Solanum mauritianum *	tobacco weed, woolly nightshade
Solanum pseudocapsicum *	Jerusalem cherry
Sophora chathamica (cult.)	kowhai
Sophora fulvida (cult.)	Anawhata kōwhai
Sophora molloyi (cult.)	Molloy's kōwhai, Cook Strait kowhai
Sophora tetraptera (cult.)	large-leaved kōwhai
Syzygium australe * (cult.)	brush cherry. In Japanese Garden.
Syzygium paniculatum * (cult.)	magenta lilly pilly
Syzygium smithii * (cult. and naturalised)	lilly pilly, monkey apple
Tecomanthe speciosa (cult.)	tecomanthe, Three Kings vine
Tetrapanax papyrifera * (cult.)	rice paper plant
Teucrium fruticans * (cult.)	silver germander
Tibouchina urvilleana * (cult.)	lasiandra, glory bush
Tilia americana * (cult.)	American basswood
Toona ciliata * (cult.)	red cedar
Tristaniopsis laurina * (cult.)	water gum, kanooka
Ulex europaeus *	gorse
Veronica sp. (cult.)	hebe
Veronica parviflora (cult.)	kōkōmuka-tāranga.
Veronica speciosa (cult.)	tītīrangi
Veronica stricta (cult.)	koromiko
Viburnum japonicum * (cult.)	Japanese viburnum. Fukuoka Garden
Vitex lucens (cult.)	puriri
Westringia fruticosa * (cult.)	coastal rosemary

The vegetation of Repo Ki Pūkorokoro Reserve, Pūkorokoro-Miranda, Waikato

Nick Goldwater

Introduction and ecological context

The Department of Conservation recently purchased 19.6 ha of grazed coastal flats at Pūkorokoro-Miranda with the aim of restoring and increasing wildlife habitat along the coastal margin and adjoining the Ramsar wetland of the Firth Thames. The new reserve – Repo Ki Pūkorokoro – will be managed by a community-led Trust. In April 2019, the company I work for (Wildland Consultants Ltd) was commissioned to prepare a comprehensive ecological restoration plan, which will provide the Trust with guidance on ecological restoration opportunities and priorities, and underpin future applications for restoration activity funding. It is hoped that the implementation of this plan will result in the protection and enhancement of ecological values on the reserve and a significant increase in the extent and quality of indigenous habitats present.

Repo Ki Pūkorokoro Reserve is located on the inland side of East Coast Road in the Hauraki Ecological District, near the boundaries of Hunua and Hapuakohe Ecological Districts (Fig. 1). The coastal wetland to the east of the reserve is a site of international significance and contains extensive habitat for threatened indigenous flora and fauna. Prior to the arrival of European settlers, natural wetlands would have originally covered a much greater area of the flats surrounding the Firth of Thames; however, these have been progressively modified and reduced in size through the establishment of networks of drains to support pasture-based farming. The remaining wetlands are largely restricted to small estuarine areas around the mouths of the major streams and in shallow depressions between ridges of accreted sand and shells, as well as the intertidal flats along the coastline.

The estuary ecosystems and chenier plain are identified as 'Naturally Uncommon' ecosystems on a national scale (Williams et al. 2007). Only around 12 chenier plain systems have been identified globally, and in New Zealand chenier plains are confined to the Hauraki Gulf and Waitemata Harbour. The coastline at Pūkorokoro-Miranda has the most extensive chenier plain system in New Zealand, and is the only known example, globally, of a chenier plain that is currently aggrading (Clarkson et al. 2014). The most seaward chenier formed around 1969 and has advanced *c*. 1.5 km southward and parallel to the previous shoreline (Hayward 2013).

A vegetation survey conducted by Merrett and Clarkson (1997) mapped seven major vegetation and habitat types across the area seaward of East Coast Road, being mangrove (*Avicennia marina*) forest, bare shell banks, glasswort (*Salicornia quinqueflora*)

herbfield, bachelor's button (*Cotula coronopifolia*)–*Thyridia repens* herbfield, *Carex divisa* sedgeland, rye grass (*Lolium perenne*)–bur medic (*Medicago* sp.) grassland, and saltmarsh ribbonwood (*Plagianthus divaricatus*)-mingimingi (*Coprosma propinqua*) shrubland. Since this survey took place, the most significant changes have been the southward expansion of mangroves, the emerging dominance of fennel (*Foeniculum vulgare*) in ungrazed pasture, and the regeneration of indigenous shrubs along a fenced strip of East Coast Road to the north of the Miranda Naturalists' Trust Shorebird Centre.

Historically, saltmarsh vegetation in Pūkorokoro-Miranda has been heavily affected by human activity, especially alterations to hydrology resulting from extensive drainage systems, flap-gated culverts and stop banks (e.g. on the Pūkorokoro and Miranda Streams), road construction, grazing, and pest plant invasion. Upper level saltmarsh shrubland characterised by saltmarsh ribbonwood, pōhuehue (*Muehlenbeckia complexa*), mānuka (*Leptospermum scoparium*), and flax (*Phormium tenax*) has largely disappeared except where it has been maintained by planting and fencing. Salt meadow plant communities have been adversely affected by grazing and mangrove expansion, and *Thyridia repens* herbfields have largely (but not entirely) been out-competed by rank grass when stock have been excluded. However, Pūkorokoro-Miranda to Kaiaua remains the Auckland–Waikato stronghold for *T. repens*, which is an 'At-Risk-Naturally Uncommon' species (de Lange et al. 2018).

Vegetation in Repo Ki Pūkorokoro Reserve

Overview

The vegetation (see Appendix) is broadly characterised by grazed exotic grassland and sedgeland together with small and discrete patches of saline herbfield, saltmarsh, and mangrove shrubland. Areas of flood-prone mudflats and depressions are a feature in the western and northeastern parts of the reserve.

The reserve is bisected by two major watercourses: Pūkorokoro Stream flows south-north while a major drain to the west of Pūkorokoro Stream flows north-south. Permanent farm drains partially bound the northern and southern boundaries of the reserve, and an earth bund borders the entire true left floodplain of Pūkorokoro Stream. The stream flows into the tidal reaches of the Miranda Stream, which drains a large catchment to the west. At high tides, seawater flows into the lower reaches of the Pūkorokoro Stream, which has facilitated the establishment of saline plant communities in the reserve.

Seven terrestrial vegetation types were identified during the survey:

1. *Carex divisa* sedgeland
2. *Thyridia repens* herbfield
3. Exotic grass–*Carex divisa*–hawkbit mosaic
4. Mangrove–saltmarsh ribbonwood–*Carex divisa* shrubland
5. Slender clubrush sedgeland
6. Exotic herbfield
7. Bachelor's button–*Carex divisa*–bare mud herbfield

Carex divisa sedgeland

Grazed pasture dominated by *Carex divisa* is the most abundant vegetation type at the reserve, occasionally occurring with exotic grass species, hawkbit (*Leontodon saxatilis*), and bachelor's button. This vegetation type forms a dense monoculture along the margins of Pūkorokoro Stream (Fig. 2).

Thyridia repens herbfield

The prostrate saline herb species, *Thyridia repens*, is locally abundant in muddy depressions and drains in the northeastern part of the reserve, covering some 5,000 m^2 (Fig. 3). Other indigenous saline herb species such as bachelor's button and remuremu (*Selliera radicans*) (Fig. 4) are local on the margins of this vegetation type together with patches of *Carex divisa*. Small 'islands' of raised ground within this vegetation type are dominated by *Carex divisa*. The muddy depressions that support *Thyridia repens* have been extensively pugged by stock (Figure 5), although this does not appear to have adversely impacted its abundance or vigour.

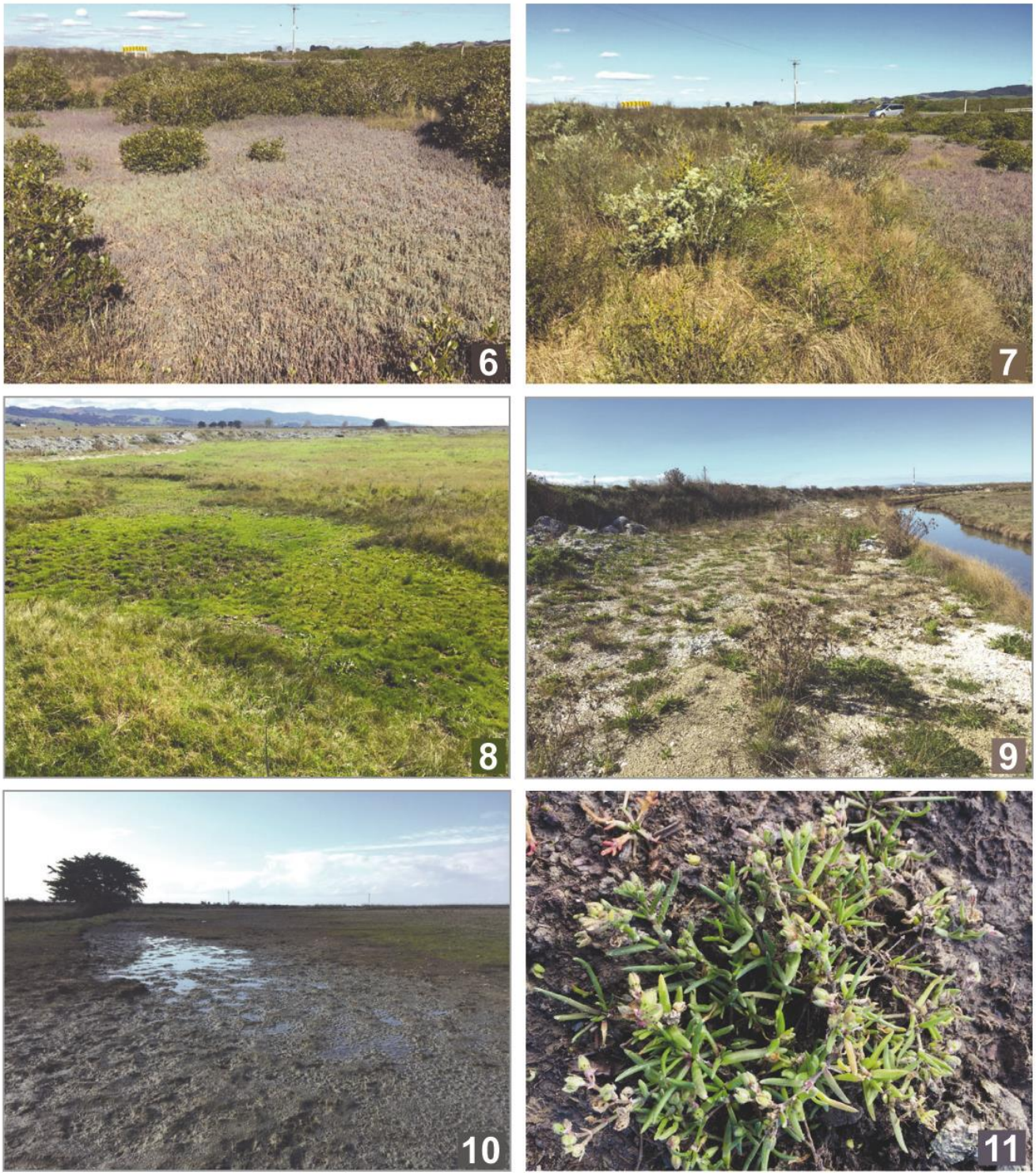
Exotic grass–*Carex divisa*–hawkbit mosaic

Areas that are slightly elevated land and less prone to inundation and saline influence are dominated by grazed exotic grasses, *Carex divisa*, and hawkbit with local white clover (*Trifolium repens*). Occasional to frequent species include creeping bent (*Agrostis stolonifera*), rats tail (*Sporobolus africanus*), barb grass (*Parapholis strigosa*), narrow-leaved plantain (*Plantago lanceolata*), sea aster (*Aster subulatus*), and dovesfoot cranesbill (*Geranium molle*).

Mangrove–saltmarsh ribbonwood–*Carex divisa* shrubland

A discrete area of saline vegetation occurs at the southern end of the reserve and is partially bounded by East Coast Road. It includes scattered mangroves up to three metres tall with large patches of bare mud and locally common glasswort (Figure 6). Also present is a small patch of saltmarsh ribbonwood fringed by patches of māakoako (*Samolus repens*) and remuremu. Sea rush (*Juncus kraussii* subsp. *australiensis*) occurs occasionally where the salinity is elevates, while species such as *Stipa stipoides*, *Carex*

Figs. 1–5: 1. Location of the reserve (denoted by black cross-hatched area). Grid of 1 km squares. NZ Topomap50 modified by Nick Goldwater and Joshua Salter. **2.** *Carex divisa* bordering Pūkorokoro Stream. All photographs taken by the author, 17 May 2019. **3.** Partially inundated *Thyridia repens* herbfield with four-legged curators in the background. **4.** *Selliera radicans* on edge of drain. **5.** *Thyridia repens* herbfield with extensive pugging by stock.



Figs. 6–11: 6. Glasswort herbfield fringed by mangroves. **7.** Saltmarsh ribbonwood and *Austrostipa stipoides* grading into glasswort and mangroves. **8.** Small depression dominated by *Isolepis cernua*. **9.** Exotic herbs occupying the true left floodplain of Pūkorokoro Stream. **10.** Bachelor's button fringing wet mudflats on the west side of Pūkorokoro Stream. **11.** *Spergularia marina* in flower on mudflats.

divisa and tall fescue (*Lolium arundinaceum* subsp. *arundinaceum*) are restricted to more elevated ground (Figure 7). This vegetation type is contiguous with mangrove forest and shrubland that extends west along the tidal reaches of Miranda Stream and south towards the Firth of Thames.

Slender clubrush sedgeland

Small depressions present on the eastern side of Pūkorokoro Stream are characterised by slender clubrush (*Isolepis cernua*) with occasional *Thyridia repens* and locally grazed *Bolboschoenus caldwellii*), and scattered broadleaved plantain (*Plantago major*)

and sea aster (Fig. 8). These depressions are largely bounded by *Carex divisa*. The slightly lower elevation of this vegetation type and the prevalence of the halophytic slender clubrush indicates a regular saline influence.

Exotic herbfield on floodplain

The true left floodplain of Pūkorokoro Stream ranges from c. 3 to 10 m wide and is partially vegetated by a range of exotic herbs including narrow-leaved plantain, sea aster, Scotch thistle (*Cirsium vulgare*, dead and live), orache (*Atriplex prostrata*), puha (*Sonchus oleraceus*), creeping buttercup (*Ranunculus repens*), and curled dock (*Rumex crispus*) (Fig. 9). *Carex divisa* is local along the edge of the stream. A sole macrocarpa tree is the only woody species on the floodplain.

Bachelor's button–-*Carex divisa*–bare mud herbfield

On the western side of Pūkorokoro Stream, saline herbfield dominated by common bachelor's button occurs. *Carex divisa* is frequent on the drier margins of the mudflats and depressions, while in more regularly inundated parts of the mudflats (Fig. 10) the vegetation is restricted to scattered bachelor's button and sea spurrey (*Spergularia marina*) (Fig. 11).

Fauna

Ten indigenous birds were recorded during the survey: white-faced heron (*Egretta novaehollandiae*), banded rail (*Gallirallus philippensis*; footprints only); riroriro (grey warbler; *Gerygone igata*), poaka (pied stilt; *Himantopus himantopus leucocephalus*), welcome swallow (*Hirundo neoxena neoxena*), kawau (black shag; *Phalacrocorax carbo novaehollandiae*), pūkeko (*Porphyrio melanotus melanotus*), paradise shelduck (*Tadorna variegata*), kotare (kingfisher; *Todiramphus sanctus vagans*), and spur-winged plover (*Vanellus miles novaehollandiae*). Two bird species (banded rail and poaka/pied stilt) are classified as 'At Risk–Declining' by Robertson et al. (2017).

Two other threatened bird species that have been recorded from the site on previous occasions are royal spoonbill (*Platalea regia*; At Risk–Naturally Uncommon; roosting in macrocarpa, N. Goldwater pers. obs.) and Pacific golden plover (*Pluvialis fulva*, Non-resident native; K. Woodley, pers. comm.).

Shore skink (*Oligosoma smithi*) has been recorded on the Miranda coastline, *c.* 270 m to the west of the reserve.[1] This species may occur at the reserve, together with the more common copper skink (*O. aeneum*).

[1] https://inaturalist.nz/observations/9712042

Excluding domestic stock, two introduced mammal species were observed during the survey: house mouse (*Mus musculus*) and brown hare (*Lepus europaeus*).

Discussion

Eleven indigenous and 48 naturalised plant species were recorded at the reserve during the survey, including one 'At Risk' species (*Thyridia repens*). Despite the relatively low richness of indigenous plant species, the populations that are present seem fairly resilient. It is likely that a combination of grazing and salinity have suppressed weed species such as pampas, gorse and wild fennel.

Interestingly, *Thyridia repens* seems to have benefited from the presence of stock (noting that stocking rates are currently low and animals are regularly moved around the site). The actions of grazing and trampling, together with regular saline inundation, are likely to keep a check on competing species such as *Carex divisa* and possibly bachelor's button.

Another species of interest in the wider area is pikirangi (green mistletoe; *Ileostylus micranthus*). Although I did not encounter pikirangi during the survey, there are nine records of the species within 2 km of the study site (AK 221698, AK 221701, AK 153654, AK 221697, AK 221699, AK 221700, AK 199657, AK 221696, and AK 174344). Host plants include saltmarsh ribbonwood, *Muehlenbeckia australis*, *M. complexa*, macrocarpa, *Coprosma propinqua*, and gorse (*Ulex europaeus*). Clearly, pikirangi is not a fussy species.

The future management of the reserve will include the usual combination of pest plant and animal control, and indigenous planting. A few discrete areas will be fully revegetated with species such as mānuka, saltmarsh ribbonwood, mingimingi, tī kōuka (*Cordyline australis*) and harakeke, while other areas (e.g. mudflats) will be partially planted with species such as oioi (*Apodasmia similis*) and subsequently monitored.

It is also intended to carry out trials whereby no planting is undertaken once stock have been excluded. The objective of this approach is to determine what plant species will regenerate in the absence of stock and whether or not it will have a deleterious impact on the *Thyridia* population, i.e. by facilitating the growth of competing plant species.

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Appendix. Vascular plant list for Repo Ki Pūkorokoro Reserve

This list is based on records from surveys undertaken on 17 April and 7 May 2019 by Nick Goldwater.

* = naturalised species

Gymnosperms

Cupressus macrocarpa *

Dicots

Atriplex prostrata *
Avicennia marina
Bellis perennis *
Beta vulgaris subsp. *maritima* *
Cirsium vulgare *
Cotula coronopifolia
Crepis capillaris *
Daucus carota *
Erigeron bonariensis *
Erigeron sumatrensis *
Erodium moschatum *
Foeniculum vulgare *
Geranium molle *
Helminthotheca echioides *
Leontodon saxatilis *
Lepidium didymum *
Lycium ferocissimum *
Lysimachia arvensis *
Malva sylvestris *
Modiola caroliniana *
Orobanche minor *
Plagianthus divaricatus
Plantago australis *
Plantago lanceolata *
Plantago major *
Polygonum aviculare *
Pseudognaphalium luteoalbum agg.
Ranunculus repens *
Ranunculus sardous *
Rumex crispus *
Samolus repens *
Salicornia quinqueflora
Selliera radicans
Sedum acre *
Solanum chenopodioides *
Sonchus asper *
Sonchus oleraceus *
Spergularia marina *
Symphyotrichum subulatum *
Taraxacum officinale *
Thyridia repens
Trifolium arvense *
Trifolium dubium *
Trifolium pratense *
Vinca major *

Monocots

Agrostis stolonifera *
Austrostipa stipoides
Bolboschoenus caldwellii
Carex divisa *
Cortaderia selloana *
Cyperus eragrostis *
Cynodon dactylon *
Lolium arundinaceum *
Isolepis cernua
Juncus kraussii
Paspalum dilatatum *
Parapholis strigosa *
Phalaris minor *
Sporobolus africanus *