

NATURAL HERITAGE PLAN FOR PUKEPUKE LAGOON, MANAWATŪ



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View across one of the open water areas of Pukepuke Lagoon. Raupō dominates the fringes of water bodies, with tī kōuka treeland occurring over raupō on the drier margins.

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1. INTRODUCTION

The Department of Conservation manages Pukepuke Lagoon Conservation Area (approximately 80 hectares), located on the west coast of the North Island between Himatangi Beach and Rangitikei River. Pukepuke is a Stewardship Area under the Conservation Act and is managed for Department of Conservation's intermediate outcome that 'the diversity of our natural heritage is maintained and restored'. Department of Conservation's intermediate outcome objective for Pukepuke is '1.1 a full range of NZ's ecosystems is conserved to a healthy functioning state'.

Pukepuke has very significant historic heritage values and is a significant site for local Iwi. From an Iwi perspective, an immense amount of work is required to fully restore this ecosystem to a healthy functioning site. The site is also used for game bird hunting between May and August. Several of the bird species present are seldom found elsewhere in the Manawātū region, including New Zealand dabchick (*Poliiocephalus rufopectus*) and Australasian bittern (*Botaurus poiciloptilus*). Threatened or At Risk plant species have previously been recorded at the site and may still be present, including *Zannichellia palustris* and dwarf musk (*Mazus novaezeelandiae* subsp. *novaezeelandiae*). Fish species include a large population of shortfin eel (*Anguilla australis*), and longfin eel (*A. dieffenbachii*) and inanga (*Galaxias maculatus*) are also present.

There is no recently compiled, cohesive document for integrated management at Pukepuke; the last management plan was drafted in 1987 (Avis 1987). There is now a desire to work in partnership to restore Pukepuke Lagoon Conservation Area and the Department of Conservation requires a cohesive document for integrated management at Pukepuke.

The vision is for Pukepuke to be in a healthy functioning state by 2030. This report meets the third reporting milestone required in the development of a Natural Heritage Plan. The report includes a description of the site, including background information and physical characteristics; ecological values and threats; an assessment of what a healthy functioning state of the Pukepuke site may look like; goals, objectives, and actions; and milestones and direction for day to day work.

2. METHODS

2.1 Desktop assessment

A desktop assessment and inventory of the ecology of Pukepuke Lagoon and its significance was undertaken. Flora and fauna species previously recorded within the site or likely to occur at the site were summarised. Natural history, cultural history and management history of the site were researched, including changes in hydrological and geomorphological processes over time. Current management issues and cultural values were compiled.

2.2 Field survey

A field survey at the site was undertaken on 15 March 2017, with a subsequent visit on 21 May 2017. The site was walked through and notes on the ecology taken. Lists of flora and fauna species seen during the site survey were compiled. Field maps of the latest aerial photographs were used to map vegetation and habitats within the project area. The ecological health of the site and potential opportunities for restoration and management priorities were assessed.

Vegetation types were mapped and described using the Atkinson system (Atkinson 1985). Pest plants encountered were identified and their distributions and densities were mapped in the field onto hard copy prints of aerial photographs. The maps were then used for data input into ArcGIS 10.4 (GIS programme). The locations and distributions of each environmental pest plant species were digitised. Environmental pest plant species were labelled with their common name and a brief description of the extent of the infestation, as percentage cover, and overlaid on the aerial photograph.

All bird species either seen or heard during the field survey were identified and recorded. Casual invertebrate observations were also recorded. Any other sign of fauna presence including pest animals and livestock was recorded during the field survey.

Potential sites for indigenous vegetation restoration were identified. This included areas where planting would be advisable, or where natural regeneration could be encouraged.

3. SITE DESCRIPTION AND BACKGROUND

3.1 Location

Pukepuke Lagoon is located on the west coast of the North Island between the Rangitikei and Manawatū Rivers, about four kilometres northeast of Himatangi Beach. The site lies within the Foxton Ecological District and is less than three kilometres from the coast. A location map is provided in Figure 1.

3.2 Foxton Ecological District

Foxton Ecological District lies on the southwest coast of North Island, and extends from near Patea in the north, to Paikakariki in the south. The Foxton Ecological District contains the most extensive sand dune system in New Zealand, and includes several estuaries, and many wetlands and dune lakes. Near the town of Foxton, coastal sands extend nearly 18 kilometres inland. Inland of the Foxton Ecological District lie the alluvial plains of the Manawatū Plains Ecological District, and combined, the Foxton and Manawatū Plains Ecological Districts form the Manawatū Plains Ecological Region (Ravine 1992).



Historically, spinifex (*Spinifex sericeus*) was common on seaward-facing foredunes with pīngao (*Ficinia spiralis*) almost as common. On the rear face of foredunes and on relict foredunes, tauhinu (*Ozothamnus leptophyllus*), tarakupenga (sand coprosma; *Coprosma acerosa*), and possibly matagouri (*Discaria toumatou*) were common with some sand daphne (*Pimelea villosa*) and wīwī (*Ficinia nodosa*) (Ravine 1992). Tarakupenga and sand daphne are now classified as At Risk-Declining, and pīngao as At Risk-Relict (de Lange *et al.* 2013), while matagouri is virtually missing from this coastline (Graeme La Cock pers. comm. 2017), and has a regional threat status of ‘Serious Decline’ (Sawyer 2004).

Younger dune hollows and sand plains would have been covered in low sedges and herbs, but areas of stabilised sands had oioi (*Apodasmia similis*), toetoe (*Austroderia toetoe*), tī kōuka/cabbage tree (*Cordyline australis*) and harakeke (*Phormium tenax*). Forests present on deeper soils within one kilometre of the sea would have contained akeake (*Dodonaea viscosa*), rewarewa (*Knightia excelsa*), ngaio (*Myoporum laetum*), māhoe (*Melicytus ramiflorus*), and tītoki (*Alectryon excelsus*), with some tōtara (*Podocarpus totara*) and matai (*Prumnopitys taxifolia*), and shrubs including poataniwha (*Melicope simplex*) and broom (*Charmichaelia* sp.) Further inland, podocarp-broadleaved forest would have had greater structural complexity with a greater diversity of species (Ravine 1992).

Dune systems throughout New Zealand have been heavily modified since European settlement, primarily as a result of the widespread and rapid stabilisation of active dunes with marram grass (*Ammophila arenaria*), and the establishment of radiata pine (*Pinus radiata*) plantations (Hilton 2006). The establishment of exotic plantation forestry has had a marked effect on the ecology and character of the dune field. In 1958, active dunes comprised 16,627 hectares of the Manawatū coastline, but by the 1990s this had been reduced by 80 percent to less than 2,400 hectares (Hilton 2006). The remaining fragments of indigenous dune vegetation in the Foxton Ecological District, despite their reduced area, are of national significance, and support threatened or regionally threatened species (Hilton 2006). Remaining indigenous forest areas now comprise a few small remnants of coastal swamp forest containing nīkau (*Rhopalostylis sapida*), pukatea (*Laurelia novae-zelandiae*) and kahikatea (*Dacrycarpus dacrydioides*). These forests are also likely to have had maire tawake (swamp maire; *Syzygium maire*) as a component of the canopy.

3.3 Site characteristics

Pukepuke comprises a dune lake that at its current extent of open water is approximately 500 metres long by 300 metres wide. Approximately 15 hectares of the lake lies within the Pukepuke Lagoon Conservation Area administered by the Department of Conservation, as the southeastern corner of the lake is outside the management area. The lake is less than two metres deep (Department of Conservation 2016).

Freshwater wetland surrounds the lake on all sides that fall within the Conservation Area. Wetland habitat extends for well over one kilometre in distance from the northern lake edge to the northwestern corner of the site. A straightened channel that drains surrounding farmland enters the site on the eastern boundary (Appendix 1: Plate 1) and continues to the lake body. Other farm drains to the south flow into the

lake from outside the site boundary. The outlet of the lake is also channelised and flows northward from the northern shore of the lake before a 90° bend westward directs the channel along the northern edge of the wetland vegetation (Appendix 1: Plate 2). Another elbow bend redirects the channel through wetland vegetation before leaving the site. The channel then continues for another c.2.6 kilometres through radiata pine forest to the coast. Thus, the lake is connected to the coast by less than four kilometres of straightened stream channel and provides a pathway for indigenous fish to the ocean.

Several small pockets of open water have been artificially created in the past in the east and north of the site. These are at varying depths and include areas of permanent open water and areas that are seasonally dry with dense wetland vegetation.

An unsealed access road enters the site in the eastern corner, from an easement over the farmland from the end of Pukepuke Road. The access road continues through the site to the northern boundary where it follows the outlet channel until it exits the site.

Steep to moderate undulating duneland occurs to the south and west of the lake, of which over seven hectares is included within the boundary of the reserve. Radiata pine forest is the dominant land use between the western end of the Conservation Area and the coast. Surrounding the Conservation Area on all other sides, the land use is pastoral agriculture, apart from small stands of radiata pine forest on the farm to the north. Figure 2 illustrates the shape and layout of the Pukepuke. The catchment the site lies in is c.30 km² in extent (Ogden and Caithness 1982).

3.4 A changing landscape

This is not intended to be a comprehensive account of the history of the site and affiliated Iwi, an independent more thorough historical account and timeline could be scoped to complement this Natural Heritage Plan.

The lake was formed when a rise in water table c.1600 AD joined smaller dune-flat lakes that existed between two dune complexes; dune movement then blocked the lake's natural drainage and pushed them inland over time (Ogden and Caithness 1982). The lagoon water body area has reduced from 130 hectares in 1872, 51 hectares by 1929, and 21.1 hectares by 1939, to 15.2 hectares in 2015; caused by sand dune drift, drainage for farmland, and the spread of wetland vegetation.

The Pukepuke site is of immense historical, cultural, spiritual and traditional significance to local Iwi Ngāti Apa, Ngāti Raukawa ki te Tonga and Rangitāne o Manawatū. Ngāti Kauae and Ngāti Tauira of Ngāti Apa iwi had pā close to the wetland at Pukepuke prior to European settlement; Ngāti Apa descendants retain fishing rights within the lagoon, this is administered by Te Rūnanga o ngā Wairiki Ngāti Apa. The Ngāti Apa (North Island) Claims Settlement was legislated in 2010, providing from the Crown a Statutory Acknowledgment and a Deed of Recognition for the Pukepuke Lagoon Conservation Area. For Ngāti Raukawa ki te Tonga (Raukawa), Pukepuke is one of several dune lakes in the rohe of Raukawa, the lakes were once an abundant source of mahinga kai for Raukawa who continue to celebrate these sites. In December 2016, the Rangitāne o Manawatū Claims Settlement was

legislated, providing from the Crown a Statutory Acknowledgment¹ and a Deed of Recognition² for the Pukepuke Lagoon Conservation Area.

The site was formerly administered by the Wildlife Service as a Wildlife Management Reserve and has been the subject of several studies in hydrology, wildlife and wetland-related research (Ogden and Caithness 1982). The Department of Conservation has administered the site since 1987.

4. VEGETATION AND HABITATS

4.1 Overview

The site comprises open water and extensive raupō reedland with harakeke (*Phormium tenax*), tī kōuka (*Cordyline australis*), toetoe (*Austroderia toetoe*), and several indigenous sedges in association. Duneland vegetation dominated by the exotic marram grass but being invaded by blackberry (*Rubus fruticosus*), lupin (*Lupinus arboreus*) and broom (*Cytisus scoparius*), occurs in the southwestern corner of the site. Grassland comprising several exotic species is present in several locations. The site is notably lacking in indigenous woody plant species with only localised mingimingi (*Coprosma propinqua*). Exotic trees are present including stands of crack willow (*Salix fragilis*) and at least three species of oak that have reportedly been planted by the acclimatisation society (Paul Horton, pers. comm. 2017). Fifteen vegetation and habitat types were identified and mapped (Figure 2), and these are described below.

4.2 Vegetation and habitat types

1. Raupō reedland (35.62 ha)

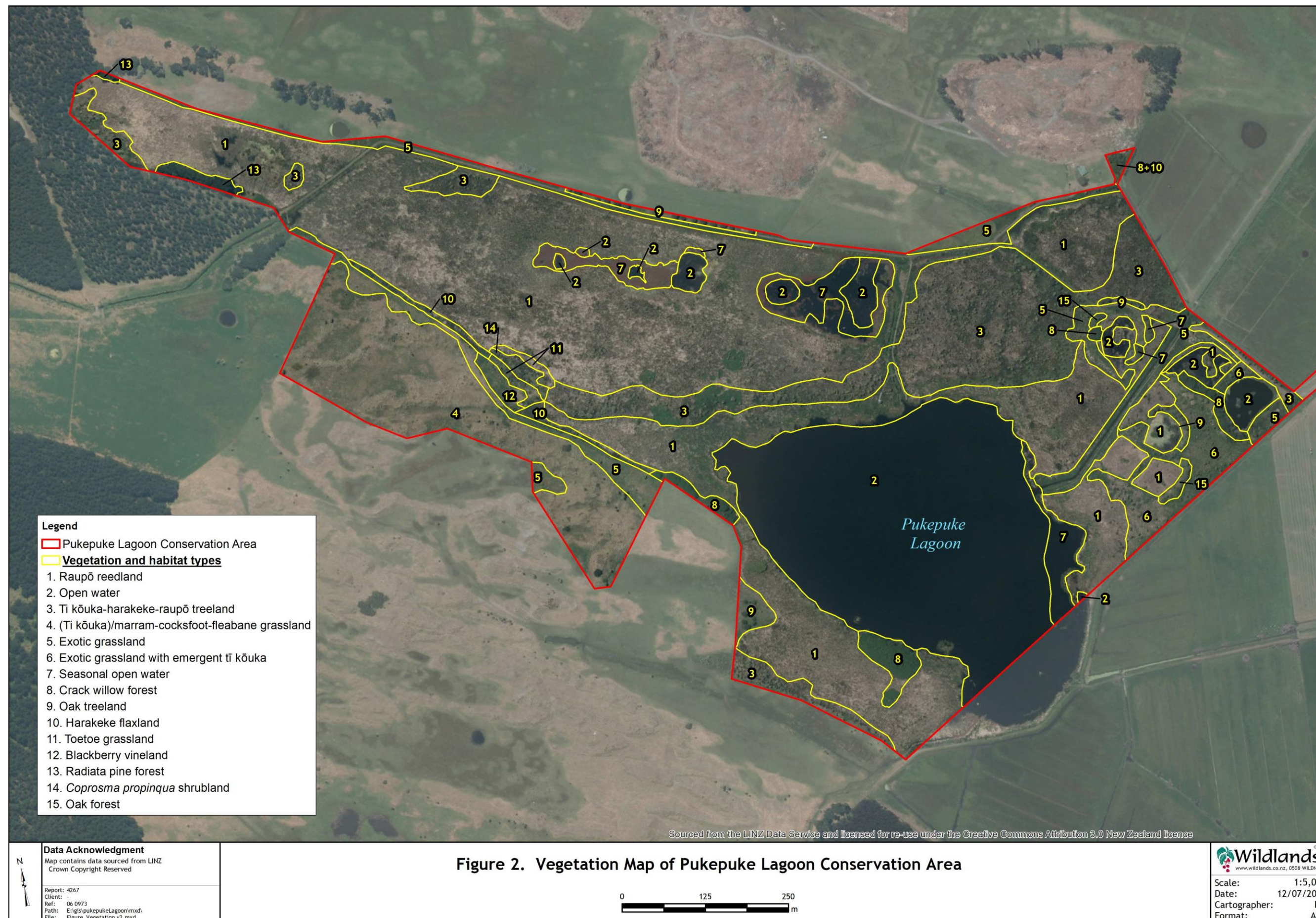
Raupō reedland is the most common habitat type across the site. Raupō is abundant, with frequent harakeke, tī kōuka, toetoe, and pūrei (*Carex secta*). Raupō is most dense where it is the emergent species within areas that are permanently wet and frequently flooded, and other species are excluded (Appendix 1: Plate 3). Pampas (*Cortaderia selloana*) is occasional.

2. Open water (15.89 ha)

Floating vegetation on the margins of open water includes duckweed (*Lemna disperma*) and *Azolla rubra* (Appendix 1: Plate 3).

¹ Because of the Crown's recognition of the association of the claimant group with the site or feature, the Statutory Acknowledgement also strengthens the notification provisions of the Resource Management Act 1991. It does this by obliging decision-makers acting under those provisions to proceed in certain ways (Office of Treaty Settlements: Ka tika ā muri, Ka tika ā mua - Healing the past, building a future)

² If a Statutory Acknowledgement has been made, the Minister of the Crown responsible for managing the area may also enter into a Deed of Recognition over the land area under management. A Deed of Recognition will provide that the claimant group must be consulted on specified matters, and that the relevant Minister must have regard to their views (Office of Treaty Settlements: Ka tika ā muri, Ka tika ā mua - Healing the past, building a future).



3. Tī kōuka-harakeke-raupō treeland (9.58 ha)

Extensive areas of tī kōuka have established on poorly drained soils throughout the site. Raupō and harakeke are the most common understorey species of this vegetation unit (Appendix 1: Plate 4).

4. (Tī kōuka)/marram-cocksfoot-fleabane grassland (7.22 ha)

The southwestern corner of the site is characterised by dunelands where the plant community is dominated by exotic grasses and broadleaved herbaceous species. Marram grass and cocksfoot are the most common species (Appendix 1: Plate 5) with occasional emergent tī kōuka. There are occasional thick swards of pōhuehue (*Muehlenbeckia complexa*) (Appendix 1: Plate 6) and bracken (*Pteridium esculentum*). Sand coprosma (tarakupenga or tātaraheke) is also present.

There are a few plants of native spinach/kōkihi (*Tetragonia implexicoma*), often under tī kōuka or pine trees. The dune community is prone to invasion of exotic plant species and infestations of blackberry, lupin, broom, and pampas are recorded as occasional to locally common. The pest plant boxthorn (*Lycium ferocissimum*) was recorded and radiata pine and red oak (*Quercus rubra*) (Appendix 1: Plate 7) have also naturalised.

5. Exotic grassland (4.28 ha)

Low thick swards of exotic grasses such as Yorkshire fog (*Holcus lanatus*), creeping bent (*Agrostis stolonifera*) and tall fescue (*Schedonorus arundinaceus*), with several herbaceous broadleaved species, occur in some parts of the site. Occasional indigenous sedges are locally present.

6. Exotic grassland with emergent tī kōuka (2.03 ha)

Exotic grasses are the dominant ground cover within this vegetation unit. Mature tī kōuka trees are common. Raupō is also locally common but its abundance is limited by the drier substrate.

7. Seasonal open water (2 ha)

A review of historic aerial imagery revealed significant seasonal fluctuations in the extent of open water at the site. In dry periods the water level drops to reveal lake and/or pond edge that is lacking emergent macrophyte species. A closer inspection of water edges during a prolonged dry period may reveal lake-turf vegetation which is a historically rare ecosystem type (Williams *et al.* 2007). When the habitat unit is covered in water, the aquatic plants *Lemna disperma* and *Azolla rubra* are often present. The margins of channels within the site that flow into and out of the lake may also fall into the category of seasonal open water, although they have not been mapped as such because of their narrow width. Within the channels many species of herbaceous plants are present.

8. Crack willow forest (1.04 ha)

Four areas of mature crack willow forest exist at the site. The canopy cover in these areas exclusively comprises crack willow (Appendix 1: Plate 3). The understorey varies and includes indigenous ferns (including *Diplazium australe*), pūrei, black nightshade (*Solanum nigrum*), and pōhuehue.

9. Oak treeland (0.73 ha)

Alongside sections of the access road through the site, oak trees have established at a wider spacing; canopy cover is discontinuous. Exotic grasses, and broadleaved species with occasional indigenous sedges, cover the ground within the canopy gaps.

10. Harakeke flaxland (0.45 ha)

Harakeke is common throughout the wetland in association with other wetland species. Flaxland where harakeke is the dominant vegetation cover in a narrow strip along the southwestern edge of the wetland (Appendix 1: Plate 8). Harakeke within this unit is mature; gaps in the strip are dominated by blackberry, bindweed (*Calystegia* sp.), pampas and exotic grasses (Appendix 1: Plate 9).

11. Toetoe grassland (0.29 ha)

Toetoe (*Austroderia toetoe*) exists in swards adjacent to mingimingi shrubland. Blackberry, bindweed, exotic grasses and indigenous sedges also exist within the vegetation unit (Appendix 1: Plate 4).

12. Blackberry vineland (0.25 ha)

An infestation of blackberry is located adjacent to toetoe grassland (Appendix 1: Plate 4).

13. Radiata pine forest (0.24 ha)

Near the northeastern boundary of the site, radiata pine forest is present within the Department of Conservation land parcel which is contiguous with the neighbouring radiata pine forest.

14. *Coprosma propinqua* shrubland (0.19 ha)

Coprosma propinqua is the dominant species within an area near the southwestern edge of the wetland vegetation (Appendix 1: Plate 4). Canopy gaps are dominated by exotic grasses, tī kōuka, blackberry, toetoe, raupō and indigenous sedges.

15. Oak forest (0.16 ha)

Several species of oak have been planted in groups and rows and form small areas of oak forest. Holm oak (*Quercus ilex*) is the most common species. The understorey beneath the dense canopy is very sparse.

5. FLORA

Twenty-two indigenous and 69 naturalised vascular plant species were recorded during the survey, of which 14 are considered pest plant species (Appendix 1). In addition, the aquatic pest plant hornwort (*Ceratophyllum demersum*) has been confirmed at the site (NIWA 2016).

Tarakupenga (sand coprosma), which has a conservation status of At Risk-Declining as per de Lange *et al.* (2013), was recorded at the site during the 2017 survey. This was the only Threatened or At Risk plant species seen during the site survey. However, the site visit did not include a thorough botanical survey, and historical records, many of which are of unknown date, indicate that the site is or has been habitat for a range of Threatened or At Risk plant species. *Mazus novaezeelandiae* subsp. *novaezeelandiae* (At Risk-Declining) and *Zannichellia palustris* (At Risk-Naturally Uncommon) are noted as present by the Department of Conservation (2016), although no date is given for these records. Neither of these species was seen in 2017, but further botanical surveys could confirm their presence at the site. Swamp nettle (*Urtica perconfusa*) (At Risk-Declining) was recorded in 1972 (NZPCN 2017). *Zannichellia palustris* and *Mazus novaezeelandiae* subsp. *Novaezeelandiae* are also classified as regionally threatened in Manawatū (Department of Conservation 2016).

Further surveys are needed to identify the Threatened or At Risk species that persist at the site, and what the key areas of habitat are for these species. Threats to their survival can then be identified, and appropriate management actions can be implemented.

6. FAUNA

6.1 Avifauna

Fifteen indigenous and 11 naturalised bird species were seen or heard during the field survey. A list of bird species recorded during the field survey is provided in Appendix 3.

Of these, six are classified as At Risk. These species and their threat classification according to Robertson *et al.* (2017) are shown in Table 1.

Table 1: List of threatened bird species recorded from Pukepuke Lagoon in 2017.

Species	Common Name	Threat Classification
<i>Anthus novaeseelandiae novaeseelandiae</i>	Pīhoihoi; New Zealand pipit	At Risk-Declining
<i>Himantopus himantopus leucocephalus</i>	Poaka; pied stilt	At Risk-Declining
<i>Phalacrocorax carbo novaehollandiae</i>	Kawau; black shag	At Risk-Naturally Uncommon
<i>Phalacrocorax varius varius</i>	Kāruhiruhi; pied shag	At Risk-Recovering
<i>Poliocephalus rufopectus</i>	Weweia; New Zealand dabchick	At Risk-Recovering
<i>Porzana tabuensis tabuensis</i>	Pūweto; spotless crane	At Risk-Declining

In addition, twelve other nationally Threatened and At Risk species as per Robertson *et al.* (2017) have previously been noted as present at the site (Avis 1987), although dates of the records were not provided.

- Matuku/Australasian bittern) (Threatened-Nationally Critical).
- Koitareke/marsh crane (*Porzana pusilla affinis*) (At Risk-Declining)¹.
- Moho-pererū/banded rail (*Gallirallus philippensis assimilis*) (At Risk-Declining).
- Mātātā/North Island fernbird (*Bowdleria punctata vealeae*) (At Risk-Declining).
- Kōtuku-ngutupapa/royal spoonbill (*Platalea regia*) (At Risk-Naturally Uncommon).
- Pārera/grey duck (*Anas superciliosa*) (Threatened-Nationally Critical).
- Little black shag (*Phalacrocorax sulcirostris*) (At Risk-Naturally Uncommon).
- Tūturiwhatu/banded dotterel (*Charadrius bicinctus bicinctus*) (Threatened-Nationally Vulnerable).
- Taranui/Caspian tern (*Hydroprogne caspia*) (Threatened-Nationally Vulnerable).
- Tarāpunga/red-billed gull (*Larus novaehollandiae scopulinus*) (Threatened-Nationally Vulnerable).
- Kōtuku/white heron (*Ardea modesta*) (Threatened-Nationally Critical).
- Tōrea/South Island pied oystercatcher (*Haematopus finschi*) (At Risk-Declining).

Of these, Avis (1987) notes that poaka, matuku, mātātā, koitareke, pārera, moho-pererū, and pūweto have been recorded as breeding at Pukepuke in the past. It is unknown which Threatened or At Risk bird species currently breed at the site.

6.2 Freshwater fish

The Manawatū-Wairarapa area contains freshwater ecosystems of national importance (Chadderton *et al.* 2004). It has one of the North Island's more diverse non-diadromous fish fauna, containing dwarf galaxias (*Galaxias divergens*), upland bully (*Gobiomorphus breviceps*), Crans bully (*G. basalis*) and brown mudfish (*Neochanna apoda*). A fish survey was not conducted as part of this study.

The Department of Conservation approved Rangitāne O Manawatū to handle indigenous fish between August 2011 and August 2014 at Pukepuke for the purpose

¹ Also reported by Kaufmann and Lavers (1987).

of a glass eel research project. Rangitāne O Manawatū has been undertaking research work releasing glass eels (juvenile life stage of tuna which migrate up-stream from the sea) at Pukepuke.

Existing Fish Records

The New Zealand Freshwater Fish Database was searched on 29 March 2017 for records in Pukepuke Lagoon and nearby waterbodies and waterways within the lowland area between the Rangitikei and Manawatū rivers (NIWA 2017). The database records indicate that at least six indigenous and one introduced species are present in the Lagoon, with a further three indigenous species present in nearby waterbodies and waterways (Table 2). Notably four of these recorded species are currently classified as At Risk-Declining by Goodman *et al.* (2014).

Table 2: Fish species recorded in and near Pukepuke Lagoon (NIWA 2017).

Common Name	Scientific Name	Conservation Status ¹
Pukepuke Lagoon		
Longfin eel	<i>Anguilla dieffenbachii</i>	At Risk-Declining
Shortfin eel	<i>Anguilla australis</i>	Not Threatened
Brown mudfish	<i>Neochanna apoda</i>	At Risk-Declining
Inanga	<i>Galaxias maculatus</i>	At Risk-Declining
Common bully	<i>Gobiomorphus cotidianus</i>	Not Threatened
Bully species	<i>Gobiomorphus</i> sp.	n/a
Common smelt	<i>Retropinna retropinna</i>	Not Threatened
Goldfish	<i>Carassius auratus</i>	Introduced and Naturalised
Omanuka Lagoon		
Brown mudfish	<i>Neochanna apoda</i>	At Risk-Declining
Common bully	<i>Gobiomorphus cotidianus</i>	Not Threatened
Lake Kaikokopu		
Eel species	<i>Anguilla</i> sp.	n/a
Kaikokopu Stream		
Longfin eel	<i>Anguilla dieffenbachii</i>	At Risk-Declining
Shortfin eel	<i>Anguilla australis</i>	Not Threatened
Brown mudfish	<i>Neochanna apoda</i>	At Risk-Declining
Inanga	<i>Galaxias maculatus</i>	At Risk-Declining
Galaxias species	<i>Galaxias</i> sp.	n/a
Common bully	<i>Gobiomorphus cotidianus</i>	Not Threatened
Giant bully	<i>Gobiomorphus gobioides</i>	Not Threatened
Redfin bully	<i>Gobiomorphus huttoni</i>	At Risk-Declining
Bully species	<i>Gobiomorphus</i> sp.	n/a
Common smelt	<i>Retropinna retropinna</i>	Not Threatened
Yellow eye mullet	<i>Aldrichetta forsteri</i>	Not Threatened
Mullet species	<i>Mugil</i> sp. or <i>Aldrichetta</i> sp.	n/a
Goldfish	<i>Carassius auratus</i>	Introduced and Naturalised
Lake Koputara		
Eel species	<i>Anguilla</i> sp.	n/a
Inanga	<i>Galaxias maculatus</i>	At Risk-Declining
Common bully	<i>Gobiomorphus cotidianus</i>	Not Threatened
Goldfish	<i>Carassius auratus</i>	Introduced and Naturalised

¹ Source: Goodman *et al.* (2014).

Common Name	Scientific Name	Conservation Status ¹
Unnamed		
Longfin eel	<i>Anguilla dieffenbachii</i>	At Risk-Declining
Shortfin eel	<i>Anguilla australis</i>	Not Threatened
Brown mudfish	<i>Neochanna apoda</i>	At Risk-Declining
Common bully	<i>Gobiomorphus cotidianus</i>	Not Threatened
Goldfish	<i>Carassius auratus</i>	Introduced and Naturalised

6.3 Invertebrates

A diverse range of indigenous invertebrates will be present in this coastal wetland closely reflecting the indigenous plant species present, ponds and the overall natural wetland habitat. Casual observations of invertebrates were recorded during the field survey, and likely habitat for particular invertebrate species noted.

Raupō supports the bulrush moth (*Scieropepla typhicola*) that feeds within its seed heads, while both flax and cabbage tree have their own fauna of moths that feed exclusively on them, both on the foliage and flower heads. Among these will be the flax notcher moth (*Tmetolophota steropastis*, Noctuidae) and flax window moth (*Orthoclydon praefectata*, Geometridae), both widespread and conspicuous in this habitat type throughout the North Island in coastal sites. Similarly, cabbage tree supports its own specialist geometrid *Epiphryne verriculata* on its foliage and *Stathmopoda aposema* (Stathmopodinae) in its flower heads.

Several maui's copper butterfly (*Lycaena edna*), whose caterpillars feed on pōhuehue, were observed (Appendix 1: Plate 10) in and near the duneland habitat at the site during the field survey. Maui's copper butterfly is common in North Island low altitude wetlands. Pōhuehue is the most important indigenous plant for indigenous insects in New Zealand with over 64 moth and butterfly species alone feeding solely on it as larvae. It is important for other insect orders too including beetles, bugs, stick insects, flies and wasps.

All these butterfly and moth species are widespread across the North Island in natural or semi-natural coastal sites where their habitat and host plants occur. Threats to indigenous insects include loss and degradation of the habitat, and predation by rats (*Rattus* spp.), hedgehogs (*Erinaceus europaeus*), song thrushes (*Turdus philomelos*) and introduced vespid wasps (Walker 2003).

A wide range of freshwater aquatic invertebrates will also be present, including caddisflies (Trichoptera), flies (Diptera) and bugs (Hemiptera).

6.4 Herpetofauna

No frog or lizard species were seen or heard at the site during the field survey. There are no known records of frogs or lizards at Pukepuke, but the exotic brown tree frog (*Litoria ewingii*) and southern bell frog (*Litoria raniformis*) have been recorded at several locations within Foxton Ecological District (Department of Conservation Herpetofauna database, accessed March 2017) and are likely to be present at Pukepuke. Records of indigenous skinks within the Foxton Ecological District between the Manawatū and Rangitikei Rivers include northern grass skink

(*Oligosoma polychroma*) (Not Threatened) and glossy brown skink (*Oligosoma zelandicum*) (At Risk-Declining) (Hitchmough *et al.* 2016).

Northern grass skink habitat includes sand dunes, grasslands and wetlands (Jewell 2011), so Pukepuke provides suitable habitat for common skink. In the North Island, glossy brown skink is found from Taranaki to Wellington. Habitat includes densely vegetated and damp habitats including in farmland and within pōhuehue (Jewell 2011), making Pukepuke a suitable site for brown skink. Ornate skink (*Oligosoma ornatum*) (At Risk-Declining) is less likely to be present given the habitat is less suitable at Pukepuke. Indigenous geckos are unlikely to be present at the Pukepuke site because the current habitats at the sites are unsuitable (i.e. there is a general lack of woody vegetation, and ground refuges such as logs or rocks).

6.5 Pekapeka/bats

Tī kōuka trees, which are abundant at the site, are known to provide roost trees for long-tailed bats (*Chalinolobus tuberculatus*) ‘Threatened-Nationally Critical’ (O’Donnell *et al.* 2018) at other sites in New Zealand. However, it is unknown whether long-tailed bats are present in this area or whether surveys for their presence have taken place nearby. Radiata pine forest at the western end of the site, and the pine forest further to the west, is also suitable habitat for long-tailed bats. If they are present, bats could utilise the Pukepuke site for foraging. The forestry company may have already undertaken surveys for bat presence.

7. ECOLOGICAL VALUES

Pukepuke Lagoon is one of several shallow dune lakes within the Foxton ED. The dune lakes have been highly modified by the effects of agricultural activities within their catchments. Pukepuke still comprises a large area of open water, and extensive raupō reedland which is highly valuable refuge for indigenous fauna within a landscape dominated by agriculture. Although there is a distinct lack of indigenous forest habitat at this site, the large wetland habitat and areas covered with indigenous plants, along with threatened plant species previously recorded at the site, hold high ecological values.

The duneland within the site also has significant ecological value. Although dominated by exotic plant species and prone to pest plant invasion, the duneland contains several significant indigenous plant species, including sand coprosma (At Risk-Declining) that would not be present if it was grazed.

The Pukepuke Lagoon Conservation Area is a significant wetland habitat for indigenous birds and freshwater fish. Several threatened fauna species are known to be at the site, and several others have been recorded in the past and still might be present.

Pukepuke Lagoon is the highest ranked lake out of twelve lakes assessed within the Manawatū-Wanganui Region using Submerged Plant Indicators (NIWA 2016). Under this assessment, Pukepuke scored a “Moderate” lake ranking because of the presence of a mixed community of indigenous and invasive submerged vegetation.

The dominance of submerged vegetation by invasive plants has increased since 2001. The presence of hornwort, named New Zealand's worst submerged invasive weed (NIWA 2016), has decreased the ecological values of the Pukepuke water body.

8. THREATS TO ECOLOGICAL VALUES OF PUKEPUKE

8.1 Overview

Environmental pest plants threaten the ecological processes and values within the area where they are present. Pest animals impact vegetation health by browsing foliage and eating the seeds of indigenous plants. Mammalian pests also prey on indigenous birds, lizards and invertebrates, therefore decreasing ecological values. The surrounding land use may also impact on the ecological values through affecting hydrology and decreasing water quality. Maintaining uninterrupted fish passage with the coast is also important for maintaining high ecological values of wetlands. The threats to the ecological values of Pukepuke are outlined below.

8.2 Pest plants

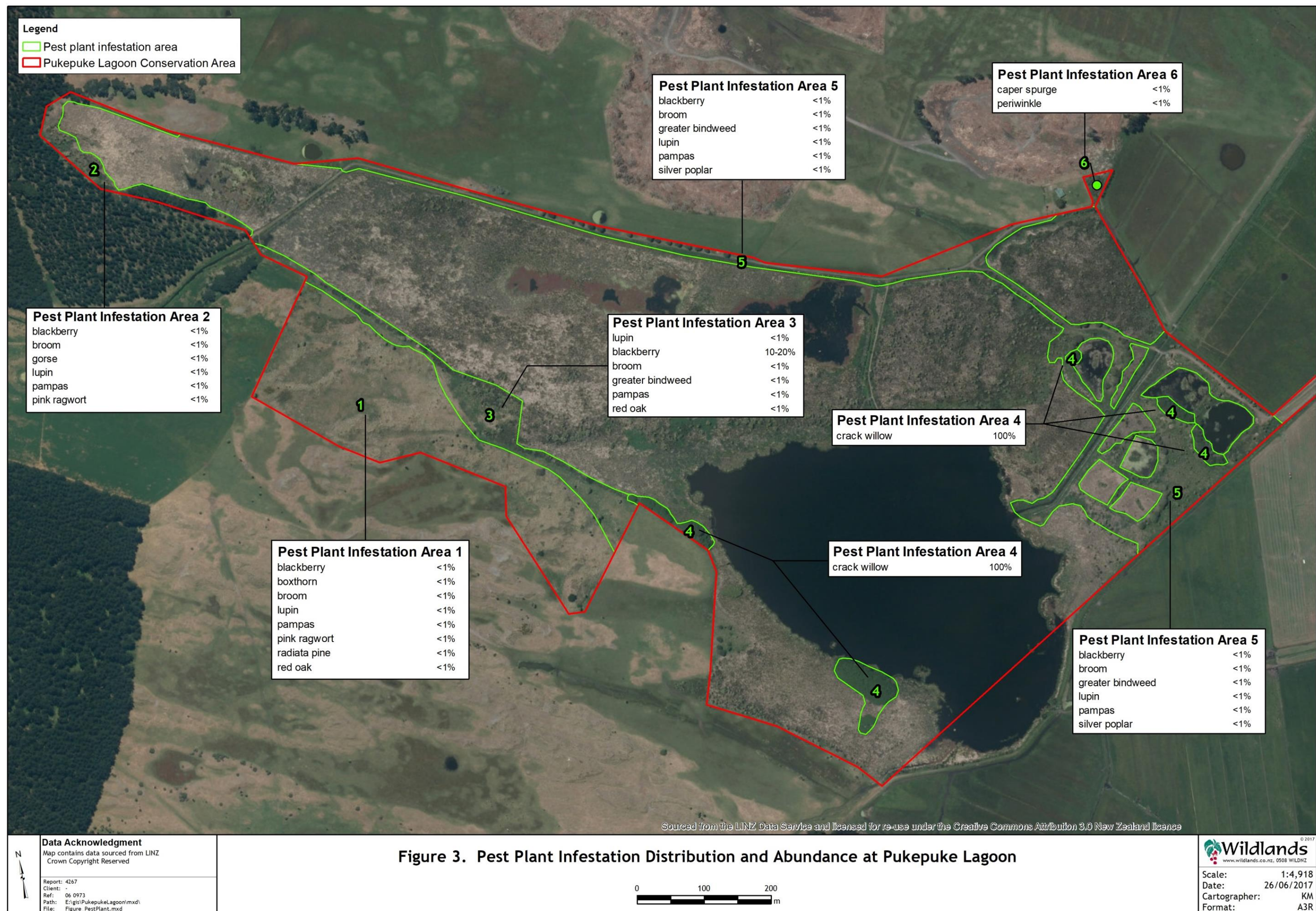
Fourteen pest plants that are recommended for control at the site are listed in Table 3; their distribution and abundance are mapped in Figure 3.

Table 3: Pest plants recommended for control.

Common Name	Botanical Name
Blackberry	<i>Rubus fruticosus</i>
Boxthorn	<i>Lycium ferocissimum</i>
Broom	<i>Cytisus scoparius</i>
Caper spurge	<i>Euphorbia lathyris</i>
Crack willow	<i>Salix fragilis</i>
Gorse	<i>Ulex europaeus</i>
Greater bindweed	<i>Calystegia sylvatica</i>
Lupin	<i>Lupinus arboreus</i>
Pampas	<i>Cortaderia selloana</i> and <i>C. jubata</i>
Periwinkle	<i>Vinca major</i>
Pink ragwort	<i>Senecio glastifolius</i>
Radiata pine	<i>Pinus radiata</i>
Red oak	<i>Quercus rubra</i>
Silver poplar	<i>Populus alba</i>

In addition, the aquatic pest plant hornwort has been confirmed at the site (NIWA 2016).

The Horizons Regional Pest Plant Management Strategy (RPPMS) (Horizons Regional Council 2015) identifies pest plant species that are required to be controlled. Four of the pest plants identified at Pukepuke are listed within the RPPMS. Hornwort is a "Zero Density" plant. The aim of zero density plants is to reduce plant numbers to zero of each infestation in its control area. Blackberry, gorse and broom are classified as "Production" plants and are subject to boundary rules on complaint (Horizons Regional Council 2015).



8.3 Pest animals

Possums (*Trichosurus vulpecula*), ship rats (*Rattus rattus*), Norway rats (*R. norvegicus*), mice (*Mus musculus*), hedgehogs (*Erinaceus europeaeus occidentalis*), cats (*Felis catus*; both feral and domestic), and mustelids (stoats *Mustela erminea*, ferrets *M. furo*, weasels *M. nivalis vulgaris*) are likely to be present at the site. Rats, hedgehogs, and mustelids are likely to be key predators of the wetland bird species present, and either preventing or reducing nesting success of Threatened or At Risk bird species, including matuku, koitareke, māātātā, pūweto, and poaka.

Possums, rats, and mice are likely to adversely impact vegetation health through browsing of foliage and seed predation. All of these mammalian pests are likely to reduce the fauna values of the remnant through the predation of birds, lizards, and invertebrates.

8.4 Fish passage

Many indigenous freshwater fish, such as tuna (eel) and inanga, are diadromous and so they require access to and from the sea to complete their lifecycles. Velocity barriers and/or the free-fall of water from culverts and weirs can impede upstream passage of fish and affect the distribution and abundance in any river or stream system of such migratory species. Care should be taken to ensure that good fish passage is maintained at structures that are built in waterways/waterbodies (e.g. weirs, culverts). Ensuring continued good connectivity from the lagoon to the coast is important for maintaining healthy fish populations within the site.

An inspection of the channel and a culvert downstream of the site revealed slight barriers to easy fish migration in the form of small drop-offs and increased velocity (Appendix 1: Plate 11). No total barriers to fish migration were seen.

Sometimes instream structures are installed to limit the incursion and presence of exotic species, such as goldfish or brown trout (*Salmo trutta*), in order to protect populations of indigenous non-migratory species, such as brown mudfish. Although these types of structures can be adapted to assist indigenous fish passage, particularly for species like eels that can climb well, they tend to still limit passage of other indigenous species, particularly those that do not climb well, such as inanga and bullies. The benefits to indigenous species and habitats, of restricting exotic and invasive fish access, therefore need to be carefully assessed against any possible negative impacts before such projects are undertaken.

8.5 Hydrology and water quality

Water flows, nutrients and contaminants entering the lake and wetland of Pukepuke may adversely affect the ecological values. Water is received into the site via farm drains, one of which on the south eastern lake shore is pumped into the lake. Potentially high nutrient loading from farming practices could lead to eutrophication within the lake which in turn would limit the range of aquatic species that could survive.

9. WHAT IS A HEALTHY FUNCTIONING STATE FOR PUKEPUKE?

A healthy functioning state for Pukepuke is one where the unique ecological values existing at the site will persist, and be protected, in perpetuity. Habitat quality, pest plant incidence, pest animal populations, and water quality have so far been at a level where the indigenous fauna present, including threatened species, have been able to persist. A healthy functioning state is where the threatened species populations can increase because high quality habitat and low predator numbers exist. It would be well buffered by ecological sequences, from wetlands to terrestrial habitats, including swamp forest and forest on the dunes. Pukepuke Lagoon would comprise highly valuable habitat for a wide range of terrestrial and aquatic indigenous flora and fauna. To build resilience so that ecosystem health does not deteriorate, the following is required:

- Pest plant and pest animal populations are controlled to low numbers.
- Water quality is at an appropriate level for indigenous flora and fauna to survive and flourish.
- The wetland habitats at the site are buffered by indigenous terrestrial ecosystems.
- Habitat connectivity is improved within the site, and if possible within the wider landscape, including fish passage between the lagoon and the coast.

10. MANAGEMENT GOALS

Ensuring that the ecosystem health of the site does not deteriorate further should be the first management priority. Enhancing the ecological values of the site to improve resilience is the second management priority.

Four goals have been developed for Pukepuke to achieve and maintain a healthy functioning state.

10.1 Goal 1: Co-management

Pukepuke is co-managed in a manner where key stakeholders are in partnership and participate fully in management decisions and actions, and work together to achieve outcomes beneficial to everyone that has an interest in the site.

There is a desire for Ngāti Tauira of Ngāti Apa and Rangitāne O Manawatū to work with the Department of Conservation, Fish and Game, the Oruoa Catchment Board, and surrounding land owners to manage the Pukepuke Conservation Area. An all-inclusive and co-ordinated approach is required to achieve and maintain a healthy functioning state. Iwi have a desire to maintain access to the site and wish to investigate opportunities to increase use of Pukepuke for recreation and cultural activities. There is also a desire to continue and expand research opportunities (e.g. glass eel migration and release) to contribute to enhancement of ecological values. Therefore, collaboration with multiple agencies and organisations is required.

10.2 Goal 2: Pest control

Natural ecosystems, ecological processes, and species are protected by controlling pest species to sufficiently low densities and preventing the establishment of new pest species.

Multiple pest animal and pest plant species are adversely affecting indigenous populations of flora and fauna, and the condition of their habitats. Controlling pest species to low levels is the key requirement to restore ecological processes, habitat condition, and indigenous species populations to a fully functioning state. Pest plant species for control are listed in Section 8.2 and pest animal species Section 8.3. Ongoing pest animal control is required to maintain pest animals to low levels as complete control is unlikely and incursions from outside will be ongoing. Effective monitoring is required to measure the success of pest animal control operations, ensure targets are being met, and so control methods and frequency of control can be adapted appropriately.

10.3 Goal 3: Habitat connectivity

Habitat connectivity between ecosystem types is enhanced within the site, and between sites in the wider landscape if possible, by enhancing the ecological function of existing habitats, and reintroducing indigenous ecosystems and species that are missing.

To achieve a healthy functioning state and the long-term enhancement of indigenous flora and fauna populations, improving the ability for indigenous species to move throughout the wider landscape is required.

Although most of the site is covered in relatively intact wetland habitat and open water, the adjacent terrestrial habitats have been severely altered, or are completely absent. Restoration is needed to improve ecological connections between wetland and adjacent terrestrial habitats. Restored terrestrial habitats around the wetland will also provide a buffer to wetland habitats, enhancing long-term resilience of the ecological values of the site.

Ensuring unimpeded fish passage within the site and between the site and the coast is critical to maintaining habitat connectivity and the long-term survival of diadromous fish species including tuna.

Identifying other sites in the wider landscape for improving habitat connectivity is difficult because there is a lack of indigenous habitats in the local area, and surrounding land tenure is in private ownership. Never the less, opportunities for improving connectivity in the landscape should be explored.

10.4 Goal 4: Quality of terrestrial and aquatic habitats

Improve the water quality flowing into, within and out of the site and manage hydrology so that open water habitat and current extent of wetland vegetation is maintained. Restore indigenous forest on dryland margins.

The site receives surface water via straightened stream channels on neighbouring farms). To achieve and maintain a healthy functioning state it is important that the quality of water coming into the site is to an adequate standard where indigenous fauna can thrive. Water moves through the site via drains, open water and by filtering through wetland habitats. Water quality should not deteriorate further, and if possible improve as it moves through the site before discharge to the sea. Improving the quality of water between receiving into, and discharging from the site, will enhance the value of the site and indicate that the ecological function of Pukepuke is in a healthy state. High water quality discharging from the site will ensure good habitat quality for aquatic fauna between Pukepuke and the marine environment.

Although the surrounding landscape is highly modified from its original state, the wetlands of Pukepuke are of high ecological value. Reasonable efforts should be made to preserve the current extent of wetland habitat (both open water and wetland vegetation). This may require manipulating the hydrology of the site, for example through the use of weirs. Restoration should also include establishment of indigenous forest ecosystems that are now entirely absent from the site.

Historically, the Pukepuke lagoon wetland was a dynamic system, naturally shifting over time in location and extent as dune processes evolved and water tables fluctuated. Land use practices within the catchment in the last century have slowed or halted the site from shifting within the landscape. As the site is protected within the conservation estate, and surrounding land use comprises private farming and forestry, it is desirable that wetland extent remains within the current cadastral boundaries.

11. PROPOSED OBJECTIVES AND ACTIONS

In this section, objectives are identified to achieve the goals. Objectives are numbered sequentially across goals. Management actions have been identified for each objective and are numbered sequentially across objectives. Several actions cross-reference across multiple objectives because several issues, and the goals, objectives, and actions to solve them are inter-linked.

11.1 Co-management

11.1.1 Objective 1: Establish a framework for management going forward, that achieves as far as possible the aspirations of the stakeholders of the site.

It is envisaged that a co-management approach will enhance the visitor and user experience of the Pukepuke Lagoon site, and protect and enhance the historical, cultural and natural features. This includes research projects (e.g. glass eel migration

and introductions), cultural and leisure activities (e.g. waka activities and walking tracks with interpretation).

Action 1: Investigate steps required to achieve co-management for Pukepuke.

11.2 Pest control

11.2.1 Objective 2: Lower and maintain the populations of pest mammals within the site to low densities so that indigenous fauna and flora populations can flourish.

Pest animal control should be undertaken to enhance the ecological integrity of the habitats, and protect indigenous flora and fauna and revegetation efforts. Pest animal control is currently being undertaken at Pukepuke, which is managed by Department of Conservation and undertaken by volunteers. DOC 200 traps for stoat control are installed around the site and baited with hen eggs. It is unknown how effective the control operations have been to date. Pest animal control monitoring has also been undertaken at the site with chew cards and tracking tunnels. Rangitane O Manawātū has undertaken some of the monitoring but the results are largely unknown. A robust monitoring and control programme is required that sets and measures pest animal control targets and outcomes for a suite of pest mammals. Pest animal control should also be undertaken to protect revegetation plantings from browsing animals such as possums and rabbits/hares if present. Extending pest control into surrounding areas will limit the rate of reinvasion, and maximise ecological gains by providing a larger core area of control.

The following pests should be considered for monitoring and/or control:

- Mustelids
- Rodents
- Cats
- Possums
- Hedgehogs
- Rabbits/hares
- Ungulates

Action 2: Undertake a detailed fauna survey to identify indigenous species present, with a focus on avifauna, and identify their relative vulnerability to predation and management requirements.

Action 3: Design and implement a robust pest animal monitoring programme to record baseline information of the current pest animal populations.

Action 4: Design and implement an ongoing pest animal control programme appropriate for the site and pest animal baseline monitoring results.

Action 5: Design and implement biodiversity monitoring to assess the outcomes of pest control (e.g. five minute bird counts, fledgling rates of vulnerable bird species).

Action 6: Undertake regular pest animal monitoring and, if necessary, adapt control operations.

Action 7: Accurately record all monitoring and control data (e.g. number of animals trapped, bait taken), present the information in a logical/easily understood manner and disseminate the information to all stakeholders.

Action 8: Explore possibilities of extending pest animal control to properties surrounding Pukepuke with landowners.

11.2.2 Objective 3: Undertake pest plant control to prevent pest plants from spreading across the site over the long-term, so that indigenous habitats can be maintained and restored, and populations of Threatened or At Risk plants are protected.

All pest plants recorded at the site and listed in Table 3 should be controlled. Pest plant distributions recorded during the field survey are presented in Figure 3. A pest plant control plan should detail priorities, methods, and timeframes for control. Initial pest plant control should be undertaken as soon as possible while their incidence is at a relatively low level and easy to manage. Control is also required in areas prior to revegetation being undertaken. Ongoing monitoring and control is required to prevent new infestations of pest plants from establishing. Hornwort should also be controlled if possible to do so. Steps should be taken to prevent pest plants that are currently absent, from establishing at the site, particularly aquatic pest plants,

Action 9: Control pest plants across the site following a pest plant control plan. Control should be in a manner that avoids damage to indigenous plants and prevents spreading of vegetative material.

Action 10: Eradicate hornwort from the site if possible. Monitor and prevent spread if eradication is not practical.

Action 11: Undertake ongoing pest plant control to follow-up on previously controlled infestations and prevent further incursions of pest plants from establishing within the site.

Action 12: Implement biosecurity measures to prevent aquatic pest plants from being introduced to the site.

11.2.3 Objective 4: Protect and enhance populations of indigenous plants, including species that are Threatened or At Risk.

Several indigenous plant populations exist within the marram-dominated duneland. These include sand coprosma (At Risk-Declining), native spinach, pōhuehue, and wīwī. There is a desire to protect and enhance populations of these low growing plants to increase habitat diversity for indigenous fauna, particularly invertebrates. As these plant species already exist at the site which is protected as a conservation area, enhancing the populations could provide a source for other duneland habitat in the wider landscape. Protected populations such as these are valuable to ensure the long-

term local survival of rarer plants such as tarakupenga (sand coprosma) and kōkihi (native spinach).

The margins of the lake and wetlands may also support populations of Threatened or At Risk plants that have been recorded as present in the past. If any of these species are still present, appropriate management actions should be identified and implemented to ensure their survival.

Action 13: Undertake a botanical survey of the lake margins and wetlands to identify what Threatened or At Risk plant species are currently present, what habitats they occur in, and what the key threats are for these populations.

Action 14: Prepare a management plan for Threatened or At Risk plant species at the site, including careful targeted pest plant control.

Action 15: Monitor the response of populations of Threatened or At Risk plants to management, including pest plant and pest animal control.

11.3 Habitat connectivity

11.3.1 Objective 5: Ensure migratory fish including tuna and galaxids have unimpeded access within the site, and between the site and the coast.

Potential barriers to fish passage within the stream channels are outlined in Section 8.4. Full inspections of all stream channels within the site, and downstream to the coast, is required to ensure there are no further known barriers to fish passage. All barriers to fish migration, including small artificial drops, should be remedied.

Action 16: Inspect all stream channels and remedy any barriers to easy fish migration.

11.4 Quality of terrestrial and aquatic habitats

11.4.1 Objective 6: Enhance quality and connectivity of aquatic habitats by providing indigenous vegetation cover over stream channels within the site, between the site and the coast, and upstream of the site.

The quality of water within the stream channels should be at a standard that is optimal for freshwater fish. The stream channels within and downstream of the site comprise open drains with very little overhead vegetation. Taller stream edge vegetation is valuable as it provides shade to stream water, therefore lowering water temperature; provides habitat for aquatic and terrestrial invertebrates; and provides organic material in the form of leaf litter which improves the habitat quality for aquatic organisms. The existing stream channels have been artificially modified in the past and several of the margins comprise of dry banks covered in grass/low vegetation that are prone to pest plant invasion. These stream margins lend themselves to revegetation with indigenous sedges, tree, and shrub species that will provide shade and habitat diversity to the in-stream habitat, improving connectivity.

Access is presently required to the stream margin for management and maintenance of the waterway for drainage. Therefore, liaison with other stakeholders is required to further explore the possibility of revegetation on the stream margins. If clear access is required (i.e. no tall vegetation) along one side of the stream only, then the opposite stream channel should still be considered for indigenous plant establishment.

Establishing indigenous vegetation along the stream channels downstream of the site will improve in-stream ecological values and habitat quality for aquatic species all the way to the coast, therefore enhancing connectivity. Options for revegetation along the stream margins between the site and the coast should be explored with forestry and drainage board stakeholders.

Several farm drains feed into the site, and connectivity of aquatic habitats upstream of the site is extremely poor. To improve habitat connectivity upstream of Pukepuke, dairy farms with drains that discharge into Pukepuke require restoration measures such as fencing and planting of riparian buffers.

Action 17: Explore opportunities with stakeholders for revegetation of riparian margins, both within the site boundaries, upstream of the site, and between Pukepuke and the coast.

11.4.2 **Objective 7:** Restore wetland buffers.

Ecological sequences from wetland to terrestrial habitats only exist on the southern edge of the wetland (Harakeke flaxland - Vegetation Unit 10). Elsewhere, the habitat change is more abrupt from raupō reedland (Vegetation Unit 1) or tī kōuka treeland (Vegetation Unit 3) to exotic grassland (Vegetation Unit 5). Clearings within the harakeke flaxland are occupied by exotic grasses, bindweed and blackberry. Pest plants, particularly blackberry, have established in several other places on the wetland edge. Restoring ecological sequences such as harakeke flaxland on the edges of wetland habitat will improve buffering of the wetland, and enhance habitat complexity and connectivity. This can be achieved by replacing pest plants on the wetland edge with indigenous plants, and establishing indigenous plants in clearings and elsewhere where ecological sequences are lacking.

Action 18: Plant harakeke and other appropriate buffer species where they are lacking around the edges of wetland habitat to restore a continuous edge of indigenous vegetation around the wetland.

11.4.3 **Objective 8:** Return indigenous forest habitats of a similar type to that which would have covered the terrestrial habitats of the site in pre-human times.

Except for wetlands and active dunes along the shoreline, most of the lowlands of the Manawatū would have been forested prior to human settlement. These indigenous forests have almost been completely lost, with only small scattered remnants remaining. As previously mentioned, there is a general lack of indigenous plant cover within terrestrial habitats of the site, particularly woody tree species, and plantings of appropriate indigenous forest species (e.g. kahikatea, pukatea, kaikomako, titoki, totara, matai) could return indigenous forest habitats to the site. This will in time

provide a wider range of roosting, nesting and foraging habitats for indigenous fauna, and in particular avifauna.

Action 19: Identify and plan revegetation areas, compile plant schedules, organise plant supply.

Action 20: Prepare, plant, and maintain revegetation areas until canopy closure occurs and most pest plants are being excluded.

12. MILESTONES

The following milestones in Table 4 provide guidance as to the likely required timeframes to achieve the desired outcomes, if resources are available and actions are implemented soon (e.g. fish passage could be achieved within 1-2 years, whereas establishment of indigenous forest could take 10-15 years). All outcomes are dependent on the support of the co-governance body, and the availability of the resources required.

Table 4: Issues, actions, outcomes, and timeframes for Pukepuke Conservation Area.

Issues	Actions	Outcome	Priority	Timeframe ¹
Co-management and collaboration.	Find a way forward for co-management. All parties to meet to discuss and make an action plan on overall management of Pukepuke including ecological restoration, developing research programmes and leisure activities.	Co-management governance body set up.	High	As soon as possible.
Barriers to fish migration potentially exist between the coast and the lake at Pukepuke.	Remedy all potential barriers to fish passage.	Unimpeded fish migration occurs.	High	1-2 years.
Pest plants are establishing at the site and will impact on ecological values.	Undertake botanical survey to confirm which Threatened or At Risk plant species are present. Identify their management requirements. Control pest plants at the site, attempt to eradicate hornwort, implement biosecurity measures.	Pest plant infestations are effectively controlled at the site, hornwort eradicated, and new infestations are prevented from establishing. Populations of Threatened or At Risk plants are protected.	High	2-5 years.
Pest mammals are impacting on ecological values.	Confirm indigenous fauna species present and assess their management requirements. Design and implement pest animal control and monitoring programmes.	Pest mammals are reduced and maintained to low levels so that indigenous fauna can thrive at Pukepuke.	Medium	2-5 years.
Stream edges have inadequate vegetation cover which is impacting on aquatic ecological values.	Establish appropriate riparian vegetation on stream edges following liaison with other stakeholders.	Riparian vegetation is restored to enhance water quality values.	Medium	5 years.
The vegetation buffer around the wetland is discontinuous and lowers the ecological integrity of the wetland system by allowing pest plants to establish.	Establish appropriate buffering vegetation to restore a continuous sequence around the lake and wetland edge.	Buffering vegetation is restored and pest plant invasion is minimised.	Medium	5 years.
There is a lack of indigenous terrestrial forest ecosystems.	Restore indigenous forest on the drier margins of the site.	Appropriate indigenous tree and shrub cover establishes on drier margins of the site so that succession to a climax forest ecosystem can occur.	Medium-Low	10-15 years.

¹ All timeframes subject to the priorities of the co-governance body and availability of resources.

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SITE PHOTOGRAPHS



Plate 1: Eastern stream channel flowing into the Pukepuke Conservation Area. 15 March 2017.



Plate 2: Stream channel flowing along the northern edge of wetland habitat. 15 March 2017.



Plate 3: Open water habitat surrounded by dense raupō reedland with crack willow forest on the far shoreline. 15 March 2017,



Plate 4: Blackberry vineland (foreground), toetoe grassland, *Coprosma propinqua* shrubland (centre), raupō reedland (back left) and tī kōuka-harakeke-raupō reedland (back right). 15 March 2017.



Plate 5: Marram grassland on dunes, southwestern portion of the site. 15 March 2017.



Plate 6: Pōhuehue growing amongst grassland on duneland habitat. 15 March 2017.



Plate 7: Red oak naturalised and growing amongst grassland on duneland habitat. 15 March 2017.



Plate 8: Several of the vegetation types at Pukepuke including tī kōuka treeland (back left), toetoe grassland (centre left), blackberry vineland (foreground), harakeke flaxland (centre), willow forest (back middle), exotic grassland (back right) and duneland (distance right). 15 March 2017,



Plate 9: Vegetation at the southwestern edge of the wetland showing blackberry, harakeke and mature tī kōuka. Raupō and bindweed are also common. 15 March 2017.



Plate 10: Maui's copper butterfly at Pukepuke Conservation Area. 15 March 2017.



Plate 11: Culvert pipe being a partial impediment to fish passage in the channel downstream of the Pukepuke Conservation Area. 15 March 2017.

VASCULAR PLANT SPECIES RECORDED AT PUKEPUKE DURING THE FIELD ASSESSMENT

Key

P = planted.

INDIGENOUS SPECIES

Gymnosperms

Podocarpus totara var. *totara* (P)¹ tōtara

Monocot. trees and shrubs

Cordyline australis tī kōuka, cabbage tree

Dicot. trees and shrubs

Coprosma acerosa s.s. sand coprosma, tarakupenga, tātaraheke
Coprosma propinqua var. *propinqua* mingimingi

Dicot. lianes

Calystegia tuguriorum pōwhiwhi, native bindweed
Muehlenbeckia complexa pōhuehue

Ferns

Azolla rubra retoretore
Blechnum minus swamp kiokio
Diplazium australe
Hypolepis ambigua
Pteridium esculentum rārahu, bracken

Grasses

Austroderia toetoe toetoe

Sedges

Bolboschoenus fluviatilis pūrui grass, kukuraho
Carex geminata
Carex pumila

¹ P = probably planted.

<i>Carex secta</i>	pūrei, makura, pūreirei, pūrekireki, pūkio
<i>Carex virgata</i>	
<i>Cyperus ustulatus</i> f. <i>ustulatus</i>	toetoe upoko-tangata
<i>Eleocharis acuta</i>	spike sedge
<i>Ficinia nodosa</i>	wīwī
<i>Schoenoplectus tabernaemontani</i>	kāpūngāwhā

Rushes

<i>Juncus edgariae</i>	wī, wīwī
<i>Juncus sarophorus</i>	

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

<i>Lemna disperma</i>	karearea
<i>Phormium tenax</i>	harakeke, flax
<i>Typha orientalis</i>	raupō

Dicot. herbs (other than composites)

<i>Geranium homeanum</i>	pinakitere
<i>Persicaria decipiens</i>	tutunawai
<i>Ruppia</i> sp.	
<i>Tetragonia implexicoma</i>	kōkihi

NATURALISED AND EXOTIC SPECIES

Gymnosperms

<i>Pinus radiata</i> (P)	radiata pine
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Dicot. trees and shrubs

<i>Chrysanthemoides monilifera</i>	boneseed
<i>Cytisus scoparius</i>	broom
<i>Eucalyptus</i> sp.	eucalyptus
<i>Lupinus arboreus</i>	lupin
<i>Lycium ferocissimum</i>	boxthorn
<i>Populus alba</i>	white poplar
<i>Quercus ilex</i> (P)	holm oak
<i>Quercus rubra</i> (P)	red oak
<i>Quercus</i> sp. (P)	oak species
<i>Rubus</i> sp. (<i>R. fruticosus</i> agg.)	blackberry
<i>Salix fragilis</i>	crack willow
<i>Ulex europaeus</i>	gorse

Dicot. lianes

<i>Calystegia sylvatica</i>	greater bindweed
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Vinca major periwinkle

Grasses

<i>Agrostis stolonifera</i>	creeping bent
<i>Ammophila arenaria</i>	marram
<i>Anthoxanthum odoratum</i>	sweet vernal
<i>Bromus willdenowii</i>	prairie grass
<i>Cortaderia jubata</i>	purple pampas
<i>Cortaderia selloana</i>	pampas
<i>Dactylis glomerata</i>	cocksfoot
<i>Holcus lanatus</i>	Yorkshire fog
<i>Paspalum distichum</i>	Mercer grass
<i>Phalaris aquatica</i>	phalaris
<i>Polypogon monspeliensis</i>	beard grass
<i>Schedonorus arundinaceus</i>	tall fescue

Rushes

Juncus articulatus jointed rush

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

<i>Alisma plantago-aquatica</i>	water plantain
<i>Asparagus officinalis</i>	asparagus
<i>Landoltia punctata</i>	purple-backed duckweed

Composite herbs

<i>Bidens frondosa</i>	beggars' ticks
<i>Cirsium arvense</i>	California thistle
<i>Crepis capillaris</i>	hawksbeard
<i>Erigeron sumatrensis</i>	Canadian fleabane
<i>Gamochaeta simplicicaulis</i>	simple-stem everlasting
<i>Hypochaeris radicata</i>	catsear
<i>Lactuca virosa</i>	acrid lettuce
<i>Senecio glastifolius</i>	pink ragwort, holly-leaved senecio

Dicot. herbs (other than composites)

<i>Apium nodiflorum</i>	water celery
<i>Cerastium fontanum</i> subsp. <i>vulgare</i>	mouse-ear chickweed
<i>Ceratophyllum demersum</i>	hornwort
<i>Conium maculatum</i>	hemlock
<i>Euphorbia lathyris</i>	caper spurge
<i>Foeniculum vulgare</i>	fennel
<i>Fumaria muralis</i>	scrambling fumitory
<i>Galium aparine</i>	cleavers
<i>Geranium molle</i>	dovesfoot cranesbill
<i>Lotus pedunculatus</i>	lotus

<i>Lotus suaveolens</i>	hairy birdsfoot trefoil
<i>Malva sylvestris</i>	large-flowered mallow
<i>Nasturtium officinale</i>	watercress
<i>Persicaria maculosa</i>	willow weed
<i>Phytolacca octandra</i>	inkweed
<i>Plantago lanceolata</i>	narrow-leaved plantain
<i>Plantago major</i>	broad-leaved plantain
<i>Polygonum aviculare</i>	wireweed
<i>Ranunculus repens</i>	creeping buttercup
<i>Ranunculus sceleratus</i>	celery-leaved buttercup
<i>Rumex acetosella</i>	sheep's sorrel
<i>Rumex obtusifolius</i>	broad-leaved dock
<i>Solanum chenopodioides</i>	velvety nightshade
<i>Solanum dulcamara</i>	bittersweet
<i>Solanum nigrum</i>	black nightshade
<i>Solanum nodiflorum</i>	
<i>Stellaria media</i>	
<i>Trifolium pratense</i>	red clover
<i>Trifolium repens</i>	white clover
<i>Vicia sativa</i>	vetch

FAUNA SPECIES RECORDED AT PUKEPUKE DURING THE FIELD ASSESSMENT

BIRDS

Indigenous

<i>Anas rhynchos</i>	kuruhengi; New Zealand shoveler
<i>Anthus novaeseelandiae novaeseelandiae</i>	pīhoihoi; New Zealand pipit
<i>Circus approximans</i>	kāhu; swamp harrier
<i>Cygnus atratus</i>	black swan
<i>Gerygone igata</i>	riroriro; grey warbler
<i>Himantopus himantopus leucocephalus</i>	poaka; pied stilt
<i>Larus dominicanus dominicanus</i>	karoro; southern black-backed gull
<i>Phalacrocorax carbo novaehollandiae</i>	kawau; black shag
<i>Phalacrocorax melanoleucos brevirostris</i>	kawau paka; little shag
<i>Phalacrocorax varius varius</i>	kāruhiruhi; pied shag
<i>Poliocephalus rufopectus</i>	weweia; New Zealand dabchick
<i>Porphyrio melanotus melanotus</i>	pūkeko
<i>Porzana tabuensis tabuensis</i>	pūweto; spotless crane;
<i>Rhipidura fuliginosa placabilis</i>	pīwakawaka; North Island fantail
<i>Todiramphus sanctus vagans</i>	kōtare sacred kingfisher; New Zealand kingfisher

Introduced

<i>Anas platyrhynchos</i>	mallard
<i>Carduelis carduelis</i>	goldfinch
<i>Carduelis chloris</i>	greenfinch
<i>Carduelis flammea</i>	redpoll
<i>Columba livia</i>	rock pigeon
<i>Emberiza citrinella</i>	yellowhammer
<i>Fringilla coelebs</i>	chaffinch
<i>Gymnorhina tibicen</i>	Australian magpie
<i>Phasianus colchicus</i>	common pheasant
<i>Sturnus vulgaris</i>	common starling
<i>Turdus merula</i>	Eurasian blackbird



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