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The biota and geology of Ngārango Otainui: A mixed indigenous / naturalised vegetation association of the Māngere Inlet, Manukau Harbour

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Abstract

An account of the geology, vegetation associations, mycobiota, flora and avifauna of Ngārango Otainui, a 0.309 ha island located at the eastern end of the Māngere Inlet, Manukau Harbour, Tāmaki Makaurau / Auckland is provided. This appears to be the first comprehensive account of the island's geology, vegetation and biota. The island has been mapped by others as Puketoka Formation; our survey confirmed this, noting that the basal exposed portion of the island appears to be a distal, heavily weathered ignimbrite over which is deposited a series of tephras (Hamilton Ashes). The flora and mycobiota of the island, assessed over three visits (2009 and 2021) recorded 125 taxa from 57 families and 100 genera from Ngārango Otainui, and vouchers for 119 (95%) of these obtained. Fifty-two (54%) of the vascular plants and four (36%) of the bryophytes are naturalised to New Zealand and most of these dominate the island's vegetation. Earliest imagery (1940) available suggests that the island was then dominated by grassland, and that since then the island has developed a woody vegetation dominated by naturalised plants, mostly from dispersal from nearby Auckland City urban sources. Fourteen of these plants are regarded as pest species within the Auckland Council Region. During two visits (January and November 2021) 14 species of bird were noted on or around the island. While no nationally threatened taxa were found, one plant, *Bromus arenarius*, five lichens and three birds seen are listed as 'At Risk' by threat listing panels using the New Zealand Threat Classification System. Nine vegetation associations (and sparsely vegetated landforms) were recognised. These are described in this paper and their extent given and mapped. Since aerial imagery became available for the island, 55% of the island has been lost through erosion, which is ongoing.

Keywords

Ngārango Otainui; Māngere Inlet; Manukau Harbour; biota, vegetation associations; naturalised plants; erosion

Introduction

Ngārango Otainui (0.309 hectares, 4 m a.s.l., -36.938736°S 174.820305°E, Figures 1, 2) is the only island within the Māngere Inlet of the Manukau Harbour, Tāmaki Makaurau / Auckland. Ngārango Otainui is located at the eastern end of the Māngere Inlet, surmounting the southern end of a broad mudbank that is covered in c.1 m of water at high tide. The island is reasonably close to land; the nearest point of land, Norana Park, Māngere, to the south west of the island is c.513 m distant.

The first mention, or really depiction, of the island is that by Hochstetter (1859, published in 1864), who called it 'Hara nui', noting also that west of the island across a channel was a 'white shell bank'. This shell bank may already have been vegetated, though Hochstetter did not mention this; irrespective, the earliest aerial imagery we can find of Ngārango Otainui (1940) shows Hochstetter's 'white shell bank' as another, low-lying, vegetated island, which had almost completely vanished through coastal erosion by 1972, and which by 1985 had completely gone. The name 'Hara nui' is of interest; 'Hara' is a te reo Māori term used to denote placement of a stick, bent at the top to indicate the site where a rangatira died, thus designating the location tapu (Williams 2001: 36). Thus 'Hara nui' may indicate the site where a prominent rangatira died (T. White, pers. comm., 23 November 2021). Subsequently the island has been variously referred to as 'Otainui' or 'Ngārango Otainui', which could refer to a species of blowfly ('Ngāro rango' or 'Ngārango', see Williams 2001: 230),

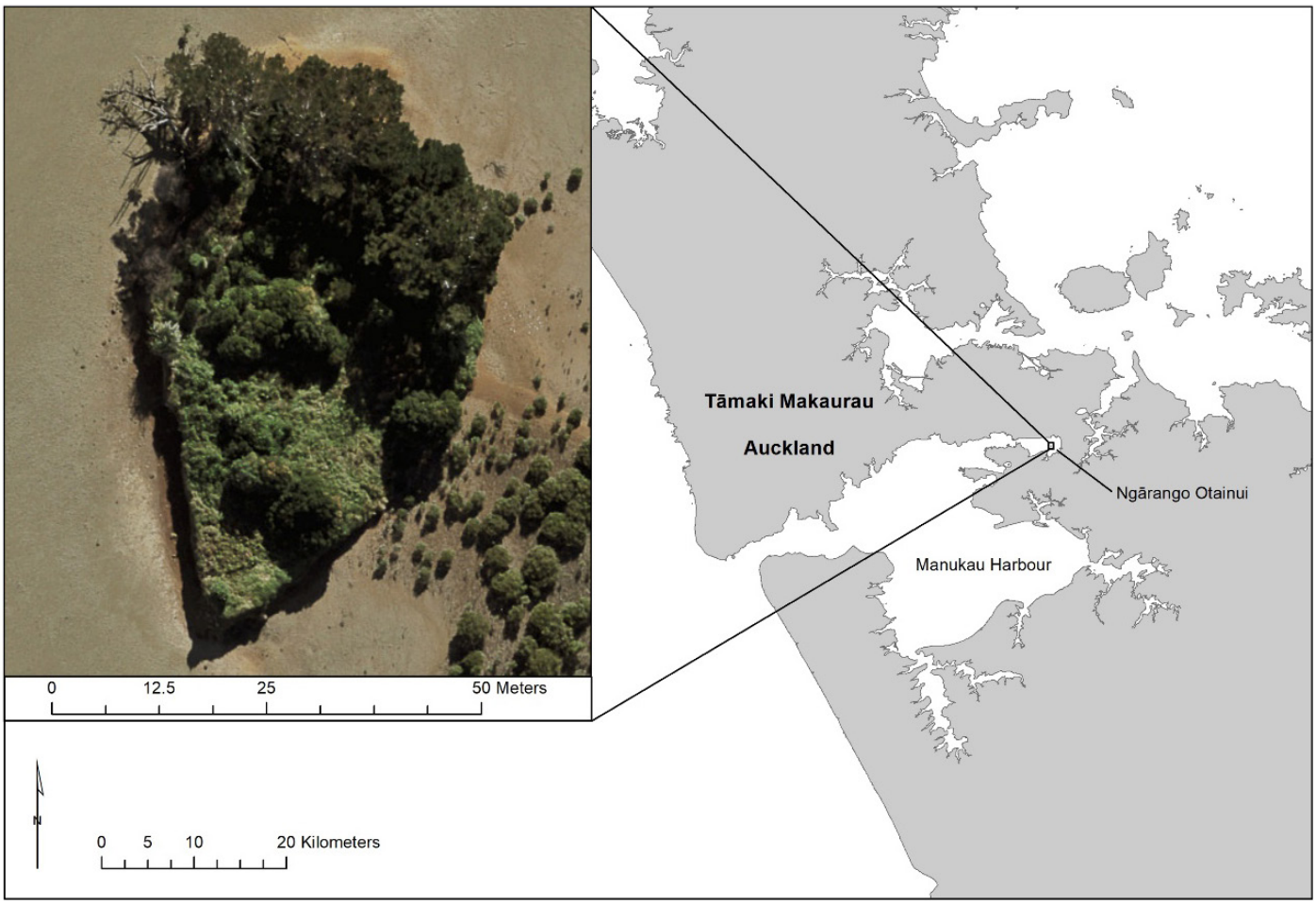

Figure 1. Location of Ngārango Otainui, Mangere Inlet, Manukau Harbour, Auckland. Aerial image courtesy of Land Information New Zealand (Eagle Technology, Land Information New Zealand).

while 'Otainui' may relate to the passage of the Tainui waka, which was hauled across the Tāmaki isthmus via Te Tō Waka and relaunched in the Māngere Inlet of the Manukau near the island (Rāwiri 2005); hence, the island name may in some way refer to a prophetic or spiritual blowfly associated with that waka, e.g, 'Ngārango o Tainui'. However, as with most Māori place names, the exact meaning without knowledge of the context in which it was given is open to speculation. We may never know the reason for the island's Māori name, nor why Hochstetter (1859, published in 1864) called it 'Hara nui' and it is now known as 'Ngārango Otainui'.

Ngārango Otainui captured public imagination when on 15 February 2016 the privately owned island was put up for sale, touted then as "one of New Zealand's smallest islands" (Gibson 2016), and soon purchased by Arzan Hajee and Arif Hajee who, it seems, then transferred it to the crown, who now hold the land "for roading purposes" (https://map.grip.co.nz/ [accessible cadastral information]).

Despite its proximity to land (Figure 1), it would seem that the island's vegetation and flora has never been documented. We can find no mention of it in the seminal works and notebooks of pioneering Auckland botanists Thomas Kirk, Thomas Cheeseman, Lucy Cranwell or Donald Petrie (who lived his last decade or so in Onehunga within sight of the island [Cockayne 1926]). Indeed, prior to our visits on 7 February 2009 (P.J. de Lange), 23 January 2021 (P.J. deLange & A.J. Marshall) and 6 November 2021 (P.J. deLange, A.J. Marshall, L.M.H. Schmid and S. Graham) we could find only one herbarium specimen, a collection of *Gladiolus ×hortulanus* made by Rhys O. Gardner from the island on 25 March 2001. We have seen no published observations about the island in regional botanical society literature either.

Ngārango Otainui, our field work and research soon disclosed, is an island that has developed from the open fernland / grassland evident in aerial imagery during the 1940s to an island supporting a flora and series of vegetation associations dominated by naturalised plants. This flora appears to have mostly colonised the island through dispersion from the adjacent urban landscape

of Auckland. Despite this intriguing vegetation, we also discovered that the island is, as past owner Stan McCloskey stated, "slowly washing away" (Gibson 2016, see also discussion below). This paper is timely, then, as it brings together for the first time the geology, biota and vegetation of Ngārango Otainui, an island which, to quote Stan McCloskey, "won't be there in 20, 30, 40 years' time" (Gibson 2016).

Geology and physiography

Ngārango Otainui (Figure 2) is aligned north to south, almost in the shape of an inverted isosceles triangle, c.46 m wide at its widest point at the northern end of the island and 5 m wide at the southern end. The highest point on the island, on the cliffs at the north-western end, we estimated at 4 m a.s.l.; the lowest point, c. 1.5 m a.s.l., is located midway along the eastern side of the island. The margins of the island are mostly sharply delineated by cliff faces (Figure 3), with those on the western side actively eroding. Otherwise the surface of the island is more-or-less flat though gradually sloping south east from the high point on the western cliffs to the lowest point on the eastern side of the island. In fact, at the time of our last visit (November 2021), at the south-western end of the island, ongoing coastal erosion had nearly undermined the sole pōhutukawa (*Metrosideros excelsa*[1]) on the island (Figure 5), and sometime between 2007 and 2009 (based on aerial imagery), erosion had caused a massive pine (*Pinus radiata*) growing at the north-western end of the same cliffs to topple into the sea (Figure 4). Material eroded from this side of the island is in part what has built up the small beach and mangrove (*Avicennia marina* subsp. *australasica*) covered bar on the eastern side of the island (Figure 1).

Kermode (1992) mapped the island as Puketoka Formation, though it is not clear whether he surmised this or based his decision on an actual field inspection. The Puketoka Formation is part of the Holocene-aged Tauranga Group (Kear & Schofield 1978; Edbrooke et al. 2001), which as interpreted by Kermode (1992) encompasses a range of lithologies including lignite beds, rhyolitic ignimbrites, tephra, peat, conglomerates and carbonaceous mudstone (see comments by Hayward

[1] Authorities for all taxa present on Ngārango Otainui, unless otherwise mentioned, are provided in Appendices 1 and 2.

Figure 2. Ngārango Otainui, as seen at low tide from the southern end looking north. Photo: Peter J. de Lange.

Figure 3. Western cliff face of Ngārango Otainui showing Hamilton Ash sequence overlying distal ignimbrite (Puketoka Formation). Photo: Peter J. de Lange.

Figure 4. Remains of two pines (*Pinus radiata*), probably originally planted ones that had fallen into the sea as a result of ongoing erosion of the western side of Ngārango Otainui. Photo: Peter J. de Lange.

Figure 5. Coastal erosion of western cliff face, southern end of Ngārango Otainui, undermining the only known pōhutukawa (*Metrosideros excelsa*) on the island. Photo: Peter J. de Lange.

& Grenfell 2010). The western shoreline of the island is delineated by a prominent c.4 m high cliff face that exposes a complete sequence from low-tide mark to the vegetated island surface (Figure 3). The basal layer comprises c.1–1.2 m of heavily weathered, greyish, finely pumiceous / siliceous clay (Figures 6A, 6B), which is distinctly gritty in the hand (interpreted here as a heavily weathered distal ignimbrite). This layer is riddled with numerous vertical holes of varying diameter (some 30 mm diameter, others 10 mm diameter), the margins of which are stained brown or in places occluded with ligneous material (Figure 6A). These we suspect may be the remains of the roots of a former vegetated surface rather than mud crab (*Austrohelice crassa* [Dana, 1851]) burrows, as during all visits no mud crabs were seen either around the island or in any of the holes, several of which were dug out for critical inspection. Above this layer there is a c.1 m thick layer of blocky greyish-orange clay, which in turn is overlaid by a c. 1.5 m series of horizontally layered dark red, red-brown and pale yellow-white bands (Figure 3). This last layer has been identified by David J. Lowe (pers. comm. 2021) as Hamilton Ash. Above the Hamilton Ash a shallow, brown-black, friable soil has developed.

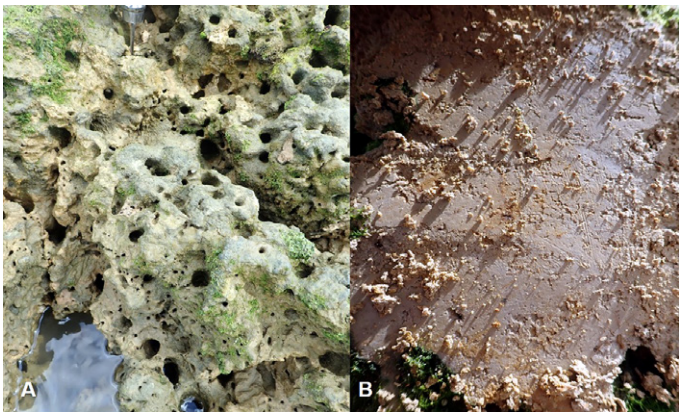

Figure 6. Basal geology of Ngārango Otainui, interpreted here as part of the Puketoka Formation showing **A**, the heavily weathered, siliceous clay assumed to be a distal ignimbrite, pitted with numerous larger vertical holes (former tree roots?) and covered with the green alga, *Ulva compressa*; **B**, portion cleared by knife to expose the unweathered pale greyish, siliceous clay. Photos: Peter J. de Lange.

Methods

Ngārango Otainui was visited by the authors on three occasions between 2009 and 2021 (see introduction above). Detailed observations of the geology, vegetation, fauna, flora, fungi and lichenised mycobiota were made during the two 2021 visits, and that data collated for this paper. Collections made were lodged in AK and UNITEC herbaria (herbarium acronyms follow Thiers 2008–onward). Taxa observed are arranged taxonomically by family as follows: Alga (Nelson 2013; Wilcox 2018), Bryophytes (Söderström et al. 2016 [hornworts, liverworts]; Crosby et al. 1999 [mosses]), Gymnosperms (World Flora online, http://www.worldfloraonline.org/), Pteridophytes and Flowering Plants (APG II-IV; PPG 1), Fungi (Mycobank, https://www.mycobank.org/page/Home), Lichenised Mycobiota (Kraichak et al. 2018) and Avifauna (Gill et al. 2010).

Vegetation associations were distinguished using the vegetation classification system of Atkinson (1985). The exception to his definitions is that the designation 'forest' is based on the height of the dominant plant (5 m tall or more) as well as the presence of a clear trunk devoid of branches.

Observations of vegetation succession and island erosion over time were made using images stored on Retrolens (https://retrolens.co.nz/) and a geospatial analysis performed using ArcMap 10.7 (https://www.esri.com/en-us/arcgis/products/arcgis-desktop/resources). To gauge the rate of erosion, a geospatial

analysis was performed using a combination of historical imagery obtained from Retrolens (https://retrolens.co.nz/), LINZ (https://www.linz.govt.nz/) and Google Earth. The Retrolens imagery was orthorectified using ArcGIS (https://www.arcgis.com/index.html) to obtain a realistic view of the island's historical size so that the rate of erosion could be calculated.

Results

Flora and mycobiota

A total of 125 taxa from 57 families and 100 genera were recorded from Ngārango Otainui (Appendix 1). Fifteen of the families and 41 of the genera present on the island are also only represented by naturalised taxa. Three species appear to have been deliberately planted, e.g., pōhutukawa. Of these, naturalisation from plantings has occurred with pines. In total 119 (95%) of those taxa recorded here are supported by herbarium vouchers lodged in AK and UNITEC. The collections comprise: two seaweeds, 14 bryophytes (three liverworts and 11 mosses), one pteridophyte, one gymnosperm, 75 flowering plants, six fungi and 20 lichens.

Marine algae, as the unstable nature of the island substrate and turbidity of the surrounding water reflect, are poorly represented. We found three seaweeds on the ignimbritic material comprising the basal portion of the island's cliff faces. The most common of these is *Ulva compressa* (Figure 7), a species that coats the island's cliffs faces from where they make contact with the estuary surface to the high tide mark, and in shaded sites, on the eastern side of the island, admixes with saltmarsh vegetation, notably *Isolepis cernua* var. *cernua*. Along the southern portion of the island cliffs, often growing in 'root holes' (see Geology and Physiography above) we noted the red seaweed *Caloglossa vieillardii* (Figure 8). During the November 2021 visit we also noted small specimens of *Ulva* sp. 1 (Nelson 2013; Wilcox 2018), an as yet unnamed species that is seasonally common during the summer months around Onehunga, where, on account of its growth and smell when rotting, it often causes problems (see https://www.scoop.co.nz/stories/AK0509/S00112/techniques-trialled-to-clean-up-onehunga-bay.htm). Within the mangroves during the January 2021 visit, occasional specimens of Neptune's necklace (*Hormosira banksii*) were observed festooning the bases of mangrove pneumatophores.

A bryophyte flora of 14 taxa was noted on the island. Three liverworts – two corticolous species,

Figure 7. *Ulva compressa* growing on assumed distal ignimbrite at and below high tide mark. Photo: Peter J. de Lange.

Figure 8. *Caloglossa vieillardii*, a red seaweed commonly seen at and just below the high tide mark on the cliff faces of Ngarango Otainui. Photo: Peter J. de Lange.

Frullania fugax and *Siphonolejeunea nudipes* var. *nudipes*, and one terricolous species – *Chiloscyphus semiteres* var. *semiteres* (Figure 9) were noted. Of these, the *Chiloscyphus* was noted occasionally within open ground in grassland, whilst *Siphonolejeunea* was common on the bark of karo (*Pittosporum crassifolium*) and pine. Eleven mosses, four of these naturalised, were noted. None were common, and most grew on exposed soil or decorticated semi-decayed branches within open ground in grassland, or under pines. The naturalised species, *Eurhynchium praelongum*, *Fissidens bryoides*, *F. taxifolius* and *Pseudoscleropodium purum*, are common weedy species of urban habitats, lawns especially, and grassland (Beever 2014; Fife 2020). Two of them, *Fissidens taxifolius* and *Pseudoscleropodium purum*, spread solely by vegetative means (Beever et al 1992; Beever 2014; Fife 2020) so we assume their presence on the island relates to accidental introduction by island visitors, or possibly dispersal by birds, perhaps as nesting material.

The terrestrial flora and lichen composition of the island is typical of successional vegetation of urban Auckland, with 56 (59%) species of naturalised plants and 39 (40%) considered indigenous, and one indigenous species, pōhutukawa, planted. Of those naturalised species, onion twitch (*Arrhenatherum elatius* subsp. *bulbosum*), moth vine (*Araujia sericifera*) and tree privet (*Ligustrum lucidum*) are the main contributors to the island's vegetation associations. Pines, which have naturalised from what appears to have been five deliberately planted trees, by virtue of their size tower over the other vegetation and so dominate the skyline of the northern third of the island. Indigenous plants, with the exception of mangrove, are mostly uncommon on the island. Only bracken (*Pteridium esculentum*), plume grass (*Pentapogon crinitus*), tutu (*Coriaria arborea* var. *arborea*) (Figure 10) and tororaro (*Muehlenbeckia complexa* var. *complexa*) are common. One species, whau (*Entelea arborescens*), a specimen of which was collected in 2009, is now absent, a further 17 vascular plants are uncommon, and four species, wiwi (*Ficinia nodosa*), *Machaerina juncea*, pōhutukawa and *Suaeda novae-zelandiae*, are known from single plants.

The lichen mycobiota is by and large poorly developed. We noted only one terricolous lichen, *Cladonia confusa*, confined to one site of bare earth exposed on the north-western cliff top. The otherwise dense grassland probably prohibits the growth of *Cladia* Nyl. and other *Cladonia* P.Browne, genera that are common throughout

Figure 9. *Chiloscyphus semiteres* var. *semiteres*, the most common of three liverworts noted on Ngārango Otainui, was noted growing in open ground within onion twitch (*Arrhenatherum elatius* subsp. *bulbosum*) grassland. Photo: Peter J. de Lange.

Figure 10. *Coriaria arborea* var. *arborea*, one of the few common indigenous plants seen on Ngārango Otainui. Photo: Peter J. de Lange.

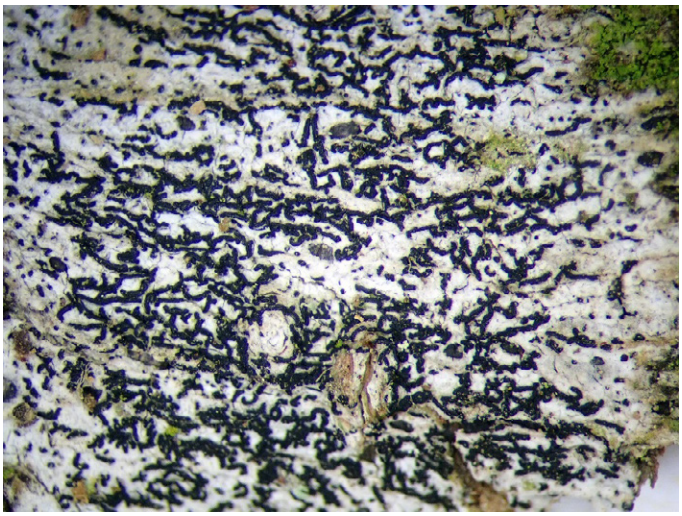

Figure 11. *Arthonia atra*, a common graphid lichen on privet (*Ligustrum lucidum*) and tutu (*Coriaria arborea* var. *arborea*) on Ngārango Otainui. Photo: Peter J. de Lange.

Auckland on bare earth and rock, while the friable, easily eroded cliff faces seem to prevent the development of crustose taxa. Corticolous and foliicolous lichens are present, with corticolous taxa dominating; though even then, few are well developed, and conspicuous coastal-forest-, shrubland- and open-grassland-dwelling Auckland foliose genera such as *Crocodia* Link and *Pseudocyphellaria* Vain. are absent, while others such as *Parmotrema* are poorly developed. The most commonly seen corticolous lichens on Ngārango Otainui are those usually found on exposed bark in coastal situations around Auckland, e.g., *Heterodermia speciosa* and *Ramalina celastri*. Crustose lichens, though common on some phorophytes, are mostly poorly developed and sparingly fertile. Of those seen, only *Arthonia atra* (Figure 11), *Bacidia leucothalamia* (Figure 12) and *B. wellingtonii* were common, and these only on tree privet, tutu, pine bark and cones, while the mangroves, which colonised the eastern side of the island about 16 years ago (see below), are as yet too young to support the lichen diversity seen on older trees (Reynolds et al. 2017).

Non-lichenised mycobiota appear to be poorly represented on the island. However, we suspect a more dedicated survey during a range of seasons may find further fungi. Of the seven seen during our surveys, five are rust fungi, a group of fungi that while easily overlooked due to their diminutive size are often widespread and common; another, *Ramularia helminthiae*, is a leaf-spot fungus that is usually found where its host, oxtongue (*Helminthotheca echioides*), is established. The only other fungus, a species of *Russula*

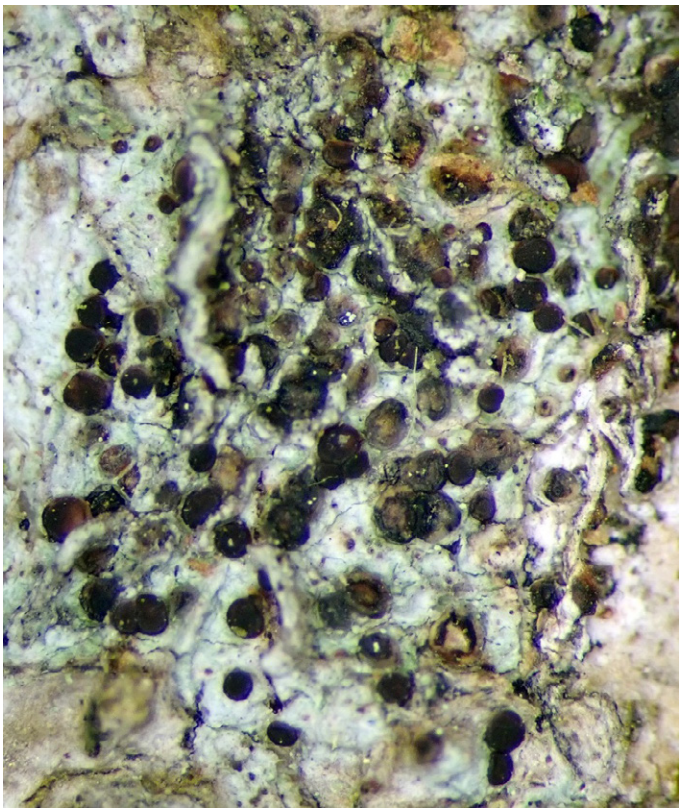

Figure 12. *Bacidia leucothalamia*, a common dot lichen on privet (*Ligustrum lucidum*) and tutu (*Coriaria arborea* var. *arborea*) on Ngārango Otainui. Photo: Peter J. de Lange.

Pers., tentatively identified as *R. amoenolens* by J.A. Cooper (pers. comm., November 2021), was noted as a single, bird-damaged fruiting body emergent under a pine in the pine forest.

Avifauna

During the January and November 2021 visits to the island, observations were made of the near shore and island bird-life, recording 14 species over three hours on the island (Appendix 2). Of these, nine are indigenous, one of these migratory and the others naturalised. Karoro / black-backed gulls (*Larus dominicanus*) were the most commonly seen bird (13 individuals) flying around the island, but we saw no evidence of their using the island as a roost or nesting ground. The most commonly seen and heard bird on the island during the November 2021 visit were greenfinches (four seen).

The pines at the northern end of the island are used by matuku moana / white-faced herons (*Egretta novaehollandiae*), kāruhiruhi / pied shags (*Phalacrocorax varius*) and kōtuku ngutupapa / royal spoonbills (*Platalea regia*) for roosting, and in the case of the herons, nesting. We noted a few kotare / kingfisher (*Todiramphus sanctus*) nest holes near the apex of the north-western cliffs and

one bird was seen near these. At the north-western end of the island near where a large pine had fallen into the sea, amidst a tangle of tororaro and pine branches, we also observed two mallard ducks (*Anas platyrhynchos*) resting up amongst the vegetation.

Despite the youth of the mangrove shrubland, the sole riroriro / grey warbler (*Gerygone igata*) noted during the November 2021 visit was observed moving across the island and then consistently out some 70 metres to the same area of mangrove. We suspect that the bird either had a nest there or was using the shrubland as a feeding habitat. Interestingly, the single pīpīwharauroa / shining cuckoo (*Chrysococcyx lucidus*) noted on the November 2021 visit was also noted in the mangrove shrubland site being frequented by the riroriro, also suggesting the mangrove was a nesting site.

Vegetation associations

Nine vegetation associations (and sparsely vegetated landforms) (Figure 13) were distinguished on the island. Seven of these are confined to the island, and two, sandy beach and mangrove shrubland, occupy the lee of the island. The extent of each association and landform is also provided.

1. Mangrove shrubland (10,668 m2) – indigenous vegetation association (Figure 14)

A low monospecific shrubland of mangrove, ranging from 1–2.5 m in height, c.20–100 mm dbh has developed since 2005 (based on aerial imagery) on the eastern side of Ngārango Otainui. In places, mangrove cover reaches 100%, though on the western flank cover drops to c.80%, leaving patches of mud and/or sparse Pacific oyster (*Magallana gigas* [Thunberg, 1793]) encrusted ground. As noted above, the trunks and branches of the mangroves, presumably because of their age (see Reynolds et al. 2017) support few lichens, and of those seen most had underdeveloped thallii. The most common lichens, which were confined to the branches and trunks of the older, taller, exposed mangrove only, are *Athallia cerinelloides* and *Lecanora carpinea*, otherwise lichen cover on the mangroves was sparse.

Figure 13. Vegetation associations and landforms of Ngārango Otainui as discussed in text. Coastal cliff vegetation is omitted from this figure because it is vertical and therefore cannot be seen in the base image. Base image courtesy of Land Information New Zealand (Eagle Technology, Land Information New Zealand).

2. Sandy beach (73 m2) – mixed indigenous / naturalised vegetation (Figure 15)

A small sandy beach of reddish pumiceous sand and yellow clay, which developed following the expansion of mangroves after c.2005, now delineates the north-western margin of the mangrove shrubland and island. The beach sand at high tide lies almost at water level, and in king tides would be completely immersed. Growing along the high tide mark within the sand were a few plants of orache (*Atriplex prostrata*), ureure (*Salicornia quinqueflora* subsp. *quinqueflora*) and one *Suaeda novae-zelandiae*. Mangroves are now rapidly colonising the beach margin to the extent that we expect this feature will soon vanish.

3. Saltmarsh (71 m2) – indigenous vegetation association (Figure 16)

On the eastern side of the island, in places where a small wave-cut terrace has developed or colluvium or clay / sand has accumulated, there is a narrow band of sparse halophytic vegetation that we collectively refer to here as 'saltmarsh'. This vegetation varies with the degree of exposure, shade and, presumably, the stability of the substrate. In the open, most exposed, and actively eroding south-eastern point of the island, this vegetation is dominated by coastal immorality grass (*Austrostipa stipoides*), a species that also occurs as isolated tussocks higher upslope on the friable Hamilton Ash sequence overlying the carbonaceous clay (see Geology and Physiography above). Further along this shoreline in more sheltered sites, this grass is replaced by mākoako (*Samolus repens* var. *repens*) and *Isolepis cernua* var. *cernua*, and in one place a small patch of ureure. In one site, just above the high tide mark, a few tussocks of *Carex flagellifera* are also present. It is notable that, with the exception of coastal immorality grass, the other species are so scarce on the island, when on the adjoining shore of the Manukau they are extremely common. Unusual, too, is the absence of *Goodenia radicans* (Cav.) Pers. and *Apium prostratum* subsp. *prostratum* var. *filiforme* (A.Rich.) Kirk., which are commonly seen in association with mākoako and the *Isolepis* and common saltmarsh plants of the nearby shoreline.

4. Coastal cliffs (235 m) – mixed indigenous / naturalised vegetation (Figure 3)

Cliffs encircle the island, and as they are the product of ongoing erosion they are only sparsely vegetated, by coastal immorality grass (south-eastern and southern

Figure 14. Mangrove (*Avicennia marina* subsp. *australasica*) shrubland. Photo: Peter J. de Lange.

Figure 15. Portion of sandy beach seen here during extreme high tide (6 November 2021). Photo: Peter J. de Lange.

Figure 16. Saltmarsh vegetation, eastern side of Ngārango Otainui, showing in this case patches of mākoako (*Samolus repens* var. *repens*), *Isolepis cernua* var. *cernua*, and *Ulva compressa* are threaded. Photo: Peter J. de Lange.

Figure 17. Onion twitch (*Arrhenatherum elatius* subsp. *bulbosum*) grassland. Photo: Peter J. de Lange.

end of island only), and at their tops with dense tangles of tororaro, pōhuehue (*Calystegia sepium* subsp. *roseata*) and, in places, moth vine. At the south-western end of the island a single 2 m tall pōhutukawa, which seems to have been planted sometime around 2014 (based on aerial imagery), grows at the cliff apex.

5. Onion twitch grassland (486 m2) – naturalised vegetation association (Figure 17)

Judging by image coverage, grassland of unknown composition has covered at least 70% of the island and was the dominant vegetation until sometime after 2014, when tree privet, tutu and bracken increased their extent. Onion twitch grassland is in places up to 1.5 m tall. Other than onion twitch, other, usually minor, associates include prairie grass (*Bromus catharticus*), cocksfoot (*Dactylis glomerata*), *Carex divulsa*, oxtongue, scotch thistle (*Cirsium vulgare*) and occasional *Carex flagellifera*. In places, notably along the south-western cliff face, plume grass can be locally abundant, such that it almost warrants recognition as a further vegetation association, i.e., onion twitch / plume grass grassland. Along the eastern side of this grassland, other minor associates include *Gladiolus* spp., pōhuehue, *Haloragis erecta* subsp. *erecta*, three species of lotus (*Lotus angustissimus*, *L. pedunculatus* and *L. suaveolens*), narrow-leaved plantain (*Plantago lanceolata*), herb Robert (*Geranium robertianum*), sowthistle (*Sonchus oleraceus*) and young vines of blackberry (*Rubus ulmifolius*). In the southern third of the island, onion twitch grassland grades into bracken / onion twitch fern / grassland described below.

6. Bracken / Onion twitch fern / grassland (463 m2) – mixed indigenous / naturalised vegetation association (Figure 18)

The main vegetation association in the southern third of the island is one in which almost equal amounts of bracken and onion twitch grow, forming tangles up to 1 m tall. Judging from aerial imagery, it seems that bracken is in the process of outcompeting onion twitch, and that given time it will replace the onion twitch grassland described above. This vegetation has a similar assemblage of associated species to onion twitch grassland except for the local dominance of Buffalo grass (*Stenotaphrum secundatum*), especially toward the southern end of the island, and presence of tororaro and King Island melilot (*Melilotus indicus*) near the eastern cliffs.

7. Tree privet forest (1044 m2) – naturalised vegetation association (Figure 19)

Tree privet forest occurs as two bands running northwest to southwest across the middle of the island, in places forming a canopy 5 m tall. Although dominated by tree privet, karo (*Pittosporum crassifolium*) and tutu are a local component of this forest, especially toward the western cliffs where tutu is more common. Near the eastern margin of the privet forest are two 3 m tall loquat (*Rhaphiolepis bibas*), a third, a sapling, grows under the privet near the western side of the island. On the eastern side of the southern-most privet forest association, there grow as canopy emergents a single monkey apple (*Syzygium smithii*), and scattered karamu (*Coprosma robusta*), coastal karamu (*Coprosma macrocarpa* subsp. *minor*) and hybrids between them. This forest has a dense subcanopy of privet, karo and occasional karamu. Threaded through this, and sometimes reaching the canopy, are tangles of moth vine and tororaro. These vine tangles are especially well developed along the southern and western fringes of this forest association, where they sometimes extend out into the bracken / onion twitch fern / grassland. The ground layer is usually devoid of plant cover; however, in a few places *Microlaena stipoides* may be present, and other occasional associates include *Geranium homeanum* and herb Robert.

8. Pine forest (1109 m2) – naturalised vegetation association (Figure 20)

Pine trees, undoubtedly the majority planted, are a feature of the island. There are two very large, multi-trunked trees c.10–14 m or so in height, with a canopy spread of 10 or more metres and trunk diameters up to 85 cm dbh. Aside from these two, and in association with them, there are a further 29 smaller trees, saplings and seedlings, and collectively they form a forest occupying about a third of the island. The canopy of the trees is a major nesting site for matuku moana / white-faced heron and a roost for kōtuku ngutupapa / royal spoonbill, resulting in a guano build-up around some of the larger trees. Structurally, this forest is less dense than the adjoining tree privet forest, the subcanopy comprising scattered tree privet, karo saplings and trees up to 6 m tall. Through these trees and forming scrambling tangles on the forest floor are occasional patches of moth vine, blackberry and tororaro, and sparse patches of prairie grass, *Bromus sterilis*, *Microlaena stipoides*, and *Fumaria muralis*. However, much of the ground layer is devoid of vegetation, being mostly covered in dense

Figure 18. Bracken (*Pteridium esculentum*) / Onion twitch fern / grassland. Photo: Peter J. de Lange.

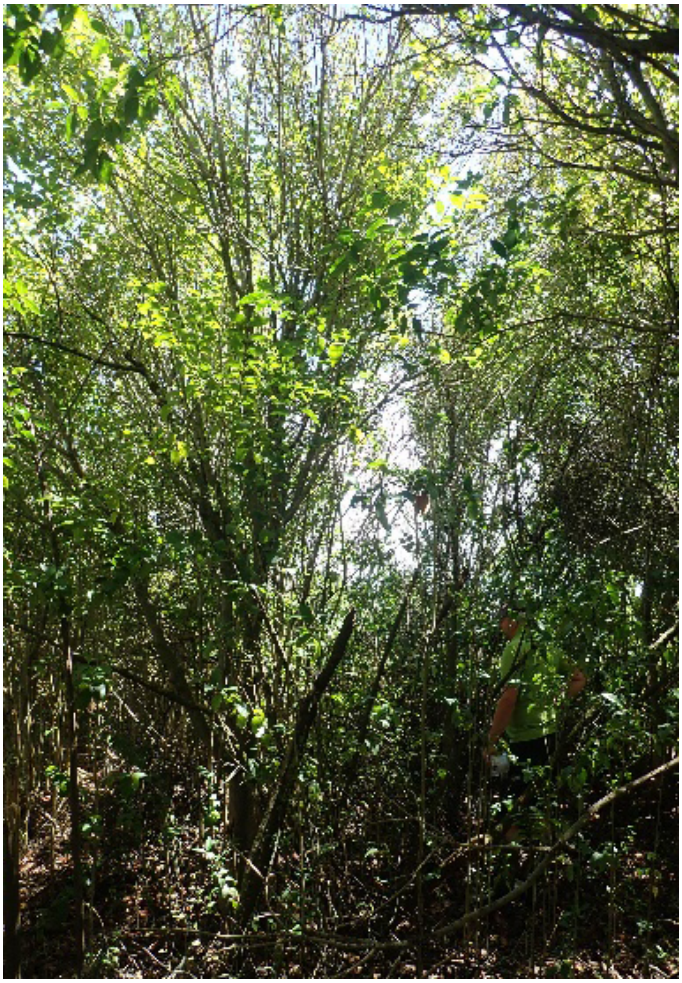

Figure 19. Tree privet (*Ligustrum lucidum*) forest. Photo: Peter J. de Lange.

Figure 20. Pine (*Pinus radiata*) forest. Photo: Peter J. de Lange.

Figure 21. Sand brome (*Bromus arenarius*) growing with *Microlaena stipoides*. Photo: Peter J. de Lange.

drifts of pine needles but also open because of deliberate cutting of saplings by people. We assume people camp here from time to time, as we found hidden away in a series of black plastic bags a carefully folded tent, and a large plastic bottle of fresh water. Though sheltered, the guano rain from the nesting herons and other roosting birds would make for an interesting camping site.

Discussion

There are 13 islands and islets within the Manukau Harbour. Prior to this investigation, the flora and vegetation of only three, Kauritutahi (Cameron 1996), Orona (Cameron 2008) and Kopuahingahinga (Hall 2011) have been documented. Ngārango Otainui, the fourth to be so covered, is in our view remarkable in that, unlike the others, it is located adjacent to a major metropolitan area (Onehunga, Mangere, Southdown) and yet we could find no documentation of the island's biodiversity prior to this publication.

Below we provide some summary points about notable taxa, vegetation succession and patterns, pest species and the ongoing rate of erosion of Ngārango Otainui.

Threatened and At-Risk Species

None of the biota recorded from Ngārango Otainui qualify as 'Threatened' using the New Zealand Threat Classification System (Townsend et al. 2008). However, nine are listed as 'At Risk' using that system and these are noted as follows.

Flora

From our combined visits we report a Flora of 80 vascular plants, 14 bryophytes, four seaweeds, six fungi and 19 lichenised mycobiota. Fifty-two (65%) of the vascular plants and four (36%) of the bryophytes are naturalised to New Zealand and most of these dominate the island's vegetation.

Only one plant recorded from Ngārango Otainui, sand brome (*Bromus arenarius*) (Figure 21), has a national conservation status of 'At Risk / Naturally Uncommon' (de Lange et al. 2018a). A strict annual, this species has a close association with sea-bird nesting sites in the northern North Island and the Chatham Islands, where it is usually found on small offshore islands. On Ngārango Otainui, a few plants were found growing in guano, under pines associated with *Microlaena stipoides*. Sand

brome, though locally common on many of the islands of the Hauraki Gulf (de Lange & McFadden 1995; de Lange & Crowcroft 1996), has hitherto not been collected from the western coastline of Auckland or the coastline, islands and islets of the Manukau Harbour.

Lichenised mycobiota

Five lichens found on Ngārango Otainui have been listed by de Lange et al. (2018b); four (*Arthonia atra* [Figure 11], *Bacidia leucothalamia* [Figure 12], *Fissurina inquinata* [Figure 22] and *Graphis elegans*) as 'At Risk / Naturally Uncommon', and one, *Chrysothrix xanthina* (Figure 23), as 'Data Deficient'. Of these, the *Arthonia* and *Bacidia* are common on the island, as, judging by recent collections lodged in UNITEC, seems also to be the case elsewhere around New Zealand. Both species would probably be more appropriately listed as 'Not Threatened' using the New Zealand Threat Classification System (Townsend et al. 2008). The *Fissurina* and *Graphis* are also more widespread than had been believed, but probably still warrant their current conservation status. Similarly, *Chrysothrix xanthina* at the time the current lichen threat listing was being prepared (2017) was then known from just one New Zealand collection (Elix & Kantvilas 2007); since 2018, dedicated collecting of the genus throughout New Zealand has found that species to be the most common of the five *Chrysothrix* Mont. species now believed to be in the country (P.J. de Lange, unpublished data).

The presence of these species on Ngārango Otainui is not in itself singular or especially noteworthy; rather it reflects the fact that there are still very few active field-based lichenologists collecting throughout New Zealand. Our knowledge of the extent of our lichenised mycobiota, and abundance of taxa within that, is still in its infancy, and this hampers accurate conservation assessments (de Lange et al. 2018b).

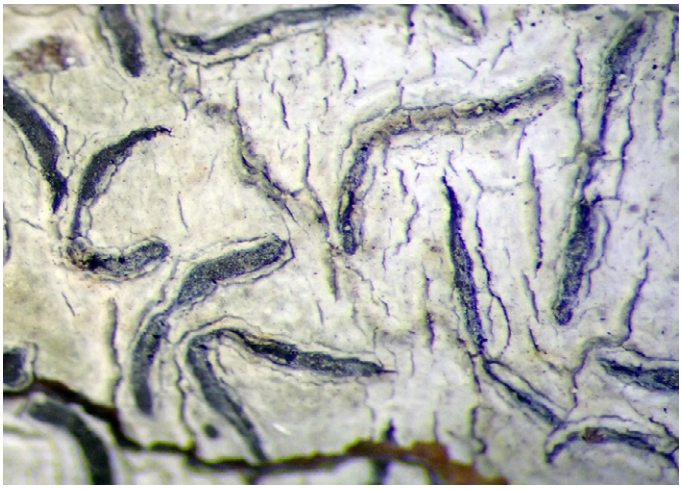

Figure 22. *Fissurina inquinata*, a graphid lichen, and one of four lichens listed as 'At Risk / Naturally Uncommon' (de Lange et al. 2018b) found on Ngārango Otainui. Photo: Peter J. de

Figure 23. *Chrysothrix xanthina*, a yellow powder lichen listed as 'Data Deficient' (de Lange et al. 2018b), was noted only on the bark of pine (*Pinus radiata*) on Ngārango Otainui. Photo: Peter J. de Lange.

Avifauna

Three indigenous birds seen on or near Ngārango Otainui are listed by Robertson et al. (2017) using the New Zealand Threat Classification System (Townsend et al. 2008): kāruhiruhi / pied shags ('At Risk / Recovering'), kōtuku ngutupapa / royal spoonbill ('At Risk / Naturally Uncommon) and tara / white-fronted tern ('At Risk / Declining'). None of these birds are confined to the island, though the shag and spoonbill use the vegetation of the island as a roost.

Vegetation assemblage, succession and patterns

Aerial imagery dating back to 1940 indicates that the island was once covered in low grass and bracken fernland, a state in which it remained until sometime between 1988 and 1994 (aerial imagery is absent between these years), when pines, initially probably planted, appeared on the island. As judged by past aerial imagery the island is now better vegetated than it was in 1940, notably now supporting forest and shrubland. We suspect this development was driven by the ongoing erosion of the island's western side causing landowners to undertake plantings (Gibson 2016).

On 25 March 2001, when the island was visited by Rhys Gardner and Brent Maxwell, they noted that pines, onion twitch grassland and bracken fernland (through which they recorded tangles of *Muehlenbeckia*), dominated the island vegetation, collectively estimated by them to cover of the island. Scattered through this vegetation they observed 1–1.2 m tall tutu. Nearer the coast and on the cliffs, they observed masses of moth vine, and in places considered pōhuehue to be abundant. Notably, they reported a few small bushes of tree privet (these up to 2 m tall), and recorded local occurrences of tree tobacco (*Solanum mauritianum* Scop.), and a *Brassica* L. sp. – two taxa not seen in the 2009 and 2021 visits. They saw no mangroves around the island. Unfortunately, their listing for the island, though detailed, was not sufficiently comprehensive to allow us to undertake meaningful species composition and vegetation association between visits.

Nevertheless, the 2021 situation, 20 years later, is drastically different. Grassland now covers 29% of the island, while privet has coalesced to form a distinct forest association. This forest merges at the northern end of the island into the pine forest and collectively these two forest associations now occupy 66% of the island, the rest being saltmarsh and beach (mangroves omitted). Mangroves now dominate the mudflats immediately east of the island.

Despite the improved forest cover, the youth of the island's woody vegetation is reflected by the island's flora and mycobiota, which has a low diversity and near absence of a range of taxa typical of Auckland coastal habitats. For example, the presence of just one pteridophyte, bracken, is notable, especially as the adjacent coastline, though highly modified, supports a range of ferns, including the terrestrial species *Doodia australis* (Parris) Parris, *Pellaea rotundifolia* (G.Forst.) Hook., *Polystichum neozelandicum* Fée, and *Pteris tremula* R.Br., all 'weedy' species common on the adjacent coastline that one would expect to see on the island. Notable, too, is the absence of *Pyrrosia eleagnifolia* (Bory) Hovenkamp and *Zealandia pustulata* (G.Forst.) Testo et A.R.Field subsp. *pustulata*, common epiphytic ferns of coastal forest and urban Auckland tree plantings. A similar pattern is evident in the bryophytes, only one liverwort, *Siphonolejeunea nudipes* var. *nudipes*, was considered common. This is a corticolous species preferring open successional woody vegetation, and which is abundant on urban trees throughout the Auckland Region. The lack of diversity in, and overall scarcity of, *Frullania* Raddi is also unusual; for example, one species common throughout Auckland, *F. pentapleura* Taylor, is absent from the island, we assume because of the lack of hard rock substrates – its preferred habitat in the region. Even *Frullania fugax*, common on pōhutukawa trees on the adjacent shoreline, is extremely uncommon on the island; we only saw it on pine trees, in places it would usually dominate elsewhere in the region. We can only assume, then, that it is a recent arrival to the island. Of the mosses seen, none were common, and most were confined to open ground within the onion twitch grassland. The absence of genera from the Bryaceae and Pottiaceae, which are common in similar habitats on the adjacent shoreline and Auckland City, is especially puzzling, as suitable habitat is common on the island, and these families are well represented on the adjacent shoreline.

The same paucity is evident in the lichenised mycobiota. Of the 20 species recorded, eight are considered abundant or common. The two abundant species, *Ramalina celastri* and *Xanthoria parietina*, are common throughout the Auckland Region, especially in coastal and urban habitats. On Ngārango Otainui, though abundant, *Xanthoria parietina* was restricted to the branches of dead or dying privet and the exposed trunks of pine. *Ramalina celastri*, while more widespread, was mostly present as small under-developed thalli. *Heterodermia speciosa*, though recorded as common, only formed large colonies on the larger privet and older pine trees. Other lichens, that are a feature of coastal and urban Auckland trees, such as species of *Amandinea* M.Choisy ex Scheird. et H.Mayrhofer, *Buellia* De Not., *Flavoparmelia* Hale, *Lepraria* Ach., *Pertusaria* DC., and *Usnea* Dill. ex Adans., were not seen. Lirelliate lichens, though present, were also mostly noted as small or poorly developed thalli. It has already been noted that the mangrove shrubland has a low diversity of lichens, with only two species, *Athallia cerinelloides* and *Lecanora carpinea*, common. Terricolous lichens, with the exception of a small colony of *Cladonia confusa*, are completely absent, which is unusual when compared with similar substrates and habitats on the adjacent shoreline, where species of *Cladia*, *Stereocaulon* Hoffm. and other *Cladonia* are common, if not abundant.

Collectively, we assume that these absences might be explained by the historical, probably human-induced, disturbance of the vegetation of Ngārango Otainui, the relatively recent development of woody vegetation and the ongoing erosion of the island cliffs (see below). We assume such disturbance has been considerable. As noted above, from 1940, when aerial images of the island

Pest plant (this paper)	Name used in Te kimi kīrearea Pest search (Tiaki Tāmaki Makaurau Conservation Auckland)
Allium triquetrum	*Allium triquetrum*
Araujia sericifera	*Araujia sericifera*
Asparagus asparagoides	*Asparagus asparagoides*
Carex divulsa	*Carex divulsa*
Gladiolus undulatus	*Gladiolus undulatus*
Ligustrum lucidum	*Ligustrum lucidum*
Osteospermum moniliferum subsp. moniliferum	*Chrysanthemoides monilifera*
Phytolacca octandra	*Phytolacca octandra*
Pinus radiata	*Pinus spp.*
Rhaphiolepis bibas	*Eriobotyra japonica*
Rubus ulmifolius	*Rubus fruiticosus agg.*
Stenotaphrum secundatum	*Stenotaphrum secundatum*
Syzygium smithii	*Syzygium smithii*
Watsonia meriana 'Bulbillifera'	*Watsonia meriana var. bulbillifera*

Table 1. Pest plants of the Auckland Region present on Ngārango Otainui. Taxa listed are those documented by the Auckland Council as pest plants (Tiaki Tāmaki Makaurau Conservation Auckland 2020).

are first available, the island has retained grass and fernland for close to 48 years before woody vegetation appeared on the island sometime around 1988.

What is notable about the islands is that the majority of the species forming the vegetation associations are naturalised to Aotearoa / New Zealand. Further, with the exception of three species that have been planted (and have spread or not), the other naturalised plants have colonised the island by natural dispersal from the adjacent mainland. Of these, it would seem that the majority (22 [42%]) of vascular plants present on the island are derived from bird dispersed (e.g., tree privet, bone seed [*Osteospermum moniliferum* subsp. *moniliferum*], *Carex divulsa*) or wind dispersed seed (e.g., moth vine, flea bane [*Erigeron sumatrensis*], sow thistle), with 12 vascular plants (23%), one moss and four fungi reaching the island in this way. At least two mosses, *Fissidens bryoides* and *F. taxifolius*, owe their origin to accidental transport to the island, either in soil or as a contaminant on footwear. It is also likely that one fungus, *Russula amoenolens*, an ectomycorrhizal species associated with pines (Cooper et al. 2022), was introduced when the pines were planted. Only a few species, notably wild gladiolus (*Gladiolus undulatus*) are likely to have colonised the island through saltwater dispersal. In a similar way, the majority of the indigenous plants are also derived from bird- and wind-dispersed seed. Only one indigenous plant, pōhutukawa, may have been deliberately planted, though it could also have naturally arrived from wind-dispersed seed, as this tree is common along the foreshore of the adjacent coast. Our supposition that it was planted is based on its

'sudden' appearance in aerial imagery after 2007.

Pest species

Fourteen of the plants currently present on the island (Table 1) are regarded as regional pest species in urban Auckland (Auckland Council 2020). Their presence on Ngārango Otainui is not considered singular, rather it reflects their abundance on the adjacent coastline and metropolitan area. In our view, as the vegetation of the island is helping reduce erosion, their control without carefully considered and well-timed replanting of other less invasive or indigenous plants would be unwise.

Two animal pest species were noted: a single rat – *Rattus* sp., black with a long tail so probably *R. rattus* (Linnaeus, 1758) – was noted running through the onion twitch grassland during the November 2021 visit, and a few garden snails (*Cornu aspersum* [O.F. Müller, 1774]) were seen. Considering the island's proximity to land, and the extent to which mudflats are exposed at low tide, the presence of rodents on the island is not unexpected. Similarly, as the island has undoubtedly been subjected to some plantings, the presence of garden snails, eggs and juveniles of which are common pot and soil contaminants, is not surprising either (see discussion on *Fissidens* mosses above).

Erosion

Our analysis of the rate of erosion revealed this to be very rapid, with the island losing over half (55%) its footprint between the first available image (1940) and the present day (Figure 24). The island has eroded at a roughly constant rate (Figure 25), although there was little change between 1962 and 1972, so 1972 imagery was not included in the analysis**,** which demonstrates the rate and location of erosion over the time of the analysis. Most of the material lost from Ngārango Otainui has been from its southwest coast, and as previously mentioned this has been deposited to the east, where a mangrove shrubland has since developed and is now rapidly expanding. Historical imagery reveals that mangroves were largely absent from the inlet where the island is situated, but have appeared in the past c. 40 years and will continue to spread as more material is deposited as a result of surrounding catchment land use

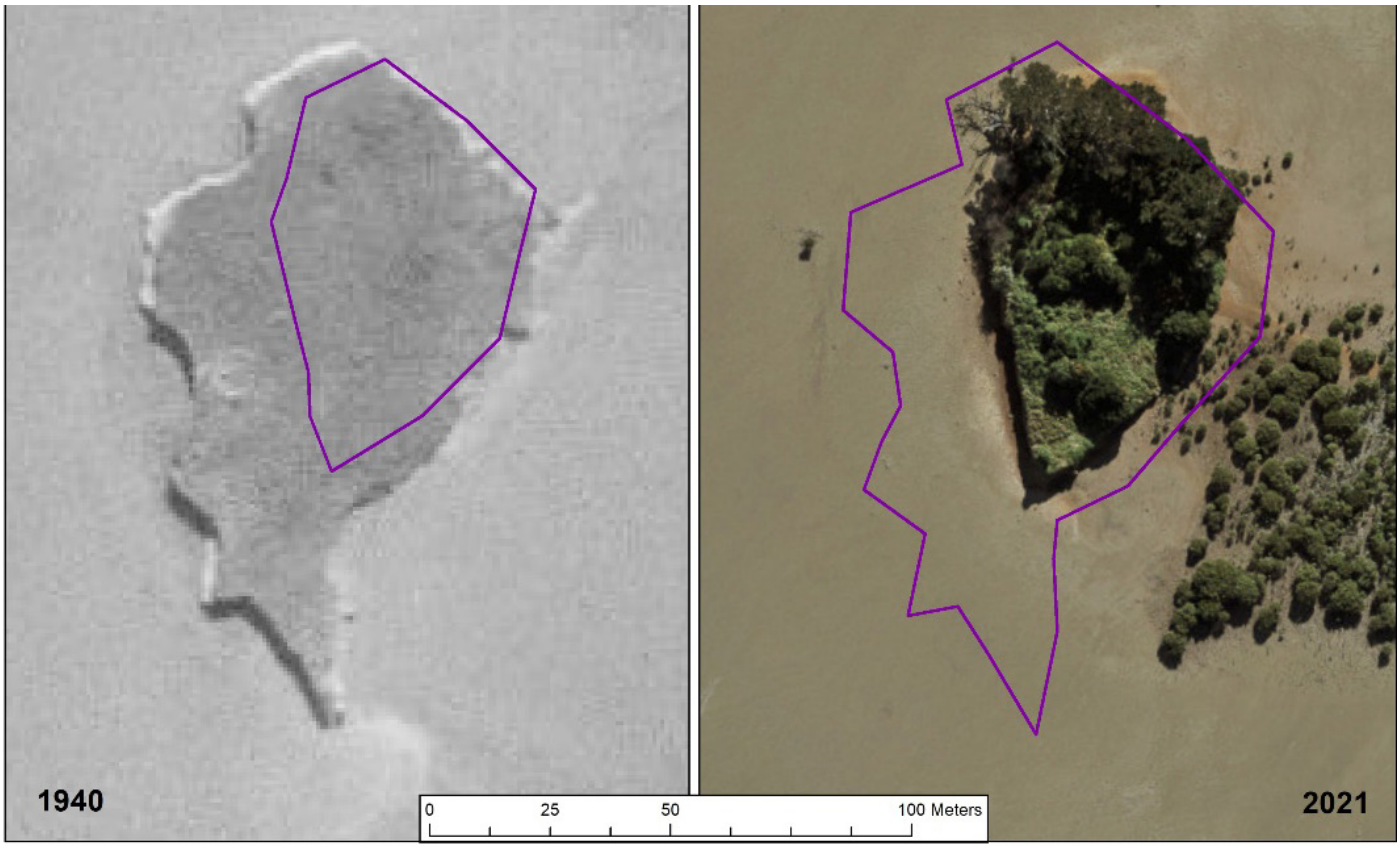

Figure 24. Extent of erosion of Ngārango Otainui gauged from when aerial images of the island first became available 1940. Base image courtesy of Land Information New Zealand (Eagle Technology, Land Information New Zealand).

Figure 25. Extent of erosion of Ngārango Otainui from 1940–2021. Base image courtesy of Land Information New Zealand (Eagle Technology, Land Information New Zealand).

and erosion of the island. Assuming the island continues to erode at the rate at which it has over the past 79 years, it will cease to exist by 2083, although there are myriad factors likely to affect the rate of erosion, so this estimate is vague at best.

While performing this analysis, the historical extent of the second island to the northwest was also calculated. In 1942 its footprint was larger than that of Ngārango Otainui (0.96 ha compared with 0.67 ha), although shadows on the imagery suggest it was much lower lying, and being – we assume – comprised of shells, more easily eroded, which may explain why this island had largely disappeared by 1972 (and had vanished altogether by 1985) while Ngārango Otainui has remained.

Acknowledgements

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APPENDIX 1: Flora and mycobiota recorded from Ngārango Otainui

*	denotes taxa naturalised to New Zealand
AK	Auckland War Memorial Museum Herbarium
UNITEC	Unitec Herbarium

	Family	Abundance	Voucher
Chlorophyta (2)			
Ulva compressa L.	Ulvaceae	abundant	
Ulva L. sp. 1.	Ulvaceae	uncommon	UNITEC 12921
Rhodophyta (1)			
Caloglossa vieillardii (Kützing) Setchell	Delesseriaceae	common	UNITEC 12922
Bryophytes (14)			
Liverworts (3)			
Frullania fugax (Hook.f. et Taylor) Gottsche. Lindenb. et Nees	Frullaniaceae	uncommon	UNITEC 12737
Siphonolejeunea nudipes (Hook.f. et Taylor) Herzog var. *nudipes*	Lejeuneaceae	common	UNITEC 12738
Chiloscyphus semiteres (Lehm.) Lehm. et Lindenb. var. *semiteres*	Lophocoleaceae	uncommon	UNITEC 12923
Mosses (11)			
Brachythecium rutabulum (Hedw.) Schimp.	Brachytheciaceae	uncommon	UNITEC 12931
**Eurhynchium praelongum* (Hedw.) Schimp.	Brachytheciaceae	uncommon	UNITEC 12924
**Pseudoscleropodium purum* (Hedw.) M.Fleisch.	Brachytheciaceae	uncommon	UNITEC 12927
**Fissidens bryoides* Hedw.	Fissidentaceae	uncommon	UNITEC 12925
**Fissidens taxifolius* Hedw.	Fissidentaceae	uncommon	UNITEC 12926
Hypnum cupressiforme Hedw. var. *cupressiforme*	Hypnaceae	uncommon	UNITEC 13007

Ptychomnion aciculare (Brid.) Mitt.	Ptychomniaceae	uncommon	UNITEC 12739
Ptychomitrium australe (Hampe) A.Jaeger	Ptychomitriaceae	uncommon	UNITEC 12928
Racopilum cuspidigerum var. *convolutaceum* (Müll.Hal.) Zanten et Dijkstra	Racopilaceae	uncommon	UNITEC 13008
Rhaphidiorrhynchium amoenum (Hedw.) M.Fleisch.	Sematophyllaceae	uncommon	UNITEC 12930
Sematophyllum homomallum (Hampe) Broth.	Sematophyllaceae	uncommon	UNITEC 12932
Pteridophytes (1)			
Pteridium esculentum (G.Forst.) Cockayne	Dennstaedtiaceae	common	UNITEC 12933
Gymnosperms (1)			
**Pinus radiata* D.Don	Pinaceae	common	UNITEC 12934
Spermatophytes (78)			
Monocots I (7)			
**Allium triquetrum* L.	Alliaceae	uncommon	UNITEC 12935
**Nothoscordum gracile* (Aiton) Stearn	Alliaceae	1 seen (2021)	UNITEC 12936
**Asparagus asparagoides* (L.) Druce	Asparagaceae	uncommon	UNITEC 12937
Phormium tenax J.R.Forst. et G.Forst.	Asphodelaceae	uncommon	UNITEC 12938
**Gladiolus undulatus* L.	Iridaceae	uncommon	UNITEC 13014
**Gladiolus ×hortulanus* L.H.Bailey	Iridaceae	uncommon	AK 254446
**Watsonia meriana* (L.) Mill. 'Bulbillifera'	Iridaceae	uncommon	UNITEC 13001
Monocots II – Commelinids (16)			
**Carex divulsa* Stokes	Cyperaceae	abundant	UNITEC 12939
Carex flagellifera Colenso	Cyperaceae	uncommon	UNITEC 12716
Ficinia nodosa (Rottb.) Goetgh., Muasya et D.Simpson	Cyperaceae	1 seen (2021)	UNITEC 12940

Isolepis cernua (Vahl.) Roem. et Schult. var. *cernua*	Cyperaceae	uncommon	UNITEC 12941
Machaerina juncea (R.Br.) T.Koyama	Cyperaceae	1 seen (2021)	
**Arrhenatherum elatius* subsp. *bulbosum* (Willd.) Schübl. et G.Martens	Poaceae	abundant	UNITEC 12942
Austrostipa stipoides (Hook.f.) S.W.LJacobs et J.Everett	Poaceae	uncommon	UNITEC 12943
Bromus arenarius Labill.	Poaceae	uncommon	UNITEC 12944
**Bromus catharticus* Vahl	Poaceae	uncommon	UNITEC 12945
**Bromus diandrus* Roth	Poaceae	uncommon	UNITEC 12946
**Bromus sterilis* L.	Poaceae	uncommon	UNITEC 12996
**Dactylis glomerata* L.	Poaceae	common	UNITEC 12947
Pentapogon crinitus (L.f.) P.M.Peterson, Romasch. et Soreng	Poaceae	common	UNITEC 12948
**Ehrharta erecta* Lam.	Poaceae	1 seen (2021)	UNITEC 12949
Microlaena stipoides (Labill.) R.Br.	Poaceae	uncommon	UNITEC 12950
**Stenotaphrum secundatum* (Walter) Kuntze	Poaceae	abundant	UNITEC 12951
Core Eudicots (55)			
Avicennia marina subsp. *australasica* (Walp.) J.Everett	Acanthaceae	abundant	UNITEC 12724
Salicornia quinqueflora Bunge ex Ung.-Sternb. subsp. *quinqueflora*	Amaranthaceae	uncommon	UNITEC 12952
Suaeda novae-zelandiae Allan	Amaranthaceae	1 seen (2021)	UNITEC 12953
**Araujia sericifera* Brot.	Apocynaceae	abundant	UNITEC 12954
Cotula coronopifolia L.	Asteraceae	uncommon	UNITEC 12955
**Cirsium vulgare* (Savi.) Ten.	Asteraceae	uncommon	UNITEC 12956
**Crepis capillaris* (L.) Wallr.	Asteraceae	1 seen (2021)	
**Erigeron sumatrensis* Retz.	Asteraceae	1 seen	UNITEC 13010
**Helminthotheca echioides* (L.) Holub	Asteraceae	uncommon	UNITEC 12957
**Hypochaeris radicata* L.	Asteraceae	uncommon	UNITEC 12958

**Osteospermum moniliferum* L. subsp. *moniliferum*	Asteraceae	common	UNITEC 12959
**Senecio elegans* L.	Asteraceae	1 seen (2021)	UNITEC 12960
**Senecio skirrhodon* DC.	Asteraceae	1 seen (2021)	UNITEC 12961
**Sonchus oleraceus* L.	Asteraceae	uncommon	UNITEC 12962
**Taraxacum sahlinianum* Dudman et A.J.Richards	Asteraceae	uncommon	UNITEC 12963
**Brassica* L.	Brassicaceae	1 seen (2001)	
**Lepidium didymium* L.	Brassicaceae	1 seen (2021)	UNITEC 12964
Calystegia sepium subsp. *roseata* Brummitt	Convolvulaceae	uncommon	UNITEC 12965
Coriaria arborea Linds. var. *arborea*	Coriariaceae	common	UNITEC 12717
**Lotus angustissimus* L.	Fabaceae	uncommon	UNITEC 12966
**Lotus pedunculatus* Cav.	Fabaceae	uncommon	UNITEC 12967
**Lotus suaveolens* Pers.	Fabaceae	uncommon	UNITEC 12968
**Medicago nigra* (L.) Krock.	Fabaceae	uncommon	UNITEC 12969
**Melilotus indicus* (L.) All.	Fabaceae	common	UNITEC 12970
**Trifolium dubium* Sibth.	Fabaceae	uncommon	UNITEC 13006
**Vicia sativa* subsp. *nigra* (L.) Ehrh.	Fabaceae	uncommon	UNITEC 12971
**Vicia sativa* L. subsp. *sativa*	Fabaceae	1 seen (2021)	UNITEC 12972
Geranium homeanum Turcz.	Geraniaceae	5 seen (2021	UNITEC 12973
**Geranium robertianum* L.	Geraniaceae	uncommon	UNITEC 12974
**Geranium gardneri* de Lange	Geraniaceae	uncommon	UNITEC 13383
Haloragis erecta (Banks ex Murray) Oken subsp. *erecta*	Haloragaceae	uncommon	UNITEC 12718
Entelea arborescens R.Br.	Malvaceae	1 seen (2009)	AK 304290
Metrosideros excelsa Sol. ex Gaertn.	Myrtaceae	1 seen (2021)	UNITEC 12975
**Syzygium smithii* (Poir.) Nied.	Myrtaceae	1 seen (2021)	UNITEC 13000
**Fumaria muralis* W.D.J.Koch	Papaveraceae	common	UNITEC 13019

**Fumaria capreolata* L. subsp. *capreolata*	Papaveraceae	common	UNITEC 12976
**Phytolacca octandra* L.	Phytolaccaceae	1 seen	UNITEC 13009
Pittosporum crassifolium Banks et Sol. ex A.Cunn.	Pittosporaceae	uncommon	UNITEC 12977
**Ligustrum lucidum* W.T.Aiton	Oleaceae	abundant	UNITEC 12978
Epilobium cinereum A.Rich.	Onagraceae	uncommon	UNITEC 12979
**Plantago lanceolata* L.	Plantaginaceae	uncommon	UNITEC 12980
Muehlenbeckia complexa (A.Cunn.) Meisn. var. *complexa*	Polygonaceae	abundant	UNITEC 12981
Muehlenbeckia australis (G.Forst.) Meisn. × *M. complexa* (A.Cunn.) Meisn. var. *complexa*	Polygonaceae	uncommon	UNITEC 12982
**Rumex conglomeratus* Murray	Polygonaceae	1 seen (2021)	UNITEC 13003
**Lysimachia arvensis* (L.) U.Manns et Anderb. subsp. *arvensis*	Primulaceae	abundant	UNITEC 12983
Samolus repens var. *repens*	Primulaceae	common	UNITEC 12984
**Rhaphiolepis bibas* (Lour.) Galasso et Banfi	Rosaceae	3 seen (2021)	UNITEC 12985
**Rubus ulmifolius* Schott	Rosaceae	uncommon	UNITEC 12986
Coprosma macrocarpa subsp. *minor* A.P.Druce ex R.O.Gardner et Heads	Rubiaceae	uncommon	UNITEC 12987
Coprosma robusta Raoul	Rubiaceae	uncommon	UNITEC 12988
Coprosma macrocarpa subsp. *minor* A.P.Druce ex R.O.Gardner et Heads × *C. robusta* Raoul	Rubiaceae	uncommon	UNITEC 12989
**Galium aparine* L.	Rubiaceae	uncommon	UNITEC 12990
**Sherardia arvensis* L.	Rubiaceae	uncommon	UNITEC 12991
**Solanum mauritianum* Scop.	Solanaceae	1 seen (2001)	
**Solanum nigrum* L.	Solanaceae	1 seen (2021)	UNITEC 12992
Chromista – Ochrophyta (Phaeophyceae) (1)			
Hormosira banksii (Turner) Dcne.	Hormosiraceae	uncommon	

Mycobiota (27)			
Fungi (7)			
**Ramularia helminthiae* Bremer et Petr.	Mycosphaerellaceae	uncommon	UNITEC 12995
Puccinia coprosmae Cooke	Pucciniaceae	uncommon	UNITEC 12993
**Puccinia coronata* Corda	Pucciniaceae	uncommon	UNITEC 12999
**Puccinia myrsiphylli* (Thüm.) G.Winter	Pucciniaceae	uncommon	UNITEC 12994
Uromyces ehrhartae McAlpine	Pucciniaceae	uncommon	UNITEC 13002
**Uromyces tranasversalis* (Thüm.) G.Winter	Pucciniaceae	common	UNITEC 13015
**Russula amoenolens* Romagn.	Russulaceae	1 seen (2021)	
Lichens (20)			
Arthonia atra (Pers.) A.Schneid.	Arthoniaceae	common	UNITEC 12728
Arthonia peraffinis Nyl.	Arthoniaceae	uncommon	UNITEC 12727
Chrysothrix xanthina (Vain.) Kalb	Chrysothricaceae	uncommon	UNITEC 12730
Cladonia confusa R.Sant.	Cladoniaceae	uncommon	UNITEC 12726
Fissurina inquinata C.Knight et Mitt.	Graphidaceae	uncommon	UNITEC 12744
Graphis elegans (Borrer ex Sm.) Ach.	Graphidaceae	uncommon	UNITEC 12726
Lecanora carpinea (L.) Vain.	Lecanoraceae	common	UNITEC 12735
Opegrapha agelaeoides Nyl.	Opegraphaceae	uncommon	UNITEC 12740
Parmotrema crinitum (Ach.) M.Choisy	Parmeliaceae	uncommon	UNITEC 12745
Parmotrema perlatum (Huds.) M.Choisy	Parmeliaceae	uncommon	UNITEC 12736
Dirinaria applanata (Fée) D.D.Awasthi	Physciaceae	uncommon	UNITEC 13013
Heterodermia speciosa (Wulfen) Trevis	Physciaceae	common	UNITEC 12731
Physica adscendens (Fr.) H.Olivier	Physciaceae	uncommon	UNITEC 13005
Bacidia leucothalamia (Nyl.) Hellb.	Ramalinaceae	common	UNITEC 12729
Bacidia wellingtonii (Stirt.) D.J.Galloway	Ramalinaceae	common	UNITEC 13004
Ramalina celastri (Spreng.) Krog et Swinscow	Ramalinaceae	abundant	UNITEC 12996

Ramalina peruviana (Ach.)	Ramalinaceae	uncommon	UNITEC 12735
Athallia cerinelloides (Erichsen) Arup, Frödén et Søchting	Teloschistaceae	common	UNITEC 12742
Teloschistes chrysophthalmus (L.) Beltr.	Teloschistaceae	uncommon	UNITEC 12732
Xanthoria parietina (L.) Beltr.	Teloschistaceae	abundant	UNITEC 12734

APPENDIX 2: Avifauna recorded from Ngārango Otainui (January and November 2021 observations)

* denotes taxa naturalised to New Zealand

Scientific Name	Family	Abundance and comments
**Anas platyrhynchos* Linnaeus, 1758	Anatidae	2 seen
Phalacrocorax varius (Gmelin, 1758)	Phalacrocoracidae	2 seen
Egretta novaehollandiae (Latham, 1790)	Ardeidae	Primary and secondary feathers on ground. Nests present in taller pines on the island.
Platalea regia Gould, 1838	Ardeidae	Primary and secondary feathers on ground. High tide roost.
Sterna striata Gmelin, 1789	Sternidae	2 seen
Larus dominicanus Lichtenstein, 1823	Laridae	13 seen
Chrysococcyx lucidus Gmelin, 1788	Cuculidae	1 heard
Todiramphus sanctus Vigors et Horsfield, 1827	Halcyonidae	1 seen
Gerygone igata (Quoy et Gaimard, 1830)	Acanthizidae	1 seen
Zosterops lateralis (Latham, 1802)	Zosteropidae	1 seen
**Turdus merula* Linnaeus, 1758	Turdidae	1 seen
**Passer domesticus* (Linnaeus, 1758)	Passeridae	1 seen
**Fringilla coelebs* Linnaeus, 1758	Fringillidae	1 seen
**Carduelis chloris* (Linnaeus, 1758)	Fringillidae	4 seen

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