ECOLOGICAL ASSESSMENT OF MAUAO HISTORIC RESERVE

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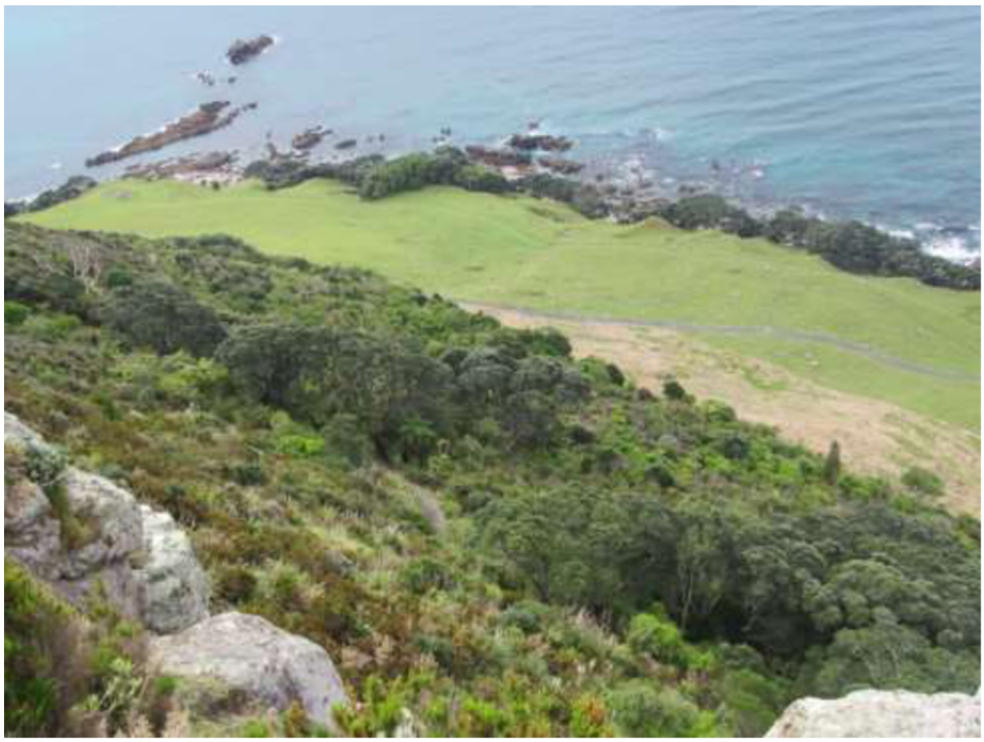

Transition from shrubland to forest to grassland to treeland on the eastern side of Mauao. The dead grassland (middle right) contains recently planted indigenous species.

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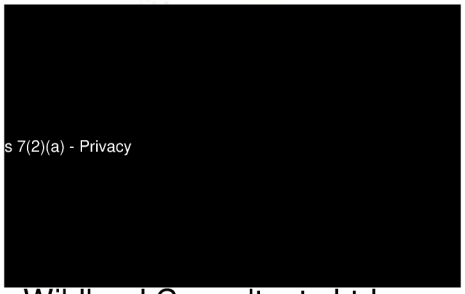

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1. INTRODUCTION

Mauao is a steep-sided rhyolitic lava dome rising 232 m above sea level at the main entrance to Tauranga Harbour. It was inhabited for centuries by tangata whenua, and visible surface archaeological features cover most of the summit and southern slopes. Mauao is a nationally significant landscape feature, and retains significant ecological values despite heavy modification by humans. Significant ecological values on Mauao include an important remnant of coastal forest and mainland populations of ōi (grey-faced petrel; *Pterodroma macroptera gouldi*) and karorā (blue penguin; *Eudyptula minor iredalei*). A large proportion of Mauao (*c.*77 ha) is a Historic Reserve which is administered by Tauranga City Council.

Tauranga City Council has recently updated their Coastal Reserve Management Plans except for the Mauao Historic Reserve Management Plan, which they intend to review shortly. Wildland Consultants Ltd was commissioned by Tauranga City Council to provide an assessment of the ecological condition and values of Mauao Historic Reserve and to evaluate future management. This assessment will be used to inform the review of the Mauao Historic Reserve Management Plan.

2. ECOLOGICAL CONTEXT

2.1 Tauranga Ecological District

Information on ecological context has been adapted from Wildland Consultants 2008.

Mauao is located within Tauranga Ecological District, within the Northern Volcanic Plateau Ecological Region. Tauranga Ecological District is situated in the western Bay of Plenty, between the eastern foothills of the Kaimai-Mamaku range and the Pacific Ocean, encompassing the western section of the coastal dune systems that stretch between Waihi beach and Opotiki. The Ecological District contains three estuaries, including the entire expanse of the Tauranga Harbour, coastal dunes and plains, and low hills. It is largely located within the coastal bioclimatic zone, with small portions extending inland into the semi-coastal bioclimatic zone.

Prior to human settlement, tall podocarp-broadleaved species forest would have covered all of the hill country and the flatter land, with the exception of the foredune and the extensive freshwater wetlands on the plains. Non-forested dunes would have included sand binding species such as pīngao (*Ficinia spiralis*), pōhuehue (*Muehlenbeckia complexa*), and spinifex (*Spinifex sericeus*), with low shrubland areas of *Coprosma* spp., kānuka (*Kunzea robusta*), karo (*Pittosporum crassifolium*), and pōhutukawa (*Metrosideros excelsa*) further back from the beach. Within the estuarine systems, there would have been extensive saltmarshes, mangrove (*Avicennia marina* subsp. *australasica*) scrub, and seagrass (*Zostera muelleri* subsp. *novozelandica*) beds. Large freshwater wetlands were present on the Kaituna-Pongakawa Plain, and around the Maketu and Waihi estuaries, while smaller wetlands would have been present along the margins of the major valleys formed by the Wairoa, Kopurererua, and Waimapu Rivers.

Vegetation and habitats within Tauranga Ecological District were modified extensively by Māori for cultivation and occupation, and in European times by conversion to agricultural, horticultural, and urban developments, the last three of which are ongoing. Currently, land used for agriculture and horticulture comprises *c.*71% of the land cover of Tauranga Ecological District, built-up areas and infrastructure for human settlement comprise *c.*10% of the land cover, and indigenous vegetation comprises *c.*8% of the land cover (Ministry for Primary Industries 2014). Relatively little indigenous vegetation remains in Tauranga Ecological District away from the margins of the harbour and estuaries, and even saline wetlands have been reduced in extent by drainage and conversion to agricultural or horticultural land uses. There are very few protected natural areas in the Ecological District, and most of these are small (Wildland Consultants 2008).

2.2 Pre-human vegetation

Prior to human occupation, Mauao would have been covered almost entirely with coastal forest dominated by pōhutukawa, pūriri (*Vitex lucens*), karaka (*Corynocarpus laevigatus*), ngaio (*Myoporum laetum*), houpara (*Pseudopanax lessonii*), and kānuka, and shrubs or small trees of karo, houpara, māpou (*Myrsine australis*), whau (*Entelea arborescens*), and nīkau (*Rhopalostylis sapida*). There are also likely to have been local occurrences of rimu (*Dacrydium cupressinum*), northern rātā (*Metrosideros robusta*), tawa (*Beilschmiedia tawa*), hīnau (*Elaeocarpus dentatus*), rewarewa (*Knightia excelsa*), mangeao (*Litsea calicaris*), and kāmahi (*Weinmannia racemosa*). Specialist species, such as *Euphorbia glauca*, would have been present on bluffs, beaches, coastal rocks and seepages.

2.3 Human-induced change

Adapted from Wildland Consultants 2004.

People lived on Mauao for many centuries and they had a dramatic effect on the vegetation:

"The most elaborate fortified sites in the Bay of Plenty Region region were at Maunganui, Mangatawa and on the hills at Papamoa. Maunganui, an isolated mount protected by the sea on all sides except the narrow sandy isthmus to the east, was an ideal site for a large fortified village. The main village was on the south side and the remnants of extensive terracing and numerous middens testify to its long occupation."
(Stokes 1980)

Fire has been an important factor in the ecology of Mauao. There may have been occasional natural fires prior to human arrival, but the increased frequency of fire after human arrival has had negative impacts on both vegetation and fauna. The original vegetation will have been cleared at an early stage, and fire would have been used repeatedly to keep Mauao relatively open. Pre-European vegetation was mapped as "fern and manuka [*Leptospermum scoparium*] scrub" (Stokes 1980), providing evidence of recovery after clearance and burning. A large fire was reported in November 1842 (Cunningham and Musgrave 1989) and an 1858 illustration shows the southern and western slopes devoid of heavy vegetation (see Wildland Consultants 1999). Oblique photographs of the eastern slopes of Mauao in 1929, the

1940s, and 1960 are also presented in Wildland Consultants (1999). In 1929, the vegetation was all low-stature, but by the 1940s pines (*Pinus* spp.) were well-established and by 1960 they were very prominent.

Analysis of aerial photographs from 1943 to 1999 indicates that fire has affected the vegetation of parts of Mauao at reasonably regular intervals over the last 60 or so years. Evidence of recent fire-related vegetation change is confined to the northern flanks of Mauao, but the extent of vegetation affected within this area appears to differ in each episode of fire. Most of the indigenous-dominant vegetation on the southern and western slopes has not been affected by fire since 1943, probably reflecting the slightly damper environment on these slopes and the lower flammability of the more advanced vegetation successions. There is no evidence of fire between 1943 and 1959, as shown by a large increase in the numbers of pines in the vicinity of the summit and in the area affected by fire prior to 1943.

Recent fires on Mauao, with the notable exception of the two most recent ones, appear to have occurred at 10-15 year intervals: pre-1943, mid-1960s, 1987, 1997, and 2003. The 1997 and 2003 fires destroyed an extensive area of vegetation covering a similar extent in the same location on the northern and northeastern slopes (see Volume 2 of Wildland Consultants 2004, Figure 9, Appendix 3).

2.4 Grazing

Adapted from Wildland Consultants 2004.

It is not clear when grazing of domestic stock was first undertaken on Mauao, but it was most likely early last century or even the later part of the 1800s. An undated manuscript held in the Tauranga Library ("Taina" - Visions of Boyhood) relates to early childhood and notes that "manuka clad its upper slopes, with many magnificent pōhutukawa and karaka in groves, or clinging above the rocky shores". It also records an observation of a "boundary rider whose job was to keep the cattle that grazed the Mount from straying".

A 1930 photograph in Cunningham and Musgrave (1989) appears to show low vegetation only over the eastern slopes, and pasture was present on the lower slopes in the early 1930s. At that time, the 'scrub line' was apparently similar to the present day, and rabbits were abundant in the grassland.

Pasture is currently present on the western, southwestern, southern, southeastern, eastern, and northeastern mid- and/or lower slopes of Mauao. Low densities of sheep graze the grassy slopes of Mauao, and cattle are no longer grazed within the Reserve.

2.5 Tracks and planting

Adapted from Wildland Consultants 2004.

The summit track was built in 1898 (Bellamy 1982) and there has been a long history of planting, extending back to the 1880s (Cunningham and Musgrave 1989) and the early 1900s (Bellamy 1982), although many of the 1880 plantings were destroyed by fire (Cunningham and Musgrave 1989). These later authors also note that there were

regular Arbor Day excursions from Tauranga in the late 1880s to plant trees, including one led by a J.C. Adams who also took scouts to the summit and had them use catapaults to scatter karaka berries in all directions.

2.6 Ecological significance

Mauao is a significant natural area in Tauranga Ecological District. The vegetation and habitats on Mauao have been split into two sites (Mauao 1 and Mauao 2) in a number of reports based on the relative ecological value of vegetation and habitat types present.

Mauao 1, which comprises the indigenous vegetation and habitats on the upper and northern slopes, has been identified as being of National significance, was ranked as a Category 1 Special Ecological Area in Tauranga City (Wildland Consultants 2009), and was identified as a Category 1 natural area in the Tauranga Ecological District (Wildland Consultants 2008). Mauao 1 has also been identified as being consistent with Policy 11(a) of the New Zealand Coastal Policy Statement because it includes a high quality example of pōhutukawa forest, a vegetation type which has been greatly reduced in extent in Tauranga Ecological District and the Bay of Plenty Region (Mauao 1; Wildland Consultants 2013). This area also provides habitat for one Threatened plant species, one At Risk fauna species, and one plant species at its known southern limit of distribution. In addition, a suite of regionally uncommon plant species are present, and there is a breeding colony of grey-faced petrel (Wildland Consultants 2013).

Mauao 2 comprises vegetation and habitats on the eastern and southern-facing lower slopes and coastal margins, and has been identified as being of Regional significance due to its buffering attributes for vegetation on the upper slopes, is ranked as a Category 2 Special Ecological Area in Tauranga City (Wildland Consultants 2005), and has been identified as a Category 3 natural area in the Tauranga Ecological District (Wildland Consultants 2008). Mauao 2 has also been identified as being consistent with Policy 11(b) of the New Zealand Coastal Policy Statement because it comprises predominantly indigenous vegetation and a breeding site for northern little blue penguin (At Risk-Declining) (Wildland Consultants 2013). Parts of the site comprise revegetation plantings that are relatively new. One Threatened and eight regionally uncommon plant species occur at this site (Wildland Consultants 2013).

Geologically, Mauao is a nationally important geological feature (eroded rhyolite dome) (Kenny and Hayward 1996). It also has high historic, archaeological, and heritage values, and forms part of the Smartgrowth 'Coastal strip' corridor, ranked as being 'highest' priority (Wildland Consultants 2007b and 2007c).

3. METHODS

Mauao was traversed on foot on 29 October 2014, and 6 and 8 November 2014 to map, describe, and evaluate the vegetation types present, record vascular plant species observed, identify threats to ecological values, and assess vegetation condition. Incidental observations of birds and other fauna were recorded.

Vegetation and habitats present were mapped in the field using hard copy digital aerial photographs, at a scale of 1:4,000 and observations were recorded on the distribution and abundance of pest plants. Vegetation and habitat types were classified and described following the structural classes of Atkinson (1985). Photographs were taken to illustrate the vegetation and habitats present.

All relevant existing hard copy and digital information relating to the ecological values and management of Mauao was collated and reviewed. Information was also obtained from relevant parties and was summarised and collated to fill any information gaps identified.

A list of vascular plant species recorded at the site is presented in Appendix 1. Selected photographs are provided in Appendix 4.

4. VEGETATION AND HABITAT TYPES

Vegetation and habitats on Mauao comprise a mosaic of vegetation types including regenerating forest, scrub, and shrubland, and grazed pasture, with small pockets of remnant indigenous vegetation (predominantly large, old pōhutukawa). Sixteen broad vegetation and habitat types were identified and mapped (see Figure 1), and are described below.

1. Pōhutukawa forest (8.0 ha)

Pōhutukawa forms a canopy up to *c.*20 m tall (range 10-20 m) on the upper eastern slopes, and lower western and northeastern slopes of Mauao. Most of the pōhutukawa within this type are large, old trees, although a small patch of forest on the lower northeastern slopes comprises younger trees with a lower, denser canopy. The understory and ground cover are variable within this type, with four sub-types reflecting these differences described below. All areas of this type are fenced to exclude domestic stock.

a. Large, old pōhutukawa form a canopy up to *c.*20 m tall over an understorey dominated by hangehange (*Geniostoma ligustrifolium* var. *ligustrifolium*) and māhoe (*Melicytus ramiflorus* subsp. *ramiflorus*), but with kawakawa (*Piper excelsum* subsp. *excelsum*) locally common, and local taurepo (*Rhabdothamnus solandri*), and mamaku (*Cyathea medullaris*) scattered throughout. Groundcover species common within this type include pukupuku (*Doodia australis*) and *Adiantum cuninghammii*. Other species present include māpou, mingimingi (*Leucopogon fasciculatus*), heketara (*Olearia rani* var. *colorata*), akepiro (*Olearia furfuracea*), kānuka, and Japanese honeysuckle (*Lonicera japonica*).

b. Large, old pōhutukawa form a canopy *c.*18-20 m tall on the lower western and northwestern slopes of Mauao. Māhoe and kawakawa are the dominant understorey species and pukupuku and *Adiantum cuninghammii* are the main groundcover species, but other species common within these tiers include hangehange, whauwhaupaku (*Pseudopanax arboreus*), mamaku, māpou, and mingimingi. Spanish heath (*Erica lusitanica*) is common on the margins of

tracks that pass through this type. Gaps in the pōhutukawa canopy contain mixed indigenous and exotic species scrub with bracken (*Pteridium esculentum*), māhoe, hangehange, whauwhaupaku, akeake (*Dodonaea viscosa*), mamaku, karamū (*Coprosma robusta*), glossy karamu (*Coprosma lucida*), kawakawa, gorse (*Ulex europaeus*), Spanish heath, and pampas (*Cortaderia selloana*) common and local Japanese honeysuckle, woolly nightshade (*Solanum mauritianum*), and kikuyu (*Cenchrus clandestinus*).

Slips of varying sizes are present throughout this type and are in various stages of revegetation/regeneration. Recent slips have a sparse groundcover of occasional pōhutukawa seedlings and herbaceous species, with occasional pampas and locally common Spanish heath amongst bare clay and rocks. Some areas have been planted with indigenous species, including māhoe, ngaio, glossy karamu, whaririki (mountain flax; *Phormium cookianum* subsp. *hookeri*), tarata (*Pittosporum eugenioides*), whau, and mānuka. Exposed areas beside the base track support patches of wīwī (*Ficinia nodosa*) and *Machaerina juncea*.

Other species present at lower densities within this type include ponga (*Cyathea dealbata*), taurepo, *Asplenium polyodon*, *A. oblongifolium*, *Oplismenus hirtellus* subsp. *imbecillis*, *Astelia solandri*, and boneseed (*Chrysanthemoides monilifera*).

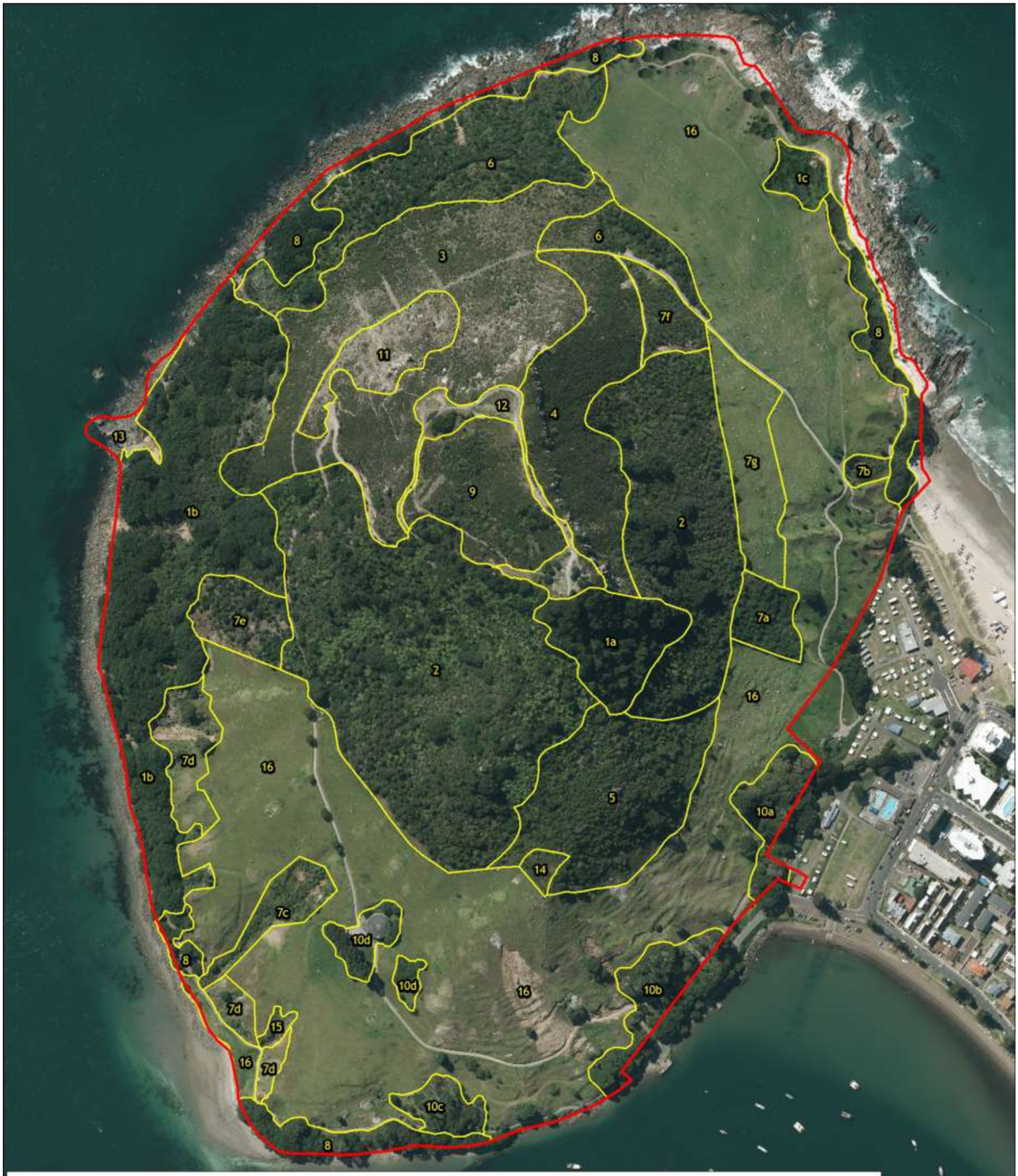
c. A small area of pōhutukawa trees form a dense canopy up to *c.*10 m tall on the northeastern, lower slopes of Mauao. This area contains a very sparse understorey of glossy karamu and does not support any groundcover species. A small slip on the northeastern margin of this type supports pōhutukawa seedlings and saplings with patches of grass (predominantly kikuyu), pōhuehue, wīwī, a few pampas (*c.*6), and gorse.

2. Pōhutukawa/māhoe-mamaku-hangehange forest (12.7 ha)

Large pōhutukawa are locally emergent over a canopy dominated by māhoe, mamaku, and hangehange with a sparse to locally dense understorey of hangehange, ponga, māhoe, māpou, kawakawa, akepiro, and rangiora (*Brachyglottis repanda*). Groundcover species common within this type include pukupuku, rereti (*Blechnum chambersii*), *Asplenium oblongifolium*, *Microsorum pustulatum*, *Blechnum filiforme*, and *Astelia solandri*. Houhere[1] (*Hoheria sexstylosa*) is locally common in the canopy in parts of this type, and occasional emergent rewarewa, rimu[1], and totara[1] (*Podocarpus totara*) are also present.

Track margins within this type support a range of species. Spanish heath is common; kiokio (*Blechnum novae-zelandiae*), Mexican daisy (*Erigeron karvinskianus*), and climbing asparagus (*Asparagus scandens*) are locally common; and hawthorn (*Crataegus monogyna*), cotoneaster (*Cotoneaster glaucophyllus*), Japanese honeysuckle, gorse, and blackberry (*Rubus fruticosus*)

[1] All these species are planted, and are not known to occur naturally on Mauao.



Legend

Project area boundary

Vegetation and habitat types

1a-c. Pōhutukawa forest (see text)
2. Pōhutukawa/māhoe-mamaku-hangehange forest
3. Mānuka-(Spanish heath)-(whaririki) shrubland
4. Mixed exotic-indigenous scrub/shrubland
5. Māhoe forest and scrub
6. Pōhutukawa-mixed indigenous species forest, treeland, and scrub
7a-g. Planted indigenous species forest/scrub/ treeland/shrubland (see text)
8. Pōhutukawa treeland
9. Mixed indigenous species scrub
10a-d. Mixed exotic and indigenous species forest/treeland (see text)
11. Rocky bluffs
12. Close-cropped grassland and paths
13. Rocky promontory
14. (Wīwī)/bracken-pōhuehue-cocksfoot shrub-grassland
15. Shallow gully
16. Pasture

Data Acknowledgment

Maps contain data sourced from LINZ
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Figure 1. Vegetation and habitat types on Mauao, November 2014

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are occasional. Some areas include regenerating koromiko (*Hebe stricta*), pōhutukawa, and houhere in association with *Adiantum cunninghamii*, pukupuku, and gorse.

A small (*c.*7 × 3 m) patch of Chinese privet (*Ligustrum sinense*) and *c.*10 hawthorn trees are present near the eastern boundary of this type where it borders Vegetation Type 4 (māhoe forest and scrub) (see Figure 3). Other species present in this area include climbing asparagus, *Calystegia sepium* × *C. soldanella*, and planted harakeke (*Phormium tenax*).

Other species present within these areas include include totara[1], kōwhai[1] (*Sophora microphylla*), kānuka, ponga, whauwhaupaku, houpara, kāmahi, rimu, mingimingi, mānuka, Japanese spindleberry (*Euonymus japonicus*), smilax (*Asparagus asparagoides*), Italian evergreen buckthorn (*Rhamnus alaternus*), Chinese privet, pampas, swan plant (*Gomphocarpus fruticosus*), and loquat (*Eriobotrya japonica*).

3. Mānuka-(Spanish heath)-(whararikī) shrubland (6.3 ha)

Shrubland dominated by planted mānuka, with locally common whararikī (planted) and Spanish heath, and scattered pōhutukawa, māpou, and pampas, is present on the upper to mid-slopes on the northern face of Mauao. Bluffs at the top of the slope within this area support Spanish heath, whararikī, radiata pine (*Pinus radiata*) seedlings, and a few pōhutukawa. Other species present include *Pomaderris amoena*, karamū, gorse, tī kōuka (*Cordyline australis*), ngaio (planted), *Hebe parviflora* (planted), *Metrosideros excelsa* × *M. kermadecensis* (planted), broadleaf (*Griselinia littoralis*) (planted), and Montpellier broom (*Teline monspessulana*). *Morelotia affinis* is locally common on exposed track margins. This vegetation type is located within the area of affected by fires in 1997 and 2003.

4. Mixed exotic-indigenous scrub/shrubland (2.8 ha)

This vegetation type is located on the upper, eastern slopes of Mauao. Rocky bluffs are present at the top of the slope on the western side of this vegetation type. The bluffs are surrounded by Spanish heath shrubland with planted whararikī, and scattered gorse, *Pomaderris amoena*, mānuka (planted), and pōhutukawa (planted). Below the bluffs, scrub is present and is dominated by Spanish heath, pampas, and gorse in association with whararikī, pōhutukawa, and mānuka. This vegetation type is located within the area affected by fires in 1997 and 2003. Slips within this type have scattered plants of pōhutukawa, pampas, Spanish heath, *Morelotia affinis*, mānuka, gorse, and tūrutu (*Dianella nigra*).

5. Māhoe forest and scrub (2.8 ha)

This type is present on the southeastern mid-slopes of Mauao. Occasional emergent pōhutukawa are present above a *c.*6 m tall canopy dominated by māhoe in association with kawakawa and mingimingi. Patches of blackberry and

[1] All these species are planted, and are not known to occur naturally on Mauao.

bracken shrubland-fernland and pōhuehue vineland are present within this type, and parts of the lower, southern margins support planted indigenous shrubland. Planted species within these areas include māhoe, whau, rimu, totara, pōhutukawa, and koromiko. Locally, Japanese honeysuckle forms dense vineland, smothering the indigenous canopy. Pampas and blackberry have been controlled near the fenceline. In these areas, a variety of herbs are growing on the bare soil including *Acaena novae-zelandiae*, woolly mullein (*Verbascum thapsus*), Scotch thistle (*Cirsium vulgare*), Californian thistle (*Cirsium arvense*), broad-leaved fleabane (*Conyza sumatrensis*), and scarlet pimpernel (*Anagallis arvensis*). Other species present within this type include māpou, kānuka, English oak (*Quercus robur*), Spanish heath, Chinese windmill palm (*Trachycarpus fortunei*), cotoneaster, sycamore (*Acer pseudoplatanus*), woolly nightshade, sweet briar (*Rosa rubiginosa*), Chinese privet, and Mexican daisy. A single radiata pine tree is present at the northern boundary of this type with Vegetation Type 1a. Some indigenous vegetation (pōhutukawa and māhoe) has been affected by herbicide spray drift during control of pampas, gorse, and blackberry.

6. Pōhutukawa-mixed indigenous species forest, treeland, and scrub (3.8 ha)

Located on the mid- and lower northern slopes of Mauao, natural and planted pōhutukawa form a canopy to *c.*5 m tall in association with planted ngaio, glossy karamu, mānuka, *Hebe parviflora*, and whararikī. Planted kawakawa, tī kōuka, and nīkau are also present. Little ground cover is present within this area: the parts of this type with a more open canopy support patches of grass and the parts with a closed canopy contain patches of ring fern (*Paesia scaberula*).

7. Planted indigenous species forest/scrub/treeland/shrubland (4.8 ha)

Restoration plantings of mixed broadleaved indigenous species have been undertaken over a number of years in various locations around Mauao. These are often located on the margins of existing vegetation, but also include small gullies. The maturity of the plantings is reflected in the vegetation structure within these areas, as described below:

a. A small area of forest dominated by pōhutukawa, māhoe, and whau on the eastern mid-slopes of Mauao. Other species present within this area include karaka, rimu, and broadleaf.

b. Treeland and scrub with natural and planted pōhutukawa in association with planted ngaio, glossy karamu, mānuka, *Hebe parviflora*, and whararikī in a small gully on the eastern lower slopes of Mauao. Planted tī kōuka and nīkau are also present. Rank grassland dominated by Yorkshire fog (*Holcus lanatus*) and kikuyu is present in canopy gaps and some slumping of steep slopes has occurred within this area.

c. Mixed indigenous species scrub and treeland in a gully with a small stream on the southwestern mid- to lower slopes of Mauao. Ngaio, pōhutukawa, harakeke, mānuka, whau, and *Hebe parviflora* represent the bulk of the planted species. Rank grassland is present between plantings.

d. Pōhutukawa saplings and small trees have been planted within rank grassland on steep lower slopes on the southwestern and western sides of Mauao. Some large, old pōhutukawa up to *c.*16 m tall are also present within this area. Occasional, naturally-occurring patches of māhoe and Japanese honeysuckle are present where parts of this type meet old-growth pōhutukawa forest. Other species present in parts of this type include hawthorn, black wattle (*Acacia mearnsii*), and gorse.

e. Forest and treeland dominated by kānuka, māhoe, houhere, karamū, whau, pōhutukawa, and koromiko forms a patchy canopy to *c.*6 m tall over fern, grass, and herb species including milkweed (*Euphorbia peplus*), sow thistle (*Sonchus oleraceus*), woolly mullein, pukupuku, ring fern, *Acaena novae-zelandiae*, browntop (*Agrostis capillaris*), and toatoa (*Haloragis erecta*). Other planted species present include totara, mānuka, māhoe, ngaio, tarata, akeake, and whararikі. Other species present within this type include Japanese honeysuckle, hawthorn, Spanish heath, pampas, and cotoneaster.

f. Mixed indigenous species scrub and shrubland to *c.*3 m tall within a triangle formed by the two main tracks to the summit. Ngaio, *Hebe parviflora*, karamū, mānuka, pōhutukawa, and whararikі are the main species planted within this area. Other planted species present include broadleaf, koromiko, glossy karamu, tī kōuka, and kōhūhū (*Pittosporum tenuifolium*). Patches of Spanish heath are also present.

g. Recently planted seedlings within rank grassland. Planted species present within this area include glossy karamu, whararikі, totara, and mānuka. Other species are likely to have been planted within this area, but are not identifiable as they have died. Whararikі plants are in good condition, glossy karamu plants are in average condition, and totara and mānuka are in poor condition. Rank grass around the plantings has been sprayed.

8. Pōhutukawa treeland (2.7 ha)

Predominantly large, old pōhutukawa form a patchy canopy over a variable groundcover and understorey in various places around the lower slopes of Mauao. In some areas, pōhutukawa trees are present over walking tracks or rocks and there are rarely any understory or groundcover species. Other areas have local patches of woody species (seedlings and saplings) and pasture. Woody species present beneath pōhutukawa trees include pōhutukawa, kawakawa, pōhuehue, and glossy karamu. Grass species present include *Rytidosperma* species and Yorkshire fog. Other species present include *Cyperus ustulatus*, *Adiantum cuninghammii*, *Carex* aff. *raoulii* ("raotest"), wīwī, wall lettuce (*Mycelis muralis*), catsear (*Hypochaeris radicata*), hawkbit (*Leontodon taraxacoides*), creeping buttercup (*Ranunculus repens*), and *Isolepis cernua*. *Samolus repens* is present growing amongst wīwī and trampled kikuyu beneath pōhutukawa trees on the seaward side of the track in the northern section of this type.

9. Mixed indigenous species scrub (1.8 ha)

Small patches of remnant scrub are surrounded by planted scrub dominated by mānuka, koromiko, and whararikiki on relatively flat land near the summit of Mauao. Remnant patches of scrub contain occasional emergent rewarewa over a *c.*4-5 m tall canopy dominated by māhoe, hangehange, and pōhutukawa with heketara, mamaku, and karamū common. The ground cover is generally sparse and mostly comprises leaf litter, with scattered kiokio, *Adiantum cuninghammii*, ring fern, and *Asplenium polyodon* also present. Other species present within this type include glossy karamu (planted), akepiro (planted), *Rubus schmidelioides*, mingimingi, miro (*Prumnopitys ferruginea*) (planted), kauri (*Agathis australis*) (planted), *Clematis paniculata*, *Pyrrosia eleagnifolia*, *Machaerina juncea*, *Gonocarpus incanus*, *Tetraria capillaris*, tūrutu, Spanish heath, cotoneaster, Japanese spindleberry, kahili ginger (*Hedychium gardnerianum*), yucca (*Yucca gloriosa*), wilding pine (*Pinus* spp.), and pampas. Some control of pampas and kahili ginger has been undertaken in this area.

Patches of grass are present within this type and informal tracks are common. A small area of *Drosera auriculata* is present within moss on the southwestern margins of this type beside the track.

10. Mixed exotic and indigenous species forest/treeland (2.4 ha)

Large, mature indigenous and exotic tree species have been planted on the southeastern, southern, and southwestern lower slopes of Mauao.

a. Mixed exotic-indigenous treeland at the boundary with the motorcamp has a canopy dominated by sycamore (up to *c.*18 m tall), with clusters of karaka, macrocarpa (*Cupressus macrocarpa*), English oak, radiata pine, Chinese windmill palm, and phoenix palm (*Phoenix canariensis*) over leaf litter and pasture grass with occasional Chinese windmill palm seedlings and saplings, strawberry dogwood (*Cornus capitata*), Chinese privet, and cotoneaster. Other species within this area include smilax, boxthorn (*Lycium ferocissimum*), and tree privet (*Ligustrum lucidum*). This area is not fenced to exclude stock.

b. Forest dominated by macrocarpa and karaka (up to *c.*20 m tall) in association with radiata pine, sycamore, and pōhutukawa on the southeastern boundary of the Reserve. This area contains a variable groundcover and understorey dominated by kawakawa in the understory, but also contains karamū, ring fern, meadow rice grass (*Microlaena stipoides*), Yorkshire fog, cocksfoot (*Dactylis glomerata*), Japanese honeysuckle, cleavers (*Galium aparine*), and sow thistle. Other species present include karo, māhoe, māpou, totara, Indian strawberry, grey sedge (*Carex divulsa*), climbing asparagus, cotoneaster, and Chinese windmill palm.

c. Treeland within grazed pasture on the southern lower slopes of the Reserve. Tree species present within this area include planted and natural pōhutukawa, and planted totara, karaka, houhere, paulownia (*Paulownia tomentosa*), melia (*Melia azedarach*), sycamore, Lombardy poplar (*Populus nigra* 'Italica'), tree

of heaven (*Ailanthus altissima*), English oak, radiata pine, silky oak (*Grevillea robusta*), sheoak (*Casuarina* species), eucalyptus (*Eucalyptus* species), and box alder (*Acer negundo*).

d. Treeland around a water tower on the southern mid-slopes of Mauao. Tree species present within this area include poplar (*Populus* species), silky oak, pōhutukawa, paulownia, melia, and pūriri.

11. Rocky bluffs (1.0 ha)

Rocky bluffs on the northwestern side of Mauao have patches of vegetative cover, predominantly grass, pampas, gorse, *Astelia banksii*, and pōhutukawa. Other species present include boxthorn, swan plant, hawthorn, and *Psilotum nudum*.

12. Close-cropped grassland and paths (0.8 ha)

Vegetation and habitats within this area comprise close-cropped grass dominated by kikuyu with scattered pōhutukawa. Tables, chairs, a trig, and paths are present throughout this area. Spanish heath is present in exposed places. Other species present within this area include ratstail (*Sporobolus africanus*), catsear, gorse, and pampas.

13. Rocky promontory (0.2 ha)

A small rocky peninsula jutting into the ocean on the northwestern side of Mauao supports scattered clumps of plants in cracks in the rocks. Plants present include wīwī, *Samolus repens*, *Senecio lautus* var. *lautus*, scarlet pimpernel, and glasswort (*Sarcocornia quinqueflora*). A small area of *Disphyma australe* is also present growing in association with glasswort.

14. (Wīwī)/bracken-pōhuehue-cocksfoot shrub-grassland (0.1 ha)

Occasional kawakawa and local patches of wīwī are emergent within bracken, pōhuehue, and cocksfoot shrub-grassland on the southwestern midslopes of Mauao. Other species present include shore bindweed (*Calystegia soldanella*) and *Acaena novae-zelandiae*.

15. Shallow gully (<0.1 ha)

A narrow band of *Cyperus ustulatus* and ring fern tussockland is present at the top of a shallow gully around a seep in the hillslope. Below the tussockland, grazed pasture with horehound (*Marrubium vulgare*), woolly mullein, and prickly sow thistle (*Sonchus asper*) grades into scrub dominated by whau and māhoe with ponga, blackberry, pōhuehue, and kawakawa. Pampas and thistles have been controlled in this area.

16. Pasture (26.1 ha)

Grazed pasture of variable composition is present around the mid- and lower slopes on the northeastern, eastern, southern, southwestern, and western sides of Mauao. Some areas of the pasture are dominated by *Rytidosperma* species and meadow rice grass, whilst other parts are dominated by either Yorkshire fog or kikuyu. Patches of ring fern, woolly mullein, horehound, wīwī, and pōhuehue are common throughout this type. Scattered trees are also present, including totara, pōhutukawa, karaka, and paulownia. Other species present within the pasture include gorse, *Acaena novae-zelandiae*, and *Oxalis exilis*.

5. FLORA

The flora of Mauao includes at least 346 species, of which 166 are indigenous and 180 are adventive (Appendix 1). Of the 166 indigenous species recorded from Mauao, four are considered to be Threatened or At Risk nationally (de Lange *et al.* 2013): Holloway's crystalwort (*Atriplex hollowayi*) (Threatened-Nationally Critical), *Olearia pachyphylla* (Threatened-Nationally Critical), *Pimelea tomentosa* (Threatened-Nationally Vulnerable), and native spinach (*Tetragonia tetragonioides*) (At Risk-Naturally Uncommon). Only one of these was seen during the 2014 survey - native spinach was observed on the southern sandy beach beneath pōhutukawa. *Pimelea tomentosa* was not seen during the current survey and was last reported from Mauao in 2004. The records of Holloway's crystalwort (Beadel *et al.* 2009) and *Olearia pachyphylla* (P. de Lange pers. comm.) are both historic records, and neither species is currently present.

Several species that are regionally uncommon in the Bay of Plenty Region (as per Beadel 2008) are present on Mauao. *Astelia banksii* is present on the western and northern lower slopes beneath pōhutukawa forest. *Lepidosperma laterale* is present within indigenous forest and scrub on the southern slopes of Mauao. This species is near its southern limit, and is found at only two other sites in the Bay of Plenty (Wildland Consultants 2008). *Oxalis rubens* is present on the eastern, coastal fringe of Mauao beneath pōhutukawa treeland. *Psilotum nudum* is present on the rock bluffs on the northwestern side of Mauao, which is one of the few known coastal occurrences of this species in the Bay of Plenty (Wildland Consultants 2008). *Tetraria capillaris* is present on the margins of secondary scrub on the northern upper slopes of Mauao. *Zoysia pauciflora* is present just above the small saltmarsh herbfields on the rocky margins on the northeastern side of Mauoa.

Mangemange *(Lygodium articulatum*), whilst not regionally uncommon, is of limited distribution in Tauranga Ecological District having only been recorded from Mauao (Wildland Consultants 1999). Mangemange was recorded from the southeastern midslopes of Mauao in 1999, but was not recorded in 2014, although it is likely to still be present.

Of the 180 adventive species, five are historical records that have not been observed on Mauao since 1984 (Wilcox and Ecroyd 1984) and some or all of these species may no longer be present. The range of species reflects the wide range of habitats present, ranging from rocky foreshore, to gentle hill slopes, to cliffs. Exotic species also occur

widely in most of these habitats, in part due to the history of disturbance on Mauao, and also the close proximity to an urban centre. Twenty-five species are listed in the Bay of Plenty Regional Pest Management Plan, and a further 30 are considered environmental weeds that should be controlled for indigenous biodiversity values. The distribution, abundance, and priority status for control of these species on Mauao is described in greater detail in Section 5.1 below.

6. FAUNA

6.1 Avifauna

Blue penguin

Blue penguin is classified as At Risk-Declining (Robertson *et al.* 2013). Three key sites are present within the Tauranga area: Mauao, Moturiki (Leisure Island), and Motuotau (Rabbit Island). These sites are thought to support *c.*300 pairs, *c.*100 pairs, and *c.*200 pairs respectively (Dave Richards, pers. comm., in Sievwright 2014). Seventy-four occupied burrows were found on Mauao during a Masters research programme in 2012-2013 (Sievwright 2014) (Figure 2). The distribution of blue penguin is relatively continuous around Mauao and burrows are primarily within *c.*10 m or so of MHWS. However, some burrows are present in the forest and grasslands of the lower slopes, and were possibly originally constructed by rabbits (Winter 2000).

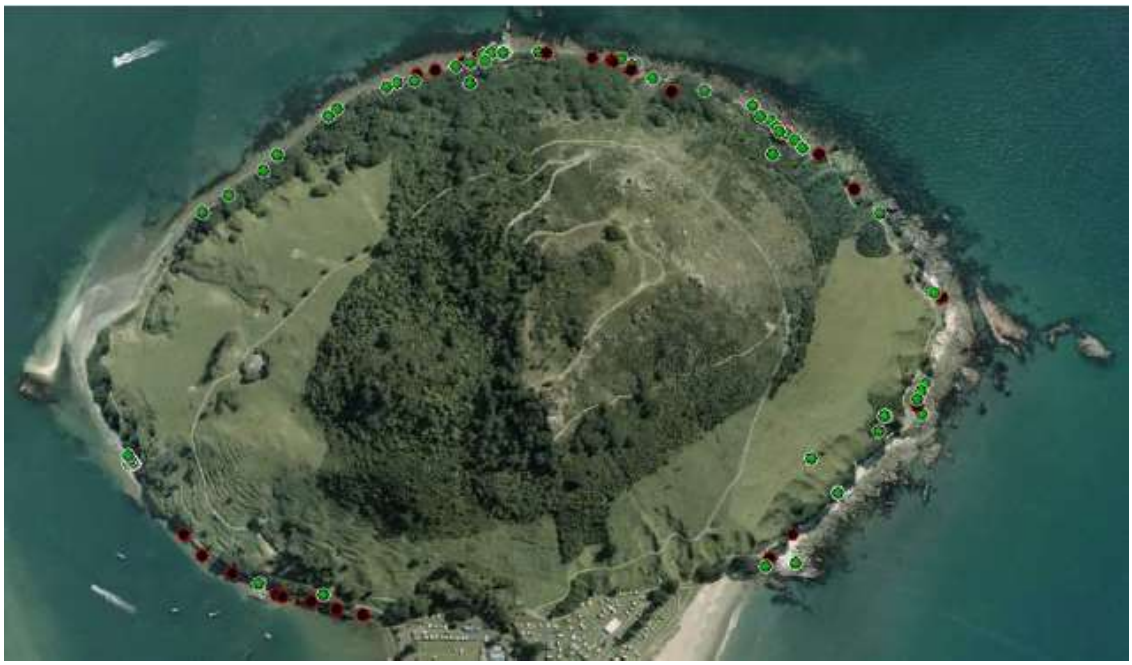

Figure 2: Locations of blue penguin burrows during the 2012-2013 breeding season. Green markers denote burrows that were accessible to researchers. Red markers denote inaccessible burrows. Image from Sievwright (2014).

Grey-faced petrel

Grey-faced petrel (*Pterdroma macroptera gouldi*) is classified as Not Threatened (Robertson *et al.* 2013). However, colonies of burrowing petrels are very rare on the New Zealand mainland due to the presence of mammalian predators. As such, the presence of grey-faced petrel on Mauao is ecologically significant. Colonies are also present on Motuotau (Jones *et al.* 2011) and Moutohora (Whale Island), with the population on Moutohora estimated to number *c*.95,000 pairs in 2003 (Imber *et al*. 2003). On Mauao, grey-faced petrel burrows are found on the lower slopes in areas of pōhutukawa forest/treeland with some burrows occurring in grazed pasture. The colony has approximately 200 pairs of birds.

Other bird species

A further 11 indigenous and 13 introduced bird species were recorded during the 2014 field survey of Mauao. A pied shag (*Phalacrocorax varius varius*; Threatened-Nationally Vulnerable) colony (up to ten nests; Cuming 2008 in Beca 2014) is present in pōhutukawa forest near the base track on the northwestern side. No other At Risk or Threatened bird species were recorded during the 2014 survey. A full list of the bird species recorded during the 2014 survey is presented in Appendix 2.

Terrestrial indigenous bird species recorded on Mauao are all relatively common, regionally and nationally, and are all species that are able to survive in the presence of introduced mammalian predators. Nevertheless, relative breeding success would increase if effective mammal pest control was to be undertaken across relevant habitats.

6.2 Reptiles

Information on reptile populations on Mauao is sparse and herpetofauna have not been formally surveyed. Shore skinks have been recorded from Mauao, but are present at low abundance (Wildland Consultants 2008). A copper skink (*Oligosoma aeneum*) was caught on Motuotau (*c*.1.5 km to the east) in 2012 (Mauao Wildlife Trust, http://mauaowildlife.org/wildlife/reptiles.html) and this species could also be present on Mauao. Areas of kānuka may support geckos (*Hoplodactylus* spp. or *Nautilinus* spp.) and other skink species may be present along the shoreline or within areas of indigenous vegetation.

6.3 Indigenous mammals

The only indigenous mammal species that occurs regularly at Mauao is the New Zealand fur seal (*Arctocephalus forsteri*; not threatened) and increasing numbers of seals are using Mauao as a haul-out site (Wildland Consultants 2008).

7. THREATS

7.1 Environmental weeds

7.1.1 Overview

Fifty-five adventive plant species considered to be environmental weeds have been recorded on Mauao. Nineteen of these species are listed in the Bay of Plenty Regional Pest Management Plan (Bay of Plenty Regional Council 2011) (Table 1). Two species, buddleia (*Buddleja davidii*) and Khasia berry (*Cotoneaster simonsii*), have not been recorded since 1984 (Wilcox and Ecroyd 1984) and are unlikely to still be present.

Table 1: Environmental weeds recorded on Mauao, their status in the Bay of Plenty Regional Pest Management Plan, and relative priorities for control.

Key: * Distribution mapped on Figures 3 and 4.

Scientific Name	Common Name	RPMP Status	Priority for Control
Acacia mearnsii	Black wattle*		High
Asparagus asparagoides	Smilax*	Restricted pest	High
Asparagus scandens	Climbing asparagus*	Restricted pest	High
Chrysanthemoides monilifera	Boneseed*	Containment pest	High
Cortaderia jubata	Purple pampas	Restricted pest	High
Cortaderia selloana	Pampas*	Restricted pest	High
Cotoneaster glaucophyllus	Cotoneaster*		High
Crataegus monogyna	Hawthorn*		High
Dipogon lignosus	Mile-a-minute	Restricted pest	High
Euyonomus japonicas	Japanese spindleberry*	Restricted pest	High
Gomphocarpus fruticosus	Swan plant*		High
Hedera helix	Ivy		High
Hedychium gardnerianum	Kahili ginger*	Containment pest	High
Ligustrum lucidum	Tree privet*	Restricted pest	High
Ligustrum sinense	Chinese privet*	Restricted pest	High
Lonicera japonica	Japanese honeysuckle*	Restricted pest	High
Ailanthus altissima	Tree of heaven*	Restricted pest	High
Arctotheca calendula	Cape daisy*		High
Eriobotrya japonica	Loquat*		High
Lycium ferocissimum	Boxthorn*		High
Metrosideros excelsa × *M. kermadecensis*	Pōhutukawa × Kermadec pōhutukawa*		High
Paraserianthes lophantha	Brush wattle*		High
Pinus pinaster	Maritime pine	Restricted pest	High
Pinus radiata	Radiata pine*	Restricted pest	High
Pinus species	Wilding pine*	Restricted pest	High
Rhanmus alternus	Italian evergreen buckthorn*		High
Senecio angulatus	Cape ivy		High
Solanum mauritianum	Woolly nightshade*	Containment pest	High
Trachycarpus fortunei	Chinese windmill palm*	Restricted pest	High
Tradescantia fluminensis	Tradescantia	Restricted pest	High
Acacia dealbata	Silver wattle		Medium

Scientific Name	Common Name	RPMP Status	Priority for Control
Berberis glaucocarpa	Barberry		Medium
Delairea odorata	German ivy		Medium
Erica lustianica	Spanish heath*		Medium
Hakea salicifolia	Willow-leaved hakea		Medium
Hakea sericea	Prickly hakea		Medium
Passiflora edulis	Black passionfruit		Medium
Phoenix canariensis	Phoenix palm*		Medium
Rosa rubiginosa	Sweet briar*		Medium
Rubus fruticosus	Blackberry*		Medium
Acer pseudoplatanus	Sycamore maple		Low
Alnus glutinosa	Common alder		Low
Chamaecytisus palmensis	Tree lucerne		Low
Cornus capitata	Strawberry dogwood*		Low
Erigeron karvinskianus	Mexican daisy*		Low
Lupinus arboreus	Lupin		Low
Miscanthus nepalensis	Himalaya fairy grass		Low
Nerium oleander	Oleander		Low
Quercus robur	English oak*		Low
Roldana petasitis	Velvet groundsel		Low
Schedonorus arundinaceus	Tall fescue		Low
Solanum marginatum	White-edged nightshade		Low
Teline monspessulana	Montpellier broom*		Low
Ulex europaeus	Gorse*	Containment pest	Low
Yucca gloriosa	Yucca*		Low

7.1.2 Environmental weed distribution, abundance, and priorities for control

Thirty-five of the environmental weed species listed in Table 1 have been mapped (see Figures 3 and 4) to show distributions and abundances on Mauao.

Pampas, Spanish heath, Japanese honeysuckle, climbing asparagus, and Mexican daisy are widespread throughout indigenous vegetation and habitats. Pampas is common in open habitats (bluffs and landslides), but is also found at lower density within scrub and shrubland habitats (Figure 4). Pampas is a high priority for control due to its ability to spread thousands of viable seeds over great distances, its wide environmental tolerances, and tendency to form large, dense patches that exclude indigenous species. Spanish heath is also widespread and forms part of the dominant vegetation on the northern mid- and upper slopes of Mauao; it is found in the same kind of habitats as pampas and is common on track margins. It is a lower priority for control than pampas as it is readily overtopped and shaded out by woody indigenous species as vegetation succession progresses.

Japanese honeysuckle is locally common in most vegetation/habitats throughout the Reserve. Scattered individuals are present within rank grassland habitat beside the base track on the southern and eastern sides of Mauao, and on the margins of tracks throughout the Reserve. Larger patches of Japanese honeysuckle are locally common at the transition between scrub/shrubland habitats and forested areas, particularly on the southern and western mid-slopes. Japanese honeysuckle is a high priority for control because it is shade tolerant and has the capacity to smother canopy species, preventing the growth and regeneration of indigenous species.

Climbing asparagus is locally common on track margins throughout the Reserve. It is a high priority for control because it is shade tolerant and has the capacity to smother canopy species, preventing the growth and regeneration of indigenous species.

Mexican daisy is locally common on track margins on the southern side of Mauao. It is a high priority for control because of its ability to form dense mats of ground cover which smothers and kills indigenous vegetation, creating habitat for other invasive weed species such as climbing vines. Mexican daisy is also a prolific seeder, with seeds that are able to spread long distances through wind dispersal.

Blackberry is locally common within short stature vegetation on the southern mid-slopes of Mauao, and at lower density within short stature vegetation in other parts of the park. Blackberry is a moderate priority for control because it can grow to form dense patches that exclude indigenous species.

Gorse is present at low densities within short stature vegetation and on track margins on the northern, western, and southern midslopes. Although gorse is readily overtopped and shaded out by taller-growing indigenous species as vegetation succession progresses, it is a moderate priority for control because it also produces many, long-lived seeds which enable it to persist in an area over many decades. Scattered gorse shrubs are also present within grazed pasture on Mauao, but plants in these habitats are controlled regularly.

Chinese privet, hawthorn, woolly nightshade, and cotoneaster are generally present at low densities throughout the Reserve, although isolated patches with higher densities of these species are also present. Chinese privet and hawthorn are scattered to locally common within scrub and forest habitats on the southwestern mid- to upper slopes. In particular, there is a small area of dense Chinese privet and several hawthorn trees near the mid-slope fence line on the southern side of the Reserve (see Figure 3). Chinese privet is a high priority for control because it is a shade-tolerant shrub that is capable of forming dense, monospecific stands that exclude all other vegetation. Hawthorn is a high priority for control because it has wide environmental tolerances and can form dense thickets, blocking access, crowding out other plant species, and preventing desirable seedlings from establishing. Individual plants of woolly nightshade and cotoneaster are scattered throughout forest and scrub habitats on the southwestern and western sides of Mauao. Cotoneaster is often present within short stature vegetation on track margins. Woolly nightshade is a high priority for control because it can quickly establish large groups of plants, which can out-compete and crowd out other desirable species. Cotoneaster is a high priority for control because it is long-lived, has wide environmental tolerances, and can form dense thickets which crowd out other plant species, and prevents desirable seedlings from establishing.

Boneseed, boxthorn, and swan plant are present at low densities in open habitats on the northern and northwestern mid-to-upper slopes of Mauao. Occasional individuals of boneseed were observed within open habitats around the midslope track on the northern and northwestern side of Mauao. Other plants are likely to be present within this habitat but surveillance and control is undertaken for this species on a regular basis. Boneseed is a high priority for control because it can spread quickly to form dense cover that shades out desirable species; it also produces copious seeds every

year, which can remain dormant for up to 10 years. Occasional boxthorn plants were observed during the field survey, but other plants are likely to be present. Boxthorn is capable of forming dense, long-lived stands which exclude desirable species and has wide environmental tolerances. Boxthorn is a high priority for control on Mauao due to its limited current distribution. Swan plants are locally common alongside the midslope track beneath the bluffs on the northern side of Mauao; a few other plants were also observed in open habitats on the western midslopes (see Figure 4). Swan plant is a high priority for control because it has the capacity to form dense thickets that exclude desirable species.

Black wattle and brush wattle were observed at low densities within open habitats on the mid- to lower slopes on the western side of Mauao in 2014. These species are likely to be present elsewhere and are a high priority for control as they are currently at low densities and have the capacity to spread and establish quickly within low stature vegetation.

Loquat, tree privet, Italian evergreen buckthorn, Japanese spindleberry, smilax, and Kahili ginger are present at low densities in isolated areas of Mauao (see Figures 3 and 4). Tree privet, Italian evergreen buckthorn, Japanese spindleberry are a high priority for control because they are capable of rapid spread and forming dense stands that exclude desirable species. Smilax is a high priority for control because it is shade-tolerant and has the capacity to smother canopy species preventing the growth and regeneration of indigenous species. Kahili ginger distribution is concentrated within short-stature vegetation northwest of the summit. It is a high priority for control because it produces massive branching rhizomes, which form a dense layer up to a metre thick, which other plants cannot penetrate. Above ground, wild ginger shades and smothers indigenous species. It may permanently displace uncommon plant species or specialised plant communities.

A few saplings and seedlings of maritime pine (*Pinus pinaster*), radiata pine, and other wilding pine species were observed within forest and scrub habitats (see Figures 3 and 4). These plants should be controlled as a high priority before they mature and produce viable seed, which is capable of spreading widely within the reserve. Two very large radiata pine trees are present beside the base track on the northern side of Mauao (see Figure 3). These trees may be difficult to control safely due to their proximity to the track.

Hybrids between pōhutukawa and Kermadec pōhutukawa (*Metrosideros excelsa* × *M. kermadecensis*) have been planted at several sites on Mauao. These plants should be removed, as a high priority, as they are highly likely to hybridise with pōhutukawa and therefore threaten the ecological integrity of pōhutukawa on Mauao.

Chinese windmill palm, phoenix palm, tree of heaven, and English oak are present at low abundances at isolated sites on Mauao. A number of old English oak are present near the boundary with the motorcamp and these trees do not generally require control. However, English oak should be controlled, as a low priority, where it is present within habitats dominated by indigenous species (see Figure 3). Chinese windmill palm and phoenix palm are locally common within mixed exotic-indigenous vegetation near the southeastern boundary of the reserve. Chinese windmill palm is

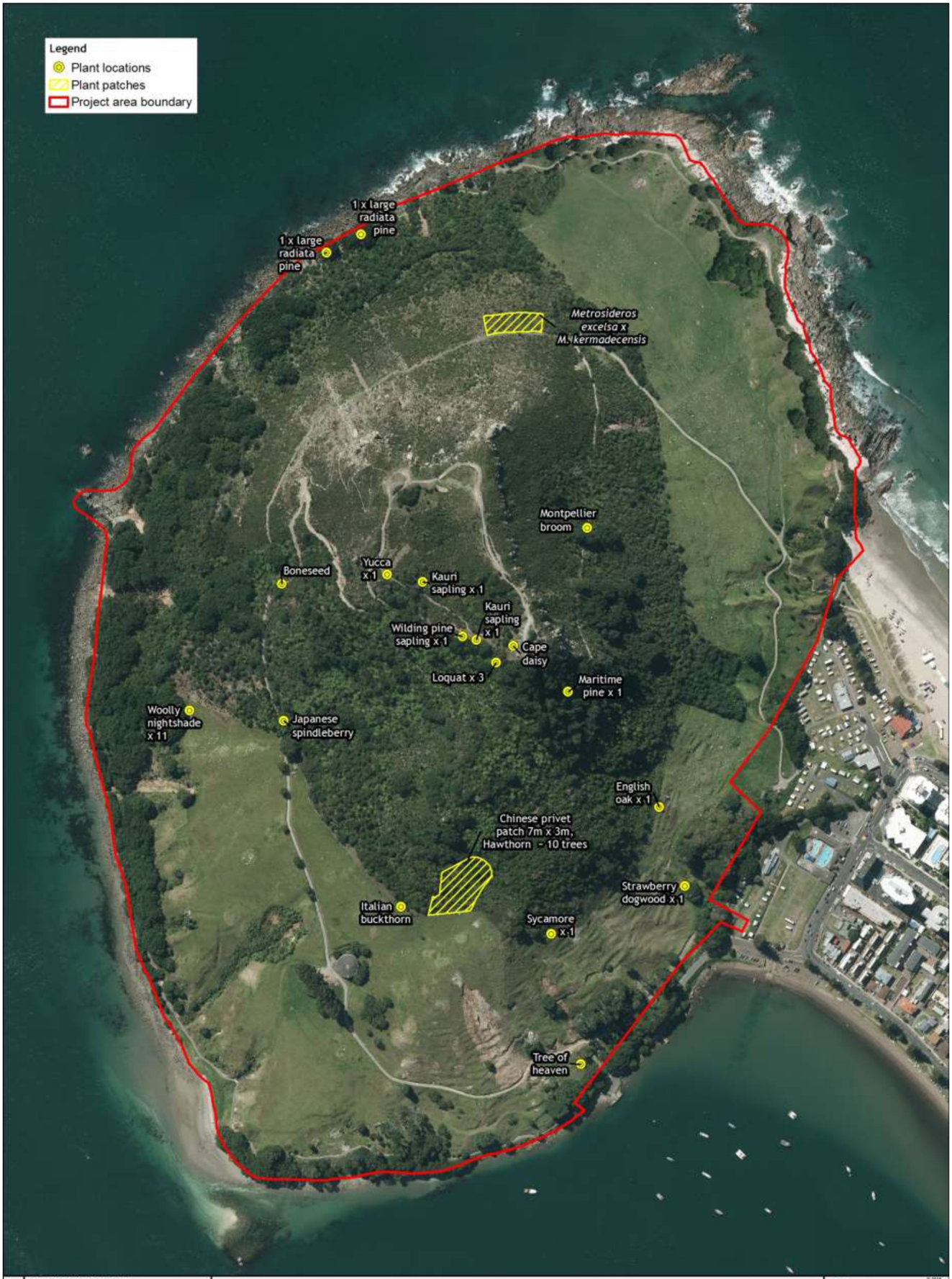
Legend
Plant locations
Plant patches
Project area boundary
1 x large radiata pine
1 x large radiata pine
Metrosideros excelsa x M. kermadecensis
Montpellier broom
Boneseed
Yucca x 1
Kauri sapling x 1
Kauri sapling x 1
Wilding pine sapling x 1
Cape daisy
Loquat x 3
Maritime pine x 1
Woolly nightshade x 11
Japanese spindleberry
English oak x 1
Chinese privet patch 7m x 3m, Hawthorn - 10 trees
Strawberry dogwood x 1
Italian buckthorn
Sycamore x 1
Tree of heaven
Data Acknowledgment
Maps contain data sourced from LINZ
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Figure 3. Isolated problem plant locations or patches on Mauao, November 2014
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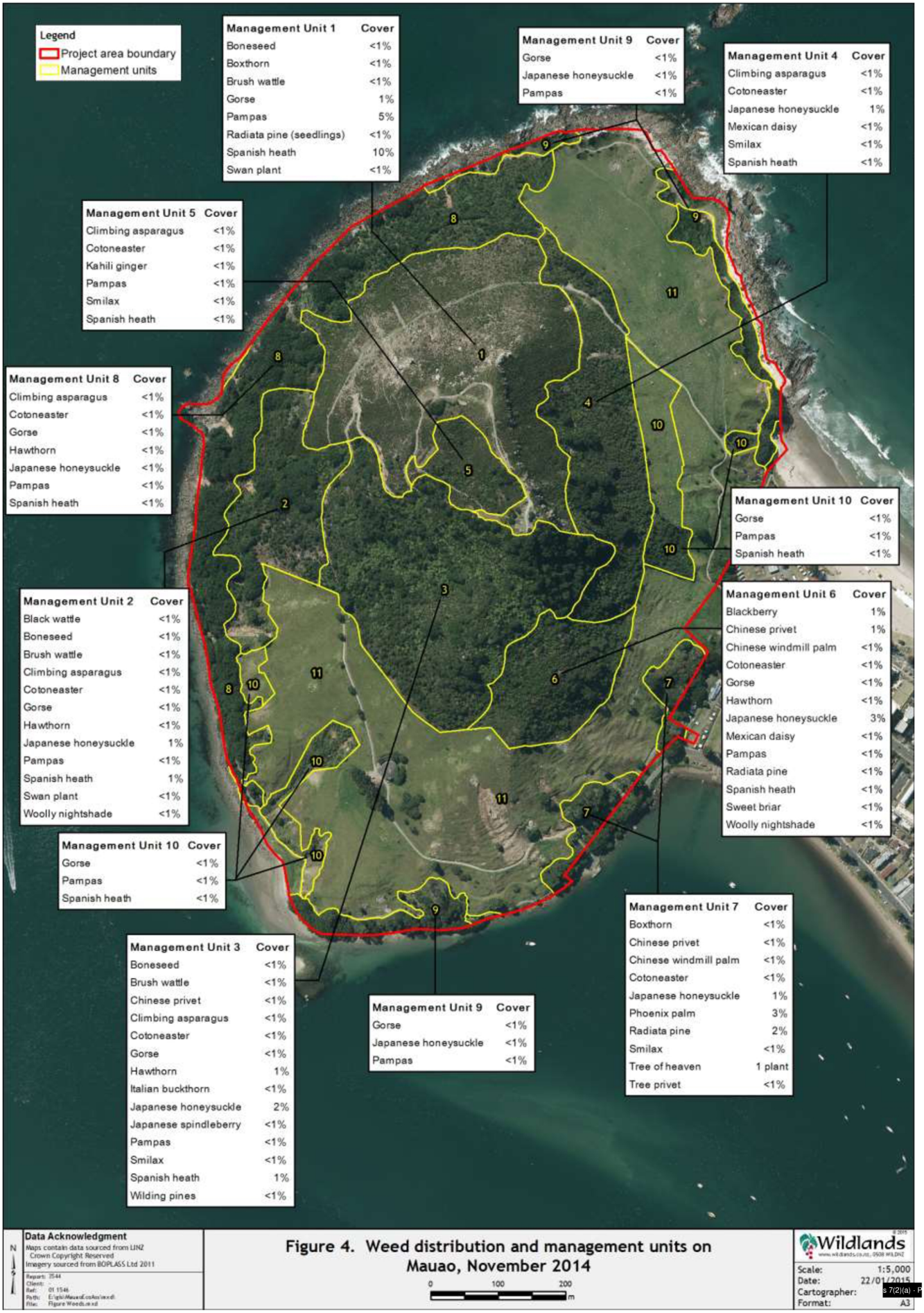

Figure 4. Weed distribution and management units on Mauao, November 2014

also present within short-stature vegetation on the southeastern midslopes of the reserve (see Figure 4). Chinese windmill palm is a high priority for control because it is fast growing, has wide environmental tolerances, produces copious seeds, and has the capacity to invade indigenous plant communities. Phoenix palm is a moderate priority for control. It has not been observed within indigenous vegetation and habitats on Mauao, but, if it were to become established, it can replace indigenous trees and inhibit regeneration by producing an impenetrable, long-lived subcanopy of saplings and seedlings.

Sweet briar is present as isolated individuals within short stature vegetation on the southwestern mid-slopes of Mauao. It is likely to be present in other areas, but at low density. It is a moderate priority for control because it can form dense, long-lived thickets that inhibit or prevent indigenous species from establishing.

Two species were only found at single locations: cape daisy (*Arctotheca calendula*) and yucca were only observed at one locality each during the 2014 field survey (see Figure 3). Cape daisy is a high priority for control because it is currently confined to one area and will not invade shrub or forest habitats. However, cape daisy is known to smother other plants growing near it, and therefore may reduce habitat for indigenous species, such as ground orchids and herbaceous species, that grow in open environments. However, Cape daisy may be more extensive on Mauao and if this is the case then it may be too extensive to control effectively. Yucca was found in one locality during the field survey; it does not pose a significant risk to indigenous biodiversity values, but it is not a suitable species in this environment and should be removed.

The provenance of the kauri saplings planted near the summit of Mauao is currently unknown and, due to this, these plants should be removed, as a medium level priority. If any future planting of this species is desired, it should be ensured that the plants are eco-sourced from natural populations in either the Tauranga or Otanewainuku Ecological Districts.

Other Environmental Pest Plants

Purple pampas (*Cortaderia jubata*), ivy (*Hedera helix*), willow-leaved hakea (*Hakea salicifolia*), prickly hakea (*Hakea sericea*), black passionfruit (*Passiflora edulis*), tree lucerne (*Chamaecytisus palmensis*), lupin (*Lupinus arboreus*), Himalaya fairy grass (*Miscanthus nepalensis*), mile-a-minute (*Dipogon lignosus*), and white-edged nightshade (*Solanum marginatum*) were not observed during the field survey in 2014. Purple pampas was mapped with pampas in 1997, so it is not possible to confirm whether this species is still present at the locations where it was observed in 1997. However extensive pampas control has been undertaken on Mauao since 1997 and it is therefore possible that this species is no longer present within the Reserve. The location and extent of ivy mapped in 1997 was outside the boundaries of the project area in 2014 and this species may therefore still be present in the area mapped in 1997. A single plant of prickly hakea was present below the summit in 1997 and 2004; this plant may have been controlled as it was not seen in 2014. A single plant of white-edged nightshade was observed on the edge of indigenous vegetation on the eastern side of Mauao in 1997; this plant was not observed in 2014 and may have been controlled. A single infestation of mile-a-minute was recorded in 1997 near the

boundary with the motorcamp on the eastern lower slopes; this species was not recorded in this area in 2014 and may have been controlled. German ivy and velvet groundsel (*Roldana petasitis*) were observed during field survey in 2014, but these species are located outside the 2014 project area and have therefore not been mapped in this report.

Surveillance for the other environmental pest plant species listed in Table 1, but not mentioned above or mapped in Figures 3 or 4, should be undertaken during the course of other weed control work. If found, they should be controlled based to the priorities listed in Table 1.

Comparison With 1997 Inventory

The distribution and abundance of forty-six pest plant species was mapped in 1997 (Wildland Consultants 1997). In 2014, the distribution and abundance of each pest plant species observed during field work was compared with the mapped extent of that species in 1997 and notes were made on differences or similarities between the extent mapped between years. Significant pest plant control has been undertaken on Mauao since pest plant distribution and abundance was last mapped in 1997 (Wildland Consultants 1997) and pest plant control is ongoing. In particular, the extent and abundance of pampas (*Cortaderia* species), wilding pines, blackberry, gorse, boneseed, hawthorn, woolly nightshade, and smilax have reduced significantly since 1997 (see Table 2 below). Pampas, gorse, boneseed, woolly nightshade, and thistles are currently the priority for control on Mauao, and regular surveillance and control of these species is undertaken (Mark Ray, Tauranga City Council, pers. comm.). Other pest plant species are controlled on an ad hoc basis as weeds are identified by Tauranga City Council staff and contractors, by the public, or by Bay of Plenty Regional Council staff and contractors (Mark Ray, Tauranga City Council, pers. comm.).

Table 2: Comparison of mapped environmental pest plant distribution and extent between 1997 and 2014.

Common Name	Comparison Between 1997 and 2014	Notes
Barberry	Increased in extent	Not widespread
Black passionfruit	Not known	Not mapped in 1997
Black wattle	Not known	Not mapped in 1997
Blackberry	Reduced in extent	Significant reduction
Boneseed	Reduced in extent	Significant reduction
Boxthorn	Increased in extent	Minor
Brush wattle	Similar in extent?	Mapped with silver wattle
Cape daisy	Not known	Not mapped in 1997
Cape ivy	Not known	Not mapped in 1997
Chinese privet	Increased in extent	Minor
Chinese windmill palm	Similar in extent	Additional plant(s) found in indigenous vegetation in 2014
Climbing asparagus	Reduced in extent	Significant reduction
Common alder	Not known	Not mapped in 1997
Cotoneaster	Increased in extent	
English oak	Not known	Not mapped in 1997
German ivy	Reduced in extent	Same location, reduced density
Gorse	Reduced in extent	Significant reduction

Common Name	Comparison Between 1997 and 2014	Notes
Hawthorn	Reduced in extent	Significant reduction
Himalaya fairy grass	Reduced in extent	Not observed in 2014
Italian evergreen buckthorn	Increased in extent	Minor. Recorded at different locations in 2014
Ivy	Not known	Outside project area
Japanese honeysuckle	Reduced in extent	Significant reduction
Japanese spindleberry	Similar in extent	Recorded at different locations in 2014
Kahili ginger	Similar in extent	
Loquat	Not known	Not mapped in 1997
Lupin	Not known	Not mapped in 1997
Maritime pine	Reduced in extent	Significant reduction
Mexican daisy	Increased in extent	Significant increase
Mile-a-minute	Not known	Not observed in 2014
Montpellier broom	Not known	Not mapped in 1997
Oleander	Not known	Not mapped in 1997
Pampas	Reduced in extent	Significant reduction
Phoenix palm	Similar in extent	
Pōhutukawa × Kermadec pōhutukawa	Not known	Not mapped in 1997
Prickly hakea	Not known	Not observed in 2014
Purple pampas	Reduced in extent	Not observed in 2014. Presume significant reduction
Radiata pine	Reduced in extent	Significant reduction
Silver wattle	Reduced in extent	Not observed in 2014
Smilax	Reduced in extent	Significant reduction
Spanish heath	Not known	Not mapped in 1997
Strawberry dogwood	Not known	Not mapped in 1997
Swan plant	Not known	Not mapped in 1997
Sweet briar	Not known	Not mapped in 1997
Tall fescue	Not known	Not mapped in 1997
Tradescantia	Similar in extent	
Tree lucerne	Not known	Not mapped in 1997
Tree of heaven	Reduced in extent	Significant reduction
Tree privet	Increased in extent	Minor. Recorded at different locations in 2014
Velvet groundsel	Similar in extent	Outside project boundary
White-edged nightshade	Reduced in extent	Not observed in 2014
Wilding pine	Reduced in extent	Significant reduction
Willow-leaved hakea	Not known	Not mapped in 1997
Woolly nightshade	Reduced in extent	Significant reduction
Yucca	Not known	Not mapped in 1997

7.2 Pest animals

Most of the common mainland suite of introduced mammalian species occur at Mauao, including mice (*Mus musculus*), rats (*Rattus* spp.), mustelids (*Mustela* spp.), brush-tailed possums (*Trichosurus vulpecula*), rabbits (*Oryctolagus cuniculus*), hedgehogs (*Erinaceus europaeus*), and feral and domestic cats (*Felis catus*), and possibly European hares (*Lepus europaeus*), The pest mammal species present on Mauao will be having negative impacts on indigenous flora and fauna and, in the case of rabbits, negative impacts on archaeological features of the site.

Ship rats (*Rattus rattus*) are present throughout the site, and Norway rats (*R. norvegicus*) are probably present around the coast. Both rat species are omnivorous and pose a significant threat to indigenous biodiversity through predation and competition for resources. Ship rats are more commonly found in forest environments and they spend much of their time in the canopy feeding on invertebrates, fruits, and seeds, and they will prey on any birds encountered in nests. Norway rats tend to be found around the coast or around waterways, and are a particular threat to ground nesting birds such as burrowing seabirds. Norway rat predation can lead to local extinctions of populations of small seabirds such as storm petrels.

Mice are likely to be present throughout the site, particularly in areas of dense vegetation such as rank kikuyu grassland where they are able to escape competition from rats. The negative effects of mice are often overlooked but they can cause significant damage to ecosystems by limiting natural regeneration through seed predation and competition for food with indigenous lizards and birds. Mouse populations tend to be suppressed in the presence of rats and their negative impacts increase when rat numbers are reduced.

At the time of the field inspections rabbits were very common in the open areas on Mauao, and were also observed in the indigenous forest and scrub areas. The burrowing behaviour of rabbits destabilises the ground and can cause slips that can damage archaeological features. Burrows can also pose a danger to walkers. Rabbits also hamper revegetation efforts by feeding on newly-planted indigenous species. If hares are present they will have similar negative effects on revegetation plantings, although not to the same extent as large numbers of rabbits.

Possums cause significant damage to indigenous vegetation and are also known to opportunistically prey on nests. Possums can be very selective in their feeding habits and are able to cause local extinctions of favoured, palatable plant species which, over time, can change the species composition of forests and woodlands. Possums are present on Mauao in very low numbers (Mark Ray, Tauranga City Council, pers. comm.) and have only been detected during night shooting operations for rabbits. Low level possum browse was noted on planted pūriri on the western slopes of Mauao in 2014.

Mustelids (particularly stoats, *Mustela erminea*) have occasionally been trapped on Mauao (Mark Ray, Tauranga City Council, pers. comm.). Stoats pose a significant threat to indigenous bird life, particularly species that nest in tree cavities, but will also prey on ground-nesting species such as seabirds. Ferrets (*Mustela furo*) may also be present and have been a significant predator of seabirds in other coastal regions of New Zealand, e.g. Otago Peninsula and the Catlins. Cats will be present, threatening populations of indigenous birds, reptiles, and larger invertebrates.

7.3 Human disturbance

Mauao Historic Reserve is utilised by large number of visitors (*c.*1.2 million/year) who traverse the base circuit track or climb to the summit on one of the formed tracks located within the Reserve. One of the formed tracks is maintained as a four-wheel-drive access track for maintenance and emergency services access to the summit.

Some informal tracks are also present throughout indigenous vegetation and habitats within the Reserve, but these are not common. Litter is not common within the Reserve.

Cliffs at the northern side of the Reserve are used on a regular basis for rock climbing and paragliders utilise the flatter surfaces with short-stature vegetation at the summit as a launch site.

The main threat to ecological values directly caused by people within the Reserve is vegetation disturbance as a result of informal track use and inadvertent transport of pest plant propagules on footwear. Although the use of cliff habitat for rock-climbing has the potential to negatively affect the *Psilotum nudum* population on the bluffs, it appears that impacts are currently minor or absent and the population is stable. However, detailed population monitoring has not been undertaken.

Penguin and petrel burrows can easily be damaged by people walking around the colony, which can lead to damaged eggs and injury to, or death of, adults and chicks. Where possible, people should be excluded from colony areas, to protect burrow-nesting birds.

7.4 Erosion

Erosion is a significant threat to vegetation and habitats on Mauao, particularly on the northern and northwestern aspects due to steep topography and exposure. The northern face of the Reserve is also likely to be more susceptible to erosion as a result of the regular disturbance of vegetation in this sector from fires.

Grey-faced petrel and penguin burrows are at risk of damage through erosion. Slips that occur during winter in areas where grey-faced petrel nest could be particularly devastating for the colony, as grey-faced petrels breed over winter. In a worst case scenario, breeding penguins and petrels and their eggs and/or chicks could be destroyed.

Continued sustained management of the rabbit population, removal of stock, and revegetation of some previously grazed and burnt areas, will help to minimise the risk of erosion.

7.5 Fire

There is a long history of fires on Mauao, and future fires are inevitable. This is due to the combined influences of high public usage, light and highly flammable vegetation, free-draining soils, high summer temperatures, and dry coastal winds. Flammable vegetation will always pose a fire risk on Mauao, although this risk will reduce slightly as existing shrub and scrub habitats develop into forest.

Fire risk to vegetation on exposed sites can be partly reduced by selecting less flammable species for use in revegetation plantings. This is discussed in more detail in Section 8 below.

Fire has the potential to kill eggs and chicks in blue penguin and grey-faced petrel burrows, and possibly adults, although they may be more likely to attempt escape.

8. REVIEW OF PREVIOUS MANAGEMENT

8.1 Previous vegetation restoration/enhancement projects

Since the early 20th century, there have been numerous attempts to beautify or enhance Mauao by clearing weed species and the planting of other exotic species. Over the past 120 years, there have also been attempts to restore indigenous vegetation on Mauao, which has included the planting of totara, ngaio, kauri (probably not found naturally on Mauao), and pōhutukawa, scattering of karaka berries and planting karaka trees, and distribution of seed of a variety of species (Wildland Consultants 1999).

The reasonably regular occurrence of major fires on Mauao has kept large areas of the northern and eastern slopes open, or covered in a low scrub that has historically been dominated by gorse (Wilcox and Ecroyd 1984) and pampas (Wildland Consultants 1999). The prevalence of these two species is due to their ability to rapidly spread highly viable seed, and their tolerance of extremely dry conditions. Although gorse and pampas have been, and continue to be, a high priority for control within the Reserve, the extent and density of these species has been reduced considerably (see Figure 4 and Section 7.1 above) since the extent of pest plant species was last mapped in 1997 (Wildland Consultants, 1997). Restoration planting of indigenous species has also been undertaken in parts of the Reserve since 1997. Gorse is no longer a significant component of the vegetation on Mauao, but another highly flammable species (Spanish heath) on the northern and northeastern faces is now locally common. Gorse seed weevil (*Exapion ulicis*) and gorse pod moth (*Cydia succedana*) are present in the Tauranga District and have played a significant role in reducing the extent of gorse on Mauao (Andrew Blaney, Bay of Plenty Regional Council, pers. comm.).

Restoration plantings have primarily been located in areas heavily affected by fire, in areas of mixed indigenous-exotic vegetation, or within grassland; however some underplanting has been undertaken within existing, established indigenous-dominated vegetation, e.g. slips within pōhutukawa forest and treeland. Restoration planting of indigenous species is concentrated on the northern, northeastern, and eastern mid- and upper slopes of the Reserve, with smaller areas of plantings on the midslopes and lower slopes on the western side. Plantings are generally dominated by ngaio, whaariki, and māhoe, with lesser quantities of other species including pōhutukawa, glossy karamu, whau, *Hebe parviflora*, broadleaf, kawakawa, nīkau, and tī kōuka. Local areas have a high proportion of mānuka.

The current restoration/revegetation strategy for Mauao is to extend the bush line into habitats currently containing grazed pasture by moving the fence downslope by 50 metres and planting the newly available space with indigenous species (Mark Ray, Tauranga City Council, pers. comm.).

8.2 Previous pest animal control

Several groups are currently undertaking pest mammal management on Mauao to protect and enhance indigenous biodiversity. Rabbits, rodents, possums, and mustelids are being controlled using a combination of toxic baits, traps, and shooting.

Rabbits were recently targeted through the use of pindone in all pasture areas (Mark Ray, Tauranga City Council, pers. comm.). Pindone should have produced a significant reduction in rabbit numbers and the population will continue to be reduced through night shooting on five nights every two months. As described in Section 7.2 above, possums are in very low numbers on Mauao, and there is therefore no targeted control of this species being undertaken.

Rodents are currently being controlled using diphacinone baits in a network of bait stations across the site. Approximately 40 stations have been placed around the perimeter of the main bush area, with about 40 more in other areas. A further 20-30 bait stations have been placed around the grey-faced petrel colony to enhance breeding success. Five DOC200 traps are used on Mauao to control mustelids and hedgehogs and these are moved to different locations as required. Further DOC200 traps are permanently located close to the grey-faced petrel colony.

8.3 Blue penguin

The first published account of blue penguin distribution on Mauao is by Winter (2000). It is not known whether blue penguins have been monitored since this baseline was established. Sievwright (2014) monitored the breeding success and survival of blue penguin in the area, but did not compare her counts to that of Winter (2000). The long-term population trends of blue penguin on Mauao are therefore not known.

Blue penguin were significantly affected by the Rena MV oil spill on 5 October 2011. By 21 October 2011, approximately 120 penguins had been taken from Mauao to the oiled wildlife facility, and most were released back to the wild. Research undertaken by Sievwright (2014) indicated that survival by rehabilitated penguins was not significantly different to that of control penguins, although control penguins may also have been affected by oil to an unknown degree.

8.4 Grey-faced petrels

The grey-faced petrel colony at Mauao has been studied since 1991 and several thousand birds have been banded from Mauao and the neighbouring Motuotau Island colony, and productivity has been monitored (Clifford 2001; Jones *et al.* 2011). Intensity of mammal pest control has varied over the last *c.*30 years, from no control in the early part of this period, through to varying levels of rodent and mustelid control. Mammal pest control around the main petrel breeding colony currently comprises bait stations for rodents and DOC200 traps for mustelids. Productivity appears to respond to pest control, with little or no breeding success in years with no control (Clifford 2001; Wildland Consultants 2004), and up to 32 chicks fledge per season following pest control (Wildland Consultants 2009).

Birds New Zealand Bay of Plenty has compiled a number of reports on the Mauao grey-faced petrels but these were not able to be reviewed for this report.

9. FUTURE MANAGEMENT

9.1 Management constraints

Management of vegetation and habitats for indigenous fauna and ecological values must be integrated with other key uses of the Reserve, such as protection of archaeological features, restoration of areas damaged by fires, landscape management, and visitor management. Key constraints when considering management for ecological values are:

- Protection and enhancement of existing areas of indigenous vegetation, while recognising that some local management of vegetation development may be required to protect significant archaeological features.
- Selection of indigenous revegetation species to reduce, or at least not increase, fire risk.
- Maintenance of view-shafts and tracks for recreational users of the reserve.
- Retention of pasture in key areas of archaeological landscape.
- Retention of historic exotic specimen trees

9.2 Vegetation management units

The project area has been divided into eleven management units (see Figure 4) based on management required in each area and relative priorities for management. Specific goals and recommendations for each unit are provided below. However, individual weed species that are of high priority for control should also be given a high priority at all locations.

Management Unit 1

This unit has been heavily affected by fire over a number of years and is currently dominated by planted indigenous shrubs and naturalised pest plant species, with small areas of indigenous vegetation that were not badly affected by the most recent fires. This unit is the first priority for management because stabilisation of the substrate on the northern face of Mauao is crucial and the worst pest plant infestations occur in this area.

Goal

Reduce pest plant cover and manage back to indigenous vegetation comprising low flammability species.

Priorities

- Control of pampas and boneseed is the highest priority.
- Control radiata pine, brush wattle, boxthorn, gorse, and swan plant as a secondary priority.
- Undertake infill planting of indigenous species following pest plant control. Plant pōhutukawa, ngaio, taupata (*Coprosma repens*), karamū, karo, akeake, whararikī, *Olearia pachyphylla*, *Carmichaelia williamsii*, and meadow rice grass.

Management Unit 2

This unit retains a high degree of naturalness with good indigenous species diversity, but pest plant species are scattered throughout. This unit is also a high priority for management because indigenous species will regenerate well once pest plants are controlled, which will provide a good return for the management effort and resources expended.

Goal

Reduce pest plant cover within the unit.

Priorities

- Control boneseed, brush wattle, pampas, Japanese honeysuckle, and woolly nightshade as a high priority.
- Control other pest plant species as a secondary priority (see Figure 4).
- Undertake infill planting of indigenous species in the parts of this unit that have been planted (southern boundaries): plant pōhutukawa, pūriri, ngaio, taupata, karamū, karo, akeake, tī kōuka, houpara, and whau.

Management Unit 3

This unit retains a high degree of naturalness, with good indigenous species diversity, but pest plant species are locally common in parts. This unit is a moderate priority for management because some of the pest plant species within this unit require immediate attention to limit their further spread within the reserve. Control of pest plants within this unit will provide a good return for the management effort and resources expended, and indigenous species will regenerate well subsequent to pest plant management.

Goal

Enhance existing indigenous vegetation values through pest plant management and appropriate enhancement planting.

Priorities

- Control concentrated area of Chinese privet and hawthorn (see Figure 3) as a high priority. Cut and paste, or drill and inject each stem with herbicide and leave *in situ* to decay.
- Control boneseed, brush wattle, Chinese privet, Italian buckthorn, Japanese honeysuckle, Japanese spindleberry, and wilding pines as a high priority.
- Control other pest plant species as a secondary priority (see Figures 3 and 4).
- Optional: undertake enhancement planting of indigenous species in canopy gaps left by pest plant control. Species that could be planted in this area include pōhutukawa, pūriri, houpara, whau, *Nestegis apetala*, totara, and parapara.

Management Unit 4

This unit also retains a high degree of naturalness with good indigenous species diversity, but pest plant species are locally common in parts. This unit is a moderate priority for management because some of the pest plant species within this unit require immediate attention to limit their further spread within the reserve. Control of pest plants within this unit will provide a good return for the management effort and resources expended, and indigenous species will regenerate well subsequent to pest plant management.

Goal

Enhance existing indigenous vegetation through pest plant management and appropriate enhancement planting.

Priorities

- Control of climbing asparagus and Japanese honeysuckle is a high priority.
- Control other pest plant species as a secondary priority (see Figures 3 and 4).
- Optional: undertake enhancement planting of indigenous species in canopy gaps left by pest plant control. Species that could be planted in this area include pōhutukawa, pūriri, houpara, whau, *Nestegis apetala*, totara, and parapara.

Management Unit 5

This unit has been partially affected by fire over a number of years and is currently dominated by planted indigenous shrubs with small areas of vegetation that were not badly affected by the most recent fires. This unit is of high priority for management because some of the pest plant species within this unit require immediate attention to limit their further spread within the Reserve. Control of pest plants within this unit will provide a good return for the management effort and resources expended, and indigenous species will regenerate well subsequent to pest plant management.

Goal

Enhance existing indigenous vegetation values through pest plant management and appropriate enhancement planting. Reduce flammability of vegetation.

Priorities

- Control of kahili ginger and pampas is the first priority.
- Control other pest plant species as a secondary priority (see Figures 3 and 4).
- Undertake infill planting of indigenous species following pest plant control: plant pōhutukawa, ngaio, taupata, karamū, karo, akeake, whararikī, *Olearia pachyphylla*, *Carmichaelia williamsii*, and meadow rice grass.

Management Unit 6

This unit has been left to regenerate naturally since it was fenced to exclude stock. It comprises secondary scrub and shrubland in varying phases of regeneration with small areas of exotic dominated shrubland or vineland, and some localised restoration planting. This unit is the moderate priority for active management because some of the pest plant species within this unit require immediate attention to limit their further spread within the Reserve. Control of pest plants within this unit will provide a good return for the management effort and resources expended, and indigenous species will regenerate well subsequent to pest plant management.

Goal

Enhance existing indigenous vegetation through pest plant management and appropriate enhancement planting.

Priorities

- Control pampas, Japanese honeysuckle, and wilding pines as the first priority.
- Control Chinese privet, Chinese windmill palm, hawthorn, and woolly nightshade as a medium priority.
- Control other pest plant species as a lower priority (see Figures 3 and 4).
- Optional: undertake enhancement planting of indigenous species in canopy gaps left by pest plant control. Species that could be planted in this area include pōhutukawa, pūriri, houpara, whau, *Nestegis apetala*, totara, and parapara.

Management Unit 7

This unit is dominated by exotic species, but does contain some indigenous species. This unit is a relatively low priority for management because it will require significant management effort and resources to be expended and comprises a very minor part of the vegetation of the Reserve. It does, however, provide an opportunity to extend indigenous vegetation and habitat around the entire base of Mauao. Pest plant species

should still be managed in this unit as part of a reserve-wide goal of reducing pest plant abundance and spread.

Goal

Manage back to indigenous dominated vegetation.

Priorities

- Control of Chinese privet, Japanese honeysuckle, tree of heaven, tree privet, strawberry dogwood, and phoenix palm is the first priority.
- Control other pest plant species as a lower priority (see Figures 3 and 4).
- Consider the removal of pine trees within this unit.
- Undertake enhancement planting of indigenous species in canopy gaps left by pest plant control. Species that could be planted in this area include pōhutukawa, pūriri, tītoki (*Alectryon excelsus*), totara, nīkau, tawa, and pigeonwood (porokaiwhiri; *Hedycarya arborea*).

Management Unit 8

This unit retains a high degree of naturalness with moderate indigenous species diversity. It is a moderate priority for control because it is regularly affected by erosion as a result of landslides on the steep mid- and lower slopes and, as a result, opportunities for pest plant spread within the unit are high. This unit is dominated by large, old pōhutukawa, although enhancement planting has been undertaken in areas affected by slips or fire.

Goal

Enhance existing indigenous vegetation through pest plant management and appropriate enhancement planting.

Priorities

- Control pampas, Japanese honeysuckle, and climbing asparagus as the first priority.
- Consider the removal of large radiata pine trees in the northern part of this unit (see Figure 3). If these trees were to be removed, replace with pōhutukawa. Trees would need to be dismantled due to their proximity to the base circuit track.
- Control other pest plant species as a lower priority (see Figures 3 and 4).
- Remove pōhutukawa × Kermadec pōhutukawa as a high priority. Replace with locally-sourced pōhutukawa or other indigenous broadleaved species such as ngaio, māhoe, karamū, glossy karamu, and akeake.

- Consider planting of pōhutukawa on the rocky, seaward side of the base track. Some existing trees are showing signs of dieback.
- Undertake infill planting of indigenous species on landslide scars that have already been partially planted. Species that could be planted in this area include pōhutukawa and whaririki.

Management Unit 9

This unit retains a moderate degree of naturalness with low indigenous diversity. This unit is a moderate priority for management because it comprises a relatively small proportion of the Reserve and pest plant abundance is low. However, control of pest plants within this unit will provide a good return for the management effort and resources expended.

Goal

Enhance existing indigenous vegetation values through pest plant management and appropriate enhancement planting.

Priorities

- Control pampas and Japanese honeysuckle as a high priority.
- Control gorse as a lower priority.
- Optional: undertake enhancement planting of indigenous species within pōhutukawa canopy gaps, beneath pōhutukawa trees, and in gaps left by pest plant control. Species that could be planted in this area include pōhutukawa, ngaio, *Nestegis apetala*, *Pomaderris kumerahou*, and whaririki.

Management Unit 10

This unit comprises areas that support restoration plantings of varying ages and densities. This unit is a high priority for management to fill in gaps and prevent pest plant establishment

Goal

Create canopy closure by infill planting to prevent pest plant species establishment.

Priorities

- Control all pest plants within this unit as a high priority (see Figure 4).
- Control gorse as a lower priority.
- Plant mānuka, kānuka, taupata, karamū, karo, akeake, tī kōuka, houpara, whau, and whaririki.

Management Unit 11

This unit comprises grazed pasture and is a low priority for management. Opportunities for additional restoration planting exist in the northeastern part of this unit as it has a low density of archaeological sites (see Figure 1, Wildland Consultants 2004).

Goal

Identify appropriate areas for additional restoration plantings. Reduce pest plant species distribution and abundance.

Priorities

- Plant appropriate indigenous species in areas identified for restoration planting. These could include pōhutukawa, mānuka, kānuka, totara, nīkau, taupata, karamū, karo, akeake, tī kōuka, houpara, whau, and whaririki.

9.3 Management aims

The overall aims of the revegetation/restoration work and the activities undertaken are fundamentally important if management is to be successful. The aims of vegetation management on Mauao should be to:

- Reduce the distribution and abundance of pest plant species within natural areas;
- Re-establish indigenous vegetation in areas heavily affected by fire;
- Restore the full suite of indigenous plant species that would have been formerly present;
- Identify opportunities for further restoration planting; and
- Encourage the natural regeneration of indigenous vegetation.

The aims of fauna management on Mauao should be to:

- Enhance the condition of indigenous vegetation;
- Protect plantings;
- Maintain existing seabird and other indigenous fauna populations;
- Restore habitats of indigenous fauna; and
- Re-establish seabird populations formerly present.

9.4 Environmental weed management

All weed control requires annual follow-up monitoring and control. Care should be taken to ensure surrounding indigenous vegetation is not affected by herbicide overspray.

9.5 Restoration planting

9.5.1 Species selection

Only plant species that currently occur naturally on Mauao or would have previously occurred naturally on Mauao should be used for any revegetation within the Reserve. Pōhutukawa is a key element of the vegetation on Mauao (and along the Bay of Plenty coast in general) and should continue to be a key species for restoration plantings.

Another particularly important consideration is the relative flammability of species. A list of plant species suitable for inclusion in plantings on Mauao and their relative flammability is provided in Appendix 3. Other issues considered include the overall appearance of the mountain and requirements for low maintenance of plantings. In addition to the relatively common plant species listed in Appendix 3, there is an opportunity to reintroduce nationally or regionally threatened species[1] that occur naturally in coastal areas in the Bay of Plenty Region and which may have been present historically on Mauao. Potentially suitable species and the appropriate habitats for establishment are listed below. Small scale planting trials should be considered, as the causal factors of decline may still be operating and hence re-establishment may be difficult. All plantings should be monitored.

<u>Beaches</u>

Atriplex hollowayi (Threatened-Nationally Critical)
Poa billardierei (hinarepe, sand tussock) (At Risk-Declining)
Ficinia spiralis (pīngao) (At Risk-Declining)
Euphorbia glauca (Waiu-o-Kahakura) (At Risk-Declining)
Lepidium oleraceum (Nau, Cook's scurvy grass) (Threatened-Nationally Vulnerable)
Pimelea villosa (sand daphne) (At Risk-Declining)
Tetragonia tetragonioides (New Zealand spinach) (At Risk-Naturally Uncommon)

<u>Shrubland and Secondary Forest</u>

Pimelea tomentosa (Threatened-Nationally Vulnerable)
Olearia pachyphylla (Threatened-Nationally Critical)
Carmichaelia williamsii (At Risk-Relict)

<u>Forest</u>

Nestegis apetala (coastal maire) (At Risk-Naturally Uncommon)
Pisonia brunoniana (parapara) (At Risk-Relict)
Ptisana salicina (para; king fern) (At Risk-Declining)

All plants should be sourced from Tauranga Ecological District or local Bay of Plenty genetic stock, and should generally be grown from seed.

[1] All threat rankings are from de Lange *et al.* 2013.

9.5.2 Planting guidelines

Site preparation, including the control of weeds and pest animal species, are key factors in the successful implementation of this project. Rabbits and hares pose a particular risk to the viability of any restoration planting undertaken on Mauao. Consideration could be given to the erection of rabbit- and hare-proof fences around any new (and existing) restoration plantings. Plantings should be monitored on a regular basis in the first year post planting to identify any issues that may arise with establishment, and identify areas that will require infill planting as a result of plant death. Planting of indigenous species should ideally be undertaken in the autumn and winter months when regular rainfall is more assured and will therefore result in reduced numbers of plant deaths.

9.6 Pest mammal management

Overall, the pest mammal control programme currently in place on Mauao is generally well-designed and should be making reasonable reductions in the populations of pest mammal species present. However, some areas have been identified where alterations to the control regime may improve protection of indigenous biodiversity as discussed below.

9.6.1 Rabbit control

Rabbit numbers were very high at the time of inspection and an effective control strategy needs to be developed, and also for hares if they are present. Construction of rabbit-proof fences could be considered around indigenous habitats and restoration plantings as a means to mitigate the influence of rabbits on indigenous ecological values.

9.6.2 Rodent control

Diphacinone baits in bait stations are an effective method of reducing rodent numbers. However, more bait stations are needed to maximise control efficacy. A 50 m grid of stations through the forest, scrub, and shrubland areas and around any non-forest/ scrub/shrubland areas of ecological interest, such as the petrel colony and any areas where indigenous lizards may be found, will provide more effective rodent control than a less regular bait station distribution. Three pulses of bait a year should be a minimum and it would be beneficial to monitor rodent numbers using tracking tunnels before and after each poison pulse, to enable the success of control operations to be quantified. It may be advisable to fill bait stations three or four times during a pulse to allow mice access to baits after rat numbers have been reduced. Extra bait station fills should take place around two weeks following the first fills.

9.6.3 Mustelid control

Mustelids are very wary of new objects and changes in their environment. Also, traps that have never caught stoats, or have not caught stoats in a long time, can suddenly begin to catch stoats. Therefore, the regular moving of existing traps is not ideal. It is suggested that the number of DOC200 traps on Mauao is increased, allowing traps to

be left in place permanently. Use of more than one bait or lure is also beneficial as individual mammals may have different bait or lure preferences. However, the baiting regime should be consistent between the DOC200 traps.

9.6.4 Domestic animal control

Control of feral cats in areas where domestic cats may be present is difficult and has the potential to be a public relations 'problem'. Cat owners living close to Mauao should be contacted to discuss the risks cats pose to indigenous fauna, and methods of responsible cat ownership. If cats are sighted on Mauao, live traps should be used to catch the cats and, if they are not claimed, they should be destroyed.

Dogs are not permitted on Mauao, but may still occasionally be a problem, especially for penguins and other ground-nesting birds. Rangers and volunteers working on Mauao should be vigilant and ready to take steps to remove any dogs.

9.6.5 Buffer zone

With water on three sides and residential property on the other, Mauao's geography means that reinvasion by some pest species are likely to be slower than in other mainland sites. Several pulses of intensive pest mammal control on Mauao coupled with a permanently-maintained grid of bait stations and traps along the narrow neck of landing between Mauao and the "mainland", including controlling rabbits on the dunes, may lead to local eradications of some pest mammal species and a substantial, sustained reduction in numbers of others. Rat and stoat control should be considered for areas of Matakana Island adjacent to Mauao, to limit re-invasion of Mauao by animals swimming across the Tauranga Entrance.

9.7 Avifauna

Mauao has the potential to support a much larger population of burrowing seabirds than it does at present. The grey-faced petrel population is likely to be significantly restricted by predation by rats, mustelids, and cats, and possibly disturbance by people. On islands where rats have been eradicated, the grey-faced petrel population has increased significantly. A site the size of Mauao has the potential to support several thousand breeding pairs, assuming that most of the habitat available is suitable for burrowing.

In addition to grey-faced petrel, adjacent islands support Pycroft's petrel (*Pterodroma pycrofti*; At Risk-Recovering), fluttering shearwater (*Puffinus gavia*; At Risk-Relict), North Island little shearwater (*Puffinus assimilis haurakiensis*; At Risk-Recovering), northern diving petrel (*Pelecanoides urinatrix urinatrix*; At Risk-Relict), New Zealand white-faced storm petrel (*Pelagodroma marina maoriana*; At Risk-Relict), and flesh-footed shearwater (*Puffinus carneipus*; Threatened-Nationally Vulnerable). Several of these species have been successfully attracted and/or translocated to protected mainland sites. In time, such species could be considered for re-establishment or introduction on Mauao (several may well have been present in the past). Introductions need not be prohibitively expensive (e.g. translocations), but can use comparatively cheap techniques such as acoustic attraction (although these are not

always successful). However, it would not be advisable to attempt this until mammal pest control is shown to allow the existing grey-faced petrel population to increase.

Likewise, Mauao may be able to support more blue penguin pairs with sustained mammal pest control, particularly if the availability of suitable breeding habitat is increased through planting.

However, management of the existing seabird population at Mauao is the highest priority for avifauna. This will need to involve intensive pest mammal control and monitoring of the blue penguin and grey-faced petrel population numbers and productivity. Observed, sustained, increases in breeding pairs of grey-faced petrel and associated low indexes of mammalian predators should be considered to be indicative of successful management and, at this point, translocations or attraction of other seabird species can be considered.

9.8 Herpetofauna

It is suggested that a suitably-qualified herpetologist is engaged to undertake a thorough herpetological survey of Mauao, as the presence of indigenous reptile species may need to be addressed in future management.

10. CONCLUDING COMMENTS

Mauao has a long history of human occupation, has very high ecological and landscape values, and also has very high tourism and recreational values. Consequently, it is critical that the management of cultural heritage, historic sites, ecological restoration, recreation, and other activities are addressed in an integrated manner. Historic sites and cultural heritage will always be critically important on Mauao. There is nevertheless considerable scope for ongoing active ecological restoration of Mauao, in conjunction with ongoing high levels of public usage. This report discusses priorities for management of the indigenous vegetation and habitats of indigenous fauna on Mauao, and provides suggestions on appropriate management of ecological values whilst taking into account the historic and recreational values of the site.

Ongoing protection from fire, and a rapid response to any fires, continues to be a very high priority. Indigenous vegetation should be protected and enhanced by targeted pest plant and pest animal control and appropriate ecological restoration planting both within and outside existing ‘natural’ areas in accordance with the priorities outlined in this report; this could include the reintroduction of threatened and at risk indigenous plant species that are likely to have been present on Mauao historically. Habitats for indigenous fauna should be protected through increasing the extent and coverage of bait station and trap networks for pest animal control and exclusion of recreational visitors from areas where seabird burrows are located. The fauna could also be enhanced by reintroduction of indigenous species such as Pycroft’s petrel, fluttering shearwater, and North Island little shearwater, however pest animal populations would need to have been reduced significantly before reintroductions are considered. Other options for pest animal exclusion, such as a pest-proof fence, could also be reconsidered.

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s 7(2)(f)(ii) - Protection (Tauranga City Council) provided useful information on past and current management of vegetation and fauna, and visitor use of the Reserve. s 7(2)(a) - Privacy s 7(2)(a) - Privacy provided useful comments on avifauna values and pest animal management. s 7(2)(f)(ii) - Protection of publ (Bay of Plenty Regional Council) provided useful information on biological control agents in the Tauranga area.

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VASCULAR PLANT SPECIES RECORDED ON MAUAO

INDIGENOUS SPECIES

Key

* = Occurs naturally at the site
P = Planted
N = Naturalised

Gymnosperms

Agathis australis (P)	kauri
Dacrycarpus dacrydioides (P)	kahikatea
Dacrydium cupressinum (P)	rimu
Phyllocladus trichomanoides (Beadel 2004)	tānekaha
Podocarpus totara var. *totara* (P)	totara
Prumnopitys ferruginea (P)	miro

Monocot. trees and shrubs

Cordyline australis (* P)	tī kōuka, cabbage tree
Rhopalostylis sapida (P)	nīkau

Dicot. trees and shrubs

*Brachyglottis repanda**	rangiora
*Carmichaelia australis**	maukoro, tainoka, taunoka
*Coprosma grandifolia**	kanono, raurēkau, raurākau, manono
Coprosma lucida (* P)	karamū, kāramuramu, glossy karamu
Coprosma repens (* P)	taupata
Coprosma robusta (* P)	karamū, kāramuramu
Coriaria arborea var. *arborea**	tutu
Corynocarpus laevigatus (* P)	karaka
Dodonaea viscosa (*? P)	akeake
Entelea arborescens (* P)	whau
*Gaultheria antipoda**	tāwiniwini, koropuka, takapo, taupuku
Geniostoma ligustrifolium var. *ligustrifolium**	hangehange
Griselinia littoralis (P)	kāpuka
Hebe parviflora (P)	koromiko tāranga, kōkōmuka tāranga
Hebe stricta var. *stricta* (* P)	koromiko, kōkōmuka
Hoheria sexstylosa (P, N)	houhere, lacebark
*Knightia excelsa**	rewarewa
Kunzea ericoides (* P)	kānuka
*Kunzea robusta**	
Leptecophylla juniperina var. *juniperina**	prickly mingimingi
Leptospermum scoparium agg. (* P)	mānuka
*Leucopogon fasciculatus**	mingimingi

*Leucopogon fraseri**	pātōtara
Melicytus novae-zelandiae (P) (Beadel 2004)	coastal māhoe
Melicytus ramiflorus subsp. *ramiflorus* (* P)	māhoe
Metrosideros excelsa (* P)	pōhutukawa
Myoporum laetum (P)	ngaio
*Myrsine australis**	māpou, matipou, māpau
*Olearia furfuracea**	akepiro, tanguru
Olearia pachyphylla (P. de Lange pers. comm. - historic record)	
Olearia paniculata (P)	akiraho
Olearia rani var. *colorata**	heketara
Pimelea tomentosa (Beadel 2004)	
Piper excelsum subsp. *excelsum**	kawakawa
Pittosporum crassifolium (* P)	karo
Pittosporum eugenioides (P)	tarata; lemonwood
Pittosporum tenuifolium (* P)	kōhūhū, rautāhiri, rautāwhiri
*Pomaderris amoena**	tauhinu
*Pseudopanax arboreus**	whauwhaupaku, puahou, five finger
Pseudopanax lessonii (* P)	houpara
*Rhabdothamnus solandri**	taurepo
Sophora microphylla (P)	kōwhai
Vitex lucens (P)	pūriri
*Weinmannia racemosa**	kāmahi

Dicot. lianes

*Calystegia soldanella**	panahi, shore bindweed
Calystegia sepium subsp. *roseata**	pōhue
Calystegia sepium × *C. soldanella**	
*Clematis paniculata**	puawānanga
*Muehlenbeckia complexa**	pōhuehue
*Parsonsia capsularis**	akakiore
Rubus schmidelioides var. *schmidelioides**	tātarāmoa, bush lawyer

Lycopods and psilopsids

Huperzia varia (Beadel 2004)	whiri-o-Raukatauri
Lycopodium deuterodensum (Beadel 2004)	puakarimu
*Psilotum nudum**	
*Tmesipteris elongata**	
*Tmesipteris tannensis**	

Ferns

*Adiantum cunninghamii**	huruhuru tapairu, maidenhair fern
*Adiantum diaphanum**	huruhuru tapairu, maidenhair fern
*Asplenium flaccidum**	makawe, ngā makawe o Raukatauri
*Adiantum hispidulum**	huruhuru tapairu, maidenhair fern
*Asplenium oblongifolium**	huruhuru whenua
*Asplenium polyodon**	petako
*Blechnum chambersii**	rereti, nini

*Blechnum filiforme**	pānako
*Blechnum novae-zelandiae**	kiokio
Cardiomanes reniforme (Beadel 2004)	kidney fern, konehu raurenga, kopakopa
*Cyathea dealbata**	ponga, silver fern
*Cyathea medullaris**	mamaku
*Dicksonia fibrosa**	whekī –ponga, kurīpākā
*Dicksonia squarrosa**	whekī
*Doodia australis**	pukupuku
*Histiopteris incisa**	mātātā, water fern
Hymenophyllum demissum (Beadel 2004)	irirangi, piripiri, filmy fern
Hymenophyllum dilatatum (Beadel 2004)	matua mauku, filmy fern
Hymenophyllum sanguinolentum (Beadel 2004)	piripiri, filmy fern
Lygodium articulatum (Beadel 2004)	mangemange
*Microsorum pustulatum**	kōwaowao, pāraharaha, hound's tongue fern
*Paesia scaberula**	mātātā
*Pneumatopteris pennigera**	pākau
Polystichum neozelandicum subsp. *neozelandicum**	pikopiko, shield fern
*Pteridium esculentum**	rārahu, bracken
*Pteris macilenta**	titipo, sweet fern
*Pteris tremula**	turawera, shaking brake
*Pyrrosia eleagnifolia**	leather-leaf fern

Orchids

Diplodium alobulum (Beadel 2004)	
*Drymoanthus adversus**	
*Earina autumnalis**	raupeka
*Earina mucronata**	peka-a-waka
Microtis unifolia agg.*	
*Nematoceras macranthum**	
Nematoceras rivulare (Beadel 2004)	
*Pterostylis banksii**	tutukiwi
*Thelymitra longifolia**	
*Thelymitra pauciflora**	slender sun orchid
*Winika cunninghamii**	

Grasses

*Deyeuxia avenoides**	
*Dichelachne crinita**	plume grass
*Echinopogon ovatus**	
*Microlaena stipoides**	pātītī, meadow rice grass
Oplismenus hirtellus subsp. *imbecillis**	
Poa anceps agg.*	
Poa sp. *	
*Rytidosperma gracile**	
*Rytidosperma clavatum**	
*Zoysia pauciflora**	

Sedges

Carex aff. *raoulii* ("raotest")*	
*Carex breviculmis**	
*Carex dissita**	
*Carex secta**	pūrei, makura, pūreirei, pūrekireki, pūkio
*Carex testacea**	
Cyperus ustulatus f. *ustulatus**	toetoe upoko-tangata
*Ficinia nodosa**	wīwī
*Isolepis cernua**	
*Isolepis habra**	
Lepidosperma laterale (Beadel 2004)	
*Machaerina juncea**	
*Machaerina sinclairii**	toetoe tūhara, pēpepe
*Morelotia affinis**	
Schoenus apogon (Beadel 2004)	
Schoenus tendo (Beadel 2004)	wīwī
*Tetraria capillaris**	
*Uncinia uncinata**	kamu matau a Maui, kamu

Rushes

*Apodasmia similis**	oioi
*Juncus edgariae**	wi, wīwī
Luzula picta var. *picta**	

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

*Astelia banksii**	kakaha, pūwharawhara, wharawhara, kōwharawhara
*Astelia solandri**	kōwharawhara
*Collospermum hastatum**	kahakaha
*Dianella haematica**	
*Dianella nigra**	tūrutu
Lemna disperma (Beadel 2004)	karearea
Phormium cookianum subsp. *hookeri* (P)	wharariki, mountain flax
Phormium tenax (P)	harakeke, flax

Composite herbs

*Euchiton audax**	
*Euchiton japonicus**	
*Lagenifera pumila**	papataniwhaniwha
Pseudognaphalium luteoalbum agg. *	pukatea
*Senecio hispidulus**	
Senecio lautus var. *lautus**	

Dicot. herbs (other than composites)

*Acaena novae-zelandiae**	piripiri

Atriplex hollowayi (Beadel *et al.* 2009 - historic record)	Holloway's crystalwort
*Centella uniflora**	
*Dichondra repens**	Mercury Bay weed
Disphyma australe subsp. *australe**	horokaka
*Drosera auriculata**	sundew, wahu
*Galium trilobum**	
Geranium sp. *	
*Gonocarpus incanus**	piripiri
Haloragis erecta subsp. *erecta**	toatoa
*Hydrocotyle heteromeria**	
*Lobelia anceps**	punakura
*Oxalis exilis**	
*Oxalis rubens**	sand oxalis
*Peperomia urvilleana**	wharanui
*Ranunculus reflexus**	maruru
Samolus repens var. *repens**	māakoako
*Sarcocornia quinqueflora**	ureure, glasswort
*Selliera radicans**	remuremu, rekoreko, raumangu
*Solanum americanum**	raupeti
*Tetragonia tetragonioides**	kōkihi, rengamutu, rengarenga, tūtae-rimuroa
*Wahlenbergia violacea**	

NATURALISED AND EXOTIC SPECIES

Gymnosperms

Cupressus macrocarpa	macrocarpa
Pinus pinaster	maritime pine
Pinus radiata	radiata pine
Pinus sp.	

Monocot. trees and shrubs

Phoenix canariensis	Phoenix palm
Trachycarpus fortunei	Chinese windmill palm
Yucca gloriosa	yucca

Dicot. trees and shrubs

Acacia dealbata (Beadel 2004)	silver wattle
Acacia longifolia (Beadel 2004)	Sydney golden wattle
Acacia mearnsii	black wattle
Acacia sophorae (Beadel 2004)	coastal wattle
Acer negundo	box alder
Acer pseudoplatanus	sycamore maple
Ailanthus altissima	tree of heaven
Alnus glutinosa	common alder
Berberis glaucocarpa	barberry
Brachychiton acerifolius	Illawara flame tree

Buddleja davidii	buddleia
Casuarina sp.	sheoak
Chamaecytisus palmensis	tree lucerne
Chrysanthemoides monilifera	boneseed
Cotoneaster glaucophyllus	cotoneaster
Cotoneaster simonsii (Beadel 2004; Wilcox and Ecroyd 1984)	Khasia berry
Crataegus monogyna	hawthorn
Dendrobenthamia capitata	strawberry dogwood
Erica lusitanica	Spanish heath
Eriobotrya japonica	loquat
Eucalyptus sp.	eucalyptus
Euonymus japonicus	Japanese spindleberry
Gomphocarpus fruticosus	swan plant
Grevillea robusta	silky oak
Hakea salicifolia (Beadel 2004)	willow-leaved hakea
Hakea sericea (Beadel 2004)	prickly hakea
Jasminum mesnyi	primrose jasmine
Ligustrum lucidum	tree privet
Ligustrum sinense	Chinese privet
Lupinus arboreus (Beadel 2004)	lupin
Lycium ferocissimum	boxthorn
Melia azedarach	melia
Metrosideros kermadecensis	
Nerium oleander	oleander
Paraserianthes lophantha	brush wattle
Paulownia tomentosa	paulownia
Populus alba 'Nivea'	silver poplar
Populus nigra 'Italica'	Lombardy poplar
Populus sp.	poplar
Quercus ilex[1]	holm oak
Quercus robur	English oak
Rhamnus alaternus	Italian evergreen buckthorn
Rhaphiolepis umbellata	Sexton's bridge
Roldana petasitis[1]	velvet groundsel
Rosa rubiginosa	sweet briar
Rubus sp. (*R. fruticosus* agg.)	blackberry
Senecio angulatus	Cape ivy
Solanum mauritianum	woolly nightshade
Teline monspessulana	Montpellier broom
Teucrium fruticans	
Ulex europaeus	gorse

Monocot. lianes

Asparagus asparagoides	smilax
Asparagus scandens	climbing asparagus

[1] Present just outside the project area.

Dicot. lianes

Delairea odorata[1]	German ivy
Dipogon lignosus (Beadel 2004)	mile-a-minute
Hedera helix[1]	ivy
Lonicera japonica	Japanese honeysuckle
Passiflora edulis (Beadel 2004; Wilcox and Ecroyd 1984)	black passionfruit
Rumex sagittatus	climbing dock
Senecio angulatus	cape ivy
Vitis sp. (Beadel 2004)	

Grasses

Agrostis capillaris	browntop
Agrostis stolonifera	creeping bent
Aira caryophyllea	silver hairy grass
Anthoxanthum odoratum	sweet vernal
Aristida ramosa (Beadel 2004)	
Briza minor (Beadel 2004)	shivery grass
Bromus diandrus	ripgut brome
Cenchrus clandestinus	kikuyu grass
Cortaderia jubata (Beadel 2004)	purple pampas
Cortaderia selloana	pampas
Cynodon dactylon	Indian doab
Dactylis glomerata	cocksfoot
Ehrharta erecta	veldt grass
Holcus lanatus	Yorkshire fog
Lolium perenne	rye grass
Miscanthus nepalensis	Himalaya fairy grass
Paratrophis sp.	
Paspalum conjugatum (Beadel 2004)	
Paspalum dilatatum	paspalum
Poa annua	annual poa
Poa pratensis	Kentucky bluegrass
Schedonorus arundinaceus	tall fescue
Sporobolus africanus	ratstail
Stenotaphrum secundatum	buffalo grass
Vulpia myuros	vulpia hair grass

Sedges

Carex divulsa	grey sedge
Cyperus congestus (Beadel 2004)	purple umbrella sedge
Cyperus eragrostis (Beadel 2004)	umbrella sedge
Isolepis sepulcralis	

[1] Present just outside the project area.

Rushes

Juncus bufonius var. *bufonius*	toad rush

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

Arum italicum[1]	Italian arum
Colocasia esculenta (Beadel 2004)	taro
Crocosmia ×*crocosmiiflora*	montbretia
Hedychium gardnerianum	kahili ginger, wild ginger
Ixia maculata (Beadel 2004)	ixia
Narcissus pseudonarcissus (Beadel 2004)	daffodil
Tradescantia fluminensis	tradescantia

Composite herbs

Arctotheca calendula	cape weed
Bellis perennis	lawn daisy
Cirsium arvense	California thistle
Cirsium vulgare	Scotch thistle
Conyza sumatrensis	broad-leaved fleabane
Crepis capillaris	hawksbeard
Erigeron karvinskianus	Mexican daisy
Gamochaeta calviceps	silky cudweed
Gamochaeta coarctata	purple cudweed
Hypochaeris radicata	catsear
Jacobaea vulgaris (Beadel 2004)	ragwort
Lactuca serriola	prickly lettuce
Leontodon taraxacoides	hawkbit
Leucanthemum vulgare	oxeye daisy
Mycelis muralis	wall lettuce
Senecio bipinnatisectus (Beadel 2004)	Australian fireweed
Senecio sylvaticus	wood groundsel
Sigesbeckia orientalis (Beadel 2004)	Indian weed, punawaru
Soliva sessilis (Beadel 2004)	Onehunga weed
Sonchus asper	prickly puha
Sonchus oleraceus	puha, sow thistle
Taraxacum officinale	dandelion

Dicot. herbs (other than composites)

Acaena agnipila (Beadel 2004; Wilcox and Ecroyd 1984)	Australian sheep's burr
Acanthus mollis[1]	bear's breeches
Anagallis arvensis	scarlet pimpernel
Aphanes arvensis	parsley piert
Cerastium fontanum subsp. *vulgare*	mouse-ear chickweed
Dianthus armeria (Beadel 2004)	Deptford pink

[1] Present just outside the project area.

Digitalis purpurea	foxglove
Dipsacus fullonum	wild teasel
Duchesnea indica	Indian strawberry
Epilobium ciliatum (Beadel 2004)	tall willow herb
Euphorbia peplus	milkweed
Foeniculum vulgare	fennel
Fumaria muralis	scrambling fumitory
Galium aparine	cleavers
Galium divaricatum	slender bedstraw
Geranium molle	dovesfoot cranesbill
Geranium robertianum	herb Robert
Gomphocarpus fruticosus	swan plant
Hypericum perforatum (Beadel 2004)	St John's wort
Impatiens sodenii	shrub balsam
Linum bienne (Beadel 2004)	pale flax
Lotus pedunculatus	lotus
Lotus suaveolens	hairy birdsfoot trefoil
Marrubium vulgare	horehound
Medicago arabica	spotted medick
Medicago nigra	bur medick
Modiola caroliniana	creeping mallow
Myosotis sylvatica	garden forget-me-not
Nasturtium officinale	watercress
Oenothera stricta	evening primrose
Ornithopus perpusillus (Beadel 2004)	wild seradella
Oxalis sp.	
Physalis peruviana (Beadel 2004)	cape gooseberry
Phytolacca octandra	inkweed
Plantago australis	swamp plantain
Plantago lanceolata	narrow-leaved plantain
Plantago major	broad-leaved plantain
Polycarpon tetraphyllum	allseed
Prunella vulgaris	selfheal
Ranunculus parviflorus	small-flowered buttercup
Ranunculus repens	creeping buttercup
Ranunculus sceleratus (Beadel 2004)	celery-leaved buttercup
Rumex acetosella	sheep's sorrel
Rumex obtusifolius	broad-leaved dock
Sagina procumbens	pearlwort
Silene gallica (Beadel 2004)	catchfly
Solanum chenopodioides	velvety nightshade
Solanum linnaeanum (Beadel 2004)	Apple of Sodom
Solanum marginatum (Beadel 2004)	white-edged nightshade
Solanum nigrum	black nightshade
Solanum tuberosum (Beadel 2004)	potato
Stellaria media	chickweed
Trifolium pratense	red clover
Trifolium repens	white clover

Tropaeolum majus[1]	garden nasturtium
Urtica dioca	stinging nettle
Verbascum thapsus	woolly mullein
Verbascum virgatum	moth mullein
Verbena bonariensis	purple-top
Veronica arvensis	field speedwell
Veronica persica	scrambling speedwell

[1] Present just outside of survey area.

FAUNA SPECIES RECORDED ON MAUAO

Key

1 = Recorded prior to 2014 field survey.
2 = Recorded during the 2014 field survey.
3 = Recorded in Wildland Consultants (2004).
4 = Recorded in Wildland Consultants (2008).

MAMMALS

Indigenous

Arctocephalus forsteri (1)	kekeno; New Zealand fur seal

Introduced

Erinaceus europaeus (1)	European hedgehog
Felis catus (1)	cat
Mustela erminea (1)	stoat
Mustela furo (1)	ferret
Mustela nivalis vulgaris (1)	weasel
Oryctolagus cuniculus (2)	European rabbit
Rattus norvegicus (1)	pouhawaiki; Norway rat
Rattus rattus (1)	ship rat
Trichosurus vulpecula (1)	brushtail possum

BIRDS

Indigenous

Gerygone igata (2)	riroriro; grey warbler
Eudyptula minor iredalei (1)	kororā; northern little blue penguin
Hirundo neoxena neoxena (2)	welcome swallow
Larus dominicanus dominicanus (2)	karoro; southern black-backed gull
Petroica macrocephala (2)	tomtit
Phalacrocorax varius varius (2)	kāruhiruhi; pied shag
Porphyrio melanotus melanotus (2)	pūkeko
Prosthemadera novaeseelandiae (2)	tūī
Pterodroma macroptera gouldi (1)	ōi, grey-faced petrel
Rhipidura fuliginosa (2)	pīwakawaka, fantail
Tadorna variegata (2)	pūtangitangi; pari; paradise shelduck
Todiramphus sanctus vagans (2)	kōtare; sacred kingfisher; New Zealand kingfisher
Vanellus miles novaehollandiae (2)	spur-winged plover

Introduced

Acridotheres tristis (2)	common myna
Anas platyrhynchos platyrhynchos (2)	mallard
Anthus novaeseelandiae (3)	New Zealand pipit
Callipepla californica bunnescens	California quail
Carduelis carduelis britannica (2)	European goldfinch
Chrysococcyx lucidus lucidus (3)	pīpīwharauroa; shining cuckoo
Columba livia (2)	rock pigeon
Egretta sacra sacra (3)	matuku-moana; reef heron
Eudyptula minor iredalei (3)	kororā, blue penguin
Falco novaeseelandiae (3)	kārearea; New Zealand falcon
Fringilla coelebs (2)	chaffinch
Gymnorhina tibicen (2)	Australian magpie
Nestor meridionalis septentrionalis (3)	North Island kākā
Passer domesticus domesticus (2)	house sparrow
Phasianus colchicus (2)	common pheasant
Platycercus eximius (2)	eastern rosella
Pterodroma macroptera gouldi (3)	ōi, grey-faced petrel
Sterna striata striata (3)	tara; white-fronted tern
Sturnus vulgaris vulgaris (2)	common starling
Turdus merula merula (2)	Eurasian blackbird
Turdus philomelos (2)	song thrush

HERPETOFAUNA

Indigenous

Oligosoma smithii (4)	shore skink

INDIGENOUS SPECIES POTENTIALLY SUITABLE FOR PLANTING

Key

1 = Sheltered sites
2 = Salt spray zone
3 = Rocky outcrops at base of Mauao
4 = Gullies on sheltered side of Mauao
5 = Sand dunes (limited habitat available)
6 = Exposed faces

Reproduced from Wildland Consultants (2004).

Gymnosperms

Dacrycarpus dacrydioides (1)	kahikatea
Dacrydium cupressinum (1)	rimu
Podocarpus totara (1)	totara
Prumnopitys ferruginea (1)	miro
Prumnopitys taxifolia (1)	mataī

Monocot. trees and shrubs

Cordyline australis (1, 4)	tī kōuka, cabbage tree
Cordyline banksii (1)	tī ngahere, forest cabbage tree
Rhopalostylis sapida (4)	nīkau

Dicot. trees and shrubs

Alectryon excelsus var. *excelsus* (1)	tītoki
Aristotelia serrata (1)	makomako, wineberry
Beilschmiedia tawa (1)	tawa
Brachyglottis repanda s.s. (1)	rangiora
Carmichaelia australis (1)	makaka, maukoro
Carmichaelia williamsii (6)	
Carpodetus serratus (1)	putaputaweta
Coprosma acerosa (5)	
Coprosma acerosa × *C. repens* (3)	
Coprosma grandifolia (1)	kanono
Coprosma lucida (1)	glossy karamu
Coprosma robusta (1, 4)	karamū
Coprosma rhamnoides (1)	
Coriaria arborea var. *arborea* (1)	tutu
Dodonea viscosa (1)	akeake
Dysoxylum spectabile (1)	kohekohe
Entelea arborescens (1)	whau
Fuchsia excorticata (1)	kōtukutuku

Fuchsia perscandens (1)	
Gaultheria antipoda (1)	tāwiniwini
Geniostoma ligustrifolium var. *ligustrifolium* (1)	hangehange
Griselinia lucida (1)	puka
Hedycarya arborea (1)	porokaiwhiri; pigeonwood
Hoheria sexstylosa (1)	houhere, lacebark
Knightia excelsa (1)	rewarewa
Kunzea robusta	kānuka
Leptecophylla juniperina subsp. *juniperina* (1)	prickly mingimingi
Leucopogon fasciculatus (1)	mingimingi
Litsea calicaris (1)	mangeao
Piper excelsum var. *excelsum* (1)	kawakawa
Pittosporum crassifolium (1, 4)	karo
Pseudopanax lessonii	houpara
Melicytus ramiflorus subsp. *ramiflorus* (1)	māhoe
Metrosideros excelsa (1, 2, 6)	pōhutukawa
Myoporum laetum (1, 2)	ngaio
Myrsine australis (1)	māpou
Nestegis apetala (1)	
Olearia furfuracea (1)	akepiro
Olearia pachyphylla (historic record) (1, 6)	
Olearia rani (1)	heketara
Pimelea arenaria (5)	
Pisonia brunoniana (1)	
Pittosporum tenuifolium subsp. *tenuifolium* (1)	kōhūhū
Pomaderis kumerahou (1)	
Pomaderris phylicifolia (1)	
Pseudopanax arboreus var. *arboreus* (1)	whauwhaupaku, five finger
Pseudopanax crassifolius (1)	horoeka, lancewood
Pseudopanax crassifolius × *P. lessonii* (1)	
Rhabdothamnus solandri (1)	taurepo
Schefflera digitata (1)	pate
Solanum aviculare var. *aviculare* (1)	poroporo
Vitex lucens (1)	pūriri
Weinmannia racemosa (1)	kāmahi

Monocot. lianes

Freycinetia banksii (1)	kiekie
Ripogonum scandens (1)	kareao, supplejack

Dicot. lianes

Calystegia soldanella (5)	panahi
Clematis cunninghamii (1)	ngākau-kiore
Clematis paniculata (1)	puawānanga
Metrosideros diffusa (1)	rātā
Metrosideros fulgens (1)	rātā
Metrosideros perforata (1)	aka
Muehlenbeckia complexa (5)	pōhuehue

Parsonsia capsularis (1)	akakiore
Parsonia heterophylla (1)	
Rubus australis (1)	
Rubus cissoides (1)	tātarāmoa
Rubus schmidelioides (1)	akatataramoa

Ferns

Cyathea dealbata (1)	ponga
Cyathea medullaris (1)	mamaku
Dicksonia squarrosa (1)	whekī
Marratia salicina var. *salicina* (1, 4)	para, kingfern

Grasses

Microlaena stipoides (6)	pātītī, meadow rice grass

Sedges

Desmoschoenus spiralis (5)	pīngao

Monocot. herbs (other than orchids, grasses, sedges and rushes)

Arthropodium cirratum (1)	rengarenga
Astelia banksii (1)	kakaha
Libertia grandifolia (1)	mikoikoi
Phormium cookianum (1, 2, 6)	whaririki

Dicot. herbs (other than composites)

Euphorbia glauca (5)	
Lepidium oleraceum (5)	
Tetragonia tetragonioides (5)	kokihi

Relative Flammability of Indigenous Plant Species

The following material was obtained from a pamphlet produced by Forest Research in conjunction with the National Rural Fire Authority and the New Zealand Fire Service Commission. Only species suitable for planting on Mauao are listed here.

Flammability Classes

These flammability classes are intended as a guide only. They were derived from expert opinion, and represent a state-of-knowledge summary that will need to be refined in the light of future observations. Species flammability also varies as a result of genetic and environmental factors, so that the flammability of a particular species will depend on age and situation. For example, flammability may increase as a result of drought or other critical fire weather conditions, or mature vegetation could carry greater amounts of dead material, adding to the potential severity of any fire.

- *Low*

  Suitable for green breaks or defensible space, but when in the immediate vicinity of structures, there should be at least a 3-4 m break between the crowns to reduce fuel continuity.

  Low Flammability Species

Fuchsia excorticata	kōtukutuku
Pseudopanax crassifolius	horoekea, lancewood
Pseudopanax arboreus	five finger, whauwhaupaku
Coprosma robusta	karamū
Coprosma grandifolia	kanono
Geniostoma ligustrifolium	hangehange
Coprosma repens	taupata
Carpodetus serratus	putaputaweta
Corynocarpus laevigatus	karaka
Griselinia lucida	puka
Piper excelsum	kawakawa, peppertree
Solanum aviculare	poroporo

- *Low/Moderate*

  Not recommended for planting in green breaks. If planted in defensible space, elevated dead material and litter should be removed regularly, greater than 4 m should be left between tree crowns, and trees or shrubs in this category should not be within 10 m of structures.

  Low/Moderate Flammability Species

Hebe stricta	koromiko
Melicytus ramiflorus	māhoe
Aristotelia serrata	makomako, wineberry
Coriaria arborea	tutu
Myoporum laetum	ngaio
Pittosporum crassifolium	karo
Pittosporum eugenioides	tarata, lemonwood
Knightia excelsa	rewarewa
Plagianthus regius	mānatu, ribbonwood
Weinmannia racemosa	kāmahi

- *Moderate*

  Most of these species produce heavy accumulations of flammable litter and elevated dead material, and/or have flammable green foliage. Not recommended for green breaks or for planting in defensible space.

Moderate Flammability Species

Beilschmiedia tawa	tawa
Cordyline australis	tī kōuka, cabbage tree
Pittosporum tenuifolium	kōhūhū
Dacrydium cupressinum	rimu
Phormium spp.	flax
Dacrycarpus dacrydioides	kahikatea, white pine

- *Moderate/High*

  Species may have flammable green foliage and/or produce high levels of litter and elevated fuel. Not recommended for green breaks or defensible space.

  Moderate/High Flammability Species

Podocarpus totara	totara
Dodonaea viscosa	akeake
Cyathea and *Dicksonia* spp.	tree ferns
Leucopogon fasciculatus	mingimingi

- *High*

  Burn readily at Low/Moderate forest fire danger conditions.

  High Flammability Species

Kunzea robusta	kānuka
Leptospermum scoparium	mānuka

SITE PHOTOGRAPHS

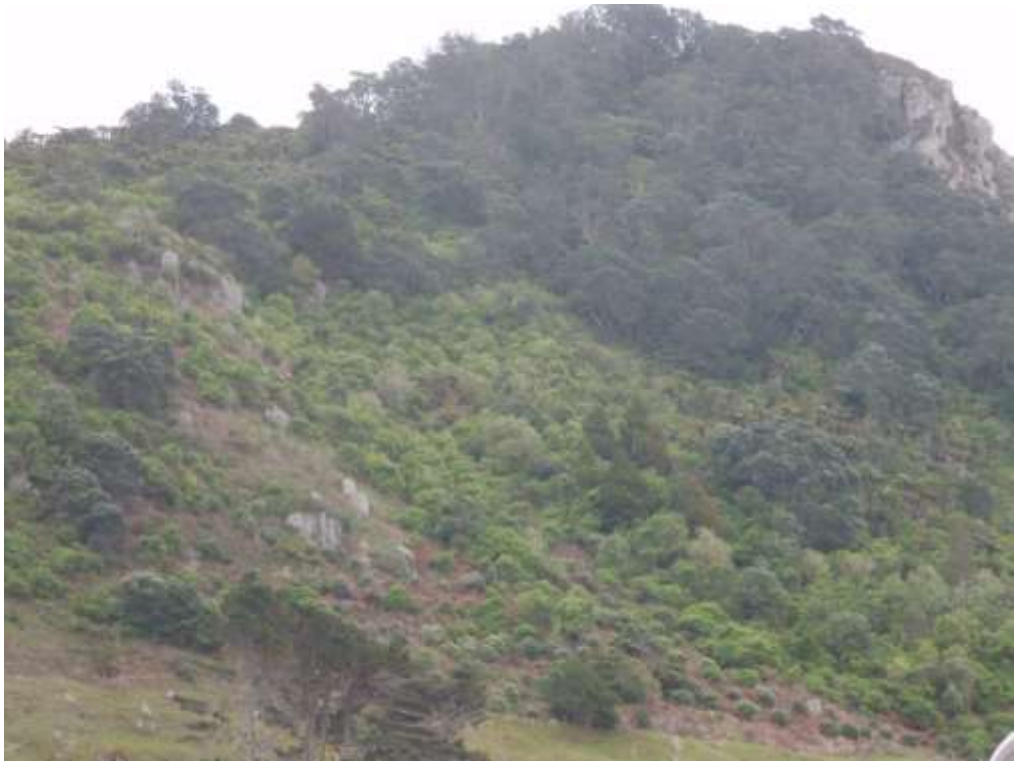

Plate 1: Pōhutukawa forest (Vegetation Type 1a) on the upper southern slopes and māhoe forest and scrub with occasional emergent pōhutukawa (Vegetation Type 5) on the midslopes. Patches of short stature exotic dominated vegetation are present within the māhoe forest and scrub. Pōhutukawa have been planted within a small area of sprayed bracken and blackberry fernland in the foreground (centre and right).

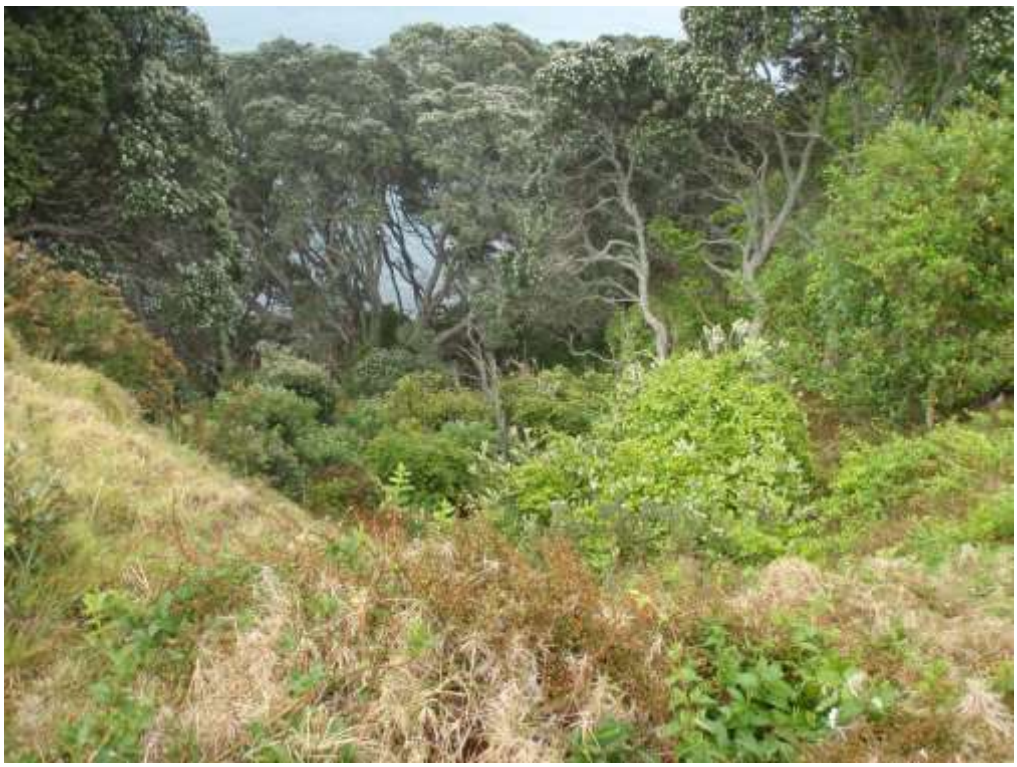

Plate 2: Canopy gaps within pōhutukawa forest on the western side contain mixed indigenous and exotic species scrub (Vegetation Type 1b). This area contains woolly nightshade, māhoe, and, karamū with local Japanese honeysuckle.

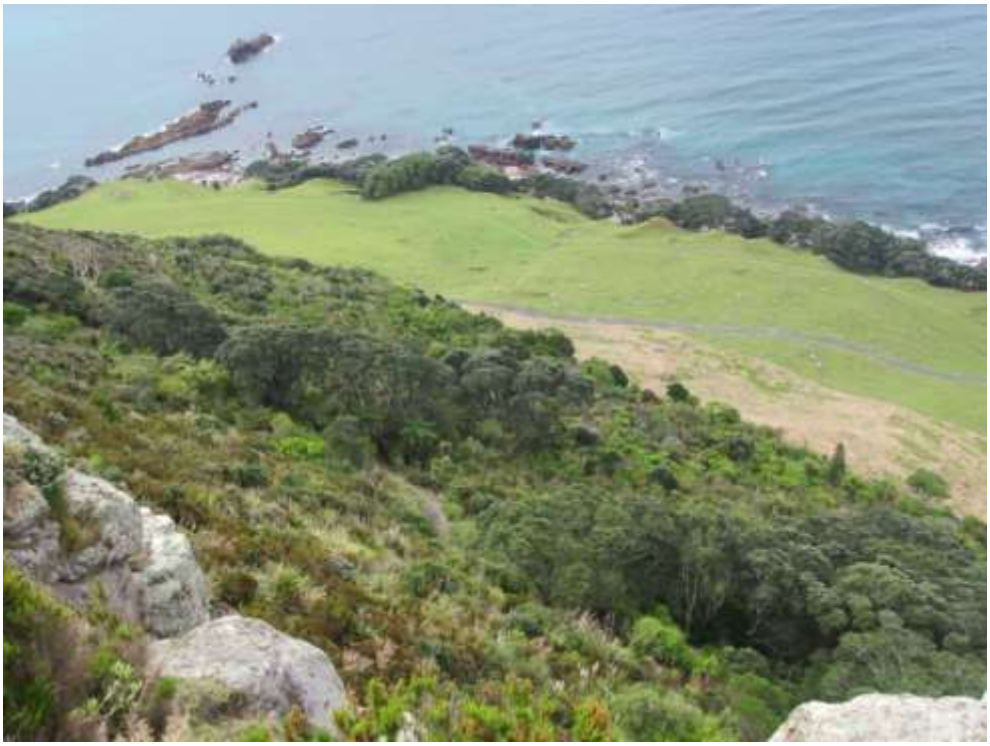

Plate 3: Scrub dominated by Spanish heath, pampas, and gorse in association with whaririki, pōhutukawa, and mānuka is present on the upper northeastern slopes above the main walking track to the summit (Vegetation Type 4). Below the track, forest dominated by pōhutukawa, māhoe, and hangehange is present on the midslopes (Vegetation Type 2), and grazed pasture is present on the lower slopes (Vegetation Type 16). The coastal margin is fringed with pōhutukawa treeland (Vegetation Type 8).

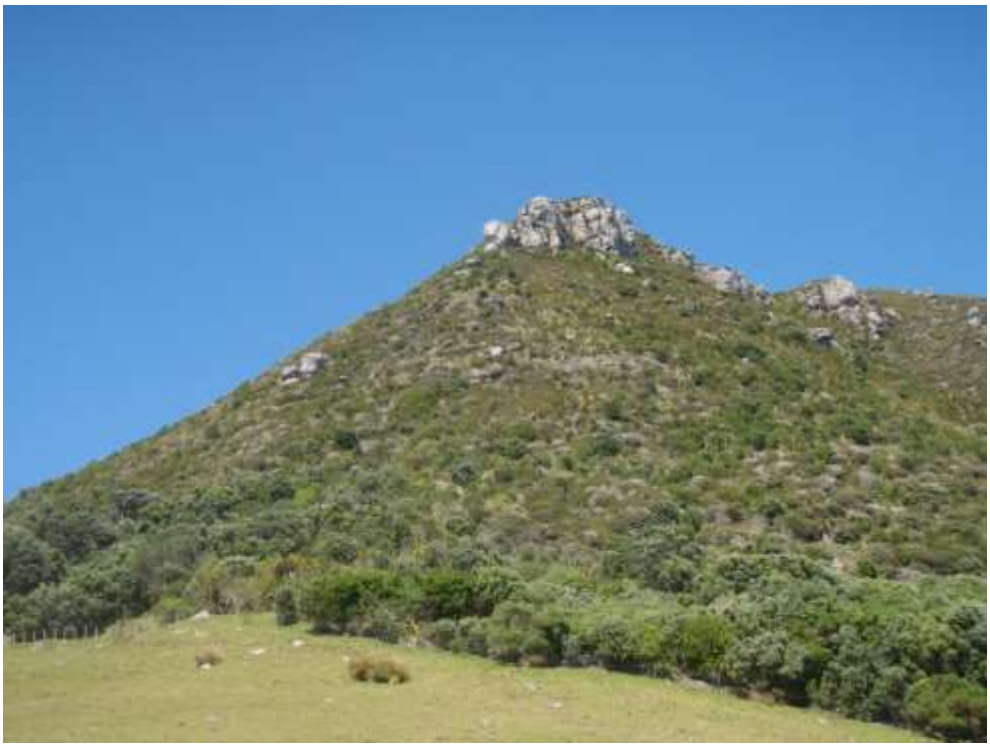

Plate 4: Short stature shrubland dominated by mānuka, Spanish heath, and whaririki is present on the upper and midslopes of the northern face (Vegetation Type 3). Lower slopes support planted indigenous scrub dominated by pōhutukawa, ngaio, glossy karamu, mānuka, *Hebe parviflora*, and whaririki (Vegetation Type 6).

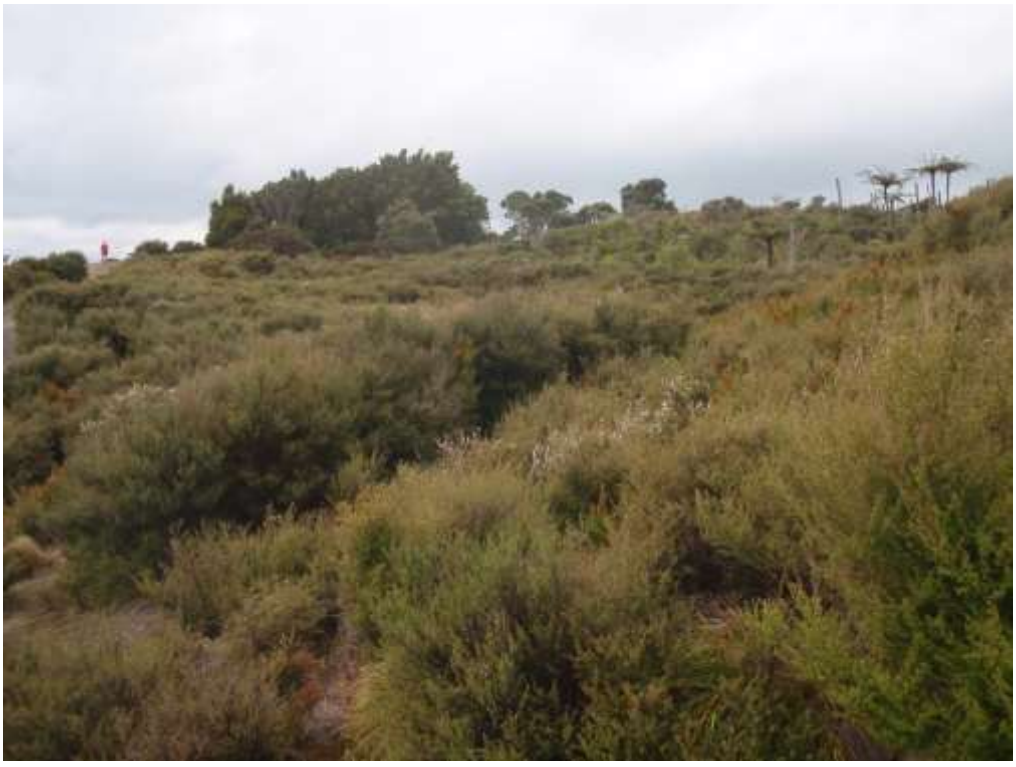

Plate 5: Planted mānuka is present around patches of existing indigenous scrub and shrubland on the northern side of the summit (Vegetation Type 9). Spanish heath is visible in the gaps within the mānuka canopy.

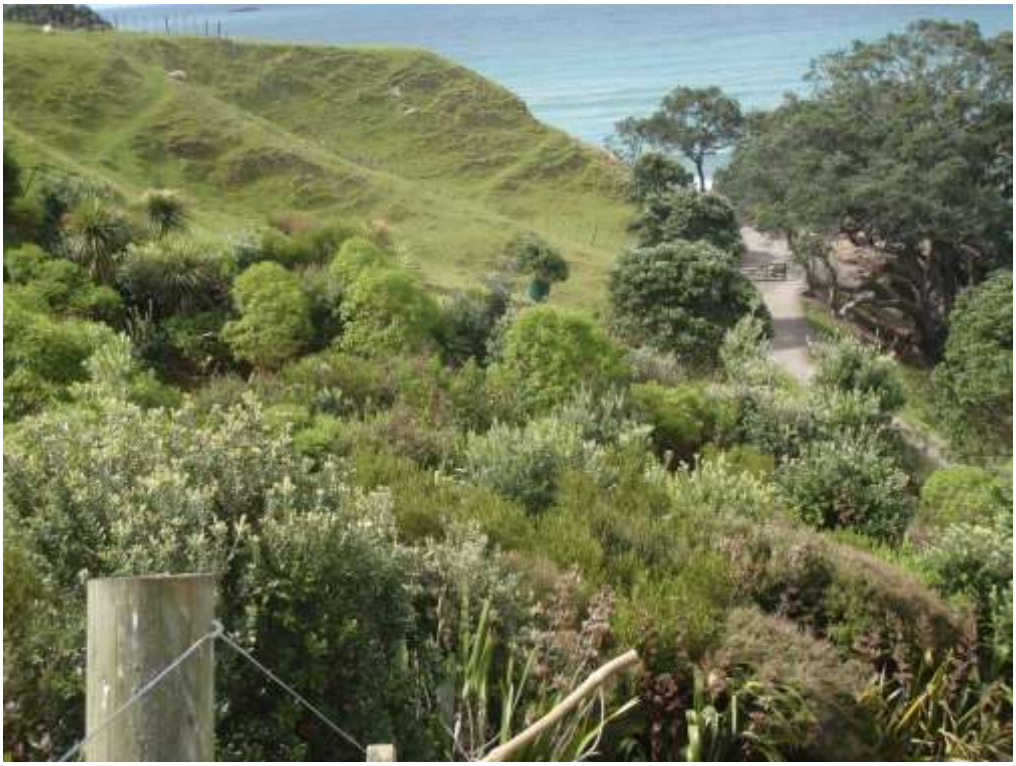

Plate 6: Mixed indigenous species planted within a gully on the eastern lower slopes (Vegetation Type 7b). Dominant species within this area include ngaio, glossy karamu, and pōhutukawa. Pōhutukawa treeland (Vegetation Type 8) is visible on the eastern side of the base track in the background (right).

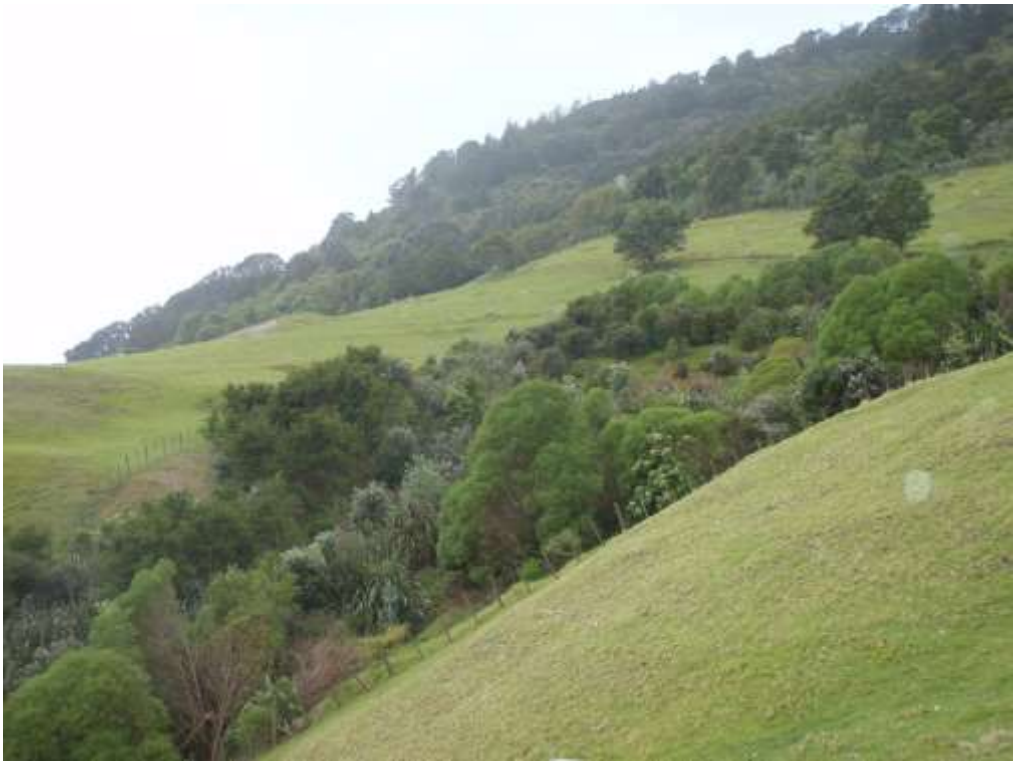

Plate 7: A mixture of indigenous species have been planted within a long, narrow gully on the western lower slopes (Vegetation Type 7c). Dominant species within this area include ngaio, pōhutukawa, harakeke, mānuka, whau, and *Hebe parviflora*. Patches of rank grassland are present between planted trees in large parts of this area.

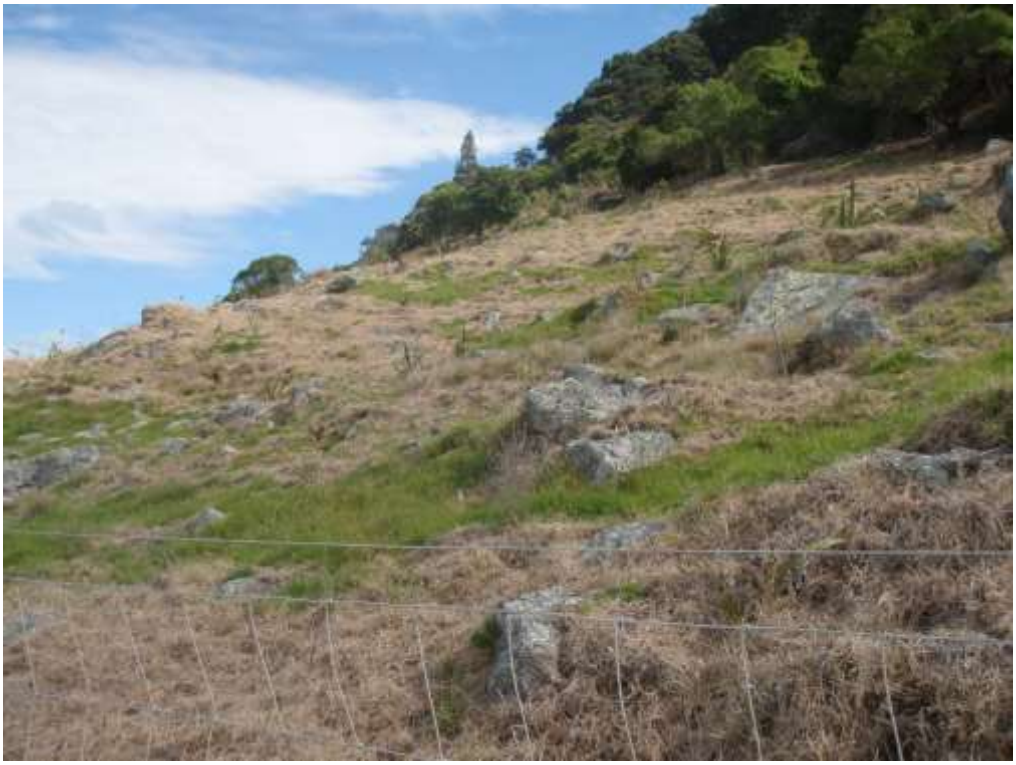

Plate 8: A mixture of indigenous species have been planted recently within rank grassland on the eastern midslopes near the main summit track (Vegetation Type 7g). Planted indigenous species within this area have had mixed success; whaririki has established well, but many dead stems are present.

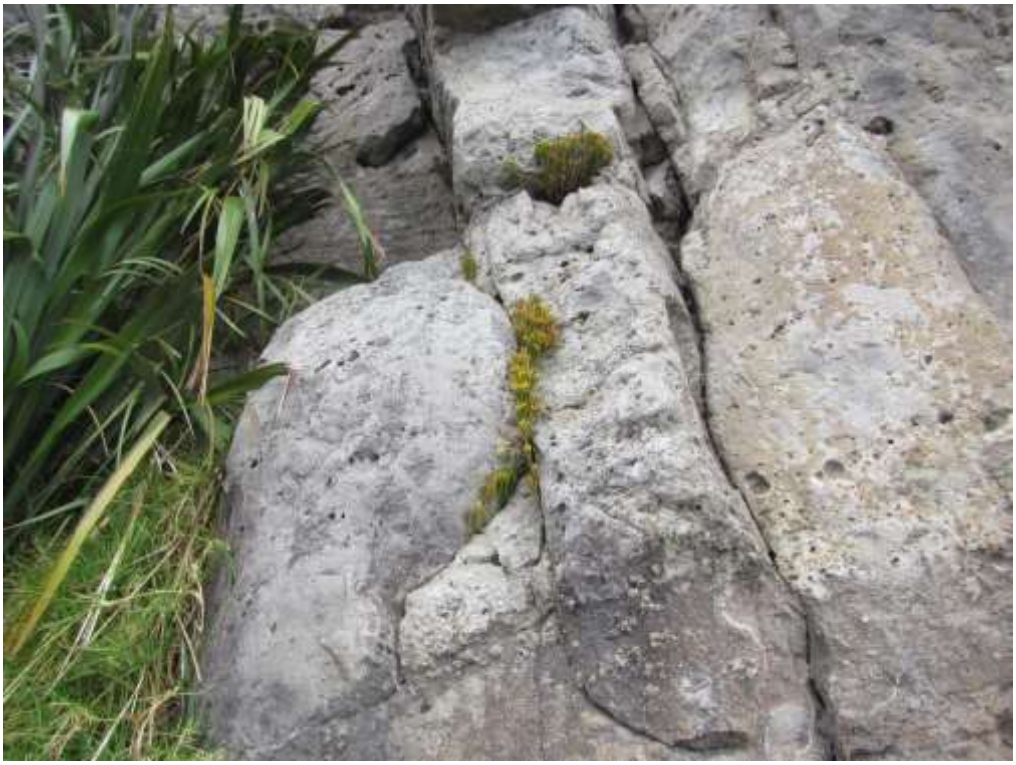

Plate 9: *Psilotum nudum* is present in cracks and crevices within the bluffs on the northern midslopes (Vegetation Type 11).

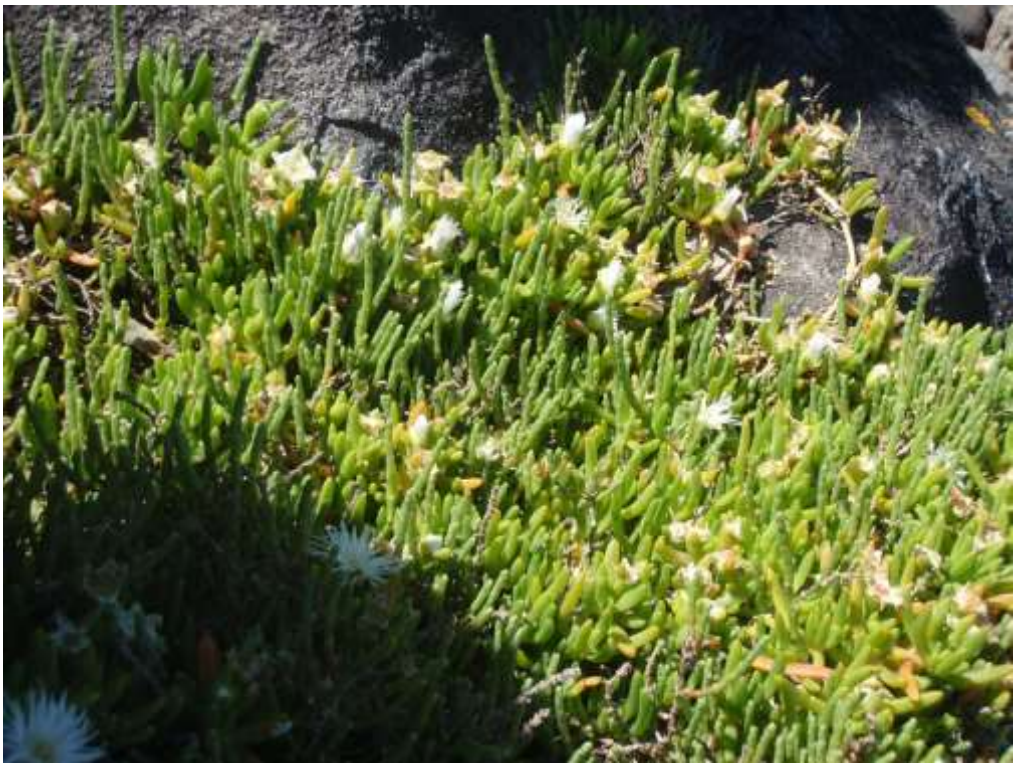

Plate 10: A small population of *Disphyma australe* occurs in association with glasswort on the southern side of a small rocky peninsula jutting into the ocean on the northwestern side (Vegetation Type 13).

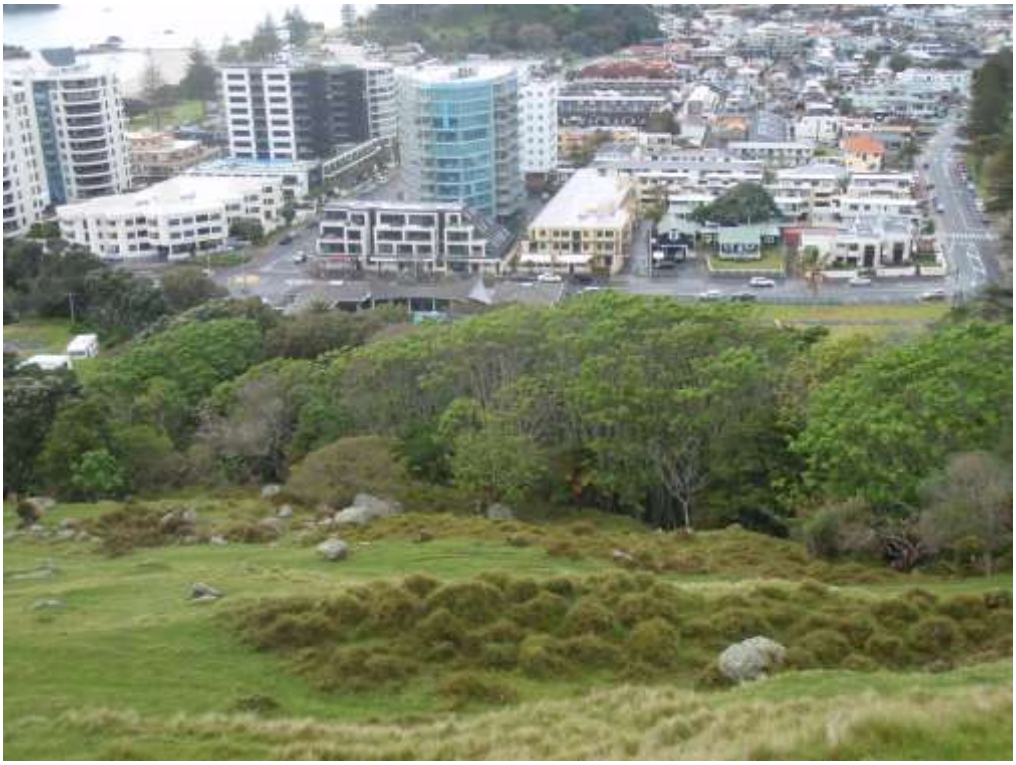

Plate 11: Patches of pōhuehue are locally common within grazed pasture on the southern side (Vegetation Type 16). Mixed indigenous and exotic treeland (Vegetation Type 10a) is present at the boundary of the Reserve with the Holiday Park. Sycamore trees dominate this part of Vegetation Type 10a.

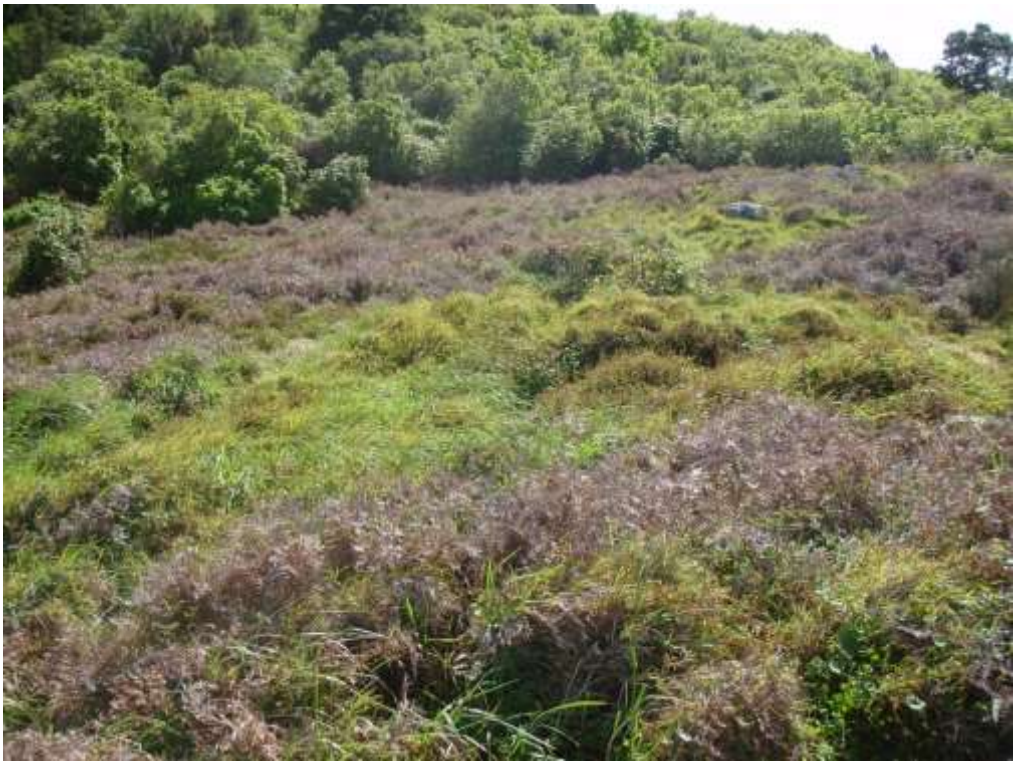

Plate 12: Bracken, pōhuehue, and cocksfoot dominate a small area that is regenerating near the southwestern boundary of natural vegetation on midslopes (Vegetation Type 14). A clear demarcation is present between the short stature vegetation and the surrounding māhoe scrub (Vegetation Type 5).

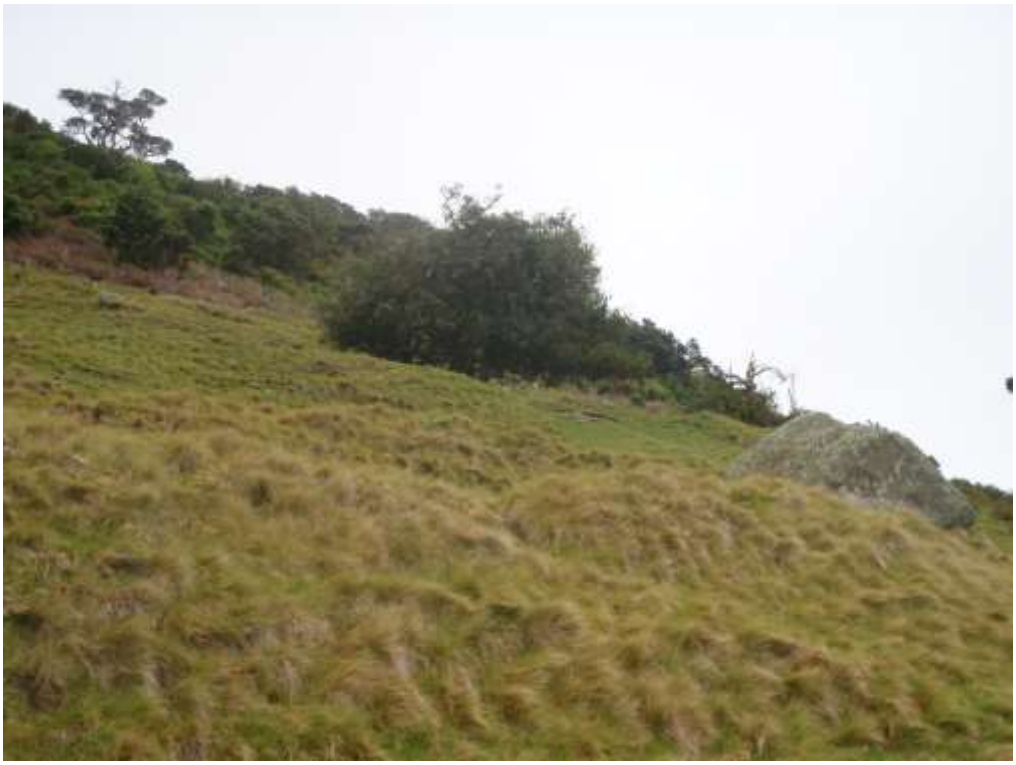

Plate 13: Grazed pasture on the mid- and lower slopes (Vegetation Type 16) comprises a mixture of indigenous and exotic grass species. In the foreground the pasture is dominated by meadow rice grass and *Rytidosperma* species, and in the midground it is dominated by kikuyu.

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