

ASSESSMENT OF INDIGENOUS BIODIVERSITY AT ROKAWAU LAKES AND ENVIRONS, KARIKARI PENINSULA, NORTHLAND



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View looking south across the main wetland at adjacent to Lake Rotokawau.

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1. INTRODUCTION

The Rotokawau dune lakes and associated wetlands, scrub, and dunelands are situated near Rangiputa on the north-western tip of the Karikari Peninsula, Northland. In order to optimise management options, Lucklaw Farm Ltd, the client and landowner, wishes to better understand the biodiversity values of the wetland vegetation and other habitats surrounding the lakes, and the threats to them. Pest plant incursions have been observed by the client and, at present, these pose a management dilemma. Decisions around the methods used to control or eradicate the pest plants will be dependent upon the biodiversity values identified and (in some cases) their precise locations.

The area of interest comprised two lakes, Lake Rotokawau West (63.3 hectares, 12 metres depth) and Lake Rotokawau East (21.3 hectares, <1 metre depth), the area of wetland, to the east of Lake Rotokawau West and the north of Lake Rotokawau East to Puwheke Road, the forest and scrub bordering the northern boundaries of the wetland and Lake Rotokawau West, and areas of forest, scrub and duneland to the north extending all the way to the foredunes of Puwheke Beach. This represents a mix of crown-owned and privately owned entities.

The area of wetland, which is predominantly own by Lucklaw Farm, was of special interest, as Wells and Champion (2013) had indicated that it “may contain endangered plants”. Wells and Champion (2013) also ranked the ecological status of both lakes as moderate, and though their water quality was recorded as poor, it is clear they provide valuable habitat for various water birds and fish.

Wildland Consultants Ltd undertook an assessment of indigenous biodiversity values within the site, with a focus on lakeside and wetland vegetation. This included a desktop review, site visit, and assessment of the biotic and other threats to that indigenous biodiversity.

2. METHODS AND SCOPE

2.1 Desktop review

A literature and digital media search were undertaken to identify ecological information relevant to the site. Sources included:

- Aupouri PNAP report (Department of Conservation).
- The Threatened Environment Classification (Landcare Research NZ).
- Northland Lakes Ecological Status reports (Northland Regional Council) for records on the Rotokawau Lakes.
- Department of Conservation herpetofauna database for records of lizards.
- New Zealand Freshwater Fish Database (NZFFD), for records of freshwater fish.
- The Protected Natural Areas Programme (PNAP) reports, natural area survey reports, or significant natural area survey reports including the Aupouri Ecological District survey report (Conning and Holland 2003).

- The most recent species threat classification lists for birds (Robertson *et al.* 2021), vascular plants (de Lange *et al.* 2018), freshwater fauna (Dunn *et al.* 2018), reptiles (Hitchmough *et al.* 2021), snails (Barker *et al.* 2021) and spiders (Sirvid *et al.* 2021) based on the threat classification system of Townsend *et al.* (2008).

2.2 Fieldwork

2.2.1 Vegetation

Field surveys were undertaken on 13-15 April 2023 during warm but often windy conditions. Key vegetation and habitat types were described and mapped (Figure 1), with a particular focus on the main wetland and surrounding vegetation, noting that due to time constraints, not all vegetation on the property was mapped. All vascular plant and fauna species observed were recorded and are presented in Appendices 1 and 2, and additional photos of fauna and flora are presented in Appendix 3.

2.2.2 Avifauna surveys

All bird species seen or heard during the botanical surveys were recorded, noting the habitat in which the observation was made. Targeted surveys for North Island fernbird, and spotless crane were undertaken at environmental DNA (eDNA) sampling locations within the main wetland using recorded playbacks of bird calls.

2.2.3 Lizard surveys

One two-hour night time spotlighting survey for tree-dwelling nocturnal gecko species was undertaken during fine conditions on 13 April 2023. Opportunistic daytime searches for geckos and skinks were also undertaken in suitable habitats such as mānuka (*Leptospermum scoparium* var. *incanum*) shrubland and dunelands.

2.2.4 Aquatic surveys

eDNA samples were collected from 12 locations within the study site (Figure 2). At each sampling location, kick-netting was used to collect fish and aquatic invertebrates, all of which were released shortly after capture. Full eDNA results are provided in a separate attachment to this report. It should be acknowledged that eDNA technology is still in its infancy, particularly when it comes to the detection of invertebrates. However, its use was considered valuable and appropriate in the context of this investigation.

2.2.5 Terrestrial invertebrate surveys

Large terrestrial invertebrates such as dragonflies and spiders were recorded and photographed wherever encountered during the survey. Land hoppers were collected from two locations in kānuka (*Kunzea linearis*) dominant forest and scrub, which involved manual searching through leaf litter and turning over logs and other woody debris. In addition, targeted searches for katipō (*Latrodectus katipo*; At Risk – Declining) and Archey’s snail (*Succinea archeyi*; Threatened – Nationally Critical) were undertaken in duneland habitat along Puwheke Beach. There is a historic record of Archey’s snail at the eastern end of nearby Karikari Beach.

3. ECOLOGICAL CONTEXT

Lucklaw Farm is located on the Karikari Peninsula in the Far North, approximately 70 kilometres northwest of Kerikeri. It lies in the coastal bioclimatic zone of the Aupouri Ecological District, which is one of the most distinctive ecological districts in New Zealand. This is because of its topography, particularly the length of coastline relative to land area with the high number of dune lakes and wetlands, three of the least modified harbours in New Zealand, and because of the dominance of sand peninsulas (Conning and Holland 2003).

Aupouri Ecological District covers 119,422 hectares (including the Parengarenga, Houhora, and Rangaunu Harbours, which total 18,168 hectares) and is part of the northern Northland Region. It comprises mainly dune sands, both consolidated and mobile, with swampy depressions and chains of dune lakes. Ninety Mile Beach on the west coast is the longest sandy beach in New Zealand. This beach, together with a series of long sandy beaches on the east coast and on the Karikari Peninsula, provides several sites of threatened plants and a coastal margin which is habitat for a large number of bird species, including the threatened northern dotterel (*Charadrius obscurus aquilonius*) (Conning and Holland 2003).

Wetlands within this ecological district represent some of New Zealand's rarest remaining natural ecosystems, which in themselves provide habitat for a very high number of threatened wetland species (Conning and Holland 2003). As in many other parts of the country, however, wetlands continue to be drained and converted to farmland. In terms of indigenous forest cover, only a few isolated remnants of pōhutukawa (*Metrosideros excelsa*) and coastal broadleaved species forest remain in the ecological district. It is only the fragmented scrub and shrubland areas, many currently dominated by aggressive colonising pest plant species, which offer an opportunity for the regeneration of indigenous forests which are virtually absent in the ecological district.

The area of interest comprising Lucklaw Farm and associated crown-owned land is a microcosm of the Aupouri Ecological District ecosystems described above. There is a long sandy beach (Puwheke Beach) behind which are consolidated and mobile dune sands, with the occasional swampy depression. Due to the topography and underlying geology, there are several dune lakes and ponds present in the area, as well as multiple wetlands including the large wetland of particular interest to the east of Lake Rotokawau West and the north of Lake Rotokawau East. Dune barrage lakes are formed by wind-blown deposits either blocking a valley, or creating depressions between two or more dunes that subsequently fill with water, and dune deflation lakes are created when hollows are excavated by wind erosion, underneath which an impermeable aquiclude may be present (e.g., from the formation of an iron-pan). The dune lakes present are likely show to have characteristics of both types, as water levels fluctuate to a degree with the water table in some of the smaller lakes and ponds closer to the beach, and most, including the two largest lakes, are associated with the presence of an impermeable hard iron pan overlaid by sand.

There has been a long history of disturbance at this site. Much of the woody indigenous vegetation on the dunes and around the large lakes was cleared to make way for pastoral farming, and for many decades, stock likely had access to large areas of forest, scrub

and wetland habitats. Consequently, at the start of the new millennium, these fragile ecosystems were in a highly degraded state. Restoration of the site commenced when the previous owners of the property began planting indigenous trees in the corridor to the west of Lake Rotokawau West. Fencing off of sensitive areas where possible continues today (J. Sturgess, pers. comms.).

4. VEGETATION AND HABITATS

4.1 Overview

The following 11 broad vegetation types were identified and mapped during the survey (Figure 1):

1. Kānuka-mānuka forest and scrub
2. Kānuka forest and scrub
3. Mānuka scrub and shrubland
4. Mānuka-kānuka-Sydney golden wattle forest and scrub
5. *Schoenus brevifolius* sedgeland
6. Tangle fern-wire rush- *Schoenus brevifolius* association
7. Marsh vegetation mosaic
8. Pampas tussockland
9. Raupō reedland
10. *Isolepis prolifera*-swamp millet-alligator weed sedgeland
11. Kānuka-Sydney golden wattle scrub

Aquatic habitats such as small dune lakes and dune hollows were also mapped when encountered. Each vegetation and habitat type is described in more detail below.

4.2 Kānuka-mānuka forest and scrub (Vegetation Type 1)

Forest and scrub dominated by kānuka and mānuka covers much of the old dune and dune hollows between Lake Rotokawau and Puwheke Beach, where it occurs as large contiguous tracts, narrow ribbons, and small isolated remnants (Plate 1). Sydney golden wattle is a common emergent species, particularly in areas closer to the beach. The understorey is often sparse in this vegetation type, often limited to a few species such as *Machaerina juncea*, *Schoenus tendo*, bracken (*Pteridium esculentum*) and gorse (*Ulex europaeus*), as well as seedlings of kānuka and mānuka where light levels are sufficient (Plate 2). Many areas of this vegetation type support small dune hollows that are characterised by open water and/or wetland vegetation such as pale rush (*Juncus pallidus*), *Machaerina juncea*, *Isolepis prolifera*, and waterfern (*Histiopteris incisa*). Where open water and sufficient light are present, surface macrophytes such as duckweed (*Lemna minor*) and ferny azolla (*Azolla pinnata*) are common. Where grazing on adjacent grassland has been discontinued, there has been a rapid regeneration of species such as kānuka, mānuka, mingimingi (*Leucopogon fasciculatus*), bracken, and ripgut brome (*Bromus diandrus*) (Plate 3).



Plate 1: Dense canopy of kānuka-mānuka forest and scrub behind the back dunes of Puwheke Beach. 14 April 2023.



Plate 2: Locally common *Machaerina juncea* (an indigenous sedge species) is abundant in the understorey of Vegetation Type 1. 13 April 2023.



Plate 3: Ungrazed areas between kākūka-mānuka forest and scrub remnants are characterised by ripgut brome (exotic grass species) and regenerating non-palatable species such as kākūka and gorse 1. 15 April 2023.

4.3 Kākūka forest and scrub (Vegetation Type 2)

A long, contiguous band of regenerating forest occupies steep slopes along the northern boundary of Lake Rotokawau. Kākūka dominates the canopy, which is relatively open in some parts, and reaches up to six metres in height (Plate 4). Mature pōhutukawa are locally frequent along the lake shore together with occasional houpara (*Pseudopanax lessonii*) and tōwai (*Pterophylla sylvicola*). The understorey comprises young kākūka and gorse in more open and disturbed areas, together with indigenous species such as mingimingi, prickly mingimingi (*Leptecophylla juniperina*), sword sedge (*Lepidosperma laterale*), *Machaerina juncea*, *Dianella haemata*, and occasional *Veronica diosmifolia* and *Dracophyllum sinclairii*. Twiggy coprosma (*Coprosma rhamnoides*) is locally common in the western extent of this vegetation type, where it occurs with frequent mingimingi and bracken.

In the central to eastern parts of this vegetation type, the understorey is dominated by kakaha (*Astelia banksii*), where it grows terrestrially rather than epiphytically (Plate 5). Where the kākūka forest and scrub borders mānuka scrub and shrubland (Vegetation Type 3) on more even ground, tall mānuka and Sydney golden wattle (*Acacia longifolia*) become frequent over an understorey of *Machaerina juncea*, hukihuki (*Coprosma tenuicaulis*), tangle fern (*Gleichenia dicarpa*), and occasional harakeke (*Phormium tenax*), and waterfern. The threatened fern species *Todea barbara* is locally frequent at the base of the slopes throughout this vegetation type.



Plate 4: Kānuka dominates the canopy in Vegetation Type 2 where sub-canopy vegetation is sparse to absent. 13 April 2023.



Plate 5: The indigenous lily kakaha dominates the ground tier on a steep slope within Vegetation Type 2. 13 April 2023.

4.4 Mānuka scrub and shrubland (Vegetation Type 3)

Mānuka scrub and shrubland of varying height forms a dense canopy on flat terrain between the two lakes, providing an important buffering function (Plate 6). Sydney golden wattle is a frequent emergent species. A smaller area of mānuka scrub and shrubland occurs at the eastern end of the main wetland. Where this vegetation type bounds Vegetation Type 5, mānuka is relatively low in stature (<2 metres) and hukihuki is frequent.

4.5 Mānuka-kānuka-Sydney golden wattle forest and scrub (Vegetation Type 4)

Forest and scrub on even terrain along the northern boundary of the main wetland comprises co-dominant mānuka and kānuka in the canopy with common Sydney golden wattle. Woolly nightshade (*Solanum mauritianum*) is local in the canopy and sub-canopy, while *Dracophyllum sinclairii*, hangehange (*Geniostoma ligustrifolium*) and mingimingi are occasional in the sub-canopy. Understorey species include gorse, *Schoenus tendo*, tangle fern, and bracken (Plate 7). The indigenous liana taihoa (*Cassytha paniculata*) is locally common in this vegetation type and was not observed anywhere else in the study site.

4.6 *Schoenus brevifolius* sedgeland (Vegetation Type 5)

Dense swathes of the indigenous sedge species *Schoenus brevifolius* dominates a large bog system within the wetland, including the wetter central area (Plate 8). Small 'islands' of emergent vegetation frequently occur throughout the sedgeland, and are characterised by *Schoenus tendo*, wire rush, *Machaerina rubiginosa*, tangle fern, and mānuka. Inundated areas with water up to 20 centimetres deep are common and support the exotic bladderwort species *Utricularia gibba*. The remains of what is likely an old swamp forest are also present in some of the larger pools (Plate 9). Sphagnum moss is common throughout this vegetation type.

4.7 Tangle fern-wire rush-*Schoenus brevifolius* association (Vegetation Type 6)

Dense indigenous vegetation characterised by tangle fern, wire rush (*Empodisma robusta*) and *Schoenus brevifolius* occur on the slightly drier margins of the main wetland to the east of Lake Rotokawau (Plate 10). Mānuka, Sydney golden wattle, and bracken are occasional on the margins of this vegetation type. More open (and possibly more acidic) areas of this vegetation type support sphagnum moss and uncommon plant species such as the forked sundew (*Drosera binata*).

4.8 Marsh vegetation mosaic (Vegetation Type 7)

Much of the southern part of the main wetland comprises marsh ecosystems (i.e., less acidic and more fertile than Vegetation Types 5 and 6). This vegetation type supports a relatively diverse range of indigenous and exotic species, with harakeke, mānuka, *Machaerina rubiginosa*, *Schoenus brevifolius*, and oval sedge (*Carex leporina*) being the most prominent (Plate 11). Occasional species include swamp willowherb (*Epilobium pallidiflorum*), *Machaerina teretifolia*, and pampas.



Plate 6: Dense canopy of mānuka within Vegetation Type 3, close to the northeastern corner of Lake Rotokawau. 15 April 2023.



Plate 7: Hangehange and mingimingi (left and centre) are present in the sub-canopy of Vegetation Type 4, while understorey species such as tangle fern and *Schoenus tendo* (an indigenous sedge species) are visible to the right. 15 April 2023.



Plate 8: *Schoenus brevifolius* (an indigenous sedge species) is the dominant plant in Vegetation Type 5. Mānuka scrub and shrubland (Vegetation Type 3) forms a buffer in the background. 14 April 2023.



Plate 9: Flowering *Utricularia gibba* is common in open water within Vegetation Type 5. Old tree stumps are visible in the centre foreground and background. 14 April 2023.



Plate 10: *Schoenus brevifolius* growing through dense tangle fern within Vegetation Type 6. 14 April 2023.



Plate 11: Harakeke, mānuka, *Machaerina rubiginosa*, and pampas (background) present in Vegetation Type 7. 14 April 2023.

4.9 Pampas tussockland (Vegetation Type 8)

Pampas is abundant in the southwestern part of the main wetland, close to the northern boundary of the smaller lake, where presumably the soils are more fertile and drier. Analysis of historic aerial photos going back to 1985 show that the area occupied by pampas has increased rapidly since around 2010. Indigenous species such as harakeke and mānuka are scattered throughout this vegetation type.

4.10 Raupō reedland (Vegetation Type 9)

A discrete area of reedland is located on the northeastern margin of the smaller lake. It is contiguous with a band of lakeside vegetation that consists of kapungawha (*Schoenoplectus tabernaemontani*) bounded by pampas, water pepper (*Persicaria hydropiper*), mānuka, and water fern.

4.11 *Isolepis prolifera*-swamp millet-alligator weed sedgeland (Vegetation Type 10)

The eastern shoreline of Lake Rotokawau and pockets along the northern shoreline are characterised by dense herbaceous vegetation comprising co-dominant *Isolepis prolifera* and swamp millet (*Isachne globosa*), locally common alligator weed (*Alternanthera philoxeroides*), frequent Mercer grass (*Paspalum distichum*), spike sedge (*Eleocharis acuta*), and lotus (*Lotus pedunculatus*) (Plate 12), and occasional emergent species such as pale rush and raupō. Harakeke and hukihuki are locally common along the inland margin of this vegetation type, while wetland species such as giant twig sedge (*Machaerina articulata*) and kapungawha are frequent emergent species in the shallow margins of the lake.

4.12 Kānuka-Sydney golden wattle scrub (Vegetation Type 11)

A narrow band of scrub bounds the farm access road along the northern boundary of the main wetland. The canopy comprises co-dominant kānuka and Sydney golden wattle, while light-demanding pest plants such as pampas and gorse are local on the roadside margin of this habitat type (Plate 13). Sydney golden wattle are also present on the margin. Occasional canopy and sub-canopy species include mānuka and tī kōuka.

4.13 Aquatic habitats

4.13.1 Eastern dune lakes

Two small dune lakes occur near the eastern end of the main wetland. Although they are not fenced, the water quality appears to be relatively good and each lake is partially buffered by a mixture of *Isolepis prolifera*, pale rush, and rank exotic grasses (Plate 14). Both lakes were highly infested with gorse until recently, but a program of careful removal and limited spot spraying has greatly improved their health status.



Plate 12: Vegetation Type 10 forms a transitional habitat between open water and lakeside forest along much of Lake Rotokawua's northeastern and eastern shoreline. 13 April 2023.



Plate 13: Kānuka and Sydney golden wattle are co-dominant within Vegetation Type 11. 14 April 2023.



Plate 14: Small dune lake near the eastern boundary of the farm. 14 April 2023.



Plate 15: Raupō and giant twig sedge are emergent in the narrow dune hollow. Gorse and regenerating Sydney golden wattle are visible on the right bank due to a nearby seed source. 15 April 2023.

4.13.1 Northern dune hollow

A small dune hollow that bounds the rear dunes along the northern property boundary (Figure 1) supports open water and a mosaic of indigenous wetland plants species. Raupō, giant twig sedge, kapungawha, and giant umbrella sedge (*Cyperus ustulatus*) are common, while harakeke and pale rush are occasional on the margins (Plate 15). The dune hollow is buffered by kikuyu and regenerating Sydney golden wattle and serves as a potential fire break between the rear dunes of Puwheke Beach and indigenous scrub on the farm.

5. FLORA

5.1 Overview

One hundred and thirteen (113) plant species were recorded during the survey of forest, scrub, wetland, and duneland habitats (Appendix 1). Of these species, 79 (70%) are indigenous and 34 (30%) are exotic.

5.2 Threatened and At Risk and other notable vascular plant species

Of the 79 indigenous species recorded at the site, four species are classified as ‘At Risk’ and three species are classified as ‘Threatened’ in the current threat classification system for New Zealand flora (de Lange *et al.* 2018). One species is classified as regionally significant.

- Kānuka (*Kunzea linearis*) is classified as ‘Threatened – Nationally Vulnerable’. Although this is the dominant tree species at the study site, it has a restricted range and is threatened by coastal resort development and farming throughout its range. Very few populations occur on protected land (NZPCN 2023¹). It is also threatened by the fungal pathogen myrtle rust (*Austropuccinia psidii*), which infects plants in the Myrtaceae family.
- Mānuka (*Leptospermum scoparium* var. *incanum*) is endemic to northern Northland where it is abundant from Te Pahi to Ahipara. It is classified as ‘Threatened – Nationally Vulnerable’, although this status is largely precautionary due to the threat posed by myrtle rust. This species has much larger seed capsules (Appendix 3: Plate A) than the more common and widespread form of mānuka and also pink or pink flushed flowers. A specimen has been supplied to the Auckland herbarium.
- *Todea barbara* is an indigenous fern classified as ‘Threatened – Nationally Vulnerable’. This species was frequently observed in kānuka forest and scrub (Vegetation Type 2, Appendix 3: Plate B). A specimen has been supplied to the Auckland herbarium.
- Sand daphne/autetaranga (*Pimelea villosa*), pīngao (*Ficinia spiralis*), and sand coprosma (*Coprosma acerosa*) are all classified as ‘At Risk – Declining’, and occur on fore and mid-dunes along Puwheke Beach (Appendix 3: Plates C and D). All three species are vulnerable to rabbit (*Oryctolagus cuniculus*) browse, although

¹ <https://www.nzpcn.org.nz/flora/species/kunzea-linearis/>

none was observed during the survey. This was likely due to the inclement weather during the survey period.

- *Senecio biserratus* is an indigenous herb species in the daisy family that has a threat classification of ‘At Risk – Declining’. A few plants were observed growing amongst pōhuehue in the back dunes at the eastern end of Puwheke Beach (Appendix 3: Plate E).
- *Veronica diosmifolia* is a regionally significant species in Northland. There appears to be a healthy population of this species within the lakeside kānuka forest and scrub (Vegetation Type 2, Appendix 3: Plate F). A specimen has been supplied to the Auckland herbarium.
- Forked sundew (*Drosera binata*) is not a threatened species, although it is considered notable due to it being restricted to bog habitats. There is a small but healthy population of forked sundew in the eastern part of the main wetland (Appendix 3: Plate G). A specimen has been supplied to the Auckland herbarium.



Figure 1. Vegetation and habitat types at Lucklaw Farm and Lake Rotokawau, Karikari Peninsula



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Wildlands
 www.wildlands.co.nz, 0508 WILDNZ
 Scale: 1:7,500
 Date: 29/05/2023
 Cartographer: FM
 Format: A3R

5.3 Pest plant species

Pest plant species are limited in number and tend to be localised in their distribution throughout the study site. Sydney golden wattle is the most common pest plant species and largely grows in association with kānuka and mānuka in Vegetation Types 1, 4, and 11. Pampas is most prevalent in the southern end of the main wetland (Vegetation Type 8) and occurs occasionally along bush margins and track edges. Woolly nightshade is largely restricted to Vegetation Type 4. Alligator weed is present in Vegetation Type 10 along the northern and eastern shoreline of Lake Rotokawau. However, it is evident that the alligator weed beetle (*Agasicles hygrophila*), introduced as a biocontrol for alligator weed, is having a significant effect on the plant (Plate 15). Observations made by NIWA in 2013 reported that alligator weed was a dominant species around the margins of Lake Rotokawau (Wells and Champion 2013). This no longer appears to be the case.



Plate 15: Alligator weed beetle on heavily browsed plant. 13 April 2023.

6. FAUNA

6.1 Avifauna

Eighteen indigenous species were recorded during the survey of terrestrial, wetland, and duneland habitats, as summarised in Table 1. Two of the bird species are classified as ‘Threatened’, five species are classified as ‘At Risk’, and the remaining 11 species are classified as ‘Not Threatened’ (Robertson *et al.* 2021). Interestingly, tūī (*Prothemadera novaezeelandiae*) and kererū (*Hemiphaga novaeseelandiae*) were not observed during the survey. New Zealand dotterel (At Risk – Recovering) was not seen

during the survey, although at least one pair is known to be resident at Puwheke Beach (J. Sturgess, pers. Comms.).

Table 1: Indigenous bird species recorded during the field survey.

Māori and common names	Scientific name	Conservation status (as per Robertson <i>et al.</i> 2021)	Location
Riroriro (grey warbler)	<i>Gerygone igata</i>	Not Threatened	Forest and scrub
Pīwakawaka (North Island fantail)	<i>Rhipidura fuliginosa placabilis</i>	Not Threatened	Forest and scrub
Kāhu (Australasian harrier)	<i>Circus approximans</i>	Not Threatened	Flying overhead
Kakīānau; black swan	<i>Cygnus atratus</i>	Not Threatened	Small lake
Tauhou (silvereeye)	<i>Zosterops lateralis lateralis</i>	Not Threatened	Forest and scrub
Warou (welcome swallow)	<i>Hirundo neoxena neoxena</i>	Not Threatened	Lakes
Mātātā; North Island fernbird	<i>Poodytes punctata</i>	At Risk – Declining	Mānuka scrub in main wetland
Matuku-hūrepo; Australasian bittern	<i>Botaurus poiciloptilus</i>	Threatened – Nationally Critical	One bird seen in main wetland
Kōtare (sacred kingfisher)	<i>Todiramphus sanctus vagans</i>	Not Threatened	Forest and scrub, lake edge
Pīhoihoi; New Zealand pipit	<i>Anthus novaeseelandiae novaeseelandiae</i>	At Risk – Declining	One bird seen at river mouth
kāruhiruhi; pied shag	<i>Phalacrocorax varius varius</i>	At Risk – Recovering	Flying over Lake Rotokawau
Pūtangitangi; paradise shelduck	<i>Tadorna variegata</i>	Not Threatened	Pasture
Taranui (Caspian tern)	<i>Hydropogone caspia</i>	Threatened – Nationally Vulnerable	Flying over Lake Rotokawau
Torea (variable oystercatcher)	<i>Haematopus unicolor</i>	At Risk – Recovering	Beach and river mouth
Tarāpunga; red-billed gull	<i>Larus dominicanus dominicanus</i>	At Risk – Declining	Beach
Karoro (black-backed gull)	<i>Larus dominicanus dominicanus</i>	Not Threatened	Beach and river mouth
Spur-winged plover	<i>Vanellus miles novaehollandiae</i>	Not Threatened	Pasture
Weweia; New Zealand dabchick	<i>Poliocephalus rufpectus</i>	At Risk – Recovering	Several birds seen on Lake Rotokawau

The following 11 introduced species were recorded during the survey:

- Canada goose (*Branta canadensis*).
- Eurasian skylark (*Alauda arvensis*).
- European goldfinch (*Carduelis carduelis britannica*).
- European greenfinch (*Carduelis chloris*).
- Mallard (*Anas platyrhynchos*).
- Yellowhammer (*Emberiza citrinella*).
- Blackbird (*Turdus merula*).

- Common pheasant (*Phasianus colchicus*).
- Australian magpie (*Gymnorhina tibicen*).
- Common pheasant (*Phasianus colchicus*).
- Wild turkey (*Meleagris gallopavo*).

6.2 Herpetofauna

Two indigenous skink species were observed in the foredunes at the eastern end of Puwheke Beach (Figure 2): moko skink (*Oligosoma moco*; At Risk – Relict) and shore skink (*O. smithi*; At Risk – Naturally Uncommon) (Appendix 3: Plate H). No gecko species were observed during day and night time searches, nor recorded in any of the eDNA samples, despite the abundance of suitable habitat. The introduced plague skink (*Lampropholis delicata*) was observed in forest and scrub habitats and the introduced green and golden bell frog (*Ranoidea aurea*) was frequently seen in terrestrial and wetland habitats (Appendix 3: Plate I).

6.3 Aquatic fauna

One indigenous fish species, common bully (*Gobiomorphus cotidianus*; Not Threatened) (Appendix 3: Plate J) and one exotic fish species, mosquito fish (*Gambusia affinis*) were observed in both lakes during the survey. Mosquito fish are particularly abundant. eDNA sampling revealed the presence of an additional five indigenous fish species at the study site: longfin eel (*Anguilla dieffenbachii*; At Risk – Declining), shortfin eel (*A. australis*; Not Threatened), inanga (*Galaxias maculatus*; At Risk – Declining), banded kōkopu (*G. fasciatus*; Not Threatened), and redfin bully (*Gobiomorphus huttoni*; Not Threatened).

eDNA sampling detected an unspecified galaxiid species in the main wetland (sampling location WL3), which is assumed to be either banded kokopu or inanga. Black mudfish (*Neochanna diversus*; At Risk – Declining) were not seen during the surveys or detected in the eDNA samples. All fish species recorded during the survey and using eDNA analysis are listed in Table 2 together with their threat classifications. The waterboatman (*Diaprepocoris zealandiae*) was seen to be very abundant in all samples taken from the two main lakes, but interestingly did not show up on any of the eDNA results. Of the larger macroinvertebrate species, only the aurora bluetail damselfly (*Ischnura aurora*) and a caddisfly belonging to the subfamily Leptocerinae were detected by eDNA. Many species of annelid worm and water flea were also detected by the eDNA survey.

Table 2: Fish species detected during the survey and by eDNA analysis.

Common names	Scientific name	Conservation status (as per Dunn <i>et al.</i> 2018)	Location
Common bully	<i>Gobiomorphus cotidianus</i>	Not Threatened	Lakes, main wetland, D1 (drain)
Shortfin eel	<i>Anguilla australis</i>	Not Threatened	All sampling locations except eastern dune lakes (EDL)
Banded kokopu	<i>Galaxias fasciatus</i>	Not Threatened	Main wetland (WL3)

Common names	Scientific name	Conservation status (as per Dunn <i>et al.</i> 2018)	Location
Redfin bully	<i>Gobiomorphus huttoni</i>	Not Threatened	D1 (drain)
Inanga	<i>Galaxias maculatus</i>	At Risk – Declining	D1 (drain)
Longfin eel	<i>Anguilla dieffenbachii</i>	At Risk – Declining	Lake Rotokawau (LL1)
Unidentified galaxiid species	<i>Galaxias</i> spp.		D1 (drain)
Mosquitofish	<i>Gambusia affinis</i>	Introduced	Both lakes, main wetland, D1 (drain)

6.4 Terrestrial invertebrates

Twenty-eight terrestrial invertebrate species were recorded during the survey, 14 of which are likely to be indigenous (their indigenous/exotic status is difficult to tell with some species) and 13 introduced. Two threatened species were discovered in dune habitat at the western end of Puwheke Beach: katipō (At Risk – Declining¹; Appendix 3: Plates K and L) and empty shells of Archey’s snail (*Succinea archeyi*; Threatened – Nationally Critical²; Appendix 3: Plate M).

Dragonflies (Appendix 3: Plate N), damselflies (Appendix 3: Plate O) and moths were commonly observed in and around the main wetland, and several spider species including an unidentified wolf spider (*Anoteropsis* sp.) were recorded in terrestrial and wetland habitats (Appendix 3: Plates P to S). Two landhopper species were collected during the survey. *Waematau kaitaia* (Appendix 3: Plate T) is endemic to New Zealand and is now known to occur sporadically in forests from the Auckland region to the Whangarei District. This species was collected from both of the kānuka-dominant forest and scrub sites surveyed. This record is significant as it pushes the known distribution of this species much further north than previously thought. The second landhopper species found (also at both survey sites) was *Arcitalitrus dorrieni*. This species was introduced from Australia and is now found in many parts of New Zealand, particularly where habitats have been disturbed. There is evidence that *A. dorrieni* displaces indigenous landhopper species so it was encouraging to see *W. kaitaia* apparently holding its own. Other notable indigenous terrestrial invertebrates observed included the Auckland tree wētā (*Hemideina thoracica*) (Appendix 3: Plate U), a leaf-veined slug (*Athoracophorus* sp.) (Appendix 3: Plate V), and the smooth stick insect (*Clitarchus hookeri*).

All terrestrial invertebrate species recorded during the survey are listed in Table 3 together with their conservation status.

¹ Sirvid *et al.* (2021)

² Barker *et al.* (2021)

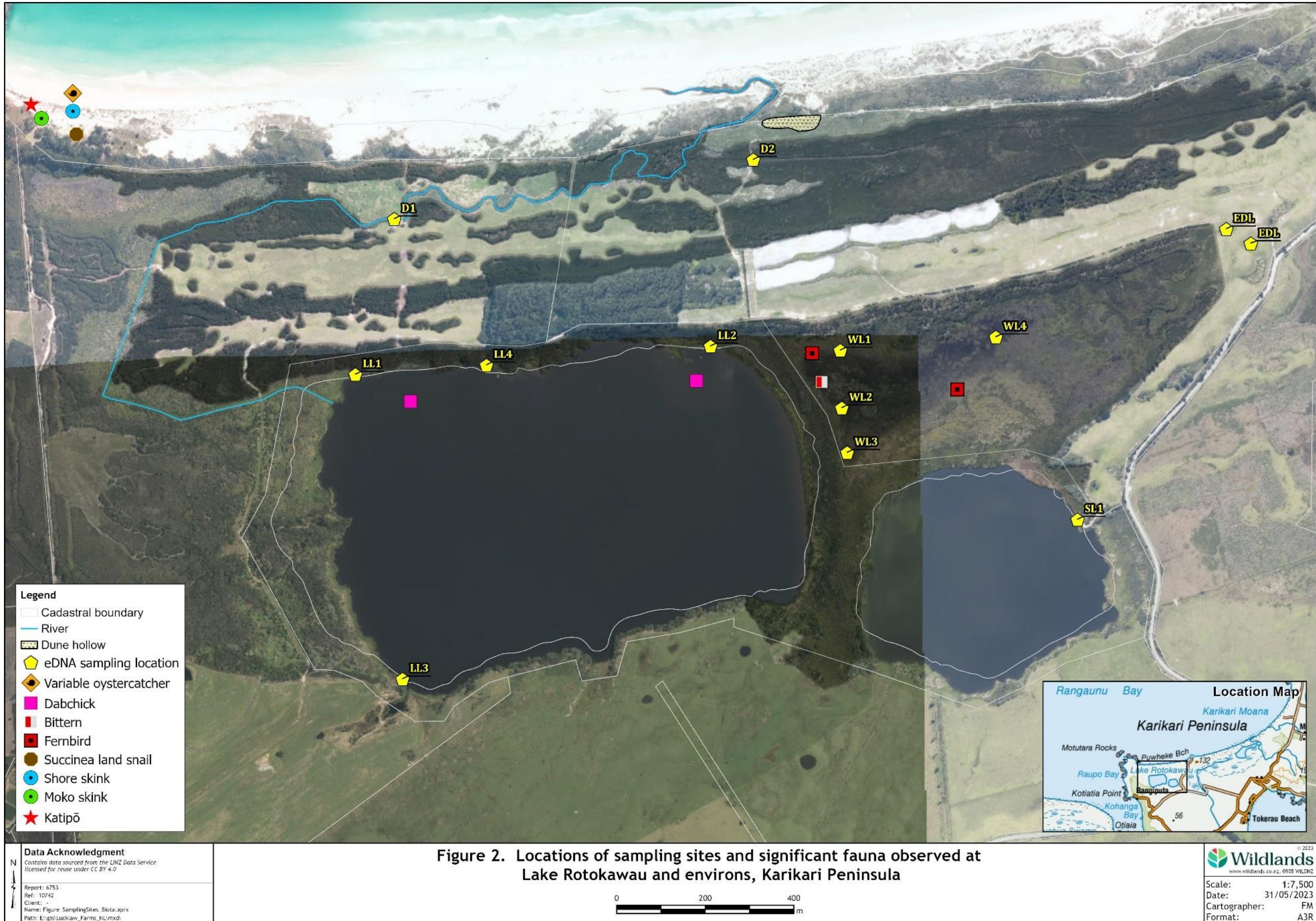
Table 3: Indigenous and introduced terrestrial invertebrates recorded during the field survey.

Common names	Scientific name	Conservation status	Native/exotic
Archey's dune snail ¹	<i>Succinea archeyi</i>	Threatened – Nationally Critical	Indigenous
Aurora bluetail	<i>Ischnura aurora</i>	Not Threatened	Indigenous
Blackish meadow katydid	<i>Conocephalus semivittatus</i>	Not Threatened	Indigenous
Blue damselfly	<i>Austrolestes colenisonis</i>	Not Threatened	Indigenous
Crane fly	<i>Leptotarsus albistigma</i>	Not listed	Indigenous
Katipō	<i>Latrodectus katipo</i>	At Risk – Declining	Indigenous
Landhopper (pekepeke-whenua)	<i>Waemataua kaitaia</i>	Not listed	Indigenous
Leaf-veined slug	<i>Athoracophorus</i> sp.	Taxonomic uncertainty	Indigenous
Long-jawed orbweaver	<i>Leucauge dromedaria</i>	Not Threatened	Indigenous
Long-jawed orbweaver	<i>Tetragnatha</i> sp.	Taxonomic uncertainty	Indigenous
Smooth stick insect	<i>Clitarchus hookeri</i>	Not Threatened	Indigenous
Tree wētā	<i>Hemideina thoracica</i>	Not Threatened	Indigenous
Wandering percher	<i>Diplacodes bipunctata</i>	Not Threatened	Indigenous
Wolf spider	<i>Anoteropsis</i> sp.	Taxonomic uncertainty	Indigenous
African praying mantis	<i>Myomantis caffra</i>	-	Exotic
Alligator weed beetle	<i>Agasicles hygrophila</i>	-	Exotic
Asian paper wasp	<i>Polistes chinensis</i>	-	Exotic
Australian paper wasp	<i>Polistes humilis</i>	-	Exotic
Brown shield bug	<i>Dictyotus caenosus</i>	-	Exotic
Buff tailed bumble bee	<i>Bombus terrestris</i>	-	Exotic
Darkling beetle	<i>Amarygmus watti</i>	-	Exotic
Garden snail	<i>Cornu aspersum</i>	-	Exotic
Grass-veneer moth	<i>Culladia cuneiferellus</i>	-	Exotic
Landhopper	<i>Arcitalitrus dorrieni</i>	-	Exotic
Leaf-footed bug	<i>Acantholybas brunneus</i>	-	Exotic
Long-legged sidymella	<i>Sidymella longipes</i>	-	Exotic
Small pointed snail	<i>Cochlicella barbara</i>	-	Exotic
Tropical armyworm	<i>Spodoptera litura</i>	-	Exotic

¹only empty shells found.

6.5 Pest mammal species

Two brushtail possums (*Trichosurus vulpecula*) were seen in kānuka during the spotlighting survey, and possum droppings and trails were frequently observed around the study site, particularly in Vegetation Types 2 and 4. Feral pig (*Sus scrofa*) sign was also commonly observed throughout terrestrial habitats. The usual suite of mammalian pest species is likely to be present at the study site and wider area, including rats (*Rattus* spp.), mice (*Mus musculus*), mustelids (*Mustela* spp.), hedgehog (*Erinaceus europeaus*), and rabbits. eDNA analysis confirmed the presence of possums near sampling location D1, pigs near the smaller lake, Norway rat (*Rattus norvegicus*) at the eastern dune lakes (EDL) and house mouse at D2.



7. ECOLOGICAL VALUES

7.1 Overview

The study site contains a range of terrestrial, wetland, and lacustrine ecosystems that form a semi-contiguous ecological sequence with dune habitat at Puwheke Beach. In a report prepared by Wildland Consultants (2011) for Northland Regional Council, the Rotokawau dune lakes and wetland were ranked 15th out of 304 wetlands in Northland. The report summarises the site as follows:

This site is part of a complex of lakes with a hard sand pan, wetlands, and shrublands linked to the Puwheke Beach dunes. The site is a good example in Aupouri Ecological District of a wide diversity of habitats including coastal wetlands stretching from the Rangiputa coast to Karikari Moana, containing high wildlife values. Dune lakes are especially rare on the east coast of Northland. Representative for four ecological units and contains a rare freshwater-shrubland-dunefield ecological sequence. The site supports seven threatened species, 15 'At Risk' species, and four regionally significant species...and is partially buffered by indigenous shrubland and exotic plantation. Threats include drainage, grazing, run-off, and weeds. Approximately 64.4 hectares of the site are protected within a Marginal Strip (administered by the Department of Conservation).

7.2 Wetland values

The large wetland that abuts the northern boundary of the eastern dune lake is an excellent example of a coastal bog system that is highly intact and supports a diverse range of wetland plant communities and fauna species. With the exception of *Utricularia gibba*, which is restricted to open pools, exotic plants are absent from the bog plant communities. All wetland plant associations within Vegetation Types 3, 5, and 6 are highly representative of coastal bog ecosystems. In addition, the wetland vegetation forms an intact freshwater-terrestrial ecological sequence with adjacent manuka scrub and shrubland.

Bittern (Threatened – Nationally Critical) and fernbird (At Risk – Declining) were both recorded during the survey in low numbers and the wetland likely provides important local habitat for both these species. Interestingly, neither spotless crane/pūweto (*Zapornia tabuensis*) nor marsh crane/kotoreke (*Z. pusilla*) were recorded in the wetland, despite multiple call playback surveys for the former. Both species have been previously recorded from the site (Wells and Champion 2013) and are likely to be present in low numbers, though we note that marsh crane were also not detected in a recent survey by Boffa Miskell.

More indigenous fish species (five species) were detected in the wetlands and associated drains than in the two main lakes (three species). Inanga (At Risk – Declining), banded kokopu (Not Threatened), and redfin bully (Not Threatened) were only detected in the wetlands and associated drains, and not in the lakes, indicating their value.

Black mudfish (At Risk – Declining) were not seen during the surveys or detected in the eDNA samples taken from the wetlands or the lakes. This is despite the species being recorded in a DOC SSBI report from 1993 in both main lakes (Wells and Champion 2013). However, we have found no entry for the species at the site in the New Zealand Freshwater Fish Database for 1993. It is possible that this species still persists in the wetland and lake areas and that the eDNA sampling lacked sufficient sensitivity to detect it, despite sampling being undertaken in ideal black mudfish habitat.

The value of the large wetland for invertebrates is also evident. Adult dragonflies and damselflies were abundant throughout, and several species of indigenous spider were observed, including an unidentified wolf spider as well as species known to frequent wetter areas (e.g., *Tetragnatha* sp.).

7.3 Rotokawau dune lakes

The Rotokawau dune lakes support a wide range of indigenous waterfowl, including threatened species such as dabchick (weweia) and Caspian tern (*Hydropogone caspia*; Threatened – Nationally Vulnerable), which were observed during the survey. Other notable bird species that have previously been recorded from the lake but were not seen during this survey include Australasian crested grebe (*Podiceps cristatus*; Threatened – Nationally Vulnerable) and pied shag (*Phalacrocorax varius*; At Risk – Declining). Neither of these species was detected via eDNA.

The diversity of fish species appears to be relatively limited; only three indigenous species were recorded during the present survey. Most significantly, longfin eel (At Risk – Declining) were recorded in the large western lake. This species has not been recorded in the Rotokawau Lakes area previously, so this is an encouraging observation. Shortfin eel (Not Threatened) and common bully (Not Threatened) were common throughout the lake and wetland areas.

The water boatman *Diaprepocoris zealandiae* was the most abundant macroinvertebrate collected in the lakes. It was surprising therefore that the species was not picked up by eDNA. However, many aquatic invertebrates were detected via the eDNA samples including the ubiquitous and indigenous New Zealand mud snail (*Potamopyrgus antipodarum*) (present in both main lakes), the introduced acute bladder snail (*Physella acuta*), and several species of Diptera (flies), water fleas, copepods, segmented worms, and hydra. Although most of these species can inhabit higher quality ecosystems, they are more indicative of low water quality freshwater bodies. Freshwater shrimp (*Paratya curvirostris*) were not detected during our eDNA survey despite being recorded in previous surveys (New Zealand Freshwater Fish Database). Also not detected were kōura (*Paranephrops planifrons*; Not Threatened (Grainger *et al.* 2013)). As far as we know, kōura have not been seen in the lakes previously, and the condition of the lakes is unsuitable for this species. Adult (flying) stages of various odonate species were conspicuous and abundant around the lakes and wetland areas, so it is surprising that only one species at one wetland site was picked up by the eDNA samples.

The water was turbid in both lakes during the surveys and it is likely that they are receiving nutrient inputs from the adjacent Pamu farm to the south. Sediment depth was noticeably higher along the southern margins of the larger lake, which is likely a result of less vegetation buffering and nutrient and soil inputs from the neighbouring farmland to the south. Sediment on the lakebed was very deep (c. 0.5 metre) in parts of the smaller lake and a strong sulphur smell was noticeable when walking on the sediment, indicating eutrophic conditions. Monitoring of two lakes undertaken by NIWA (Wells and Champion 2013) approximately ten years ago showed that the lakes were likely suffering from nutrification at the time. NIWA rated the water quality of the large and small dune lakes as ‘poor’, and their overall quality as ‘moderate’ as they provide valuable habitat for water birds and fish. The water quality of the smaller eastern dune lake was noticeably poorer than that of the large lake during this most recent survey.

7.4 Forest, scrub and shrubland values

As outlined in the report prepared by Boffa Miskell, the mānuka and kānuka species that dominate the terrestrial habitats at the farm are ‘local endemic’ species or subspecies, both of which are classified as ‘Threatened – Nationally Vulnerable’. There are likely to be few locations in eastern Northland where large areas of kānuka persist on consolidated dunes, which is largely a consequence of very limited legal protection.

Forest, scrub, and shrubland habitats at the farm are largely intact and provide important buffering to and connectivity with the two main dune lakes and large wetland. Intact freshwater-terrestrial sequences – particularly those supporting bog vegetation – are becoming increasingly rare both regionally and nationally. The lakeside forest and scrub support good populations of other threatened and regionally significant plant species such as the fern *Todea barbara* (Threatened – Nationally Endangered) and the shrub species *Veronica diosmifolia*.

Fernbird is present in shrubland habitats (Vegetation Type 3) and ‘At Risk’ gecko species such as Northland green gecko (*Naultinus greyi*) and possibly Te Paki gecko (*Dactylocnemis* “North Cape”) and Matapia gecko (*Dactylocnemis* “Matapia”) could be present throughout forest, scrub and shrubland habitats, albeit in low numbers due to a lack of predator control. The presence of the indigenous landhopper *Waematau Kaitaia*) is also encouraging as it suggests the area has been more or less constantly occupied by indigenous vegetation of sufficient quality such that some indigenous invertebrates have been able to persist.

7.5 Duneland values

The report prepared by Boffa Miskell (2022) describes the dunes as “*high quality examples with relatively undisturbed expanses of native dune plant communities. Species richness and diversity is high, with healthy populations of at least two ‘At Risk’ plants (pingaō, Ficinia spiralis and sand coprosma, Coprosma acerosa).*” Findings from our survey concur with this description; the foredunes and mid-dunes of Puwheke Beach are largely intact and free of pest plant species. Although only two variable oystercatchers and half a dozen southern black-backed gulls were observed on the beach during the survey, the area is known to be a regularly used habitat for other Threatened or At Risk indigenous shorebird species including New Zealand dotterel, Caspian Tern, white-fronted terns, and red-billed gulls (Boffa Miskell 2022). It is likely that the very windy conditions encountered during the survey pushed most of these species off the beach area into more sheltered locations.

The present survey also confirmed the presence of the following threatened plant and animal species: sand daphne/autetaranga (At Risk – Declining), *Senecio biserratus* (At Risk – Declining), katipō (At Risk – Declining), shore skink (At Risk – Declining), moko skink (At Risk – Relict), and the land snail *Succinea archeyi* (Threatened – Nationally Critical). Rear dunes comprise the most modified habitat along Puwheke Beach, where Sydney golden wattle is locally common in central and eastern parts of the beach while radiata pine (*Pinus radiata*) is locally frequent at the western end of the beach.

8. THREATS TO ECOLOGICAL VALUES

8.1 Introduced mammalian pests

Where they occur, introduced mammalian pests present the most serious indirect anthropogenic threats to indigenous flora and fauna in this country. The assumption is that most or all of the major mammalian predators will be present at the Rotokawau Lakes site. This includes ship rats, Norway rats, house mice, possums, feral cats (*Felis catus*), pigs, hedgehogs and mustelids (stoats and perhaps ferrets and weasels). These will be preying upon many of the indigenous species observed during this and previous surveys, and will be depleting their populations.

The presence of Norway rats, possums, house mice and pigs in and around the lakes and wetlands was confirmed via the eDNA survey. Norway rats, also known as the water rat or brown rat, are widespread and abundant in all habitats but are more likely to be found near bodies of water, so it was not surprising they were detected. Together with the ship rat, feral cat and mustelids, these will be preying on indigenous birds, lizards, and invertebrates. This likely explains the low numbers of observations for species such as fernbird and bittern, and the lack of any gecko records in and around the wetland and scrub areas. The current owners have reported a large increase in the number of feral cats since 2020, possibly as a result of the wetter summers.

Previously, pest control using cyanide on the Crown-owned areas was undertaken by the Department of Conservation, and this appeared to be very effective. However, this has since been discontinued, eliminating an important buffer that otherwise would have reduced pests invasion rates into the Lucklaw property. Northland Regional Council has advised the landowners that pigs will be managed (J. Sturgess, pers. comms.), but this appears to be insufficient as pigs are abundant and continue to cause localised damage across the property, as witnessed during our surveys.

Rabbits were also seen during the survey and these will provide food for feral cats and stoats. This ensures that the predators will remain in the area, and switch to indigenous species when rabbit numbers decline. Rabbits will also pose a problem in the dune areas where they feed on pīngao and sand coprosma. Being opportunistic, pigs will be preying on whatever indigenous animal and plant species they come across, as well as disturbing the vegetation and soil, which creates light gap and promotes invasion by exotic woody weeds.

8.2 Pest plants

The most serious weeds at the site are Sydney golden wattle, woolly nightshade and pampas grass. Sydney golden wattle is abundant throughout various vegetation types, and can at times heavily define a habitat type. The seedbank for this species is long-lived. However, this is a light-demanding species so is much more of a threat in disturbed areas such as where the radiata pines have been recently harvested. Sydney golden wattle seedlings, often in conjunction with kānuka seedlings make up the bulk of the regrowth in that area, so care will need to be taken with the management of that and other disturbed areas. Sydney golden wattle will be less of a problem in the more established habitats. There are significant seed sources of Sydney golden wattle close to the site, including the rear dunes of Puwheke Beach and the Kaimaumau wetland, to the west of the site. Continual reinvasion of this pest plant species is therefore a threat to the ecological integrity of forest and scrub habitats at Lucklaw Farm.

In comparison to Sydney golden wattle, woolly nightshade is more shade tolerant and can present on-going challenges in disturbed as well as the more established habitats. Larger woolly nightshade trees should be located and eliminated to reduce the seed sources for this species.

Pampas grass is the most serious pest plant in the southern part of the large wetland. The infestation is most likely a result of increased nutrient inputs from the neighbouring Pāmu property. Known to be a pest plant of wetland margins (among other habitat types), the infestation of pampas will likely be having several adverse ecological effects such as displacing indigenous vegetation, disrupting ecological processes and altering the habitat of indigenous fauna (e.g., wetland birds). Eliminating this species from the wetland may be possible and this would lead to multiple benefits.

8.3 Pastoral farming and land use

Pastoral farming is often associated with the degradation of land and water values. These include structural damage to sensitive soils and vegetation, as well as sedimentation and nutrient enrichment (through the use of chemical fertilisers and faecal contamination) of water bodies. There is no doubt that farming practices have had, and continue to have, a severe ecological impact on the lakes and wetlands. Tellingly, cattle DNA was detected in the large western lake in the eDNA survey. With the right farm management plan, adverse effects on the environment can be minimised. Unfortunately, however, the greatest threat to the Rotokawau Lakes area appears to come from neighbouring properties to the south, where intensive cattle farming is taking place. Large fertiliser plumes extending over the lakes have been observed and photographed by the current owners (A. Sturgess, pers.comms.), and this is likely to adversely impact almost all indigenous fauna that live or forage in the lakes, including water fowl.

In the near future (2025 for Northland and most other parts of the country), all pastoral farms over 20 hectares will need to develop a freshwater farm plan. These are ultimately designed to stop further degradation and bring New Zealand's waterways and aquatic ecosystems back to a healthy state. All farms will eventually need to do this, including the Lucklaw farm and the Pāmu farm bordering it. This will hopefully ensure that strict practices are put in place by the neighbouring properties. This could also be seen as an

opportunity for Lucklaw farm to start to develop its own freshwater farm plan as part of a greater farm management plan in anticipation of the new regulations.

8.4 Disturbance of dune habitat

An ongoing issue is the continued use of vehicles in the dunes by members of the public. On numerous occasions, the landowners report seeing vehicles driven over the sensitive vegetation along the dunes, as well as through the “river” where it emerges onto the beach. From the results of the survey, as well as recent work conducted by Boffa Miskell (2022), multiple significant biodiversity values on this beach have been identified, from Threatened and At-Risk plants, shorebirds and lizards to a Nationally critical sand dune snail and an At Risk taonga species of spider, the katipō. There is little doubt that vehicular traffic on the beach and dunes at Puwheke Beach poses a significant risk to these species as well as the natural character of the beach and dunes.

9. MANAGEMENT RECOMMENDATIONS

9.1 Pest animal control

The key pest animal species that require control across the study site are possums, rats, and feral pigs, although species such as stoats, ferrets, and hedgehogs should also be included in a pest control regime. As discussed with the landowners, a practical and efficient means by which to control rats and possums is to deploy Feracol Strikers around the property, with a focus on vegetation types 1 and 2, particularly the areas of forest and scrub that bound the lakes and main wetland. The active ingredient in the Strikers is cholecalciferol, which is a form of vitamin D3. The baits are fast-acting, fully biodegradable, and do not require a bait station.

DOC200 kill traps should be deployed to control mustelids and hedgehogs. The traps can be placed at approximately 200-metre intervals and baited with a combination of dried rabbit and whole eggs.

A professional hunter should be contracted to shoot feral pigs. Any feral cats encountered during pig control should be shot, if possible.

9.2 Pest plant control

The key pest plant species that require control within terrestrial habitats is Sydney golden wattle and, to a lesser extent, woolly nightshade. Vegetation Types 1, 4, and 11 should be targeted for the control of these species. Drill and fill (with undiluted glyphosate) can be used to control larger trees, while smaller wattles and all woolly nightshade shrubs can be cut at the base and treated with herbicide paste (100ml triclopyr (600g/L) per 1L water; or 5g metsulfuron-methyl (600g/kg) per 1L water for Sydney golden wattle and Tordon Brushkiller or triclopyr 600 EC (100ml/L) or Vigilant gel for woolly nightshade). Sydney gold wattle trees or even shorter shrubs on the habitat margins should be included in control efforts as these will grow rapidly in such high light areas and act a source of seed for years to come. All trees and shrubs can be left to breakdown on site.

The key pest plant species that requires control within wetland habitats is pampas, particularly the large infestation in the southern part of the main wetland. While a ground-based operation can be used to control pampas on the periphery of wetland habitats, it would not be practical for the large infestation (Vegetation Type 8). It is recommended that an aerial application of grass-specific herbicide such as haloxyfop is used to control this infestation. The herbicide could be sprayed either from a helicopter or a drone, but should only be done during fine, calm conditions.

9.3 Stock exclusion

Priority should be given to excluding stock from all dune lakes and dune hollows on the farm, including the smaller eastern dune lakes between the main wetland and Puwheke Road, and the dune hollow along the northern property boundary. However, this needs to be done in the context of the most appropriate weed management. For example, gorse is still a major problem around the eastern dune lakes so it is likely that more work will need to be done around these before they can be fenced off. It is acknowledged that resources are not currently available to fence all areas within Vegetation Type 1, although it would be beneficial to fence those areas that support wetland vegetation in their interiors.

9.4 Reducing lakes nutrient levels

There is an opportunity to engage with Pāmu to find a solution that involves reducing the amount of nutrients leaching from their pastoral land into the two lakes. Interpretation of aerial photography indicates the presence of numerous dune lakes, wetlands, streams, and drains on the Pāmu property, all of which are vulnerable to stock incursion and effluent. As a minimum, all streams and drains that discharge into the lakes and surrounding vegetation should be fenced to exclude stock. This should be captured by the Pāmu farm when establishing their freshwater farm plan. This may also involve placing limits on rates of lime and fertiliser applications per year.

9.5 Vehicle access to Puwheke Beach and duneland

Objective 1 of the New Zealand Coastal Policy Statement (2010) (NZCPS) is:

“To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by:

- maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature;
- protecting representative or significant natural ecosystems and sites of biological importance and maintaining the diversity of New Zealand’s indigenous coastal flora and fauna; and...”...etc.

Also, policy 11A of the NZCPS seeks to:

“a. avoid adverse effects of activities on:

- i. indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists.
- ii. indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare.”

Given that Puwheke Beach comprises a threatened coastal habitat that is still relatively unmodified by weeds and other factors, and as the ecological values at the site are considered to be very high, it is evident that Puwheke Beach is representative of a highly intact coastal duneland that is under threat from the use of private vehicles. Based on these findings, it is important to the long-term viability of the dune habitats that private vehicles should not be allowed on the beach and dunelands at Puwheke Beach.

ACKNOWLEDGMENTS

We are grateful to Andrea and John Sturgess for their very kind hospitality during the site visit and also for the very useful background information they provided.

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LIST OF VASCULAR PLANT SPECIES RECORDED FROM
LUCKLAW FARM, LAKE ROTOKAWAU AND ENVIRONS, AND
PUWHEKE BEACH

INDIGENOUS SPECIES

* = planted

Gymnosperms

*Dacrydium cupressinum** rimu
Podocarpus totara var. *totara** tōtara

Monocot. trees and shrubs

Cordyline australis tī kōuka, cabbage tree
*Rhopalostylis sapida** nīkau

Dicot. trees and shrubs

Coprosma acerosa s.s. sand coprosma, tarakupenga, tātaraheke
Coprosma lucida karamū, kāramuramu, glossy karamū
Coprosma repens taupata
Coprosma rhamnoides
Geniostoma ligustrifolium var. *ligustrifolium* hangehange
Kunzea linearis rawiri mānuka, kānuka
Leptecophylla juniperina var. *juniperina* prickly mingimingi
Leptospermum scoparium var. *incanum* mānuka
Leucopogon fasciculatus mingimingi
Metrosideros excelsa pōhutukawa
Myrsine australis māpou, matipou, māpau
Pimelea villosa s.s. autetauranga; sand pimelea
Pseudopanax lessonii houpara
Pterophylla silvicola tōwai
Veronica diosmifolia
*Vitex lucens** pūriri

Dicot. lianes

Calystegia soldanella shore bindweed
Cassytha paniculata taihoa, māwhai
Muehlenbeckia complexa pōhuehue

Lycopods and psilopsids

Lycopodiella cernua mātukutuku
Phlegmariurus billardierei īwituna, hanging clubmoss
Pseudolycopodium densum puakarimu

Ferns

<i>Asplenium flaccidum</i> subsp. <i>flaccidum</i> splenwort	makawe, ngā makawe o raukatauri, drooping
<i>Asplenium oblongifolium</i>	huruhuru whenua, shining spleenwort
<i>Asplenium polyodon</i>	petako, paratao, sickle spleenwort
<i>Blechnum minus</i>	swamp kiokio
<i>Blechnum novae-zelandiae</i>	kiokio, horokio
<i>Gleichenia dicarpa</i> fern	matua-rarauhe, tangle fern, swamp umbrella
<i>Gleichenia microphylla</i>	waewaekākā, carrier tangle fern
<i>Histiopteris incisa</i>	mātātā, water fern
<i>Hiya distans</i>	
<i>Pteridium esculentum</i> subsp. <i>esculentum</i>	rārahu, bracken
<i>Pyrrosia elaeagnifolia</i>	leather-leaf fern
<i>Todea barbara</i>	todea

Grasses

<i>Austroderia splendens</i>	coastal toetoe
<i>Isachne globosa</i>	swamp millet
<i>Lachnagrostis billardierei</i>	sand wind grass
<i>Lachnagrostis filiformis</i>	

Sedges

<i>Carex pumila</i>	
<i>Carex testacea</i>	
<i>Carex virgata</i>	pūrei
<i>Cyperus ustulatus</i>	toetoe upoko-tangata
<i>Eleocharis acuta</i>	spike sedge
<i>Eleocharis sphacelata</i> paopao	giant spike sedge, ngāwhā, kuta.kutakuta,
<i>Ficinia nodosa</i>	wīwī
<i>Ficinia spiralis</i>	pīngao
<i>Isolepis prolifera</i>	
<i>Lepidosperma australe</i>	
<i>Lepidosperma laterale</i>	
<i>Machaerina articulata</i>	
<i>Machaerina juncea</i>	
<i>Machaerina rubiginosa</i>	
<i>Machaerina teretifolia</i>	
<i>Schoenoplectus tabernaemontani</i>	kāpūngāwhā
<i>Schoenus brevifolius</i>	

Rushes

<i>Apodasmia similis</i>	oioi
<i>Empodisma minus</i>	wire rush
<i>Juncus pallidus</i>	wī, wīwī

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

<i>Astelia banksii</i>	kakaha, pūwharawhara, wharawhara,
kōwharawhara	
<i>Dianella haemata</i>	
<i>Dianella nigra</i>	tūrutu
<i>Lemna disperma</i>	karearea
<i>Phormium tenax</i>	harakeke, flax
<i>Typha orientalis</i>	raupō

Dicot. herbs (other than composites)

<i>Centella uniflora</i>	
<i>Drosera binata</i>	sundew, wahu
<i>Epilobium pallidiflorum</i>	tawarewa
<i>Glossostigma elatinooides</i>	
<i>Gonocarpus incanus</i>	piripiri
<i>Lobelia anceps</i>	punakura
<i>Myriophyllum propinquum</i>	
<i>Persicaria decipiens</i>	tutunawai
<i>Solanum americanum</i>	raupeti

NATURALISED AND EXOTIC SPECIES

Dicot. trees and shrubs

<i>Acacia longifolia</i>	Sydney golden wattle
<i>Acacia mearnsii</i>	black wattle
<i>Paraserianthes lophantha</i>	brush wattle
<i>Pelargonium capitatum</i>	rose-scented geranium
<i>Solanum mauritianum</i>	woolly nightshade
<i>Ulex europaeus</i>	gorse

Ferns

<i>Azolla pinnata</i>	ferny azolla
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Grasses

<i>Anthoxanthum odoratum</i>	sweet vernal
<i>Briza minor</i>	shivery grass
<i>Bromus diandrus</i>	ripgut brome
<i>Cenchrus clandestinus</i>	kikuyu grass
<i>Cortaderia selloana</i>	pampas
<i>Holcus lanatus</i>	Yorkshire fog
<i>Lagurus ovatus</i>	harestail
<i>Paspalum distichum</i>	Mercer grass
<i>Paspalum urvillei</i>	Vasey grass
<i>Sporobolus africanus</i>	ratstail

Rushes

<i>Juncus effusus</i> var. <i>effusus</i>	soft rush, leafless rush
<i>Juncus tenuis</i> var. <i>tenuis</i>	track rush

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

<i>Aristea ecklonii</i>	aristea
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Composite herbs

<i>Ageratina adenophora</i>	Mexican devil
<i>Erigeron sumatrensis</i>	broad-leaved fleabane
<i>Hypochaeris radicata</i>	catsear
<i>Senecio elegans</i>	purple groundsel

Dicot. herbs (other than composites)

Alternanthera philoxeroides

Lotus pedunculatus

Lotus suaveolens

Ludwigia palustris

Ludwigia peploides

Pelargonium capitatum

Persicaria hydropiper

Phytolacca octandra

alligator weed

lotus

hairy birdsfoot trefoil

water purslane

primrose willow

rose-scented geranium

water pepper

inkweed

LIST OF FAUNA SPECIES RECORDED FROM LUCKLAW FARM, LAKE ROTOKAWAU AND ENVIRONS, AND PUWHEKE BEACH

MAMMALS

Introduced (feral)

<i>Oryctolagus cuniculus cuniculus</i>	European rabbit
<i>Sus scrofa</i>	feral pig
<i>Trichosurus vulpecula</i>	brush-tail possum

BIRDS

Indigenous

<i>Anthus novaeseelandiae novaeseelandiae</i>	pīhoihoi; New Zealand pipit
<i>Botaurus poiciloptilus</i>	matuku-hūrepo; Australasian bittern
<i>Bowdleria punctata vealeae</i>	mātātā; North Island fernbird
<i>Circus approximans</i>	kāhu; swamp harrier
<i>Cygnus atratus</i>	kakānau; black swan
<i>Gerygone igata</i>	riroriro; grey warbler
<i>Haematopus unicolor</i>	tōrea; tōrea pango; variable oystercatcher
<i>Hirundo neoxena neoxena</i>	warou; welcome swallow
<i>Hydroprogne caspia</i>	taranui; Caspian tern
<i>Larus dominicanus dominicanus</i>	karoro; southern black-backed gull
<i>Larus novaehollandiae scopulinus</i>	tarāpunga; red-billed gull
<i>Phalacrocorax varius varius</i>	kāruhiruhi; pied shag
<i>Poliiocephalus rufopectus</i>	weweia; New Zealand dabchick
<i>Rhipidura fuliginosa placabilis</i>	pīwakawaka; tīrairaka; North Island fantail
<i>Tadorna variegata</i>	pūtangitangi; paradise shelduck
<i>Todiramphus sanctus vagans</i>	kōtare sacred kingfisher; New Zealand kingfisher
<i>Vanellus miles novaehollandiae</i>	spur-winged plover, masked lapwing
<i>Zosterops lateralis lateralis</i>	tauhou; silvereye; wax-eye; white-eye

Introduced

<i>Acridotheres tristis</i>	myna
<i>Alauda arvensis</i>	Eurasian skylark
<i>Anas platyrhynchos</i>	mallard
<i>Branta canadensis</i>	Canada goose
<i>Carduelis carduelis britannica</i>	European goldfinch
<i>Carduelis chloris</i>	European greenfinch
<i>Emberiza citrinella caliginosa</i>	yellowhammer
<i>Gymnorhina tibicen</i>	Australian magpie
<i>Meleagris gallopavo</i>	wild turkey
<i>Phasianus colchicus</i>	common pheasant
<i>Turdus merula merula</i>	Eurasian blackbird

REPTILES/MOKOMOKO

Skink

Oligosoma moco (AR-Rel)
Oligosoma smithi (AR-NU)

moko skink
shore skink

Introduced and Naturalised

Lampropholis delicata

plague skink, rainbow skink (Unwanted Organism-MPI)

FISH

Indigenous

Anguilla australis
Anguilla dieffenbachii
Galaxias fasciatus
Galaxias maculatus
Gobiomorphus cotidianus
Gobiomorphus huttoni

shortfin eel, tuna
longfin eel, tuna
banded kōkopu
īnanga
common bully
redfin bully

Introduced and Naturalised

Gambusia affinis

mosquitofish

FROGS

Naturalised

Ranoidea aurea

green and golden bell frog



FRESHWATER INVERTEBRATES

<i>Acanthocyclops robustus</i>	Cyclops
<i>Amyntas cortices</i>	Earthworm (Clitellata)
<i>Aporrectodea trapezoids</i>	Earthworm (Clitellata)
<i>Arcella cf. vulgaris</i>	Amoeba
<i>Astrohydra japonica</i>	Hydra
<i>Bosmina longirostris</i>	Water flea
<i>Bosmina meridionalis</i>	Water flea
<i>Bothrioneurum sp.</i>	Aquatic worm (Clitellata)
<i>Chaetogaster diaphanus</i>	Aquatic worm (Clitellata)
<i>Chaetogaster diastrophus</i>	Aquatic worm (Clitellata)
<i>Chironomus cloacalis</i>	Grey midge
<i>Chydorus brevilabris</i>	Water flea
<i>Cognettia pseudosphagnetorum</i>	Earthworm (Clitellata)
<i>Corynoneura scutellate</i>	Non-biting midge
<i>Culex sp.</i>	Mosquito
<i>Daphnia galeata</i>	Water flea
<i>Dero digitata</i>	Aquatic worm (Clitellata)
<i>Dero sp.</i>	Aquatic worm (Clitellata)
<i>Diaprepacoris zealandiae</i>	Water boatman
<i>Eubosmina coregoni</i>	Water flea
<i>Eukerria saltensis</i>	Aquatic worm (Clitellata)
Eupodidae	Mite
Eurotatoria sp.	Rotifer
<i>Hydra vulgaris</i>	Hydra
<i>Ischnura aurora</i>	Aurora bluetail
Leptocerinae	Caddisfly
<i>Limnodrilus hoffmeisteri</i>	Aquatic worm (Clitellata)
<i>Lumbriculus variegatus</i>	Aquatic worm (Clitellata)
<i>Lumbricus rubellus</i>	Earthworm (Clitellata)
<i>Megascolex laingii</i>	Earthworm (Clitellata)
<i>Mesocyclops leuckarti</i>	Cyclops
<i>Paratanytarsus grimmii</i>	Chironomid midge
<i>Physella acuta</i>	Acute bladder snail
<i>Polypedilum pavidus</i>	Chironomid midge
<i>Potamopyrgus antipodarum</i>	NZ mud snail
<i>Potamothrrix bavaricus</i>	Aquatic worm (Clitellata)
<i>Pristina sp.</i>	Aquatic worm (Clitellata)
<i>Zygoribatula sp.</i>	Mite

TERRESTRIAL INVERTEBRATES

Indigenous

<i>Anoteropsis</i> sp.	Wolf spider
<i>Athoracophorus</i> sp.	Leaf-veined slug
<i>Austrolestes colensonis</i>	Blue damselfly
<i>Clitarchus hookeri</i>	Smooth stick insect
<i>Conocephalus semivittatus</i>	Blackish meadow katydid
<i>Diplacodes bipunctata</i>	Wandering percher
<i>Hemideina thoracica</i>	Auckland tree wētā
<i>Ischnura aurora</i>	Aurora bluetail
<i>Latrodectus katipo</i>	katipō
<i>Leptotarsus albistigma</i>	Cranefly
<i>Leucauge dromedaria</i>	Long-jawed orb weaver
<i>Succinea archeyi</i> (T-NE)	Archey's dune snail
<i>Tetragnatha</i> sp.	Long-jawed orb weaver
<i>Waemataua kaitaia</i>	Landhopper

Introduced

<i>Acantholybas brunneus</i>	Leaf-footed bug
<i>Agasicles hygrophila</i>	Alligator weed beetle
<i>Amarygmus watti</i>	Darkling beetle
<i>Arcitalitrus dorrieni</i>	Landhopper
<i>Bombus terrestris</i>	Buff-tailed bumble bee
<i>Cochlicella barbara</i>	Small pointed snail
<i>Cornu aspersum</i>	Garden snail
<i>Culladia cuneiferellus</i>	Grass veneer moth
<i>Dictyotus caenosus</i>	Brown shield bug
<i>Myomantis caffra</i>	<i>African praying mantis</i>
<i>Polistes chinensis</i>	Asian paper wasp
<i>Polistes humilis</i>	Australian paper wasp
<i>Sidymella longipes</i>	Long-legged sidymella
<i>Spodoptera litura</i>	Tropical armyworm

SITE PHOTOGRAPHS



Plate A: large seed capsules of mānuka (*Leptospermum scoparium* var. *incanum*). 14 April 2023.



Plate B: The threatened fern species, *Todea barbara*, in Vegetation Type 2 near the northern shoreline of Lake Rotokawau. 15 April 2023.



Plate C: Sand daphne/autetaranga in the mid-dunes of Puwheke Beach. 15 April 2023.



Plate D: Sand coprosma in the mid-dunes of Puwheke Beach. 15 April 2023.



Plate E: *Senecio biserratus* growing amongst pōhuehue in the back dunes of Pūwheke Beach.
14 April 2023.



Plate F: *Veronica diosmifolia* in Vegetation Type 2 near the northern shoreline of Lake Rotokawau.
13 April 2023.



Plate G: Forked sundew, a carnivorous plant species that feeds on small insects, has a small but healthy population within the main wetland.
13 April 2023.



Plate H: Adult shore skink observed in the foredunes at the eastern end of Puwheke Beach. 14 April 2023.



Plate I: Green and golden bell frog observed during night-time spotlighting for geckos. 13 April 2023.



Plate J: Common bully captured in a kick net, Lake Rotokawau. 15 April 2023.



Plate K: Male katipō observed in foredunes at eastern end of Puwheke Beach.
13 April 2023.



Plate L: Female katipō observed in foredunes at eastern end of Puwheke
Beach. 14 April 2023.



Plate M: Empty shells of the threatened snail species *Succinea archeyi* observed in the back dunes of Puwheke Beach. 14 April 2023.



Plate N: The dragonfly *Diplacodes bipunctata* observed in *Schoenus brevifolius* sedgeland (main wetland). 14 April 2023.



Plate O: The damselfly *Austrolestes colenisonis* observed in *Schoenus brevifolius* sedgeland (main wetland). 14 April 2023.



Plate P: The wolf spider (*Anoteropsis* sp.) observed in *Schoenus brevifolius* sedgeland (main wetland). 14 April 2023.



Plate Q: Long-jawed orb weaver (*Tetragnatha* sp.) observed on a pōhutukawa on the northern shoreline of Lake Rotokawau. 15 April 2023.



Plate R: Cyclops jumping spider (*Opisthoncus polyphemus*) observed in forest on the northern shoreline of Lake Rotokawau. 15 April 2023.



Plate S: Square-ended crab spider (*Sidymella longipes*) observed during night-time spotlighting. 14 April 2023.



Plate T: The indigenous landhopper *Waematau kaitaia* collected from leaf litter in kānuka-dominant forest and scrub. 15 April 2023.



Plate U: Auckland tree wētā (*Hemideina thoracica*) observed during night-time spotlighting. 14 April 2023.



Plate V: Leaf-veined slug (*Athoracophorus* sp.) observed during night-time spotlighting. 14 April 2023.



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