapping of dune landforms, identifying and mapping dune vegetation types, and assessing dune condition (see Wildlands report No. 2033). This report presents the results of the 2008 survey.

2. OBJECTIVES

The objectives of this report are:

1. Present a broad summary of vegetation types and extent of vegetation on dunes within Tauranga Ecological District.
2. Suggest methods for storage of survey data.
3. Discuss opportunities for analysis of survey data.
4. Summarise management priorities associated with each transect.

3. METHODS

Data collection methods are fully described in Wildland Consultants (2008).

4. RESULTS

This study established and measured 81 transects distributed over 21 sand dune vegetation mapping and condition assessment sites (SDVC) (see Figure 1). Detailed vegetation types were mapped, covering over 990 ha. Seventy vegetation types and habitats were identified (see Table 1) and mapped over 727 polygons. These detailed vegetation types were then assigned to one of 50 vegetation classes. Where required to capture the variability in vegetation cover, additional transects were established. Additional transects were located between Transects 16 and 17 (one transect), Transects 26 and 27 (two transects), Transects 31 and 32 (two transects), and Transects 74 and 75 (two transects). The vegetation map was digitised at 1:1,000. Hard copies of the transect data and GIS files are held by Environment Bay of Plenty and Wildland Consultants.

Figure 1 - Sheet 1

Figure 1 - Sheet 2

Table 1: List of dune vegetation types and habitats in Tauranga Ecological District.

Structural Class	Vegetation Class	Vegetation Types and Habitats
01 Forest	01 Pine forest	01.01.01 Pine forest
	02 Banksia forest	01.02.01 Banksia forest
	03 Willow forest	01.03.01 Willow forest
02 Treeland	01 Pine treeland	02.01.01 Pine treeland
	02 Banksia treeland	02.02.01 Banksia treeland
03 Vineland	01 Pohuehue vineland	03.01.01 Pohuehue-*Ficinia nodosa* vineland 03.01.02 Pohuehue-bracken vineland 03.01.03 Pohuehue-marram vineland 03.01.04 Pohuehue-kikuyu vineland 03.01.05 Pohuehue-agapanthus vineland
	02 Cape ivy vineland	03.02.01 Cape ivy vineland
	03 Periwinkle vineland	03.03.01 Periwinkle vineland
	04 Japanese honeysuckle vineland	03.04.01 Japanese honeysuckle vineland
	05 *Muehlenbeckia australis* vineland	03.05.01 *Muehlenbeckia australis* vineland
04 Scrub	01 Mixed indigenous scrub	04.01.01 Ti kouka-karamu scrub 04.01.02 Ti kouka-mamaku-karamu scrub 04.01.03 Mixed indigenous scrub
	02 Gorse scrub	04.02.01 Gorse-pohuehue scrub 04.02.02 Gorse-broom/pohuehue scrub 04.02.03 Gorse-pampas scrub
	03 Coast tea tree scrub	04.03.01 Coast tea tree scrub
	04 Grey willow scrub	04.04.01 Grey willow scrub
05 Shrubland	01 Manuka shrubland	05.01.01 Manuka-mixed indigenous shrubland
	02 Ti kouka-taupata shrubland	05.02.01 Ti kouka-taupata shrubland
	03 Lupin shrubland	05.03.01 Lupin/spinifex shrubland
	04 Gorse shrubland	05.04.01 Gorse/oioi-kikuyu shrubland 05.04.02 Gorse/exotic grasses shrubland 05.04.03 Gorse-pampas shrubland
	05 Coast tea tree shrubland	05.05.01 Coast tea tree-pine shrubland
	06 African boxthorn shrubland	05.06.01 African boxthorn/pohuehue shrubland
	07 Grey willow shrubland	05.07.01 Grey willow shrubland 05.07.02 Grey willow-mixed indigenous shrubland
06 Tussockland	01 Sea rush tussockland	06.01.01 Sea rush tussockland
	02 Pampas tussockland	06.02.01 Pampas-mixed indigenous tussockland 06.02.02 Pampas-*Ficinia nodosa* tussockland 06.02.03 Pampas-gorse tussockland 06.02.04 Pampas-grey willow tussockland
07 Fernland	01 Bracken fernland	07.01.01 Bracken-pohuehue fernland
08 Grassland	01 Spinifex grassland	08.01.01 Spinifex-pingao/*Calystegia soldanella* grassland 08.01.02 Spinifex/*Calystegia soldanella* grassland
	02 Marram grassland	08.02.01 Marram grassland
	03 Buffalo grass grassland	08.03.01 Buffalo grass-pohuehue grassland
	04 Kikuyu grassland	08.04.01 Kikuyu-pohuehue grassland
	05 Cocksfoot grassland	08.05.01 Cocksfoot grassland
	06 Knot-root bristle-grass grassland	08.06.01 Knot-root bristle-grass grassland
	07 Tall fescue grassland	08.07.01 Tall fescue-kikuyu grassland
	08 Sea couch grassland	08.08.01 Sea couch dominant grassland
09 Sedgeland	01 Pingao sedgeland	09.01.01 Pingao sedgeland
	02 *Carex testacea* sedgeland	09.02.01 *Carex testacea*-pohuehue-*Ficinia nodosa* sedgeland
	03 *Ficinia nodosa* sedgeland	09.03.01 *Ficinia nodosa*-pohuehue sedgeland
	04 *Baumea juncea* sedgeland	09.04.01 *Baumea juncea* sedgeland
10 Rushland	01 Oioi rushland	10.01.01 Oioi rushland

Structural Class	Vegetation Class	Vegetation Types and Habitats
11 Reedland	01 Raupo reedland	11.01.01 Raupo reedland
	02 *Schoenoplectus tabernaemontani-Baumea articulata* reedland	11.02.01 *Schoenoplectus tabernaemontani-Baumea articulata* reedland
13 Herbfield	01 South African iceplant herbfield	13.01.01 South African iceplant herbfield
	02 Gazania herbfield	13.02.01 *Gazania linearis-Arctotis*-South African iceplant herbfield
	03 Flatweeds herbfield	13.03.01 Flatweeds herbfield
	04 Mixed exotic herbfield	13.04.01 Mixed exotics herbfield
	05 *Asparagus densiflorus* herbfield	13.05.01 *Ficinia nodosa*/*Asparagus densiflorus-Gazania linearis*-pohuehue herbfield 13.05.02 *Asparagus densiflorus*-buffalo grass herbfield
	06 Agapanthus herbfield	13.06.01 *Agapanthus praecox-Gazania linearis*-South African iceplant herbfield
	07 Canna lily herbfield	13.07.01 Canna lily herbfield
	08 *Rorripa palustris* herbfield	13.08.01 *Rorripa palustris* herbfield
19 Sandfield	01 Sandfield	19.01.01 Spinifex sandfield 19.01.02 Pingao-spinifex sandfield 19.01.03 *Carex pumila* sandfield 19.01.04 *Ficinia nodosa-Calystegia soldanella* sandfield 19.01.05 Sea rocket sandfield
22 Open water	01 Open water	22.01.01 Open freshwater 22.01.02 Impounded open water

Table 2: Extent of each vegetation class in Tauranga Ecological District.

Structural Class	Vegetation Class	Area (ha)
01 Forest	01 Pine forest	209.49
	02 Banksia forest	0.80
	03 Willow forest	9.37
		219.66
02 Treeland	01 Pine treeland	98.61
	02 Banksia treeland	39.11
		137.72
03 Vineland	01 Pohuehue vineland	134.63
	02 Cape ivy vineland	0.33
	03 Periwinkle vineland	0.05
	04 Japanese honeysuckle vineland	0.14
	05 *Muehlenbeckia australis* vineland	0.16
		135.30
04 Scrub	01 Mixed indigenous scrub	13.35
	02 Gorse-dominant scrub	37.04
	03 Coast tea tree scrub	9.85
	04 Grey willow scrub	17.45
		77.70
05 Shrubland	01 Manuka shrubland	0.85
	02 Ti kouka-taupata shrubland	0.27
	03 Lupin shrubland	1.68
	04 Gorse shrubland	3.96
	05 Coast tea tree shrubland	27.49
	06 African boxthorn shrubland	3.64
	07 Grey willow shrubland	40.74
		78.64
06 Tussockland	01 Sea rush tussockland	1.27

Structural Class	Vegetation Class	Area (ha)
	02 Pampas tussockland	4.71
		5.98
07 Fernland	01 Bracken fernland	13.72
		13.72
08 Grassland	01 Spinifex grassland	110.65
	02 Marram grassland	3.09
	03 Buffalo grass grassland	6.21
	04 Kikuyu grassland	1.14
	05 Cocksfoot grassland	2.67
	06 Knot-root bristle-grass grassland	0.08
	07 Tall fescue grassland	0.46
	08 Sea-couchgrassland	0.02
		124.32
09 Sedgeland	01 Pingao sedgeland	0.65
	02 *Carex testacea* sedgeland	42.19
	03 *Ficinia nodosa* sedgeland	67.03
	04 *Baumea juncea* sedgeland	17.05
		126.92
10 Rushland	01 Oioi rushland	1.11
		1.11
11 Reedland	01 Raupo reedland	12.42
	02 Kapungawha/*Baumea articulata* reedland	0.41
		12.83
13 Herbfield	01 South African iceplant herbfield	1.55
	02 Gazania herbfield	8.14
	03 Flatweeds herbfield	1.02
	04 Mixed exotic herbfield	0.17
	05 *Asparagus densiflorus* herbfield	0.09
	06 Agapanthus herbfield	0.74
	07 Canna lily herbfield	0.01
	08 *Rorripa palustris* herbfield	0.24
		11.87
19 Sandfield	01 Sandfield	29.01
		29.01
22 Open water	01 Open freshwater	2.10
	02 Impounded open water	13.29
		15.38
GRAND TOTAL		**990.15**

Two photographs were taken at the inland edge of each transect. The direction of both photographs was offset at 45º from the transect line, one to the north the other to the south. For some transects, where the foredune vegetation differed markedly from the vegetation visible from the inland end of the transect, a photo was taken from the seaward end of the transect looking inland down the transect line.

A disc containing photographs of each transect is held by Environment Bay of Plenty and Wildland Consultants Ltd. Environment Bay of Plenty also holds a hard copy of these (Wildland Consultants Contract Report No. 2014).

5. MANAGEMENT PRIORITIES FOR EACH TRANSECT

5.1 Central Waihi Beach

005 Control of exotic grasses, particularly kikuyu and saltwater paspalum (*Paspalum vaginatum*), spreading into dunes from the adjacent mown grass verge around carpark, and eradication of paspalum on incipient foredune. Eradication of pampas (*Cortaderia selloana*) and dimorphotheca (*Osteospermum fruticosum*) would also enhance the ecological values and quality of dunes. Eradication of saltwater paspalum is already underway (Greg Jenks pers. comm.).

006 Eradicate buffalo grass (*Stenotaphrum secundatum*) and kikuyu (*Pennisetum clandestinum*) spreading into, and overtaking restoration plantings on dunes from adjacent mown lawns in residential properties. Encourage adjacent landowners to 'hold the line' and restrict these species to their lawns. Eradication of Cape ivy (*Senecio angulatus*), dimorphotheca, *Aloe arborescens*, pig's ear (*Cotyledon orbiculata*), and lemon scented geranium (*Pelargonium crispum*) would also enhance the ecological values and quality of dunes.

007 Fencing and providing a sand ladder on the official accessway at the southern end of the transect would reduce the impact of foot traffic on dune structure here. Eradication of South African iceplant (*Carpobrotus edulis*) and banksia, and control of buffalo grass and kikuyu spreading from mown lawns in adjacent residential properties. Encourage adjacent landowners to 'hold the line' and restrict these grasses to their lawns. Eradication of dimorphotheca, broom (*Cytisus scoparius*), rhamnus (*Rhamnus alaternus*), and climbing dock (*Rumex saggitatus*) would eliminate the degradative impacts of these dune invasive plants. Removal of *Agave americana* and *Yucca gloriosa* would also enhance the ecological values and quality of the dunes.

008 Eradicate kikuyu spreading from mown lawns in adjacent residential properties. Encourage adjacent landowners to 'hold the line' and restrict this species to their lawns. Immediate eradication of tradescantia (*Tradescantia fluminensis*) from pohuehue vineland, would be valuable before this species becomes established in dune vegetation. Removal of dimorphotheca and a range of garden escapes would also enhance the ecological values and quality of the dunes.

009 Eradicate kikuyu spreading into dunes from mown verge alongside adjacent sealed road. Hold the line on vegetative spread of kikuyu through regular control along the margin of this verge. Eradicate South African iceplant, and control exotic species spreading into dunes from garden waste dumped along roadside edge. Monitor for future dumping of garden waste (need only be a walk through survey every three-four months), and implement appropriate remedial action as necessary. Educate adjacent landowners about potential environmental impacts of dumping garden refuse.

Removal of agapanthus (*Agapanthus praecox*) would also enhance the ecological values and quality of the dunes.

010 Eradicate kikuyu spreading into dunes from mown verge along edge of adjacent carpark. Hold the line on vegetative spread of kikuyu through regular control along the margin of this verge. The low, diffuse nature of indigenous vegetation on these dunes renders them particularly susceptible to invasion by agapanthus, *Asparagus densiflorus*, and Japanese honeysuckle (*Lonicera japonica*), among others. Ongoing control with a view to eradication of these species must be undertaken at this site if the indigenous character of these dunes is to be retained. Removal of pampas, *Yucca gloriosa* and other exotic succulents would enhance the ecological values and quality of these dunes.

5.2 Bowentown Sand Dunes

011 Spot control of climbing asparagus (*Asparagus scandens*), agapanthus, and pampas by spraying. Hand pull, spray, or cut and paint banksia.

Mowing gorse and grey willow (*Salix cinerea*) (current practice) is unlikely to achieve long-term control of these species.

Grey willow should be eradicated from this site, whether by physical removal, cutting and pasting stumps, or application of foliar herbicides.

Eradicate gorse and other exotic shrubs from stoss and leeward faces of established foredune, and maintain this area gorse free.

Instigation of a 'rolling front' to progressively eradicate and supplant gorse as dominant component of vegetation over a number of years is one option. Ongoing maintenance of this front will be necessary as gorse is a component of scrub communities on north western slopes of Te Ho.

012 Remove *Allocasuarina*, banksia, and grey willow. Spot control of pampas, and blackberry (*Rubus fruticosus* agg.).

Eradication of gorse, as above.

013 Eradicate kikuyu spreading from mown lawns in adjacent residential properties. Encourage adjacent landowners to 'hold the line' and restrict this species to their lawns. Eradicate *Acacia sophorae*, banksia, African boxthorn (*Lycium ferocissimum*), and gorse (*Ulex europaeus*) on transgressive dunes. Removal of pampas and agapanthus would also enhance the quality of these dunes.

5.3 Matakana Island

015 Remove wilding radiata pine and pampas as they establish on berm. These species overtop and shade out indigenous dune vegetation.

Within wetland areas, a program of ongoing control of pampas is required to prevent pampas from invading and dominating wetland margins, and wetlands whose water tables have been lowered through drainage. Ongoing control, with a view to eradication, of grey willow from wetlands within which it has not yet formed a complete canopy is also a priority. Without control grey willow will progressively capture all but areas of open water within Matakana wetlands, as it has happened in the largest wetland in this part of the island. Eradication of grey willow from Matakana is feasible as, unlike pampas, it is largely restricted to wetland areas.

Removal of wilding and planted pine within wetland areas.

In the medium to long term, control of all willow would be desirable.

016 Remove wilding radiata pine and pampas as they establish on berm. These species overtop and shade out indigenous dune vegetation.

Ongoing monitoring and eradication of royal fern (*Osmunda regalis*) as they are detected.

Within wetland areas, a program of ongoing control of pampas is required to prevent pampas from invading and dominating wetland margins, and wetlands whose water tables have been lowered through drainage. Ongoing control, with a view to eradication, of grey willow from wetlands within which it has not yet formed a complete canopy is also a priority. Without control grey willow will progressively capture all but areas of open water within Matakana wetlands, as it has happened in the largest wetland in this part of the island. Eradication of grey willow from Matakana is feasible as, unlike pampas, it is largely restricted to wetland areas.

Removal of wilding and planted pine within wetland areas.

In the medium to long term, control of all willow would be desirable.

016.1[1] Remove wilding radiata pine and pampas as they establish on berm. These species overtop and shade out indigenous dune vegetation.

Continue monitoring for royal fern and eradication of plants as they are detected.

Ongoing monitoring and eradication of royal fern as they are detected.

Within wetland areas, a program of ongoing control of pampas is required to prevent pampas from invading and dominating wetland margins, and wetlands whose water tables have been lowered through drainage. Ongoing control, with a view to eradication, of grey willow from wetlands within which it has not yet formed a complete canopy is also a priority. Without control grey willow will progressively capture all but areas of open water

[1] This is a separate transect from 016, as per numbering system described in methods.

within Matakana wetlands, as it has already happened within the largest wetland in this part of the island. Eradication of grey willow from these wetlands at the top end of Matakana is feasible as, unlike pampas, it is largely restricted to wetland areas.

Removal of wilding and planted pine within wetland areas.

In the medium to long term, control of all willow would be desirable.

017 Eradication of marram (*Ammophila arenaria*) from incipient and established foredunes and remove wilding radiata pine (*Pinus radiata*) and pampas as they establish on foredunes. These latter species overtop and shade out indigenous dune vegetation.

Continue monitoring for royal fern and eradication of plants as they are detected.

Ongoing monitoring and eradication of royal fern as they are detected.

Within wetland areas, a program of ongoing control of pampas is required to prevent pampas from invading and dominating wetland margins, and wetlands whose water tables have been lowered through drainage. Ongoing control, with a view to eradication, of grey willow from wetlands within which it has not yet formed a complete canopy is also a priority. Without control grey willow will progressively capture all but areas of open water within Matakana wetlands, as it has happened in the largest wetland in this part of the island. Eradication of grey willow from the northern end of Matakana Island is feasible as, unlike pampas, it is largely restricted to wetland areas.

Removal of wilding and planted pine within wetland areas.

In the medium to long term, control of all willow would be desirable.

018 Continue eradication of coast tea tree (*Leptospermum laevigatum*). This will involve ground control of seedlings.

Eradication of kikuyu and marram which are establishing on foredunes, and removal of pampas and gorse on foredunes will enhance dune quality.

019 Eradication of coast tea tree. This will involve ground control of seedlings.

Eradication of banksia, as this woody coastal weed is not yet established within dune systems on Matakana Island. Removal of pampas and pine saplings from foredunes will enhance dune quality.

020 Remove pampas and pine saplings from foredunes.

021 Eradication of marram growing on and behind the established foredune is a priority here. Marram contributes to the formation of large unstable

established foredunes that are prone to catastrophic blowout, and this type of dune is not characteristic of the foredune systems dominated by indigenous vegetation. Removal of pine saplings and pampas on incipient and established foredunes would also enhance the quality of these dunes.

022 Eradication of buffalo grass is an absolute priority and should be undertaken immediately. This is one of the few patches of buffalo grass on dunes on Matakana Island. A walk through survey for other patches of buffalo grass and kikuyu on foredune of Matakana is also recommended with a view to maintaining the dunes free of these grasses. Eradication of marram on foredunes at this site is also a priority. Removal of wilding pine and pampas on foredunes would also benefit these dunes.

023 Removal of wilding radiata pine and pampas on foredune is a priority here as the shade they cast directly impacts a population of sand pimelea (*Pimelea arenaria*) within the transect. Care must be taken to avoid damage to sand pimelea plants and seedlings through the course of this work. Several sand pimelea seedlings are present within the transect. Rabbit control may also benefit sand pimelea and sand coprosma (*Coprosma acerosa*) here.

024 Remove pampas and wilding pine from foredunes.

025 Eradicate marram from transect, and remove pampas from foredunes.

026 Eradicate marram from transect, and remove wilding radiata pine and pampas on foredunes.

026.1 Removal of dimorphotheca is a priority. This dune weed currently occurs at low abundance on Matakana Island and, given its abundance on mainland dunes, has potential to increase. Removal of wilding radiata pine and pampas would benefit dunes.

026.2 Eradication of kikuyu, marram, and dimorphotheca is top priority. Removal of wilding pine and pampas would also benefit indigenous dune vegetation.

027 The eradication of marram and Chinese privet (*Ligustrum sinense*) is a priority here. Removing pampas from foredunes would also benefit indigenous dune vegetation.

028 Eradication of sea couch (*Elytrigia pycnantha*) from dune is top priority here. Removal of wilding pine and pampas on foredunes would benefit indigenous dune vegetation.

Elytrigia pycnantha in Transect 028.

029 Removal of radiata pine wildings in *Ficinia-Muehlenbeckia*-dominant vegetation, and removal of pampas, would benefit indigenous

vegetation here.

030 Remove pampas and wilding radiata pine from foredunes.

031 Eradication of marram and removal of wilding pines and pampas are management priorities here.

031-1 Eradication of marram and Chinese privet, and removal of wilding pines and pampas from foredunes are priorities here. Pampas and pine may directly impact sand pimelea within this transect through the shade they cast. Care must be taken to avoid damage to sand pimelea plants through the course of this work. Rabbit control will also benefit sand pimelea.

031-2 Removal of pampas and wilding pine from foredunes would benefit dune vegetation on foredunes. Eradication of Japanese honeysuckle (*Lonicera japonica*) under pine within transgressive dunefield would prohibit further spread of this pest plant.

032 Eradication of coast tea tree and marram. *Leptospermum* control operations will involve ground spraying of seedlings established on bare sand around dead adults killed by aerial spray operations. Removal of pampas and wilding pine from foredunes would benefit dune vegetation on foredunes.

033 Eradication of coast tea tree. This will involve ground control of seedlings established in bare sand around base of adult trees killed by aerial application of herbicide. Eradication of African boxthorn and removal of pampas from foredunes would also be beneficial.

034 Eradicate coast tea tree and *Acacia sophorae*. For coast tea tree this will involve on-the-ground follow-up to control remaining live adults, and ongoing control of seedlings.

Several adult trees in this transect are leafy and green, cutting prior to flowering next spring would reduce further contributions of seed into the seed bank from which seedlings are emerging.

Removal of pampas from foredunes would also benefit dune vegetation and quality of dunes.

035 Eradicate coast tea tree, this will involve on-the-ground follow-up to control remaining live adults, and ongoing control of seedlings. Removal of Chinese privet from under pines on the transgressive dunes would help prohibit further spread of this pest plant.

036 Eradicate coast tea tree and *Acacia sophorae*, both present as seedlings and small shrubs. These species have the potential to impact sand coprosma growing within this transect. Removal of wilding pine (radiata pine and maritime pine; *Pinus pinaster*) and rhamnus (*Rhamnus alaternus*) from foredunes will also benefit dune vegetation.

037 Eradicate coast tea tree, this will involve on the ground 'mopping-up' of remaining adults and ongoing control of seedlings.

Removal of wilding pine and rhamnus from foredunes would also benefit dune vegetation.

038 Eradicate marram and boneseed (*Chrysanthemoides monolifera*). Remove wilding pines and pampas from foredune.

039 Eradicate marram and gorse from incipient dunes on berm. Removal of wilding pine and rhamnus would also benefit dune vegetation. Control of pampas and gorse in open area around entrance markers would facilitate capture of this site by indigenous dune species. Removal of Japanese honeysuckle from under pines on transgressive dunefield would help prohibit further spread of this pest plant.

5.4 Shark Alley to Kaituna A

040 Restrict kikuyu to mown verge. Alter position of fence at seaward end of dunes. Accretion of Aeolian sand at the base of incipient foredune is burying the existing fence.

041 Eradicate *Acacia sophorae*, South African iceplant, and pig's ear. Eradication of buffalo grass at this site should also be considered longer term. Buffalo grass at this site has invaded from adjacent mown lawn and ascended to dominance within vegetation on established foredunes and within the transgressive dunefield. At the very least the current margin of this infestation (which lies well inside this transect) should be actively maintained until such time as eradication can be attained.

042 Remove agapanthus, eradicate climbing asparagus, *Asparagus densiflorus*, and South African iceplant.

Eradication of climbing dock should be considered in the longer term.

Control exotic species spreading into dunes from garden waste dumped along roadside edge, in particular tradescantia, nasturtium (*Tropaeolum majus*), *Watsonia bulbifera*, and also a range of succulents. Monitor for future dumping of garden waste (need only be a walk through survey every three-four months), and implement appropriate remedial action as necessary. Educate adjacent landowners about potential environmental impacts of dumping garden refuse.

043 Eradication of South African iceplant (*Carpobrotus edulis*) and buffalo grass (*Stenotaphrum secundum*) from this site should be considered.. Buffalo grass at this site has invaded from adjacent mown lawn and ascended to dominance within vegetation on established foredunes and within the transgressive dunefield. At the very least the current margin of this infestation (which lies well inside this transect) should be actively maintained until such time as eradication can be attained.

Removal of exotic succulents would enhance dune vegetation quality.

044 Eradicate buffalo grass and kikuyu, which are spreading from mown lawns in adjacent residential properties. Encourage adjacent landowners to 'hold the line' and restrict this species to their lawns. Removal of agapanthus, South African iceplant, pig's ear, and blue morning glory (*Ipomea indica*) would prohibit likely future ascendancy of these species to site dominance. Removal of exotic succulents would enhance the quality of these dunes.

045 Eradication of Cape ivy and climbing dock from pohuehue dominated vegetation on transgressive dunes, and eradication of agapanthus, South African iceplant, and pig's ear from foredunes and dune swales will facilitate continued dominance of these areas by indigenous species. *Acacia sophorae* should also be eradicated. Numerous seedlings of rhamnus are established within the transect, likely derived from the large shrubs felled whose remains lie on surrounding dunes. Control of these seedlings will be easy once they have grown to a detectable size, c.40 cm, but should be removed before they start setting seed. Repeat control operations will probably be necessary to ensure capture of all rhamnus seedlings, and to ensure kill of *Agapanthus, Carpobrotus* and *Senecio.*

Removal of exotic succulents would enhance the quality of these dunes.

Two unofficial walkways are present within the transect, and are having a slight negative impact on dunes under current levels of use. Putting sand ladders on these walkways, in sensitive areas such as stoss and lee faces of established foredunes, should continue.

046 A range of exotic weeds are invading dune vegetation from residential properties adjacent the dunes, in particular agapanthus, *Ipomea indica* and *Vinca major*, and the buffalo grass. *Vinca major* is displacing pohuehue in parts. Buffalo grass is otherwise absent from dunes in the local area, and its eradication from this site is a priority. Encourage adjacent landowners to 'hold the line' and restrict this species to their lawns. Eradication of *Ipomea indica* and *Vinca major* in this early phase of what is becoming a heavy invasion of pohuehue dominated vegetation is necessary to retain the indigenous character of the transgressive dunes. Removal of *Arctotis*, South African iceplant, and pig's ear from spinifex-dominant vegetation on foredunes is also a priority. Control of montbretia (*Crocosmia crocosmioides*), *Sedum praealtum*, and *Yucca gloriosa* with a view to eradication will enhance the quality of these dunes in the longer term. Numerous seedlings of rhamnus are established within the transect, likely derived from the large shrubs felled whose remains lie on surrounding dunes. Control of these seedlings will be easy once they have grown to a detectable size, *c*.40 cm, but should be removed before they start setting seed. Repeat control operations will probably be necessary to ensure control of all rhamnus seedlings.

Stormwater discharge from the drain to the north of the transect is altering patterns of sand deposition in local area, primarily scouring leading to sand deposition deficit on the beach. This has reduced the profile of the beach, which remains relatively wetter between tides. This has flow on effects into the surrounding dunes in that levels of Aeolian sand flow are lower off the lower-profile part of the beach. This deficit carries through the entire dune system as sand is blown inland at a rate greater than it is replenished. These dunes exhibit one symptom of generally poor practices of storm water management in urban and suburban areas. However, remedial action is unlikely without major infrastructural revision.

5.5 Otira Sand Dunes

048[1] Kikuyu is invading dune vegetation from roadside verge at back of transgressive dunefield. Eradicate kikuyu spreading into dunes from mown verge along edge of adjacent carpark. Hold the line on vegetative spread of kikuyu through regular control along the margin of this verge. Eradication of the patches of moth plant (*Araujia sericifera*) and climbing dock scattered through transgressive dunefield, and of South African iceplant scattered though the foredune system is priority. Removal of pampas, African boxthorn, rhamnus, and blackberry will be necessary in the longer term as these species increase in size and number, and their visual and ecological impact increases proportionally.

This transect is dissected by a myriad of unofficial tracks crossing the foredunes and the seaward transgressive dunes. Some of these tracks, particularly main accessways from roadside, are cutting into and causing severe erosion of dunes. Putting in place sand ladders or a combination of sand ladders and fencing of the largest and most heavily used unofficial tracks would benefit dunes, and retain stability in what is otherwise a heavily vegetated, stabilized, transgressive dunefield.

049 Eradication of kikuyu, which is spreading from adjacent mown lawns around carparks and in residential properties is a priority. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads, and encourage residents to do the same. Control with a view to eradication of moth plant and climbing dock would benefit vegetation on the transgressive dunefield, as would eradication of South African iceplant on foredunes. Removal of pig's ear and agapanthus is also a priority. Removal of exotic succulents would benefit quality and ecological integrity of dunes.

050 Kikuyu and climbing dock are spreading into dunes from mown grass verges around carparks, and along official and unofficial tracks. Eradication of these two species from the dunes is a priority. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads. The control with a view to eradication of South African

[1] No data were collected for Transect 047 as it was located on rocky coast.

iceplant from foredunes is also a priority. Eight plants of sand pimelea are present within this transect and care must be taken not to damage these through the course of any management operations.

Pimelea arenaria within Transect 050 at Otira Sand Dunes

Putting in place sand ladders or a combination of sand ladders and fencing of the largest and most heavily used unofficial tracks would benefit dunes, and retain stability in what is otherwise a heavily vegetated, stabilized, transgressive dunefield.

051 A large area of knot-root bristle grass is established around an unofficial accessway through dunes. While this is a relatively common grass in modified habitats, this was the only patch observed on dunes during this survey. It is displacing pohuehue, and deserves eradication. Kikuyu is spreading into dunes from mown grass around adjacent lawn. Eradication of this species from the dunes is a priority. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads. Eradication of moth plant, climbing asparagus, and South African iceplant from dunes is also a priority.

Putting in place sand ladders or a combination of sand ladders and fencing of the largest and most heavily used unofficial tracks would benefit dunes, and retain stability in what is otherwise a heavily vegetated, stabilized, transgressive dunefield.

5.6 Papamoa Sand Dunes

052 Eradicate kikuyu, which is spreading from mown lawns alongside adjacent road. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads. Control with a view to eradication of climbing dock, and removal of Chinese privet would also benefit dune vegetation.

053 Eradicate kikuyu, which is spreading from mown lawns alongside adjacent road. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads. Eradicate tradescantia, *Vinca major*, and other exotic species spreading into dunes from garden waste dumped along roadside edge. Monitor for future dumping of garden waste (need only be a walk through survey every three-four months), and implement appropriate remedial action as necessary. Educate adjacent landowners about potential environmental impacts of dumping garden refuse. Control with a view to eradication of smilax (*Asparagus asparagoides*) and climbing dock in transgressive dunefield, and South African iceplant would also benefit the maintenance of indigenous character of these dunes.

054 Eradicate kikuyu, which is spreading from mown lawns alongside adjacent road. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads. Eradicate Cape ivy, *Vinca major*, and other exotic species spreading into dunes from garden waste dumped along roadside edge. Monitor for future dumping of garden waste (need only be a walk through survey every three-four months), and implement appropriate remedial action as necessary. Educate adjacent landowners about potential environmental impacts of dumping garden refuse. Control with a view to eradication of smilax, pampas, and climbing dock in transgressive dunefield, and South African iceplant would also benefit the maintenance of indigenous character of these dunes. *Prunus campanulata* should also be cut and painted.

055 Eradicate kikuyu, which is spreading from mown lawns alongside adjacent road. Hold the line on vegetative spread of kikuyu through regular control along verge margins around carparks and roads. Eradicate Cape ivy, *Vinca major*, and other exotic species spreading into dunes from garden waste dumped along roadside edge. Monitor for future dumping of garden waste (need only be a walk through survey every three-four months), and implement appropriate remedial action as necessary. Educate adjacent landowners about potential environmental impacts of dumping garden refuse. Control with a view to eradication of smilax, pampas, and climbing dock in transgressive dunefield, and South African iceplant would also benefit the maintenance of indigenous character of these dunes. *Prunus campanulata* should also be cut and painted.

5.7 Shark Alley to Kaituna B

056 Eradicate kikuyu and Indian doab (*Cynodon dactylon*), which are spreading from mown lawns alongside adjacent road. Hold the line on vegetative spread of these grasses through regular control along verge margins around carparks and roads.

Control with a view to eradication of South African iceplant and agapanthus.

057 Eradicate Indian doab spreading into dunes from adjacent mown lawn. Hold the line on vegetative spread of these grasses through regular control along lawn margins. Remove mature *Banksia integrifolia* and control seedlings on dunes with a view to eradication. Follow up control work on South African iceplant.

058 Eradicate kikuyu and Indian doab that are spreading from mown lawns in adjacent residential properties. Encourage adjacent landowners to 'hold the line' and restrict this species to their lawns. Control South African iceplant with a view to eradication. Removal of agapanthus and pig's ear would also enhance the quality of these dunes.

5.8 Kaituna Sand Dunes and Wetland

059 Eradication of gorse is feasible at this site. Abundance of other weeds within, and in areas adjacent to, this transect are low, and complete suppression of all herbaceous weeds is possible with ongoing vigilance. Isolated individuals of South African iceplant, *Gazania linearis*, African boxthorn, and dimorphotheca should all be sought and destroyed.

060 Eradicate kikuyu and maintain.

061 Eradicate kikuyu from dunes. Hold the line on vegetative spread of this grass through regular control along edge of managed area.

062 No management priorities.

063 Remove African boxthorn and pampas.

064 Remove African boxthorn and pampas. Control blackberry with a view to eradication.

5.9 Maketu Spit

065 Eradicate marram on foredunes, and kikuyu and other exotic grasses invading from vehicle track along estuarine margin. Maintain eradication. Remove pampas and boxthorn from estuary edge and elsewhere as appropriate, including around carpark and the cut. Eradicating rats at the cut carpark may have positive flow on effects down the spit for indigenous birdlife.

066 Remove pampas and pine.

067 Remove pampas from estuary edge. Remove nearby *Metrosideros kermadecensis* which have been planted along the estuarine margin.

068 Remove scattered pampas from estuary edge.

5.10 Okerei Point

071[1] No recommendation.

5.11 Pukehina Spit

074-1 Eradicate marram, South African iceplant, and dimorphotheca. These three weeds are currently in low numbers at this site, which is also home to sand tussock (*Austrofestuca littoralis*).

074-2 Eradicate kikuyu and Indian doab which are spreading from mown lawns around carpark. Hold the line on vegetative spread of kikuyu and Indian doab through regular control along verge margins around carpark. Control moth plant and South African iceplant with a view to eradication. These species are displacing pohuehue on established foredune, and on the estuarine side of spit.

075 Monitor for encroachment of kikuyu and other exotic grasses from adjacent residential lawns. Control South African iceplant with a view to eradication. Removal of dimorphotheca would also enhance the quality of these dunes.

5.12 Pukehina Beach

076 Eradicate buffalo grass, South African iceplant, and pig's ear. Encourage adjacent landowners to 'hold the line' and restrict buffalo grass to their lawns. Removal of other exotic succulents and agapanthus would enhance the quality of these dunes.

077 Eradicate South African iceplant, and pig's ear. Removal of other exotic succulents and agapanthus would enhance the quality of these dunes but may not be a move welcomed by adjacent residents given that the agapanthus have been planted recently.

078 Progressive control with a view to eradication of *Arctotis,* South African iceplant, pig's ear, and dimorphotheca. Remove banksia. Any removal of vegetation from these dunes is likely to be unpopular with adjacent residents, and is best done after consultation with them, and only with their approval. Erosion of foredunes is in some cases severe along Pukehina, and in many areas these thinnest of vegetative veneers are perceived to be protecting valuable assets. Contravention of this veneer will not be popular. However, a strategy entailing progressive replacement of exotics by native dune

[1] Note there is no Transect 72 or 73 because there were no dunes at these points along the coast.

binding vegetation may engage all parties. Attaining the outcome desired by these management recommendations will require the support of the local community and their involvement is important.

079 This transect embodies the perspective outlined in Transect 078 above where marram, pingao (*Desmoschoenus spiralis*), and a range of weedy garden species, including agapanthus and *Agave americana*, have been planted in response to erosion of foredunes. Marram should be removed, and agapanthus, South African iceplant, pig's ear progressively controlled with a view to eradication, following consultation with adjacent residents.

080 Eradicate kikuyu which is spreading from lawns in adjacent residential properties. Encourage adjacent landowners to 'hold the line' and restrict this species to their lawns. Progressive control with a view to eradication of South African iceplant, pig's ear, dimorphotheca and *Arctotis* would benefit quality and ecological integrity of these dunes.

5.13 Pukehina to ED boundary

081 Eradicate saltwater paspalum.

082 Remove pampas, African boxthorn, blackberry and gorse.

083 Eradicate marram and South African iceplant. Control smilax with a view to eradication.

085 Remove adult African boxthorn and follow up on seedlings with a view to eradication.

086 Eradicate African boxthorn from this otherwise relatively weed-free transect.

6. HIGH PRIORITY WEED MANAGEMENT ACTIONS

In many respects the maintenance of indigenous biodiversity values within the Ecological District depends on good stewardship in light of degradative processes impacting remaining natural areas.

Degradation of remaining habitats by exotic plants is associated with a loss of indigenous cover and biodiversity as indigenous species are usurped by invasive exotic species.

Impacts by exotic animals again require monitoring using appropriate methods.

6.1 Species focused management actions

Dune vegetation is particularly susceptible to invasion by weeds. The dynamic nature of dunes generates open spaces into which exotics germinate that may then ascend to dominance through faster growth rates. The dynamic nature of dune systems means

opportunities for micro-site invasion and capture occur far more frequently than in forests, alpine areas, and wetlands.

Dune vegetation is typically low profile with moderate to low cover abundance, and is readily invaded by light demanding drought tolerant weeds.

Coast tea tree is a serious threat to dune vegetation at a regional and national level.

Kikuyu is a pervasive threat as it has the capacity to overgrow and smother indigenous dune vegetation on transgressive dunefields and established foredunes.

Eradication of kikuyu from all dune vegetation can be achieved while the invasion front on transgressive dunes and established foredunes is confined to areas adjacent managed edges. In these areas kikuyu could be sprayed with Gallant without negatively impacting surrounding dicot herbs and vines, including pohuehue into which kikuyu is typically invading. There is also the possibility that kikuyu could be eradicated from dunes without adversely impacting surrounding indigenous plants by application of granular salt, as kikuyu is not as salt tolerant as most indigenous dune species. Eradication of kikuyu from dunes would be beneficial to dune character, visual appearance of dunes and dune stability. Kikuyu has potential to smother and replace existing vegetation, it is a vibrant green, and it does not trap sand as effectively as indigenous dune vegetation. Ongoing follow up control work around margins of all lawns and verges that abut dune vegetation must be an annual component of dune vegetation management.

Marram is also a threat to dune systems. Marram forms dense tussocks which not only overtop and crowd out indigenous dune vegetation but also tend to form more hummocky peaked dunes (Hesp 2000). These peaked dunes are more susceptible to blow out than the lower more spreading dunes formed by rhizomatous indigenous dune plants like spinifex and pingao, and hence alter the dynamics of dune establishment, migration, and erosion. Marram sets low amounts of viable seed, but these can be dispersed for considerable distances. Once eradicated from within an area it will be relatively easy to maintain eradication with ongoing monitoring.

Other species which are longer-term priorities for control, with a view to eradication, are South African iceplant, buffalo grass, and pig's ear.

Saltwater paspalum is currently the subject of a control operation and this should be continued.

There are many other pest plants on the dunes in varying amounts which are also a priority for control. These include, but are not limited to, rhamnus, Japanese spindle tree, Cape ivy, *Acacia sophorae*, climbing dock, smilax, agapanthus, prickly pear, pampas, banksia, and boneseed. Several of these have been the subject of major or intensive control operations on the dunes, e.g. rhamnus, prickly pear, and Acacia, and control of these and other pest plants should continue to be undertaken.

Biennial monitoring of roadside and trackside margins for dumping of garden waste is necessary to prevent the establishment of new weeds, and new sites for weeds already present (and in some instances established from garden dumpings) in other areas.

Weeds established in this fashion include tradescantia, *Vinca major*, and a range of succulents.

6.2 Site focused management actions

If a focus on sites is preferred, then management could be directed toward the Kaituna dune and wetland system. Here the greatest benefit can be derived with minimal effort due to the currently low levels of weed invasion. Management at this site should focus on eradicating all perennial weed species from this dune system, including gorse, South African iceplant, *Gazania linearis*, and so on. This would safeguard the character of these dunes and the populations of threatened species they contain.

Alternatively effort could focus on Matakana Island, particularly the dune and wetland system in the north west of the island for the same reasons, large areas, relatively weed free dunes, one wetland site relatively weed free and another in early stages of invasion by grey willow.

7. DISCUSSION

Two of the objectives of the project were to suggest methods for storage of survey data, and to discuss opportunities for analysis of survey data. While we did not complete data entry or perform any data analysis, we were asked to provide recommendations on best practices and opportunities in both areas.

7.1 Suggestions on data storage

We suggest that data storage follow the format illustrated in the example Microsoft Excel file on CD attached with this report. In this file separate spreadsheets are devoted to recording site-, transect-, and polygon-specific information. Different categories of data are then separated into separate spreadsheets, i.e. presence and abundance of weeds, impacts. This sorts data into manageable partitions which will make identifying key issues of interest possible, as well as identifying broad changes to vegetation pattern and conditions over time. Within these data spreadsheets it is critical to preserve the nested pattern inherent in sampling design for data entry. This is achieved by recording transect number and site number for each polygon whose data is entered. A statistician can then analyse the data by exporting it into another statistical program (e.g. Minitab) from this spreadsheet.

All blanks in the spreadsheet cells equal zero. There is no need to enter zeros as they can be entered later by find and replace if the particular statistical program chosen to undertake the comparison requires this (many do not).

A hard copy of all data sheets, and a hard copy of the completed spreadsheet should also be stored as a physical back up, preferably in duplicate in two different locations.

7.2 Opportunities for data analysis

Medium to long-term ecological monitoring programs are a globally rare phenomenon, and the potential utility of the data collected by this survey cannot be understated.

7.2.1 Major differences in current degree of weed invasion

The nested sampling design implemented in combination with the data collected in enables a number of different questions to be addressed. Comparisons between the current degree of weed invasion can be made between different vegetation classes and between different sites for individual weed species or all weed species together. Differences resolved by these comparisons may help focus future vegetation management actions.

Differences in the percentage cover of individual weed species between different vegetation types may indicate whether or not weeds have different impacts in different vegetation types. This may help focus management action.

Different levels or types of weed infestation may help focus efforts to prevent or reduce weed infestations with different adjacent land use.

7.2.2 Major changes in degree of weed invasion over time

Major changes in degree of weed invasion in different vegetation types can be detected by comparing the cover scores across years. Changes in degree of invasion by individual species and by all invasive species together can be detected and quantified. Changes in degree of invasion over different areas, for instance at the transect level, the site level, and at the level of the entire Ecological District are also possible.

The quantification of cover means that subtle changes in degree of invasion are unlikely to be detected, but major changes in the cover of exotic species within vegetation types can be. We suggest that a change of magnitude equal to or greater than two cover classes be regarded as indicative of real change in cover, due to the influences of season and inter-individual variance in quantification of cover.

7.2.3 Occurrence of invasive weeds

Presence of weed species is recorded for each vegetation unit within each transect. The presence of weed species allows an assessment of whether individual weeds are restricted to certain habitat types. This may enable an estimate of the extent of dunes likely to be occupied once invasion has run to completion, on the basis of the extent of those vegetation types as mapped with GIS. Changes in the frequency of occurrence of weed species within transects over time can be used as a proxy indicator of population level trends for these species, and as a logical check on cover class scores indicating species spread. This again may trigger management action.

7.2.4 Differences in impacts through time

Impacts associated with each vegetation unit can be compared across years. Correlation between impacts on each vegetation type may be correlated with changes in the condition of that unit in the long term. They may also be correlated with the occurrence of rare and threatened species.

7.2.5 Occurrence of rare and threatened indigenous species

Presence of rare and threatened species is recorded for each vegetation unit within each transect. The presence of rare and threatened indigenous species within vegetation types enables an estimate of their likely current range to be made on the basis of the extent of those vegetation types as mapped with GIS. This may assist to focus management activities directed at these species, for example in identifying potential reintroduction sites. Changes in the frequency of occurrence of species within transects over time can be used as a proxy indicator of population level trends for these species. This again may trigger management action.

7.2.6 Assessment of overall dune condition

A single scaled metric reflective of overall dune condition could be derived simply through averaging condition scores. This would yield an average condition, but this might not reflect the average condition encountered within the field if heavily invaded sites are small and weed-free sites are large. A more sensitive indicator of dune condition would be to derive an average that is scaled by the within-transect area of the polygons to which they apply,

$$= \sum_{1}^{n} c\left(\frac{a}{t}\right)$$

where c is polygon condition, a is area of that polygon, and t is the total area under consideration. Usually this would be the total area of the transects included, but could be a transect, site, ecological district or other area of interest. Dune condition can be generalized from within transect conditions because the areas sampled by each transect should constitute a representative example of the coastal dune system as a whole. This metric would then be sensitive to increasing area of heavily invaded vegetation types as well as deterioration in condition of vegetation types. The relative contribution of both processes to deterioration or improvement in overall condition can be established by comparing change in metrics through years.

7.3 Quality control

A subjective assessment of abundance, such as that undertaken by this survey, carries with it certain caveats that must be acknowledged. Firstly, quantification of abundance is restricted to six categories. Therefore detection of change in vegetation condition is restricted to instances where weed abundance crosses one of the five transitions between categories. While changes in abundance from less than 1% cover

to more than 25% cover will undoubtedly be detected and communicated through this system, more subtle changes, particularly those occurring between the broader categories will not. Furthermore, the quantification of change in dune condition using six categories of abundance might not reflect the dynamics of weed invasion appropriately. This would be the case if, in invaded areas weed species attained a moderate relative abundance relatively quickly, and then stabilized about that abundance. This may have already happened in weed invaded areas within the Tauranga ED. In this case the metric proposed could be particularly valuable for quantifying the course of deterioration in dune vegetation.

Inter-individual variance in observation. Different observers will undoubtedly have different takes on the same vegetation structure, and as a result of differing amounts of previous experience and different outlooks, they may not quantify vegetation in exactly the same way as previous observers. This is not a problem of subjectivity or objectivity, it is a problem of perception.

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GLOSSARY OF COMMON NAMES USED IN THE TEXT

African boxthorn	*Lycium ferocissimum*
African ice plant	*Carpobrotus edulis*
agapanthus	*Agapanthus praecox*
arctotis	*Arctotis stoechadifolia*
banksia	*Banksia integrifolia*
blackberry	*Rubus fruticosus* agg.
blue morning glory	*Ipomea indica*
broom	*Cytisus scoparius*
buffalo grass	*Stenotaphrum secundatum*
Cape ivy	*Senecio angulatus*
Chinese privet	*Ligustrum sinense*
coast tea tree	*Leptospermum laevigatum*
dimorphotheca	*Osteospermum fruticosum*
gorse	*Ulex europaeus*
grey willow	*Salix cinerea*
Indian doab	*Cynodon dactylon*
Japanese honeysuckle	*Lonicera japonica*
kikuyu	*Pennisetum clandestinum*
lemon scented geranium	*Pelargonium crispum*
lupin	*Lupinus arboreus*
maritime pine	*Pinus pinaster*
marram	*Ammophila arenaria*
moth plant	*Araujia sericifera*
pampas	*Cortaderia selloana*
paspalum	*Paspalum dilatatum*
periwinkle	*Vinca major*
pig's ear	*Cotyledon orbiculata*
pingao	*Desmoschoenus spiralis*
pohuehue	*Muehlenbeckia complexa*
prostrate amaranth	*Amaranthus deflexus*
radiata pine	*Pinus radiata*
red fescue	*Festuca rubra* subsp. *rubra*
royal fern	*Osmunda regalis*
saltwater paspalum	*Paspalum vaginatum*
sand coprosma	*Coprosma acerosa*
sand pimelea	*Pimelea arenaria*
sand tussock	*Austrofestuca littoralis*
sea rocket	*Cakile maritima*
smilax	*Asparagus asparagoides*
South African iceplant	*Carpobrotus edulis*
tall fescue	*Schedonorus phoenix*
tradescantia	*Tradescantia fluminensis*

QUALITY CONTROL

If a logical check on both the reliability of qualitative assessments of abundance, and undetected changes in relative abundance is required data on cover abundance will need to be collected. There are two kinds of abundance data, the numbers of individuals or individuals of each species within a community, and for plants, the relative areas occupied by species. The metric used in this survey quantifies the relative area occupied. The collection of cover abundance data can be achieved through extension of the existing sampling design with ease, in one of two ways.

1. Transect-Based Methods

   Sample at intervals of 1 meter along a line transect. At each interval record the species present under the point. One or more transects of this kind could be placed within existing belt transects. The relative cover abundance of each species, and bare sand could then be calculated simply by the number of sample points occupied by the species of interest by the total number of sample points. The sample size (number of points) required to obtain an adequate sample from an area could be established using rarefaction methods to assess species accumulation through the course of sampling. A rarefaction approach will also quantify how heterogeneous vegetative cover is within each transect, and estimate how many species present at the site have been missed by the sample. Data from different transects can be combined, to increase sample size. Rarefaction methods would be particularly useful for comparisons of this nature between dune areas as they correct for unequal sample sizes (Gotelli and Colwell 2001).

2. Plot-Based Methods

   Bounded 2 × 2 m plots could be laid out within a transect in a regular or stratified pattern, and photographs of the bounded area taken from above. The photographs could then form the basis for collection of cover abundance data using a modification of the point sampling method proposed above. Photographs would have the additional advantage of providing a quantified visual record of change in vegetation composition through time, in addition to those listed above. One potential drawback is that the physical plants are not present when they are identified and data about them collected. This could be corrected for through judicious collection of field notes associated with each photo.

These are but two examples. Many other strategies could be devised to collect cover abundance data in a meaningful and repeatable fashion from dunes in ways that are compatible with, and a logical extension of, the existing methodology. Of course, this would involve an increased amount of field work and subsequent data compilation, input, and analysis in the office.

PHOTOGRAPHS OF VEGETATION CLASSES

01.01 Pine forest.

01.02 *Banksia integrifolia* forest.

01.03 Willow forest.

02.01 Radiata pine treeland.

03.01 Pohuehue vineland.

03.02 Cape ivy vineland.

03.05 *Muehlenbeckia australis* vineland.

04.01 Mixed indigenous scrub.

04.02 Gorse scrub.

04.03 *Leptospermum laevigatum* scrub.

05.02 Ti kouka-taupata shrubland.

05.04 Gorse shrubland.

05.06 African boxthorn shrubland.

06.01 Searush tussockland.

06.02 Pampas tussockland.

08.01 Spinifex grassland.

08.02 Marram grassland.

08.03 Buffalo grass grassland.

08.04 Kikuyu grassland.

08.05 Cocksfoot grassland.

08.07 Tall fescue grassland.

09.01 Pingao sedgeland.

09.02 *Carex testacea* sedgeland.

09.03 *Ficinia nodosa* sedgeland.

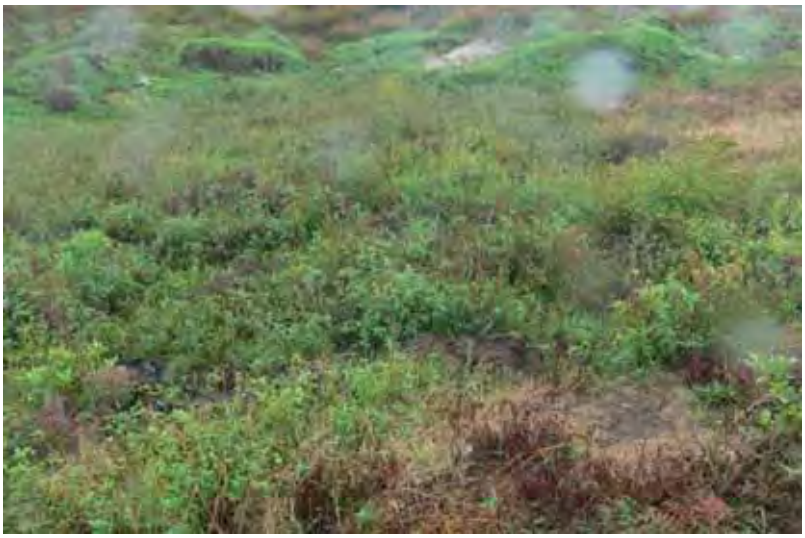
10.01 Oioi rushland.

11.01 Raupo reedland.

13.01 South African iceplant herbfield.

13.02 Gazania herbfield.

13.03 Flatweeds herbfield.



13.04 Mixed exotics herbfield.

13.05 *Asparagus densiflorus* herbfield.

13.08 *Rorripa palustris* herbfield.

19.01 Sandfield.

22.01 Open freshwater.

23.01 Beach sand.